Individual CIE Report

CIE Review of BSAI and GOA Pacific Cod Stock Assessment Models

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By

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Executive Summary

This CIE review covers the stock assessment models for the stocks of Pacific cod in the Eastern Bering Sea and Gulf of Alaska. This reviewer was impressed by the amount and quality of work carried out on the assessment models for these stocks, and by the high standard of data collection and analyses that underpin these models. The best scientific information available appears to have been used throughout in the stock assessment models. Recommendations cover a number of areas, as stipulated in the Terms of Reference. These include ongoing support for the age-determination work and any work that would advance the Nichol *et al*. study on survey catchability, as well as a suggestion for the inclusion of temperature data, if practicable, to help better model annual variation in survey catchability. The current use of the Jensen-based estimates of natural mortality, and external estimation of both between-individual variability in size-at-age and input sample sizes for size and age composition data are supported, as are the use of the Nichol *et al*. study to tune survey catchability, the practice of fixing at least one fishery selectivity to be asymptotic, and the partitioning of data to allow for data features and limitations in SS functionality. Survey data are a key input to the assessment models, and should remain so, with fishery CPUE included (but not fitted) as a useful and independent comparison. Areas that could be improved include modelling time-varying selectivity with a constrained random walk over time instead of in time blocks, using a more flexible growth curve than the current version of the Richards curve (e.g. for EBS cod), and incorporating bi-modal selectivity as an option (e.g. for GOA cod). Furthermore, a coarser bin structure for the larger sizes that does not lead to a significant loss of information could be explored, as could the possibility of fixing σ_R to a sensible value instead of pursuing a time-consuming iterative procedure. Areas of concern include the statistical treatment in the overall likelihood of non-independent data, the internal estimation of the extent of ageing bias (is this possible?), and the "perfect" model fit to the GOA sub-27 survey data, indicating over-parameterisation. There are also concerns about whether the year-to-year changes in model structure, which should reduce somewhat as models mature, remain justified.

Introduction

This review concerns the stock assessments for Pacific cod in the Bering Sea/Aleutian Islands (BSAI) and Gulf of Alaska (GOA). Because the assessment for the former only models the Eastern Bering Sea stock, with adjustments afterwards to account for the Aleutian Islands stock, it will be referred to below as the Eastern Bering Sea (EBS) assessment. Although the Pacific cod assessments undergo thorough review on an annual basis, including calls for new model proposals and two fully reviewed drafts of the stock assessment reports, this is the first time since 2001 that it has undergone a Center for Independent Experts (CIE) review. A bibliography of materials provided for the review is listed in Appendix 1, and a copy of the CIE Statement of Work can be found in Appendix 2. The panel membership and list of participants to the first two days of the meeting is found in Appendix 3, and Appendix 4 lists the additional model runs that were carried out during and immediately after the meeting.

The reviewers' role comprised the following:

- Studying the material provided beforehand (documents 1-7, Appendix 1), with a particular focus on the latest stock assessment reports (documents 1b and d).
- Attending and participating in the meeting at the Alaska Fisheries Science Center in Seattle, Washington during 14-18 March 2011.
- Listening to presentations on collection and analysis of data, and development of models (presentations 8-19, Appendix 1), and to ask relevant questions where necessary.
- Working with the review panel chair, senior assessment author and other panel members (Appendix 3) to review and explore the assessment models for EBS and GOA cod. This included in-depth discussions of various aspects of the models, and suggestions for additional runs that could assist in answering the Terms of Reference (TOR) as set out in Annex 2 of Appendix 1.
- Studying the additional model runs (Appendix 4) in accordance with the TOR. Some of this had to occur after the meeting because the model runs were not available during the meeting.
- Compiling an independent peer review report, in accordance with the Statement of Work (Appendix 2).

The amount and quality of work carried out on the assessment models for Pacific cod are impressive by any standard, and the data collection regimes, fishery-dependent and independent, are some of the best and most comprehensive to be found anywhere today. This report acknowledges this, and tries to supplement this excellent work with some suggestions, pointing out potential problems where they have been encountered. In the report, Models A, B and C refer the models as described in the latest stock assessment reports (documents 1b and d, Appendix 1).

Summary of findings for each TOR

1. ***Use of age data, including:***
    a. ***Use of age composition data***
    Although there are clearly ongoing issues with regard to age determination of Pacific cod, age-determination methodologies and validation techniques (presentations 13 and 14, Appendix 1) have progressed to the point where there appears to be

reasonable confidence in and understanding of the age data for Pacific cod. Given the inclusion of an ageing error matrix, accounting for potential ageing bias which may be caused by some of these issues, there is great value in keeping age composition data in assessment models. There are clearly problems when age data are omitted, such as for Model C where there is a complete mismatch of length-at-age modes and implausible lengths for the youngest ages for the EBS assessment, and unrealistic estimates of spawning biomass as a fraction of $B_{35\%}$ for the GOA assessment.

b. Use of mean-size-at-age data

Mean size-at-age data, which are used simultaneously with age composition data (from the same age samples), were needed for the estimation of cohort-specific deviations in growth rate that formed part of Model A. Mean size-at-age data continued to be included in Model B, even though these data appear not to be needed when assuming a constant growth rate in Model B. This is demonstrated in model runs CIE10 and CIE11 (Appendix 4), the first of which explores turning off the mean size-at-age data alone – it seems that this model is estimable, albeit with a maximum gradient component 2 orders of magnitude larger than the base run CIE0 (compare ss3.par files), which may of course be due to insufficient number of jitters (25). Given that mean size-at-age and age composition data are based on the same age and length frequency samples, there is the question about whether these data should be treated independently, as they currently are in Models A and B, or whether the mean size-at-age data should be omitted when age composition data are used, as in CIE10.

Although CIE11 omits mean size-at-age data, it makes the simultaneous use of survey age composition and length frequency data (i.e. data based on the same length frequency samples appear in two components of the overall likelihood, with the statistical distribution of these two components treated as independent of each other). Is this approach any more justifiable than the simultaneous use of age composition and mean size-at-age data? The appropriate statistical treatment of data that are based on the same samples but appear in more than one component of the overall likelihood needs to be considered carefully.

c. Use of ageing bias as an estimated parameter

The internal estimation of ageing bias is a new feature of SS, so instead of trying to re-tune the ageing bias in order to achieve a better match to the observed age modes (an iterative and probably time-consuming process), it makes sense to make use of this new feature. This was investigated during the meeting through implementation of runs CIE5 and CIE11 (Appendix 4). Unfortunately, in neither case was the ageing bias tried on its own, so direct comparisons with the base run (CIE0) are not straightforward. However, CIE5 can be compared with CIE1, because both incorporate the Richards growth model and only differ by the implementation of ageing bias estimation in CIE5. In both cases, the quality of the model fit is in doubt. CIE1 is discussed under TOR 3. For CIE5, although the maximum gradient component appears reasonable (unlike for CIE1), there are other worrying aspects to the model fit, such as a poor fit to the post-81 survey length frequencies (a number of very large residuals, as for CIE1), strange behaviour of time varying selectivity for the post-81 shelf survey (see e.g. "sel6_timevary_surf_flt11sex1.png"), and a very low stock size at the beginning of the time-series (see e.g. "ts7 Spawning biomass (mt) with 95 asymptotic intervals intervals.png"). A further strange feature of CIE5 is that the CV associated with the ageing error matrix appears to decline with age for age 4+

(see e.g. "numbers5_ageerrorMeans.png" and "numbers5_ageerrorSD.png") – is this realistic? The presentation that discusses the precision of ageing agreement (slide 6, presentation 13, Appendix 1) seems to indicate the opposite.

