BSAI Crab Plan Team Report

The North Pacific Fishery Management Council's Bering Sea Aleutian Islands (BSAI) Crab Plan Team (CPT) met September 19-21, 2017 at the Alaska Fisheries Science Center, Seattle, WA

Crab Plan Team members present:
Bob Foy, Chair (NOAA Fisheries /AFSC – Kodiak)
Karla Bush, Vice-Chair (ADF&G – Juneau)
Diana Stram (NPFMC)
Ben Daly (ADF&G – Kodiak)
Miranda Westphal (ADF&G – Dutch Harbor)
Jack Turnock (NOAA Fisheries/AFSC – Seattle)
Shareef Siddeek (ADF&G – Juneau)
Martin Dorn (NOAA Fisheries /AFSC - Seattle)
William Stockhausen (NOAA Fisheries /AFSC - Seattle)
Bill Bechtol (Univ. of Alaska Fairbanks/CFOS)
Brian Garber-Yonts (NOAA Fisheries – AFSC - Seattle)
Ginny Eckert (Univ. of Alaska Fairbanks/CFOS – Juneau)
André Punt (Univ. of Washington)
Katie Palof (ADF&G - Juneau)
Krista Milani (NMFS AKRO - Dutch Harbor)

Members of the public and State and Agency personnel in attendance for all or part of the meeting (also via teleconference): Joshue Songstaed, Stehpani Zador, George Steers, Maura Sullivan, Paul Dale, Lance Farr, Craig Lowenberg, Lee Cronin-Finc, Anne Vanderhoeven, Matt Robinson, Edward Poulson, Laura Slater, Jim Ianelli, Elizabeth Siddon, Jie Zheng, Toshide Hamazaki, Jon Richar, Dean Fasnutte, Leonard Hertzog, Landry Price, Scott Kent, Justin Leon, Madison Shipley, Gary Stauffer, Scott Goodman, Jocelyn Runnebaum, Cody Szuwalski, Heather McCarty, Steve Martell, Kate Steff, Crystina Jubie, Doug Wells, Brett Reasor, Gary Loncan, Linda Kozak, Tyson Fisk, Tom Suryan, Rex Capri, and Trent Harthill

Administration

The attached agenda was agreed upon for the meeting.
http://legistar2.granicus.com/npfmc/meetings/2017/9/964_A_Crab_Plan_Team_17-09-19_Meeting_Agenda.pdf?id=6b9b8af8-fc50-4d07-940e-ed2782dbe742

A teleconference line was made available for the meeting and posted to the Council website. All powerpoint presentations were posted to the agenda. The Team reviewed the assignments and the logistics for finalizing introductory sections and minutes. Diana noted the compressed timing of finalizing the SAFE report and the necessity of completing minutes within the meeting and the SAFE by Monday for distribution to the SSC.

CPT meetings in 2018: January 9-11, 2018 (Hilton; Anchorage); May 7-10, 2018 (TBD, Anchorage); September 10-13, 2018 (AFSC Seattle)

EBS Trawl Survey

Bob Foy (AFSC) summarized results from the 2017 NMFS survey. The 2017 survey was conducted from June 4 through July 31, with additional resampling conducted between August 10 - 15 in 20 stations in Bristol Bay necessitated due to a temperature-driven delay in the red king crab reproductive cycle. Distribution of survey results to SA authors, typically occurring on August 15, was delayed as a result. Bob briefly reviewed the deployment of survey vessels, noting that the F/V Vesteraalen was engaged on special projects early in the survey period, and the F/V Alaska Knight experience mechanical problems, preventing the usual deployment of sampling side by side in adjacent cells in all but the most western portion of the survey region.

Six special projects were conducted, including: sample collection for Bitter crab syndrome, which was found to be prevalent during sampling in 2016 and was continued for 2017 (results to be published later this year); snow crab sampling for annual versus biennial reproductive cycle; spatial variance of snow crab shell structure and calcification to define baseline shell conditions for monitoring OA effects; collection of live Snow and Tanner crab for growth study; chela measurements on all Tanner crab collected to improve maturity index estimations for male Tanner crab; collection of live EBS snow crab for ADF&G study of genetics of mating dynamics. In response to a question, Bob indicated that growth and chela data collected in 2017 survey are currently available, reproductive cycle data will be available for May meeting, and Bitter crab study is expected to conclude in 2018, while results from the other special projects are on a longer timeline.

Both surface and bottom temperatures measured during 2017 were lower on average than in 2016. The recent warming period is still in effect, but seems more pronounced in surface temperatures compared to the bottom. Sea ice was relatively thin during 2017 but persisted into the survey season. The cold pool also persisted later during 2017, but was distributed in an unusually narrow band of < 2 °C water extending from NW to SE, and with a separate zone of sub-1 °C water in the SE extent of the pool. In contrast, bottom temperature was relatively warm to the NE along the northern shelf in Bristol Bay; the temperature pattern resulted in delayed molt/mate cycle in RKC, and, combined with persisting stock distribution effects of high temperatures in 2016, contributed to an unusual spatial distribution of RKC this year.

Consistently across surveyed commercial crab stocks, mature male biomass continued the declining trend observed since the 2014 peak, dropping to approximately 100,000 t in 2017. Biomass and abundance estimates for each stock were presented and discussed, with spatial distributions detailed by sex, size, shell- and reproductive-condition.

Bristol Bay red king crab

BBRKC mature male and female abundance declined by 9% and 21% from 2016, while immature male and females increased by 8% and 55%. Survey densities of mature male and female RKC were high in the middle of Bristol Bay, despite colder temperatures, while juvenile densities were concentrated in shallow water in the east of the bay; juvenile densities were higher offshore in retow samples. The centers of spatial distribution for both mature males and females in 2017 was shifted north compared to 2015 and 2016. Length-frequency graphs showed no strong evidence for new recruitment in recent years.