CIE11 appears more reasonable, but there are too many things that are different compared with the base model to allow proper understanding of the impact of various components of the model. Given the potential problems with the Richards growth model for EBS cod, it may be worth investigating the impact of ageing bias estimation on its own.

*d. **External estimation of between-individual variability in size at age***
Attempts to estimate standard deviations of length-at-age led to a large maximum gradient component (slide 58, presentation 19, Appendix 1), so it appears that this is not possible under current model configurations, and continued external estimation seems a reasonable way forward.

2. Data partitioning/binning, including:

a. Catch data partitioned by year, season, and gear
A statistical analysis of the seasonal structure of the catch data using data from 2003-2008 led to an optimal catch season structure of 5 periods for both EBS and GOA (although the periods are not identical for the two). The argument for this approach was to have better statistical representation of catch patterns; this new seasonal structure was used for Models B and C for both EBS and GOA. Three selectivity periods were maintained by collapsing the first two catch seasons into the first selectivity period, the final two catch seasons into the third selectivity period, and allocating the middle catch season to the second selectivity period. The statistical approach to defining the catch seasons appears reasonable, and opens the way to simplifying the fishery structure from three gears per selectivity period (a total of 9 fisheries per year) to one generic gear per catch season (a total of 5 fisheries per year), an approach which was pursued for CIE11 and CIE12 (Appendix 4).

b. Size composition data partitioned by year, season, gear, and 1-cm size intervals
The argument for introducing a finer bin structure was to allow it to correspond to the actual resolution of the observations, leading to maximal use of the information content of the size composition data, and therefore maximising the ability to infer selectivity and growth patterns from this data. Although this may be beneficial for the smaller sizes, where a finer bin structure may offer a better opportunity to separate out different population processes reflected in the data because of faster growth at smaller sizes, there is a question about whether anything more will be gained with a finer bin structure at larger sizes, given the modelling cost of the finer bin structure – this aspect needs to be explored further. Dynamic binning (bins at the lower and upper ends of the length frequency data are combined until a minimum threshold number of observations are collected for each length frequency distribution) was explored during the meeting (CIE9 and GOA9, Appendix 4), and these appear to work. However, Teresa A'mar raised the possibility of a coding error with how SS treats effective sample size when combining bins (Teresa to be approached for more details).

c. Age composition data partitioned by year, season, and gear
Although fishery age composition data (a single year only) were used in Model A for both EBS and GOA, they were not used for Models B and C, for which only age

composition data from surveys were used. Therefore, only survey data are covered below.

The EBS trawl survey is partitioned into 1981 and earlier, and 1982 and later to deal with a gear change instituted in 1982. This split is sensible. Given that the 1981 and earlier portion of the series comprises only three years of data, and does not included age composition data, there is a question about whether this earlier data should continue to be used. If the additional parameters needed are supported by the data, then there is no harm in keeping the data in, even though these data may have minimal influence on current population estimates, unless there are known problems with the data that are not easily accommodated in the modelling framework.
The GOA trawl survey is partitioned by length into sub-27 and 27-plus components, to deal with the problem of a missing age 2 mode in the length frequency data, because the current version of SS does not accommodate bi-model selectivity curves. Furthermore, the 27-plus survey is partitioned into a 1993 and earlier and 1996 and later component because of the switch from 30 to 15 minute tows. These splits are sensible given the current functionality within SS and the change in tow duration, but the SS developer should be encouraged to include a bi-modal selectivity curve option to avoid the *ad-hoc* length split, and thereby improve the general functionality of SS.

3. ***Functional form of the length-at-age relationship and estimating the parameters thereof***
An attempt was made to fit the 4-parameter Richards growth curve (of which the von Bertalanffy curve is a special case), after some past problems with fitting this curve in SS were apparently sorted out. This required one of the parameters to be constrained to be positive. For the meeting, fitting the Richards curve was done in two steps, first constraining the said parameter to be positive (CIE2), then freeing the 4th parameter (CIE1, GOA1; Appendix 4). Comparing the base run CIE0 with CIE2, there is a large deterioration in both the objective function value (5388 to 8584) and the maximum component gradient (1.4×10^{-6} to 0.32). This improves somewhat when the 4th parameter is estimated (comparing CIE2 to CIE1, objective function value improves from 8584 to 6032, and maximum component gradient improves slightly from 0.32 to 0.16), but this is still substantially worse than CIE0, with some very large residuals for the fits to the post-81 trawl survey length frequency data. This appears to indicate that for the EBS dataset, constraining the one growth parameter to be positive leads to a marked deterioration in model fit. This problem does not occur for the GOA dataset because the above-mentioned growth parameter is already positive for GOA0, so fitting the Richards growth curve leads to an improvement in both the objective function value and maximum component gradient (comparing GOA0 with GOA1, they improve from 3774 to 3732, and from 5.8×10^{-4} to 4.0×10^{-4}, respectively).

4. ***Number and functional form of selectivity curves estimated, including assumptions regarding which selectivity curves should be forced to exhibit asymptotic behaviour***
It is often considered necessary to make the conservative assumption that at least one fishery exhibits asymptotic behaviour, or else dome-shaped selection can result throughout, with the descending limb being confounded with other model parameters (e.g. natural mortality, catchability, etc.). For EBS and GOA cod, a ranking procedure is used to determine those fisheries that exhibit asymptotic behaviour, but this procedure is *ad-hoc* (slides 43-47, presentation 18, Appendix 1), and it is not clear whether such a procedure is the best approach for determining which fisheries exhibit asymptotic

selectivity. The procedure results in several fisheries being assumed to exhibit asymptotic behaviour for EBS, but only one for GOA – an alternative may be to force only one major fishery to have asymptotic selection for each stock (e.g. the Jan-April trawl fishery in each case), but the additional parameters that result need to be identifiable and justifiable, given model selection criteria.

SS appears to be somewhat limited in its choice of selectivity curves available, which has meant that the GOA trawl survey data has had to be re-arranged and fitted as two separate time series (sub-27, 27-plus components) in order to deal with bi-modal selectivity (not available in SS). There appears to be no other reason for treating the GOA trawl survey data in this manner, and the additional functionality in SS would be useful, and may even reduce the number of parameters required.

Currently, time-varying selectivity is achieved either by estimating selectivity parameters on a survey-by-survey basis for some of the trawl survey components, or by defining a single selectivity block or selectivity blocks in multiples of 5 years for commercial fisheries (slide 33, presentation 18, Appendix 1). There was even the option of estimating some selectivity parameter for the whole time period, while estimating others by block. The last analysis of block structure appears to have been performed in 2008 (slides 48-49, presentation 18, Appendix 1), and the nature of the block-selection procedure raises the question about how often this time-consuming procedure should be repeated. An alternative approach that would side-step this question would be to model time-varying selectivity as a constrained random walk over time. However, SS currently appears to lack this functionality (although it can do random walk by age), so until this functionality becomes available, continued use of the block structure to capture time-varying selectivity (which really is a combination of various factors, including gear selectivity and fish availability), coupled with a process to reassess block structure (e.g. every 3-4 years?), as was last performed in 2008, may be a way forward if the current data structure continues to be used.