Density patterns suggest that the stock was moving during the survey period, which is expected, and Bob noted that this is controlled for in survey biomass estimates by basing male biomass exclusively on the first leg of the survey and female biomass based on replacement of sample results for selected stations with retows conducted after the standard survey (retow stations are selected to target 85% or more of the females sampled in the standard survey. This avoids recounting the same crabs in successive legs, as well as providing data to assess egg condition when the molt/mate cycle is delayed by cold bottom conditions. In retow samples, 89% of females were mature, of which 100% were in new, hard-shell condition with uneyed eggs, compared to 29% in the standard survey, and with majority showing full or three-quarter full clutches. Bob noted that clutch fullness measured in the retow was substantially greater than that shown in 2016.

Pribilof Islands red king crab

Pribilof Islands red king crab abundance declined by 12% from 2016 for mature males, declined 73% for mature females, 83% for juvenile males, and no juvenile females were collected. Bob noted that these estimates are highly uncertain, with the spike in abundance in 2015 based on a single survey station. Andre inquired regarding the significance of annual changes in abundance, and suggested that survey samples from the same stations for successive years could be treated as paired samples and tested for significance; Bob agreed and noted that paired testing could mitigate that statistical influence of single stations. There is no evidence of the 2015 abundance peak propagating in shell-condition and length frequency data, and no evidence of juvenile recruitment in the 2017 survey

Pribilof Islands blue king crab

Pribilof Islands blue king crab abundance increased by an estimated 96% from 2016, while female abundance decreased by 42%; estimates are highly uncertain given extremely low survey abundance. Spatial distributions of both males and females where similar to previous years, as were length-frequency distributions. Females mostly exhibited uneyed eggs and full clutches, as expected given colder temperature conditions.

St Matthew Island blue king crab

Estimated abundance of mature male blue king crab decreased by 44% from 2016 in the St. Matthew Island Section; no significant change was estimated for female and juvenile abundance, noting that both tend to be inshore during the survey and aren't collected. Variance was relatively low in the overall mature male abundance; 53% of crab collected in 2017 were collected at the hotspot station that contributes to higher abundance estimates in some years, suggesting that the declining population trend is not an artifact. There was a suggestion that the time-series figures label the estimated value for last three data points. Old and very old shell condition crab observed in length-frequency results from recent years were not in evidence in 2017 data.

Bering Sea Tanner crab

Abundance estimates for Tanner crab east of 166° W long increased slightly for mature males, increased by 39% from the extremely low 2016 estimate for mature females and remain extremely low; immature females increased 214% and immature males decreased 36%. West of 166° W long., mature males abundance declined by 31% compared to 2016, and mature females declined by 17%, while juveniles

exhibited similar directional changes as in the east. Biomass density was concentrated along western margin of the survey area, particularly in the southwest and northwest. Length-frequency distributions by shell condition indicating a pulse of new shell crab the east in 2012 advancing into old-shell condition in 2015-2017 data, but minimal recruitment of new-shell crab in 2016 and 2017. In the western district, in contrast, recruitment has continued after 2012, with a strong recruitment of new shell crab in the smaller size classes in 2017, more than doubling the results from 2016. The spatial distribution of shell condition indicates that the southern area of both districts in 2017 is dominated by old shell and very old shell crab, with new hard shell crab distributed predominantly in the north of both districts; in contrast, new shell crab were well represented in stations in the south of both districts during 2016.

Contrasted results for reproductive conditions in the east and west indicate that females in the east district exhibit distinctly greater proportions of old and very old shells, eyed egg, barren, and empty case egg condition, and less than full clutches compared to the western district. Ginny inquired whether the time difference between sampling in the east and west could contribute to the differences observed in reproductive status, and Bob indicated that this was unlikely, but could be tested with examination of time of sampling for individual stations.

Bering Sea snow crab

Estimated abundance of mature male snow crab was slightly lower than 2016, while mature female abundance increased by 99%, with similar relative increases of both male and female juveniles (it was pointed out that the juvenile abundance values cited represented all juveniles but the figure showed only 99-105 mm CW). Bob noted that increases in abundance estimates are to some degree attributable to crab moving south back into the survey area after retreating north to escape warm water in 2016, as indicated by the concentration of high density stations along the northern margin of the survey area. Spatial distribution with respect to maturity and shell condition were typical. Male length-frequencies by shell condition showed the predominance of new hard shell crab, and strong recruitment in the lower size classes in 2016 and 2017. Female reproductive conditions were generally typical.

Hybrid snow/Tanner crab

Hybrid male biomass remained approximately constant, while female hybrid biomass continued to decline from level observed in 2012-2014, and spatial distributions were as usual.

Northern Bering Sea Survey

Bob briefly reviewed preliminary results from the Northern Bering Sea survey. Snow crab catch in the survey indicted high abundance of small male and immature female snow crab, noting that crabs mature small in the north and assessment of male maturity will be improved once chela data that was collected has been processed.

Groundfish Bycatch Overview

Krista Milani (NMFS-AKRO) provided an overview of observer coverage in the BSAI groundfish fisheries. Observer coverage falls under three categories – full coverage (vessels carry an observer for all fishing), partial coverage (vessels carry an observer for an entire fishing trip selected at random), and vessels with no observer coverage (66 vessels under 40 ft who had no observer coverage in the BSAI in

2016). There is a push for some of the smaller vessels to incorporate electronic monitoring (EM), although currently a very small percentage of boats voluntarily use this method (only 2-3 vessels). There was concern among Plan Team members on how data from EM coverage would be extracted from the video and used to estimate numbers and size-composition of bycatch. Most vessels in the Bering Sea fall under the full coverage category. Goals for observer coverage are established pre-season and published in an Annual Deployment Plan (ADP). These goals determine how many trips are randomly selected to be covered in the partial coverage group using the Observer Declare and Deploy System (ODDS).