The removal of block structure for fishery selectivity was attempted during the meeting, and this is reflected in runs CIE3 and GOA3 (Appendix 4). An AIC_c comparison between CIE0 and CIE3 shows that CIE0 should be selected, indicating that the block structure leads to an improved model fit, although a comparison of the fishery selectivity curves indicates that asymptotic selectivity may not have been handled in the same way in the two models (forced for all but 3 fisheries in CIE0, but apparently for none of the fisheries in CIE3, meaning CIE3 has more free parameters than thought), but this only reinforces the improved fit for CIE0. Similar conclusions are drawn when comparing GOA3 to GOA0 (including the lack of forced asymptotic selection for any of the fisheries for GOA3), except that there also appear to be serious problems with the GOA3 fit (e.g. the almost complete lack of fit to the 27-plus trawl survey index).

5. ***Fixing the trawl survey catchability coefficient for the recent portion of the time series such that the average product of catchability and selectivity across the 60-81 cm size range equals the point estimate obtained by Nichol et al. (2007)***
The Nichol *et al*. study provides valuable insight and data on the availability of cod to the trawl survey gear, and this is currently used as a basis for tuning the combined catchability-selectivity parameters for parts of the EBS and GOA survey data. Concerns include the low number of archival tags used for the estimates from the Nichol *et al*. study (only 11), and the fact that the precision of these estimates (poor) is ignored in the

assessments. Nevertheless, use of this study is sensible, and planned future field work to help improve estimates is encouraging and should be supported, given the importance of obtaining appropriate estimates of survey catchability/selectivity.

One of the runs during the meeting (CIE7, Appendix 4) looked at estimating catchability instead of tuning it so that the average of its product with selectivity over the size range 60-81 cm equalled the estimate of 0.92 from the Nichol *et al*. study for EBS cod. CIE0 continues to have a better (only slightly) AIC_c score (and maximum component gradient 3 orders of magnitude smaller), but the catchability parameters differ only slightly (0.77 for CIE0, vs. 0.735 for CIE7), so the estimated value is not far off the value implied by the Nichol *et al*. study. It may be useful to repeat this exercise for GOA.

A worrying feature of the GOA assessments is the almost perfect fit to the sub-27 survey index, apart from the final year, 2009 (see for example "index2_cpuefitSub27_Trawl_Survey.png" for GOA0). This is probably because the sub-27 index represents mostly age 1 (see Table 2.10c, document 1d, Appendix 1), and because catchability for the sub-27 index is a free parameter for every survey (apart from the most recent one in 2009, for which the catchability is set equal to the one for the immediately preceding survey), the model is able to fit the data exactly. This is not a parsimonious parameterisation!

6. ***Fixing the natural mortality rate at the value corresponding to Jensen's (1996) Equation 7***
Internal estimation of M appears to have been investigated in some detail during 2007 (presentation 18, Appendix 1), with one of the concerns being that models with very high estimates of M resulted in high estimates of ABC, which was felt to be unreasonable. There is no shortage of candidate values for M (slide 36, presentation 18), and these were discussed in detail for EBS during 2008 (slide 37, presentation 18), with justification provided for the continued use of the Jensen estimate in assessments. Unless new studies come to light (e.g. controlled tagging experiments specifically designed for the estimation of M), use of the Jensen-based estimates for both EBS and GOA seems a reasonable approach.

Nevertheless, the internal estimation of M for EBS was explored during the meeting (CIE8). An informative prior, assuming a normal distribution with mean 0.4 and CV of 30%, was used for this purpose. There was no improvement over CIE0 in AIC_c terms. Furthermore, the estimated M in CIE8 was very close to the fixed M in CIE0 (0.345 compared to 0.340), and there was a marked deterioration in the maximum component gradient (from 1.4×10^{-6} in CIE0 to 1.2×10^{-2} in CIE8), raising questions about the quality of the model fit for CIE8, or whether there is enough information to be able to estimate M given this model configuration.

7. ***Input sample sizes for size composition and age composition data, and input log-scale standard deviations for survey abundance data***
Specifying the input sample sizes for the size composition data is a complex procedure, performed externally to the assessment model and involving the use of harmonic means from a bootstrap analysis of the fishery length data from 1990 on. For the years not included in the bootstrap analysis, the consistency of the ratio between the raw harmonic means and the actual sample sizes allowed a constant adjustment factor to be defined for the period 1998 and earlier (0.16), and for the period 1999 and later (0.34). All sample

sizes, based either on the bootstrap harmonic means or modified with the adjustment factors, were then rescaled proportionally so that the average value across all samples was 300. Once a model fit was obtained, effective sample sizes could be calculated and compared with the input sample sizes to determine how well the model was fitting the relevant size composition data (effective sample size >> input sample size indicating a good fit to the data). The determination of the input sample sizes externally to the model is key, and the statistical procedure used to do this seems more justified than the previous *ad hoc* "square root" rule.

The procedure used for specifying the input sample sizes for age composition data was much simpler, involving the proportional re-scaling of the actual number of otoliths read each year so that the average across all input sample sizes was 300. This approach puts the age composition data on a par (in weighting terms) with the length frequency data. With regard to the input standard deviations for the survey abundance data, one of the panel members pointed out early on during presentation 11 (Appendix 1) that the variance calculation (slide 23) assumes randomness, but the EBS survey has a stratified systematic design, implying that the variance calculation is not appropriate. This issue needs to be re-visited in order to ensure that the survey abundance data points receive the appropriate weighting in the assessments.

8. ***Allowing for annual variability in trawl survey selectivity***
   One of the issues with the assessments for EBS and GOA cod is the differing interpretation of survey catchability and selectivity across the different models, although the product of these two factors appears to have the same interpretation throughout. For example, in some cases catchability is allowed to vary on a survey-by-survey basis while selectivity is kept constant (sub-27 survey for GOA), whereas in other cases, catchability is kept constant while the selectivity is allowed to vary on a survey-by-survey basis (27-plus survey for GOA, and the 1982+ survey for EBS, where the ascending width of the survey selectivity varies annually). Therefore, this TOR should have referred to annual variability in the product of trawl survey catchability and selectivity, rather than selectivity alone.

   Given the tremendous efforts to standardise survey gear (presentations 11 and 12, Appendix 1), it is counter-intuitive to think of annually varying survey selectivity, if it is meant to represent gear selectivity, but clearly this is not the case for EBS and GOA cod, where the availability of fish is strongly influenced by environmental conditions (see e.g. slides 31-35 in presentation 11), and model flexibility is limited by the use of a generic modelling framework (instead of a custom-built one). One possibility for assessments is to try to incorporate knowledge about the effect of water temperature on survey catchability, with corresponding data – this may help separate out issues of availability and selectivity, with a possible model configuration being to keep survey selectivity time-invariant (with the benefit of reduced parameters) and to make survey catchability some function of water temperature. However, this may not be possible under the current SS framework.

9. ***Setting the input standard deviation of log-scale recruitment (σ_R) equal to the standard deviation of the estimated log-scale recruitment deviations***
   Although iterative algorithms have the appearance of objectivity, they are often not satisfactory from a statistical perspective (the objective of iterating until there is no change is hardly a statistical one), and can be time-consuming for complex models. An

approach often used is to fix σ_R externally to some sensible value (e.g. a value of 0.6 is often used – see Smith and Punt 1998).

10. ***Use of survey data and non-use of fishery CPUE data in model fitting***
Use of standardised survey data is absolutely key to the assessments of EBS and GOA cod, and these should continue to form the basis of these assessments. Although none of the models actually attempt to fit the fishery CPUE, these data are nonetheless included in the assessment models for comparison only, so provide an independent view of stock trends. It is useful to keep them in as an aid to understanding the data, and a warning for potential problems (e.g. of all fishery CPUE show a consistent trend that is at odds with the survey index).

Aspects that arose outside the TOR

Catch estimation
Catch estimation for Pacific cod is underpinned by both industry reports and one of the most comprehensive observer programs to be found anywhere (presentation 9 and report 20, Appendix 1). Although variance estimates are not currently available, they are in the pipeline and could be used in future to challenge the assumption of no error in total catch data in current assessment models. The provision of these variance estimates should be encouraged, if practicable, to ensure the models are based on appropriate assumptions regarding the catch data.

Other runs
In order to investigate the influence of fishery size composition data on model outputs, an additional run was carried out for which the size composition data received very low weight in the model fit (weight set equal to 0.001; CIE6, Appendix 4; but see also description of CIE4, which was run with the incorrect model setting, and is therefore not discussed further). The fishery size composition data could not be entirely discounted (i.e. allocated zero weight) because the data were still needed to estimate the fishery selectivity parameters. Compared with base run CIE0, there are differences in the model output (e.g. larger L_{inf} and large stock size at the start of the time-series for CIE6), indicating that the fishery size composition data are having an impact, but general stock trends are similar. Importantly, however, inclusion of the fishery size composition data leads to more precise estimates of stock size (compare for example "ts7 Spawning biomass (mt) with 95 asymptotic intervals intervals.png" for the two models), which is important for the provision of management advice.

Possible coding problems
During the meeting, a couple of potential coding problems in SS were identified. The first has already been mentioned under TOR 2b above. The second relates to the lack of fit to the 2010 trawl survey size composition data at the smallest sizes (<20cm; see e.g. "comp_sizefit_flt11sex1mkt0_page1.png" for CIE0). Given that these are mostly age 1, and given that the recruitment deviation has nothing else to fit to, this lack of fit is surprising and may be indicative of a coding error.

In addition to these, the fit to the GOA 1990 May-Aug Trawl survey size composition data produces enormous residuals at the smaller sizes in "comp_lenfit_residsflt2sex1mkt0.png", but these do not seem to show up in "comp_lenfit_flt2sex1mkt0.png" – this may be easily explained, but needs looking into in case there is a problem.

Model complexity and looking ahead

The need for a time-consuming process of "jittering" for each new model run to avoid local minima and general problems of lack of convergence point to the data and model configuration being pushed close to the limit in terms of being estimable. This problem affected the effectiveness of the review, because on the whole, jittering was not possible during the meeting due to time constraints, and panel members could not be confident (to the extent jittering gives such confidence) that results presented during the meeting reflected the best fit for a given model configuration. More seriously, however, it raises the possibility that the current models for EBS and GOA cod are too close to being over-parameterised. There are procedures for investigating parameter redundancy (see e.g. Gimenez *et al*. 2004), and perhaps some of these should be employed for these models, if practicable. The model configuration for CIE11 is one attempt towards simplification that may have some merit, and further attempts along these lines should be encouraged.

A related point is that the annual process of coming up with the best assessment seems to have become extremely time-consuming, and raises the question about whether things really are changing that much from year to year (reflected by year-to-year changes in model structure), or whether one is just essentially modelling noise. In this context, a figure produced for presentation is revealing (slide 7, presentation 17) – it shows year-on-year perceptions of stock trends given whatever flavour of model structure is considered best at the time. An alternative approach would be to settle on a particular model structure for a longer period (say 3-5 years), because real change would probably only be detected on such a time-scale anyway. Of course, detailed work on the next model can continue in the interim period, making use of the latest scientific research, but also keeping an eye on the current model to make sure that assumptions are not violated to the extent that the model leads to poor management decisions. This approach also opens the way to management strategy evaluation (presentation 17, Appendix 1).

Another issue is the debate about whether stock assessment should be "custom-built", or whether "off the shelf" modelling frameworks should be used. There are pros and cons on both sides of the argument, and this debate may have occurred for Pacific cod a while back (or at least the decision was made to stay with SS when the original assessment developer moved on?). There are a few examples of compromises for the Pacific cod models to enable the SS framework to continue to be used (e.g. lack of bi-modal selection for GOA leading to a split in the survey data, and lack of constrained random walk over time leading to selectivity by time blocks), but given that these models appear to have reached their limit in terms of complexity within SS (a cause of the jitter problem?), perhaps now is the time to revisit this debate?

The NMFS review process

This section interprets the "NMFS review process" mentioned in point 2d of Annex 1 in Appendix 2 as the current review process for EBS and GOA cod. Background material was received on time and well in advance of the meeting. The meeting itself was well-organised, with useful and relevant presentations on the first day, covering various aspects of data collection and analysis, as well as on fisheries management. The senior assessment author provided comprehensive presentations on the second day, covering the historical development of the assessments, current models, and possible future models. The remainder of the meeting consisted of a smaller group (the panel members listed in Appendix 3) going through a detailed and well thought-out TOR, covering various aspects of the assessments and involving detailed discussions and planning of additional model runs to help explore the TOR. This procedure worked well. Communication of presentations and model results was through a "tiny URL" ftp site, which also worked very well.

Particularly helpful during the meeting was to have the participation of another experienced modeller (Teresa A'mar) who also had experience with using a graphics tool that could convert SS model output into graphical displays (R4SS) – this proved very useful and essential for the review process. Nevertheless, the graphics tool had some features that could be improved (e.g. it was not always clear what some graphs referred to, and there were some problems with duplicated or failed outputs).

The model outputs from SS are not user-friendly, and in particular parameter names are not intuitive or easy to identify (e.g. MGparm[4]?), so one suggestion is that a similar tool be developed for non-graphical output so that model parameters and other useful diagnostics (e.g. likelihood component values and RMSE "scores") are easily identified and interpreted – this would be a huge help for reviewers, and assessment authors may also find it a time-saving device for the own purposes.

Conclusions and recommendations in accordance with TORs

Stock assessments for Pacific cod are clearly underpinned by comprehensive and high-quality fishery-dependent and independent data collection and analysis programs, ensuring the best scientific information is available. The annual, thorough stock assessment review process ensures that this information is reflected in assessment models. However, this approach can lead, and probably has led, to the problem of a "never-ending assessment", where the assessment model structure changes every year, and stock perceptions (both current and historical) along with it. Although this may be acceptable during the initial stages of model development, it should happen less as the model matures, or else one is in danger of modelling noise instead of real change. Recommendations with regard to the TORs follow.