Crab bycatch from the observer data is based on observed hauls which are then extrapolated to unobserved hauls. There were questions from the Plan Team as to how these data are extrapolated (it is currently thought that crab bycatch is being scaled by the target species catch by trip, not by haul) and the specific calculations that are performed to get the crab bycatch numbers/biomass. Additionally, the Plan Team would like to understand the variability of this data, specifically in terms of the spatial coverage of observed hauls and the proportion of the crab bycatch that is extrapolated versus observed. The CPT requests that this be provided at a future meeting.

A brief summary of the 2016 BSAI observer coverage rates and observed catch was provided. In 2016, 86.5% of fishing trips were observed by onboard observers. However, the observers only sample a proportion of the hauls and these hauls are subsampled. The Plan Team would like more information on the proportion of hauls sampled and the methodology behind subsampling of hauls.

As an example, a spatial summary of the 2016/17 Pribilof Islands blue king crab (BKC) mortality in both the fixed gear and trawl gear fisheries was provided. Additionally, a weekly bycatch report for the Pribilof Islands blue king crab (as well as other species) is posted on the NOAA website each Thursday. This is to keep tabs on the BKC bycatch in the groundfish fisheries to avoid overfishing (as occurred in 2016).

At either the May or Sept 2018 meeting, the Plan Team would like to see information on:
1) **How the observed crab bycatch is extrapolated to the unobserved catch**
2) **The methods for determining which hauls are observed on observer covered boats**
3) **An estimate of variance for crab bycatch estimates, especially those in the pot fisheries.**
4) **Ensure that the data sent to the stock assessment authors does not include handling mortality.**

Crab Bycatch Overview

Ben Daly (ADF&G) presented an overview of data collection in the BSAI crab fisheries. The observer program began in 1988 in the Bristol Bay red king crab fishery and was originally designed to monitor compliance with size and sex regulations and to provide information for inseason management. Currently, observers are responsible for at-sea species composition sampling, monitoring for regulatory compliance, and interviewing captains for fishing effort, catch, and location information. Dockside samplers sample retained catch at the time of landing, determine average weights for the landed catch, and interview captains for fishing effort, catch, and location information.

There are three primary sources of data: retained catch sampling, edited fish tickets, and pot lift sampling. Both observers and dockside samplers sample retained catch at the time of landing. Dockside samplers cover unobserved vessels, whereas observers sample the retained catch from the vessel on which they are

deployed. While sampling retained catch, both dockside samplers and observers estimate average weights of crab (based on weight and number of crab in three brailers), collect size-composition data, and assess deadloss. Dockside and observer retained catch information is collected the same way and the data is combined. The sampling rate by dockside samplers is high; more than 90% of all deliveries are sampled.

Confidential interviews (CIFs) are conducted by both observers and dockside samplers and the information is used to edit fish ticket information. CIFs record detailed information on where crab catch was harvested, as well as how many crab were caught and how many pots were used in each ADF&G statistical area. Most fish tickets are modified by using the information found in the CIF. Modifications include adjusting the ADF&G statistical areas and percentage fished in each area, pot lifts, and average weights of crab; total landed weight is never modified. Often the information on the CIF comes from the federally required daily fishing logbook (DFL). Currently the DFLs used for crab are hand written in paper logbooks. However, the hook and line and trawl catcher processor fleet for groundfish is required to use electronic logbooks which is available through the interagency eLandings program. There was some discussion about trying to move the crab fleet over to the electronic logbook, which would ease access to the information and may be especially important if future funding for the dockside program decreases making it more difficult to collect paper logbooks and conduct in-person interviews. Currently one crab CP vessel uses the electronic logbook voluntarily. Several other vessels have tested the feasibility of the electronic logbook while crab fishing but found it needed to be adapted to pot fishing. ADF&G encourages a federal regulation change that would make electronic logbooks required for all crab fishing. Modification of fish ticket data is important because it allows for more accurate CPUE, effort, and area fished information than is typically recorded at the time of landing. This information is used by stock assessment authors and fishery managers.

Pot-lift sampling is conducted by observers while at sea. There are two sampling protocols; count-pots and measure-pots. In count-pot, the observer counts all crab species by sex, sublegal males, legal retained males, and legal not-retained males. Measure pot sampling additionally includes size, shell condition, female maturity, clutch condition, and other biological information. There is a goal for each fishery for the number of pots to be sampled. This goal may be adjusted if there is a need. Currently, 1-5% of all pots pulled in a fishery are sampled by an observer.

There was substantial discussion about the uncertainty of legal not-retained crab recorded by observers in their sample pots. Legal not-retained crab is determined by the observer following a discussion with the skipper on what legal sized males the vessel intends to discard while fishing. For example, this may be based on an industry preference for larger crab or for new shell crab. The observer then samples all the catch from a pot-pull and classifies "retained" vs. "non-retained" catch according to this discussion. However, there may be a discrepancy between what the skipper has told the observer and what the deck crew is actually doing, causing a disconnect between what the observer is recording and actual vessel activity. ADF&G expressed a willingness to review and change how this information is collected if there is a better way to fulfill the needs of stock assessment authors. However, it was noted that ADF&G uses legal/legal not-retained to ascertain if high-grading is occurring and may reduce TACs based on this information. Two stock assessment authors use the legal/legal not-retained information differently in their models. The Tanner crab assessment uses a subtraction method to arrive at discarded legal males. The entire CPUE is used and then retained catch is subtracted to get discards. The snow crab assessment relies on the legal/legal not-retained information to estimate discards. There was interest in aligning all

the stock assessments to use the subtraction method. There was also a comment that perhaps some special studies can be done to examine this issue more.