TOR 1:
- Age composition data are valuable, and their continued use, coupled with an ageing error matrix, is highly recommended. This approach is supported by ongoing research into age-determination methods and validation techniques, and this ongoing research is encouraged. The application to fishery data is also encouraged.
- The appropriate statistical treatment of non-independent data (e.g. when data based on the same samples are used in two components of the overall likelihood) should be investigated.
- The feasibility of internal estimation of ageing error bias should be explored (the runs considered by the review panel were not focused enough to consider this properly).
- The provision of external estimates of between-individual variability in size-at-age data should continue as is (efforts to estimate them internally were not successful).

TOR 2:
- Although the finer bin structure may be justified for smaller sizes, this might not be the case for larger sizes, and a coarser bin structure should be explored for the latter.
- If there is no compelling reason to remove the pre-1982 data for EBS cod, then they should be retained.
- The partitioning of data to deal with data features (e.g. change in gear) and limitations in SS functionality (e.g. lack of bi-model selection) is sensible. However, there are problems

with the fit to the GOA sub-27 index (exact fits, indicating over-parameterisation) that need looking into.

TOR 3:

- The need to constrain one of the growth parameters to be positive to enable the Richards growth curve to be used leads to poor model fits when this constraint becomes active (e.g. for EBS, but not for GOA). This indicates that the constrained Richards model is actually less flexible than the unconstrained Von Bertalanffy model in some cases, and that more flexible growth models should be considered.

TOR 4:

- The forcing of just one major fishery to have asymptotic selection (e.g. the Jan-Apr trawl fishery for both stocks) should be explored. This is an alternative to the *ad hoc* approach used to force a number of fisheries to exhibit such behaviour for EBS, but needs to be justifiable, given the additional parameters that may be required.
- The inclusion of bi-model selection may avoid some of the issues surrounding the fit to the sub-27 GOA survey index, and should be explored.
- An alternative to block selectivity is to consider a constrained random walk over time, but if this is not practicable, the current block structure could be justified given model selection criteria (this was not verifiable during the meeting given the runs considered).

TOR 5:

- The Nichol *et al*. study provided valuable insight into survey selectivity, but relied on a few archival tags, resulting in estimates with poor precision. The assessments should continue to use the Nichol *et al*. estimates, but any further work along these lines should be encouraged.
- As mentioned in TOR 2 and 4, the modelling of the GOA sub-27 index appears to suffer from over-parameterisation, because the index essentially covers only age 1, with the free catchability parameter for each survey allowing each data point to be fitted almost exactly. This parameterisation is not parsimonious and needs to be re-considered.

TOR 6:

- The continued use of the Jensen-based natural mortality estimates is sensible, unless other reliable studies (aimed at estimating natural mortality for Pacific cod) come to light.

TOR 7:

- The process for deriving estimates of input sample size external to the model appears to be sensible and should continue (although consideration should be given to a reviewer's alternative suggestion to use number of stations/trips rather than number of samples).
- The estimation of input standard deviations for the survey abundance data relies on the assumption of randomness, but the EBS survey has a stratified systematic design, implying these standard deviation estimates are not appropriate, and their estimation should be re-visited.

TOR 8:

- Survey catchability is strongly influenced by water temperature, and any attempts to incorporate this knowledge and data into assessment to help quantify year-to-year changes in catchability (rather than modelling annual variability in survey selectivity) should be explored.

TOR 9:

- Consideration should be given to fixing σ_R externally to some sensible value (e.g. 0.6) rather than using a time-consuming iterative procedure, which may be difficult to justify on statistical grounds.

TOR 10:

- Survey data are key to the Pacific cod assessment and should continue to form the basis of the assessments. Continued inclusion of the fishery CPUE data in assessment models (although they are not fitted) is useful for comparative purposes, and allows an independent check on model outputs.

Finally, the senior assessment author should find ways to minimise jittering as it cannot be good for his health!

References

Gimenez, O., Viallefont, A., Catchpole, E. A., Choquet, R. & Morgan, B. J. T., 2004. Methods for investigating parameter redundancy. Animal Biodiversity and Conservation, 27.1: 561–572.

Smith, A.D.M., and Punt, A.E. 1998. Stock assessment of gemfish (*Rexea solandri*) in eastern Australia using maximum likelihood and Bayesian methods. In Fisheries stock assessment models. Edited by T.J. Quinn II, F. Funk, J. Heifetz, J.N. Ianelli, J.E. Powers, J.F. Schweigert, P.J. Sullivan, and C-I. Zhang. Alaska Sea Grant College Program, AK-SG-98-01. pp. 245–286.

Appendix 1
Bibliography of materials provided for review

Materials supplied prior to the review meeting (sent by email on 28th February 2010):

1) The 2009 and 2010 assessments documents for BSAI and GOA Pacific cod stocks:
   a. Chapter 2: Assessment of the Pacific Cod Stock in the Eastern Bering Sea and Aleutian Islands Area. December 2009. Grant G. Thompson, James N. Ianelli and Robert R. Lauth.
   b. Chapter 2: Assessment of the Pacific Cod Stock in the Eastern Bering Sea and Aleutian Islands Area. December 2010. Grant G. Thompson, James N. Ianelli and Robert R. Lauth.
   c. Chapter 2: Assessment of the Pacific Cod Stock in the Gulf of Alaska. December 2009. Grant G. Thompson, James N. Ianelli and Mark E. Wilkins.
   d. Chapter 2: Assessment of the Pacific Cod Stock in the Gulf of Alaska. December 2010. Grant G. Thompson, James N. Ianelli and Mark E. Wilkins.

2) The Stock Synthesis files corresponding to the final models from last year's assessments (*.ctl, *.dat, *.par, *.ss, and ss3.exe).

3) Relevant excerpts from the minutes of the December, 2010 and February, 2011 SSC meetings.
   a. Draft Report of the Scientific and Statistical Committee to the North Pacific Fishery Management Council. December 6-8, 2010 (4pp).
   b. Draft Report of the Scientific and Statistical Committee to the North Pacific Fishery Management Council. January 31st-February 2nd, 2011 (2pp).

4) Relevant excerpts from the minutes of the November, 2010 BSAI Plan Team (BPT), GOA Plan Team (GPT), and Joint Plan Team (JPT) meetings.
   a. Minutes of the Joint Plan Teams for the Groundfish Fisheries of the Gulf of Alaska and Bering Sea Aleutian Islands. November 15-16, 2010 (3pp).
   b. Minutes of the Bering Sea and Aleutian Islands Groundfish Plan Team. November 16-19, 2010 (1pp).
   c. Minutes of the Gulf of Alaska Groundfish Plan Team. November 16-19, 2010 (2pp).

5) Comments on the assessments submitted by Quantitative Resource Assessment LLC, on behalf of the Freezer Longline Coalition (QRA comments, February 20th, 2011, 14pp).

Further materials supplied on request prior to the review (sent by email on 8th March 2010):

6) User Manual for Stock Synthesis. Model Version 3.20 (Updated Jan 21, 2011). Richard D. Methot Jr., NOAA Fisheries, Seattle, WA.

7) Technical Description of the Stock Synthesis II Assessment Program. Version 1.17, March 2005. Richard D. Methot, NOAA Fisheries, Seattle, WA.

Materials presented during the meeting (placed on a server at the following address: ftp://ftp.afsc.noaa.gov/afsc/public/Pcod/default.htm):

8) Description of the pacific cod fishery – Grant Thompson (Fishery_overview.pptx, 13 slides)

9) Catch Data – Jennifer Mondragon (CatchData.pdf, 12 slides)

10) Fisheries Monitoring and Analysis Division. North Pacific Groundfish Observer Program – Patti Nelson (North_Pacific_Observer_Program.ppt, 15 slides)

11) Eastern Bering Sea shelf bottom trawl survey of groundfish and invertebrate resources – Bob Lauth (CIE_TrawlSurvey_EBSPcod.ppt, 38 slides)

12) Pacific Cod: What Bottom Trawl Surveys of the Gulf of Alaska and Aleutian Islands Tell Us – Mark Wilkins (Cod_in_GOA_and_AI_Surveys.ppt, 42 slides)
Supplementary material: AI_distmaps.ppt (11 slides) and GOA_distmaps.ppt (11 slides)

13) Age Determination of Pacific Cod (*Gadus macrocephalus*) at the Alaska Fisheries Science Center – Delsa Anderl (Pcod_CIE_2011_2.ppt, 15 slides)

14) Preliminary Age Validation of Pacific Cod (*Gadus macrocephalus*) using Stable Oxygen Isotopes ($\delta^{18}O$) – Craig Kastelle (Kastelle.ppt, 17 slides)

15) Some Management Considerations Regarding Pacific Cod Stock Assessments – Jane DiCosimo (Pcod_CIEreviewF.ppt, 3 slides)

16) Landscape genetics of Pacific cod in the Aleutian Islands and Bering Sea – Ingrid Spies (Spies_CIE_talk.ppt, 29 slides)

17) Management strategy evaluation of the GOA Pacific cod fishery – Teresa A'mar (GOA Pacific cod MSE.pdf, 26 slides)

Further materials presented during the meeting (circulated on a USB memory stick):

18) History of the EBS and GOA Pacific cod stock assessments – Grant Thompson (CIE assessment history.ppt, 100 slides

19) Overview of the final 2010 BSAI and GOA Pacific cod stock assessments and recent research – Grant Thompson (Current assessments and recent research.pptx, 58 slides)

Report provided for interest on final day of meeting (paper copy):

20) Evaluation and Analysis of Current Field Sampling in North Pacific Groundfish Fisheries. Task 1: Biological Sampling Protocols. Final Report, prepared by MRAG Americas Inc., Tampa, Florida for National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, Washington, April 2003.

Further background material (not presented) was available on ftp://ftp.afsc.noaa.gov/afsc/public/Pcod/default.htm.

Appendix 2
Copy of CIE Statement of Work

External Independent Peer Review by the Center for Independent Experts
BSAI and GOA Pacific Cod Stock Assessment Review

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Technical Representative (COTR), and reviewed by CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance with the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in **Annex 1**. This SoW describes the work tasks and deliverables of the CIE reviewer for conducting an independent peer review of the following NMFS project. Further information on the CIE process can be obtained from www.ciereviews.org.

Project Description: The Alaska Fisheries Science Center (AFSC) requests a Center of Independent Experts (CIE) review of stock assessments for the Bering Sea/Aleutian Islands (BSAI) and Gulf of Alaska (GOA) Pacific cod stock assessments. The Pacific cod fisheries are large and Pacific cod is a key component of the BSAI and GOA ecosystems. The Pacific cod stock assessments routinely undergo thorough review by the AFSC, the North Pacific Fisheries Management Council's Groundfish Plan Teams and Scientific and Statistical Committee, and members of the public. The annual process for producing the Pacific cod stock assessments includes calls for new model proposals and two fully reviewed drafts of the stock assessment report. However, the Pacific cod stock assessments have not had the benefit of a CIE review since 2001. Therefore, a CIE review in 2011 would be timely. The Terms of Reference (ToRs) of the peer review are attached in **Annex 2**. The tentative agenda of the panel review meeting is attached in **Annex 3**.

Requirements for CIE Reviewers: Three CIE reviewers shall conduct an impartial and independent peer review in accordance with the SoW and ToRs herein. CIE reviewers shall have expertise and working knowledge in the application of current stock assessment, including population dynamics, survey methodology, estimation of parameters in complex nonlinear models, and the Stock Synthesis assessment program in particular. CIE reviewers shall have recent experience conducting stock assessments for fisheries management. Each CIE reviewer's duties shall not exceed a maximum of 14 days to complete all work tasks of the peer review described herein.

Location of Peer Review: Each CIE reviewer shall conduct an independent peer review during the panel review meeting scheduled at Alaska Fisheries Science Center in Seattle, Washington during the tentative dates of March 14-18, 2011.

Statement of Tasks: Each CIE reviewer shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein.

Prior to the Peer Review: Upon completion of the CIE reviewer selection by the CIE Steering Committee, the CIE shall provide the CIE reviewer information (full name, title, affiliation, country, address, email) to the COTR, who forwards this information to the NMFS Project Contact no later than the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewers. The NMFS Project Contact is responsible for providing the CIE reviewers with the background documents, reports, foreign national security clearance, and other information concerning pertinent meeting arrangements. The NMFS Project Contact is also responsible for providing the Chair a copy of the SoW in advance of the panel review meeting. Any changes to the SoW or ToRs must be made through the COTR prior to the commencement of the peer review.

Foreign National Security Clearance: When CIE reviewers participate during a panel review meeting at a government facility, the NMFS Project Contact is responsible for obtaining the Foreign National Security

Clearance approval for CIE reviewers who are non-US citizens. For this reason, the CIE reviewers shall provide requested information (e.g., first and last name, contact information, gender, birth date, passport number, country of passport, travel dates, country of citizenship, country of current residence, and home country) to the NMFS Project Contact for the purpose of their security clearance, and this information shall be submitted at least 30 days before the peer review in accordance with the NOAA Deemed Export Technology Control Program NAO 207-12 regulations available at the Deemed Exports NAO website: http://deemedexports.noaa.gov/sponsor.html).

Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contact will send (by electronic mail or make available at an FTP site) to the CIE reviewers the necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE Lead Coordinator on where to send documents. CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein. The CIE reviewers shall read all documents in preparation for the peer review.

Panel Review Meeting: Each CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs, and shall not serve in any other role unless specified herein. **Modifications to the SoW and ToRs can not be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COTR and CIE Lead Coordinator.** Each CIE reviewer shall actively participate in a professional and respectful manner as a member of the meeting review panel, and their peer review tasks shall be focused on the ToRs as specified herein. The NMFS Project Contact is responsible for any facility arrangements (e.g., conference room for panel review meetings or teleconference arrangements). The NMFS Project Contact is responsible for ensuring that the Chair understands the contractual role of the CIE reviewers as specified herein. The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements, including the meeting facility arrangements.

Contract Deliverables - Independent CIE Peer Review Reports: Each CIE reviewer shall complete an independent peer review report in accordance with the SoW. Each CIE reviewer shall complete the independent peer review according to required format and content as described in Annex 1. Each CIE reviewer shall complete the independent peer review addressing each ToR as described in Annex 2.

Specific Tasks for CIE Reviewers: The following chronological list of tasks shall be completed by each CIE reviewer in a timely manner as specified in the **Schedule of Milestones and Deliverables**.