In some crab fisheries vessels are allowed to keep a crab species incidentally while targeting a different species. The Alaska Board of Fisheries recently passed new regulation allowing for 35% retention of opilio crab while directed fishing for Tanner crab. Current regulations also allow for 5% of delivery to be Tanner crab while directed fishing for opilio crab. Industry is pushing for 100% incidental crab retention of any crab species for which the vessel has quota.   It can be difficult to assign effort to crab species caught incidentally. There was some thought that it was not important to assign effort to incidentally caught species as long as the information is incorporated into the target species data. However, ADF&G noted that incidental catch is not sampled from retained catch at the time of landing. It was mentioned that perhaps each pot could have a target species designation, but ADF&G noted that gear configuration is different for each crab fishery and a vessel is not allowed to use mixed crab gear simultaneously. Because mesh size differs depending on the fishery, the gear will have a different selectivity for species caught incidentally versus targeted. For example, mesh size is larger in Tanner gear than in opilio gear. This will result in Tanner crab gear selecting for larger opilio crab because smaller opilio crab will escape through the larger mesh. It was suggested that modelers refer to gear configuration instead of species targeted.

Overall there is a need to standardize how these data are provided to stock assessment authors. Mr. Daly suggested expanding the abundance estimates by one-millimeter bins and shell condition, rather than different formats for each assessed stock. The fishery data exchange process could be further streamlined using a shared database such as the one hosted by AKFIN.

The Team appreciated the overview of this information and the opportunity to discuss how these data are incorporated in different assessments. **The Team recommends an agenda item in the May CPT meeting to discuss the differences between the use of discard data in the snow crab assessment as compared to the Tanner crab assessment.**

EBS Ecosystem Report

Stephani Zador (NMFS) presented an overview of the Bering Sea ecosystem. Due to time constraints, this presentation was an abbreviated version of the presentation that was planned and only focused on the climate and oceanography in the Bering Sea.

The Bering Sea is undergoing a period of transition and moderation from the extreme heat seen last fall. In general, the Bering Sea is cooling off and returning to climatological normal. Sea surface temperature anomalies have been seen throughout the northwest Pacific Ocean beginning in the fall of 2016. In particular, there was persistent relatively warm surface temperature in the northern Bering Sea. Winter 2016/17 had cool fall winds from the west and cold winter winds from the west north west. A weak positive Pacific Decadal Oscillation (PDO) pattern was seen in the spring. During summer of 2017, the Bering Sea shelf got a little warmer than normal with unusually warm sea surface temperatures remaining in the Bering Strait and the Chukchi Sea.

Sea level pressure irregularities were also seen throughout the transition period. During fall, large low-pressure systems created westward winds that enhanced cooling. Over the winter a large, high sea level

pressure system sat over the north Pacific, eastern Aleutian Islands, and eastern Bering Sea which implies less storminess and a weak Aleutian Low and northerly winds resulted in a colder than usual winter in the Pacific Northwest. Flow from the south into the Bering Sea remained warm, and the transition into spring brought a high-pressure system that, again, promoted calm conditions. During the spring, suppressed storminess prevailed in the eastern Bering Sea along with winds that favored downwelling in the Gulf of Alaska.

The climate indices for the northern Pacific all trended to moderation in this transition period. The ENSO was in a quiet period with respect to recent years. The PDO is still positive but with a lower magnitude. The North Pacific Index (NPI) implies a deep Aleutian Low during the summer and fall which was weak during the winter; a surprisingly strong response to a weak La Niña. The North Pacific Gyre Oscillation (NPGO) has been negative during this time period, which results in reduced flows in Alaska, similar to last season.

Sea ice was minimal in 2016/17 with the maximum sea ice extent achieved on March 30, 2017. There was an unusual lack of sea ice presumably from the pre-existing warm water and warm winds from the south in the western Bering Sea. Sea ice in the northwestern Bering Sea (Gulf of Anadyr) had the least extent since at least 2001. The sea ice that did form in Bristol Bay was thin with sea ice in the northern Pacific medium thick.

The eastern Bering Sea cold pool had a much larger extent when compared to the last three years. The cold pool is similar to that seen in 2013 but was discontinuous with a smaller footprint, most notably in the northwest. Projections from the National Multi-Model Ensemble (NMME) for 2018 sea surface temperatures indicate a continuation of warm water, with slight cooling in January, February, and March in the eastern Bering Sea and Gulf of Alaska. The strongest positive anomalies are in the western Bering Sea. With a weak PDO pattern, there is a small likelihood of a small La Niña or neutral conditions.

Snow Crab

Cody Szuwalski (AFSC) presented the snow crab assessment to the CPT. The assessment is based on the same basic model structure as the September 2016 assessment. The assessment included eight model runs that addressed the five scenarios identified by the CPT in May 2017.

- Run M16.D16. This was last year's accepted model fitted to the data on which the September 2016 assessment was based (i.e. the September 2016 final model).
- Run M16.D17. Last year's accepted model, but fitted to the updated data (fishery catch and size-composition data for the 2016 fisheries; survey index and survey size-composition data for 2017).
- Run M16.D17a. As for run M16.D17a, except that all survey data were dropped for the years before 1982 (few data for those years and Q=1 even though the area covered by the NMFS survey was smaller before than after 1981).
- Run M17A.D17a. As for run M16.D17a, except that the break between survey selectivity periods was changed after examination of the spatial distribution of the survey.
- Run M17Aa.D17a. As for run M17A.D17a, except that the survey availability parameters for the BSFRF survey were estimated in logit space with a penalty.

- Run M17B.D17a. As for run M17Aa.D17a, except that the data for length classes below the "kink" in growth are omitted, with the aim of improving numerical stability.
- Run M17C.D17a. As for run M17Aa.D17a, except M for mature females is estimated (the final 2016 model fixed the value of this parameter equal to that for mature males), with modified priors on M.
- Run M17BC.D17a. Runs M17B.D17a and M17C.D17a combined.
- [Note: the naming convention used for the scenarios reflects one of the naming conventions considered by the CPT in May.]