1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review.
2) Participate during the panel review meeting at the Alaska Fisheries Science Center in Seattle, Washington during the tentative dates of March 14-18, 2011.
3) Conduct an independent peer review in accordance with the ToRs (**Annex 2**), during the tentative dates of March 14-18, 2011 at the Alaska Fisheries Science Center in Seattle, Washington, as specified herein.
4) No later than 1 April 2011, each CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Mr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and Dr. David Die, CIE Regional Coordinator, via email to ddie@rsmas.miami.edu. Each CIE report shall be written using the format and content requirements specified in **Annex 1**, and address each ToR in **Annex 2**.

Schedule of Milestones and Deliverables: CIE shall complete the tasks and deliverables described in this SoW in accordance with the following schedule.

7 February 2011	CIE sends reviewer contact information to the COTR, who then sends this to the NMFS Project Contact
28 February 2011	NMFS Project Contact sends the CIE Reviewers the pre-review documents
14-18 March 2011	Each reviewer participates and conducts an independent peer review during the panel review meeting

1 April 2011	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
15 April 2011	CIE submits CIE independent peer review reports to the COTR
22 April 2011	The COTR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

Modifications to the Statement of Work: Requests to modify this SoW must be approved by the Contracting Officer at least 15 working days prior to making any permanent substitutions. The Contracting Officer will notify the COTR within 10 working days after receipt of all required information of the decision on substitutions. The COTR can approve changes to the milestone dates, list of pre-review documents, and ToRs within the SoW as long as the role and ability of the CIE reviewers to complete the deliverable in accordance with the SoW is not adversely impacted. The SoW and ToRs shall not be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COTR for final approval as contract deliverables based on compliance with the SoW and ToRs. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (CIE independent peer review reports) to the COTR (William Michaels, via William.Michaels@noaa.gov).

Applicable Performance Standards: The contract is successfully completed when the COTR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards:
(1) each CIE report shall completed with the format and content in accordance with **Annex 1**,
(2) each CIE report shall address each ToR as specified in **Annex 2**,
(3) the CIE reports shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

Distribution of Approved Deliverables: Upon acceptance by the COTR, the CIE Lead Coordinator shall send via e-mail the final CIE reports in *.PDF format to the COTR. The COTR will distribute the CIE reports to the NMFS Project Contact and Center Director.

Support Personnel:
William Michaels, Contracting Officer's Technical Representative (COTR)
NMFS Office of Science and Technology
1315 East West Hwy, SSMC3, F/ST4, Silver Spring, MD 20910
William.Michaels@noaa.gov Phone: 301-713-2363 ext 136

Manoj Shivlani, CIE Lead Coordinator
Northern Taiga Ventures, Inc.
10600 SW 131st Court, Miami, FL 33186
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Phone: 305-383-4229

Key Personnel:
NMFS Project Contact:
Grant Thompson
7600 Sand Point Way NE., Seattle, WA 98115-6349
Grant.Thompson@noaa.gov
Phone: 541-737-9318

Annex 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specify whether the science reviewed is the best scientific information available.

2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Summary of Findings for each ToR in which the weaknesses and strengths are described, and Conclusions and Recommendations in accordance with the ToRs.
   a. Reviewers should describe in their own words the review activities completed during the panel review meeting, including providing a brief summary of findings, of the science, conclusions, and recommendations.
   b. Reviewers should discuss their independent views on each ToR even if these were consistent with those of other panelists, and especially where there were divergent views.
   c. Reviewers should elaborate on any points raised in the Summary Report that they feel might require further clarification.
   d. Reviewers shall provide a critique of the NMFS review process, including suggestions for improvements of both process and products.
   e. The CIE independent report shall be a stand-alone document for others to understand the weaknesses and strengths of the science reviewed, regardless of whether or not they read the summary report. The CIE independent report shall be an independent peer review of each ToRs, and shall not simply repeat the contents of the summary report.

3. The reviewer report shall include the following appendices:
   Appendix 1: Bibliography of materials provided for review
   Appendix 2: A copy of the CIE Statement of Work
   Appendix 3: Panel Membership or other pertinent information from the panel review meeting.

Annex 2: Terms of Reference for the Peer Review
BSAI and GOA Pacific Cod Stock Assessment Review

For both the EBS and GOA Pacific cod assessments, CIE reviewers shall evaluate current model assumptions and make recommendations for improvements thereof, including:

11. Use of age data, including:
    a. Use of age composition data
    b. Use of mean-size-at-age data
    c. Use of ageing bias as an estimated parameter
    d. External estimation of between-individual variability in size at age
12. Data partitioning/binning, including:
    a. Catch data partitioned by year, season, and gear
    b. Size composition data partitioned by year, season, gear, and 1-cm size intervals
    c. Age composition data partitioned by year, season, and gear
13. Functional form of the length-at-age relationship and estimating the parameters thereof
14. Number and functional form of selectivity curves estimated, including assumptions regarding which selectivity curves should be forced to exhibit asymptotic behavior
15. Fixing the trawl survey catchability coefficient for the recent portion of the time series such that the average product of catchability and selectivity across the 60-81 cm size range equals the point estimate obtained by Nichol et al. (2007)
16. Fixing the natural mortality rate at the value corresponding to Jensen's (1996) Equation 7
17. Input sample sizes for size composition and age composition data, and input log-scale standard deviations for survey abundance data
18. Allowing for annual variability in trawl survey selectivity
19. Setting the input standard deviation of log-scale recruitment (σ_R) equal to the standard deviation of the estimated log-scale recruitment deviations
20. Use of survey data and non-use of fishery CPUE data in model fitting

References:

Jensen, A. L. 1996. Beverton and Holt life history invariants result from optimal trade-off of reproduction and survival. *Can. J. Fish. Aquat. Sci.* 53:820-822.
Nichol, D. G., T. Honkalehto, and G. G. Thompson. 2007. Proximity of Pacific cod to the sea floor: Using archival tags to estimate fish availability to research bottom trawls. *Fisheries Research* 86:129-135.

Annex 3: Agenda
CIE Review of EBS and GOA Pacific cod stock assessment models
Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA 98115
Building 4, Room 2076 (March 14-15), Room 2143 (March 16-18, 2011)

Review panel chair: Anne Hollowed, Anne.Hollowed@noaa.gov
Senior assessment author: Grant Thompson, Grant.Thompson@noaa.gov
Security and check-in: Julie Pearce, Julie.Pearce@noaa.gov (206)526-6547

Sessions will run from 9 a.m. to 5 p.m. each day, with time for lunch and breaks.