The CPT agreed that the changes reflected by runs M16.D17, M16.D17a, and M17A.D17a included minor "fixes" that should be implemented. However, a jitter analysis (Fig. 18 of the assessment report) was suggestive of a bimodal distribution for the OFL for run M17Aa.D17a (and several other runs). The author did not support run M17B.D17a (and hence M17BC.D17a) because of unrealistic estimates of survey selectivity and the probability of maturity, an argument the CPT concurred with.

Run M17C.D17a did not exhibit the substantial bimodality evident for run M17Aa.D17a, but the CPT (and the assessment author) was concerned that the estimate of Q for females for survey era 3 was equal to 1, likely because Q and mature female M are confounded. The CPT considered Q=1 for females, combined with Q=0.72 for males, unrealistic. However, the estimate of M for mature females exceeding that for mature males as expected.

All runs estimated that females were fully selected overall size-classes for the BSFRF survey in 2010. The assessment author indicated that this selectivity pattern was not estimated but pre-specified, but the CPT was nevertheless concerned that this feature of the assessment seemed unrealistic.

On closer inspection, it was discovered that the results in the draft assessment report for this run were based on fixed parameters whose initial values had been jittered (and should not have been, because they should have been the same for all runs) as well as the estimated parameters. This problem did not impact the MCMC analyses because the MCMC runs were initialized from non-jittered runs. However, results from the MCMC runs were problematic with a number of models exhibiting extremely slow mixing. The assessment author was requested to repeat the analyses after fixing the jittering procedure to ignore jittering initial values for parameters that were fixed (i.e., not estimated).

The results from the correctly-jittered runs indicated M17Aa.D17a now converged to only a few distinct objective function values, but the best two values (the "global" minimum and a local minima) were within a likelihood unit or two of each other, indicating the data provided almost equal support for either solution. Further, the two solutions gave fairly different results related to the OFL and other management quantities. The author and the CPT were also concerned that the original MCMC chains were not long enough to adequately explore the complicated likelihood surface the jitter runs indicated. To address this concern, the author re-ran the MCMC analysis, but starting from a model run that converged to the "second-best" solution (i.e., that converged to the lowest local minimum, rather than the global minimum). The repeated MCMC analysis confirmed that the original MCMC chain was not run long enough to sample the likelihood space adequately to characterize both solutions because the distributions for management-related quantities like OFL were substantially different (centered on the "second-best" solution and not reaching the "best" solution) from the original analysis (which was centered on the "best" solution but did not reach the "second-best" solution).

The CPT ultimately concurred with the author recommended model run M17C.D17a for the 2017 assessment. Rationale for choosing this model included the large improvements in likelihood estimates and the lack of bimodal issues relative to other model runs (including the base model M16.D17). The CPT, however, acknowledged that the unrealistic Q estimates for females in this model should be address in future assessments. As a result of the additional uncertainty in choosing the appropriate model runs and the large difference in OFL estimates between those model runs, the CPT recommended increasing the ABC buffer from 10% (last year) to 20%.

The CPT was provided with a plot of new (2017) growth data. For females, these new data suggest that there is no "kink" in growth rate unlike the current assessment. These data should be added to the next assessment.

The CPT commends the author for his willingness to address the issues that were identified regarding the jittering and MCMC runs during the meeting time frame.

The CPT recommends the following presentational issues be addressed in the future:
- The "pairs" plot of parameters from the MCMC sample was informative regarding which parameters are not mixing well, and should be provided for the author's preferred model in future assessments that report MCMC results.
- No retrospective analyses (historical and standard) were included in the report, but should have been, as they could have been informative.
- The table of parameter estimates was informative, but there should have been an indication of which parameters were estimated and which were pre-specified (including the asymptotic standard errors would be one way to achieve this).

CPT Recommendations for future work
- **Add the new growth data and re-consider the necessity for a "kinked" growth model**
- **The model should be fitted to the total and retained catches and size-compositions rather than to the retained and discarded catches and size-compositions, as is the case for the EBS Tanner crab assessment (see discussion on catch estimation).**
- **The weightings of the various data sources need to be revisited, perhaps during the 2018 January CPT meeting.**
- **The causes for the model estimating that survey selectivity is 1 for almost all sizes for females in the 2010 BSFRF survey need to be explored.**
- **There is value in conducting likelihood profiles to better understand some of the trade-offs among data sources in relation to estimated parameters (i.e. do some data sources support higher / lower values for a parameter and hence are there potential conflicting data sources). Such plots may have helped the CPT understand why Q=1 for females for survey era 3 in run M17C.D17a.**
- **Evaluate the appropriate length for MCMC chains to adequately explore the likelihood surface and characterize the posterior likelihood.**

Bristol Bay red king crab

Jie Zheng (ADFG) presented the stock assessment for Bristol Bay red king crab (BBRKC). New data included in the assessment consisted of biomass and size compositions from the 2017 NMFS EBS bottom trawl survey, retained and discard catch biomass and size compositions from the directed fishery, and bycatch biomass and size compositions from the Tanner crab fishery and the groundfish fisheries. The BSFRF side-by-side trawl survey data for 2016 was also revised—the previous estimate for total survey biomass (87,725.1 t) inadvertently included tows from the recruitment study; the revised total survey biomass was 77,815.7 t.

As in some previous years (e.g., 1999, 2000, and 2006-2012), cold water temperatures in 2017 delayed the molting and mating cycle in mature female BBRKC and only 29% of the 490 mature females sampled during the standard NMFS EBS trawl survey had extruded a new clutch of uneyed embryos. To better assess reproductive potential of females in the stock, a set of "retows" were conducted by the NMFS survey in Bristol Bay in August. Bottom temperatures significantly increased from June (3.18 °C) to August (5.01 °C), which was followed by a significant change in the ratio of numbers of females with eyed vs. uneyed eggs. In early June, the oldshell females with empty egg cases and the new, hardshell females with uneyed embryos were distributed throughout Bristol Bay. Among resurveyed female crab in early August, 89% were mature females and 100% of these were in new, hardshell condition with newly extruded uneyed embryos. These new, hardshell females had molted and mated over the 6-week period between the first sampling event in early June samples and the resample in early August. The assessment model incorporates information on females from the retowed stations (excluding data from the original tows) but only from the standard survey tows for males.

The NMFS survey data exhibited a 9% decrease in area-swept estimates of mature male biomass in 2017 relative to 2016 (from 25,481 t to 23,102 t), a 7% decrease in legal male biomass (from 22,424 t to 20,842 t), and a 21% decrease in mature female biomass (33,370 t to 26,424 t). Area-swept biomass estimates have generally been decreasing in all three categories since 2014. Jie noted that observed CPUE was no longer area-swept estimates of legal male abundance. The CPT suggested that the tracking might appear better if one were to break the time series at 2005, but that opposite trends were apparent in the last three years.

The basic structure of the model used for the assessment did not change from that used in 2016. Nine alternative model scenarios were evaluated for this assessment. The three principal model scenarios evaluated for this assessment were:

- Scenario 2a: was the same as Scenario 2a presented at the May 2017 CPT meeting. Scenario 2a differed slightly from Scenario 2, the model used for the 2016 assessment, because the time at which bycatch in the groundfish fisheries was removed from the stock was changed from occurring at the same time as the directed pot fishery to the midpoint of the crab year (at which time bycatch in the Tanner crab fishery is also taken out).
- Scenario 2b: was the same as Scenario 2a, except that bycatch in the groundfish fisheries was dis-aggregated into trawl and fixed gear components—previously, bycatch in the groundfish fisheries was aggregated across gear types.

- Scenario 2d: was the same as Scenario 2b, except that the priors on catchability for the NMFS trawl survey, based on the double bag experiments, were removed and survey catchability was parameterized using parameters on the logit-scale to ensure catchability was less than, or equal to, 1.

For each of these "major" scenarios, two minor scenarios were also evaluated that applied different approaches to iterative re-weighting of the size compositions fit in the models. These approaches were based on methods developed by Chris Francis, but were applied to either the "extended" size compositions actually fit in the models (Scenarios 2a1, 2b1, 2d1) or to sex-specific size components from the extended size compositions that were re-normalized to sum to 1 (Scenarios 2a2, 2b2, and 2d2).

Scenario 2a provided a link to the 2016 assessment. Scenario 2b allowed a better characterization of bycatch mortality by allowing the application of different handling mortality rates to bycatch in the groundfish fisheries by gear type (0.8 for trawl gear, 0.5 for fixed gear) rather than applying the handling rate for trawl gear across the aggregated bycatch. Scenario 2d addressed previous CPT and SSC requests to evaluate models that removed the priors on NMFS survey catchability. The minor scenarios addressed CPT and SSC requests to evaluate the utility of using the Francis approach to adjust input sample sizes to better reflect the information content of the size composition data.

On the whole, the major scenarios all fit the data similarly and relatively well. The CPT noted that the models tended to overestimate NMFS survey biomass over the last 8 years; Jie responded that this was primarily due to fitting the BSFRF survey data, which was mainly underestimated in the last four years.

Jie noted that the scenarios using the iterative re-weighting schemes substantially down-weighted the size compositions they were applied to (particularly the NMFS trawl survey size compositions), sometimes resulting in convergence issues and parameters at bounds. Jie concluded that the re-weighting was sensitive to the estimate of the NMFS trawl survey selectivity parameter and did not perform very satisfactorily, although the CPT noted that substantial down-weighting was indeed a possible outcome and that the issue of re-weighting needs to be revisited at the January CPT meeting. The CPT noted that it was inappropriate to apply the Francis re-weighting on the basis of the renormalized sex-specific size compositions when the "extended" size compositions were fit in the likelihood. **The CPT also suggested it might be helpful to plot the mean lengths from the size compositions vs. time, with standard deviations, to identify anomalous years with particular influence on the resulting weights.**

Of the nine scenarios evaluated, Jie preferred either 2b or 2d. Both of these used the bycatch in the groundfish fisheries disaggregated by gear type, which the CPT approved of as a refinement to the models in that it should have allowed the models to provide better estimates of overall discard mortality (since the assumed gear-specific rates for fixed and trawl bycatch are substantially different at 0.5 and 0.8, respectively) as well as to better characterize bycatch size compositions in the groundfish fisheries.

However, both preferred scenarios (all nine, in fact: Table 4 in the SAFE chapter) provided estimates of NMFS survey catchability (Q) during 1982-2017 that were extremely close to 1. Much discussion ensued on this point because CPT members were skeptical that this could be the case. Results from the BSFRF side-by-side tows suggest the catchability for the NMFS trawl survey is closer to 0.6. The CPT suggested the model was getting information on scale from the early 1980s when large catches drove down the population, but that this was in conflict with the BSFRF data providing the scale by estimating

availability such that the Q for the NMFS survey did not change. The CPT noted that this indicated structural conflicts in the model and the need to explore the tensions driving Q to 1. The CPT also reasoned that these conflicts provided a rationale for retaining the prior on Q based on the underbag experiments, because eliminating the prior would be equivalent to removing data from the model.

CPT Recommendations
- **Look at the weighting again for this assessment: it is still based on multiplicative lambda's.**
- **The difficulties achieving convergence need to be explored: they are unexpected and concerning.**
- **Jittering initial parameter values was not used in this assessment, but may be useful in evaluating convergence issues.**
- **The tensions in the assessment data leading to estimates of NMFS survey Q at 1 need to be identified and approaches to deal with them need to be developed.**
- **The assessment document needs to be updated to reflect changes in the 2016 BSFRF estimate in the main section of text, not just in the Executive Summary.**
- **Provide an explanation of why Equation A4 (catch in the directed fishery) is correct (or correct it if it is wrong).**

WAIRKC, PIGKC catch review for overfishing

Ben Daly provided an overview of the catch in relation to overfishing limits for WAIRKC (2016/17) and PIGKC (2017). In both fisheries, overfishing did not occur the previous season. Updated summaries for these stocks are contained in the introduction to the final SAFE report. Both stocks are now on a triennial cycle for assessments thus the OFLs and ABCs established in June 2017 will be in place for two years. These stocks will next be assessed in 2020.