Monday, March 14th

Preliminaries
- 09:00 Introductions – Anne Hollowed
- 09:10 Adopt Agenda – Anne Hollowed
- 09:20 Description of the Pacific cod fisheries – Grant Thompson

Data
- 09:40 Catch data – Jennifer Mondragon (via WebEx)
- 10:20 Fishery-dependent length composition data – Patti Nelson

Break (10:50)
- 11:10 EBS trawl survey – Bob Lauth
- 11:40 GOA trawl survey – Mark Wilkins

Lunch (12:10)
- 13:10 Age composition and mean-length-at-age data – Delsa Anderl and Craig Kastelle

Assessment
- 14:10 Assessment history – Grant Thompson (transferred to 09:00, following day)

Break (15:10)

Management
- 15:30 Management issues related to the stock assessments – Jane DiCosimo

Possible considerations for future assessments
- 16:00 Genetic and spatial considerations – Ingrid Spies
- 16:30 Management strategy evaluation of the GOA stock – Teresa A'mar

Tuesday, March 15th

Details of last year's assessments and pre-meeting model runs – Grant Thompson
Discussion, real-time model runs – Everyone
Assignments for models to be presented the following day – Panel

Wednesday-Thursday, March 16th-17th

Review of models assigned the previous data – Grant Thompson
Discussion, real-time model runs – Everyone
Assignments for models to be presented the following day – Panel

Friday, March 18th

Review of models assigned the previous data – Grant Thompson
Discussion, real-time model runs – Everyone
Report writing – Panel

Appendix 3
Panel Membership and other pertinent information

Panel members

Review panel chair: Anne Hollowed, Anne.Hollowed@noaa.gov
Senior assessment author: Grant Thompson, Grant.Thompson@noaa.gov

CIE Reviewers:
Yong Chen, School of Marine Sciences, University of Maine, Orono, USA, ychen@maine.edu
Chris Darby, Centre for Environment, Fisheries and Aquaculture Science, Lowestoft, UK, chris.darby@cefas.co.uk
José De Oliveira, Centre for Environment, Fisheries and Aquaculture Science, Lowestoft, UK, jose.deoliveira@cefas.co.uk

Others:
Teresa A'mar (Teresa.Amar@noaa.gov) participated in all five days of the meeting and provided valuable assistance (e.g. with the R4SS plotting program) during the meeting

Other Participants

A complete list of people (apart from panel members) attending either the first or second (or both days of the meeting) follows:

	First	Last	E-mail	Organization
1	Teresa	A'mar	Teresa.Amar@noaa.gov	AFSC
2	Delsa	Anderl	Delsa.Anderl@noaa.gov	AFSC
3	Ruth	Christiansen	Ruth.Christiansen@Alaska.Gov	ADFG
4	Marlon	Concepcion	Marlon.Concepcion@noaa.gov	AFSC
5	Elizabeth	Conners	Liz.Conners@noaa.gov	AFSC
6	Jane	DiCosimo	Jane.Dicosimo@noaa.gov	NPFMC
7	Kenny	Down	Kenny.Down@comcast.net	FLC
8	Thomas	Helser	Thomas.Helser@noaa.gov	AFSC
9	Anne	Hollowed	Anne.Hollowed@noaa.gov	AFSC
10	Craig	Kastelle	Craig.Kastelle@noaa.gov	AFSC
11	Robert	Lauth	Bob.Lauth@noaa.gov	AFSC
12	Pat	Livingston	Pat.Livingston@noaa.gov	AFSC
13	Sandra	Lowe	Sandra.Lowe@noaa.gov	AFSC
14	Brian	Mason	Brian.Mason@noaa.gov	AFSC
15	Susanne	McDermott	Susanne.McDermott@noaa.gov	AFSC
15	Peter	Munro	Peter.Munro@noaa.gov	AFSC
16	Sandra	Neidetcher	Sandi.Neidetcher@noaa.gov	AFSC
17	Patti	Nelson	Pattie.Nelson@noaa.gov	AFSC
18	Ingrid	Spies	Ingrid.Spies@noaa.gov	AFSC
19	Grant	Thompson	Grant.Thompson@noaa.gov	AFSC
20	Ken	Weinberg	Ken.Weinberg@noaa.gov	AFSC
21	Mark	Wilkins	Mark.Wilkins@noaa.gov	AFSC

ADFG = Alaska Department of Fish and Game, AFSC = Alaska Fisheries Science Center, FLC = Freezer Longline Coalition, and NPFMC = North Pacific Fishery Management Council

Appendix 4
Model runs performed during and completed after the meeting
(Compiled by Grant Thompson)

The following model runs were performed during the meeting. The model runs required "jittering" in order to be more sure of being at the global minimum (although this cannot be guaranteed), and also required further calculations in order to derived estimates of precision (via the Hessian matrix), with the latter being sensibly calculated only after the former was completed. However, because the jittering process was time consuming it could not be practically carried out during the meeting, so was only completed after the meeting. All model results can be downloaded from ftp://ftp.afsc.noaa.gov/afsc/public/Pcod/default.htm.

Tuesday night model runs

Data file CIE0.dat is the same as last year's final BS model, reformatted to be usable under V3.20b, and with corrected seasons in the size-at-age data.

Control file CIE0.ctl is the same as last year's final BS model, reformatted to be usable under V3.20b. Starting from last year's converged parameter file, this control file gives -lnL=5402.55.

Estimation of the extra parameter in the Richards growth function appears to require that L0 be positive (in last year's final BS model, the estimate was negative).

Control file CIE2.ctl is the same as last year's final BS model, but with the initial value of L0 slightly positive, and a lower bound of 0 on L0. Starting from the converged parameter file for CIE0.ctl (with L0 adjusted), this control file gives -lnL=8611.85.

Control file CIE1.ctl is the same as CIE2.ctl, but with the Richards growth coefficient freed (initial value = 1). Starting from the converged parameter file for CIE0.ctl (with L0 adjusted and an extra line added for the Richards growth coefficient), this control file gives -lnL=6048.38.

Control file CIE3.ctl is the same as CIE0.ctl, but with all time blocks removed, all selectivity parameters except fishery Smin freed, and all other selectivity parameters initialized at the midpoints of their respective ranges. Starting from the values listed in the control file, this gives -lnL=7832.28.

Wednesday night model runs

CIE4 sets lambda on fishery sizecomps equal to 0.001, with no blocks (i.e., one step removed from CIE3). R4ss plots available. –lnL=1449.91

CIE5 has Richards growth plus internally estimated ageing bias (ramp from 2 to 20). R4ss did not run completely; only partial set of plots available. –lnL=5723.77

We wanted jitters for models 1, 3, and 5, but things went slowly and we only got 12+ jitters for CIE1 (none for the others)

CIE6 will be like CIE4, but with blocks (i.e., one step removed from CIE0).

Thursday (daytime)

CIE7: Q free.

CIE8: Informative prior for M.

CIE9: Dynamic binning

Thursday night assignments

More runs for the GOA? (requires modifying control and data files to work with V3.20b)
Not CIE4 or CIE6; yes CIE3 and CIE9 and CIE1 and retro (top priority). Right to left.

"Retro" worked only for the "-1" case in the GOA model.

GOAmodel0 = GOA0.ctl + GOA0.dat (base run)
GOAmodel1 = GOA1.ctl + GOA0.dat (Richards growth with positive L0)
GOAmodel3 = GOA3.ctl + GOA0.dat (no blocks, except survey)
GOAmodel9 = GOA9.ctl (same as GOA0.ctl) + GOA1.dat (dynamic binning)

CIE10: Size-at-age turned off.

Friday runs

CIE11: Size-at-age turned off, fishery=season (i.e., 5 fisheries), random walk selectivity at age through age 8, fishery CPUE data removed; no blocks; survey sizecomps turned on in all years; ageing bias estimated internally; Richards growth turned on

CIE12: Two re-weighting (except survey CPUE) iterations removed from CIE11 (note: ageing bias estimated internally).

After the meeting (written by José De Oliveira)

All models (apart from GOA0) were re-run after the meeting in order to provide Hessian-based estimates of precision, and in order to perform jittering (25 performed for each model). GOA0 was the only model for which both these requirements had already been met (and exceeded in the case of jittering). All post-meeting material was sent by email and uploaded to the above ftp address by Monday the 28th March 2011.