EBS Tanner Crab

Buck Stockhausen presented the stock assessment for eastern Bering Sea Tanner crab for 2017. This year's assessment used a new modeling framework, TCSAM02, which was endorsed by the SSC in June. TCSAM02 is similar to previous Tanner crab assessment models, but includes improvements to the modeling of fishery and population processes. The assessment included eleven model runs that addressed CPT recommendations for model scenarios in May. In order, the issues deal with models runs were 1) improved parameterization of growth increment model, 2) incorporation of recently collected EBS growth increment data into the assessment and dropping the growth priors based on GOA Tanner crab data, and 3) reparameterization of the selectivity parameters for bycatch in the RKC fishery so that they do not hit bounds (Models B0, B0a, B1, B1a, B1c). Assessment results were not strongly affected by these changes and the CPT regarded all of them as model improvements.

Several model explorations were not successful. Model B1c greatly increased the weight on growth increment data, and Model B3 split out the bycatch in groundfish fisheries by gear type. Both of these models resulted in large number of parameters hitting bounds and poorer fit to other data components.

Another set of model runs evaluated alternative ways to model temporal variation in the retention curve, which had previously been assumed to be time-invariant (Models B2, B2a, B2b). Model B2b was

recommended by the assessment author because it showed good balance between allowing retention curves some flexibility to change over time without adding many annual parameters for retention. This model allowed for three retention periods where both the asymptote and the size at 50% selected were allowed to vary. The CPT agreed with this logic and is also recommending model B2b to set the ABC and OFL. The distribution of the 2017/18 OFL was obtained by MCMC sampling from the joint posterior distribution. The point estimate of the OFL, equal to 25.42 thousand t, was the median of posterior distribution. This value agreed to two decimal places with MLE estimate of OFL.

The CPT discussed the ABC buffer used for Tanner crab, noting that a 20% buffer had been used previously for Tanner crab. Although there were improvements to the Tanner crab assessment model, especially with the transition to the TCSAM02 modeling framework, the model results are not substantially different from the 2016 model and several concerns with current model remain such as parameters hitting bounds, and consistent overprediction of large males. Therefore, the CPT recommends that a 20% buffer be used again to set the ABC for Tanner crab. It should be noted that there was a relatively strong recruitment estimated for 2017, but this estimate is very uncertain and will need to be confirmed by subsequent assessments.

CPT recommendations concerning the Tanner crab assessment moving forward are as follows:

- Currently there is no reweighting of input sample sizes for size composition data. **Both the Francis method and the McAllister and Ianelli method should be evaluated, ideally from different starting points to determine whether this matters.**
- The likelihood for the growth increment data was not given any increased weight in the model fitting. The fit to male growth increment data was relatively poor (model is being pulled away from the growth increment data by the size composition data). **A full evaluation with a range of different likelihood weights is needed to evaluate impacts on model results**.
- **A good data set on chela height is available for Tanner crab. Approaches to incorporating these data into the model should be considered**. At the same time, whether or not survey data should parsed into mature and immature abundance before including it in the model should be evaluated. An alternative approach would be to incorporate chela height information into the assessment as priors rather than as input data.
- Some parameters in the Tanner crab assessment model are still hitting their bounds. **Possible approaches to improve this include model reparameterization, adding priors for poorly estimated parameters, or simply reducing the number of parameters being estimated.**
- Model convergence continues to be an issue for the Tanner crab assessment. **Jittering is the best way to check for a global minimum, and should continue to be done in future assessments for all candidate models.**
- The treatment of the priors for natural mortality in the model is nonstandard. **Log normal priors with the median equal to the prior value should be evaluated.**
- **The current model consistently overpredicts abundance of large males in the NMFS trawl survey. This suggests some fundamental process is not being modeled appropriately (such as growth, mortality, or selectivity). Addressing this issue should be a priority for future assessments. Some potential mechanisms to explore are whether the growth increment for the male molt to maturity is different than other molts, and whether the mortality of old males increases with age. Incorporation of chela height data into the model could help to inform which process is most likely**.

- Whether or not to include recruitment estimated for the final year in the calculations for B_{MSY} should be evaluated. This is a larger issue for all crab stocks, and a consistent approach should be used.
- Variation in retention appeared to be greater during the period 1991-1996 than in the other retention blocks. A potential refinement to Model B2b would be allow annual variation in retention for one block only.

Bering Sea Fisheries Research Foundation research update

Scott Goodman (BSFRF) provided an overview of trawl selectivity studies collected by BSFRF with a focus on *C. bairdi* studies from 2013-2016. The BSFRF surveys vary from the NMFS surveys across years. The side-by-side comparison in 2016 reveals that the BSFRF trawls collect small animals (<40 mm) that are not sampled by the NMFS survey. Because females are smaller, they are sampled at a higher proportion than in the NMFS survey. In 2017 BSFRF surveyed *C. bairdi* at 95 stations side-by-side with NMFS; 72 of the 132 stations that account for 95% of the NMFS catch were sampled side-by-side. They are working on the data to provide it to be included in the stock assessment model. BSFRF is also working on crab growth research. They collected crabs in Spring 2012, 2015, 2016 and 2017, and worked with agency scientists to track the growth of these crabs. These samples have generated about 150 growth data points.

The public asked for a schedule to incorporate BSFRF data into the model to inform trawl selectivity. Buck indicated that he is planning to incorporate it next year. Bob commented that an analysis of the BSFRF data is needed to move forward. The analysis could be conducted spatially to reveal areas that are important for small crab (<40 mm) and to highlight areas where NMFS may be under sampling large crab.

Pribilof Islands blue king crab

Buck Stockhausen (NMFS) presented the assessment for the Pribilof Islands blue king crab (PIBKC) stock. The assessment uses a random effects model to smooth out the survey biomass time series under Tier 4 for status determination but OFL and ABC are estimated using a Tier 5 approach. The directed fishery has been closed since 1999; the annual OFL and ABC apply to PIBKC bycatch in the Bering Sea groundfish and other crab fisheries. The stock remains overfished and shows no signs of rebuilding. **The CPT concurred with the author's recommended OFL based on average bycatch and a 25% buffer between OFL and ABC (same as previous years)**. This stock is now assessed on a triennial schedule.

Updated data for this assessment includes groundfish fishery bycatch (there was no bycatch from other crab fisheries) and survey biomass estimates. Groundfish fishery bycatch in the 2016/17 crab fishing year was lower than in the previous year when higher than normal bycatch lead to overfishing.

For the next assessment (in 2020), the CPT recommended:
Information regarding the model used for status determination criteria (in Appendix C) should be incorporated into the main assessment section. Additionally, more information should be included in the

presentation to the CPT (such as parameter tables and process error) in order to fully evaluate model performance.

Pribilof Islands red king crab

Jack Turnock (NMFS) presented the assessment for the Pribilof Islands red king crab (PIRKC) stock. Two assessment methods using a Tier 4 harvest control rule were presented for evaluation: one calculated an annual index of MMB derived as the 3-yr running average using inverse variance weighting, and the second was a random effects model. The random effects model was presented with three variations: 1) λ fixed, 2) a prior on λ estimated from bootstrap (with CV=2.24); and 2) a prior on λ with an arbitrary CV=4.0. Updated data for this assessment include fishery bycatch and survey biomass estimates. **The CPT recommended the Tier 4 stock status determination and selected the random effects model with a prior on λ estimated from bootstrap with CV=2.24, based on the observation that this model fits the survey data better and is a better smoother of extreme values.**

The directed fishery has been closed since 1999; the annual OFL and ABC apply to PIRKC bycatch in the Bering Sea groundfish and other crab fisheries. Fishery closures near the Pribilof Islands have resulted in low bycatch; recent bycatch has been well below the OFL. The stock is not overfished and overfishing is not occurring. **The CPT concurred with the author's recommended OFL based on the random effects model with a prior on λ estimated from bootstrap with CV=2.24 and a 25% buffer between OFL and ABC**.

For the next assessment (in 2019), the CPT recommended:
Information regarding the model should be included in the presentation to the CPT (such as parameter tables and process error) in order to fully evaluate model performance.

Saint Matthew blue king crab

Jim Ianelli (AFSC) presented an update on the SMBKC stock assessment via webex. A directed fishery has occurred since 1978. The directed fishery time series starts in 1978, but with notable closures during the time series, including a closure during the 2016/17 fishing year. The assessment model starts in 1978. Inputs in addition to retained catch include: NMFS bottom trawl surveys during 1978–2017; ADF&G pot surveys triennially during 1995–2013 and annually during 2015–2017; size-frequency data from ADF&G crab observers during 1990/91–1998/99, 2009/10–2012/13, and 2014/15–2016/17; and NMFS groundfish-observer bycatch biomass estimates during 1992/93–2016/17. The author noted that a large portion of the trawl survey catch in recent years has occurred in station R24.

The assessment examined six different models with the first three being the 2016 model, a revision to include trawl survey data, and a revision referred to as the "reference case" and which includes both the trawl survey and pot survey data. Adding trawl data slightly increased the 2017 estimate, but adding pot data dropped the estimate. Three model sensitivities were explored: VAST – a preliminary look at the survey grid; fit to survey – another exploratory run involving up-weighting to force fitting to trawl and pot surveys; and Francis' weighting. VAST results don't visually seem much better than the reference case although reference data seems to provide slightly lower estimates. When asked why the VAST model doesn't necessarily go through the survey points, the author noted the lack of recruitment data (i.e.,

for small crab) complicates modeling, and the mismatch between the survey trend and recruitment is a problem. The fit to trawl survey data is partially driven by survey points showing lower population levels but with small CVs. There was also a generally poor fit to pot survey data among model scenarios. The CPT suggested conducting a retrospective analysis of the 2017 reference model to explore the lack of fit to the pot survey data after 2013.

The author discussed an exploration of a dynamic *B0* in which fishing mortality was excluded and the population modeled to look at the influence of natural mortality. The result was an estimated 5% increase in biomass. This nominal increase suggests stock dynamics are driven largely by recruitment variability. However, the CPT noted that the survey is treated as an unbiased estimator, but there is high variability in sample size, making weighting based on sample size somewhat arbitrary owing to relative small sample sizes.

The CPT discussed the scenario of Francis' weighting. The Francis' approach is a method to somewhat standardize weighting, but there is already some weighting in the data. However, the relatively low and highly variable sample numbers again raise concerns about the assumption that the survey equally samples the available crab. The CPT also discussed the aspect of Francis' weighting given that there are only three length bins for the assessment model, and whether this is a problem. The author noted that the small number of bins could be forcing pot survey data weighting to be greater than 1.0.

The drastic increase in estimated M during the late 1990s and the potential interaction with the survey data and survey data fits was discussed. The author noted that 1999 started a period of fishery closures, yet also corresponded to severe reductions in both bottom trawl and pot survey estimates, but with tight CVs on those estimates. Given the lack of fishery removals, the model "compensated" by applying a higher natural mortality.

The CPT recognizes the problems associated with overall low and highly variable survey sample sizes, a lack of fishery catch data, and recruitment that is poorly estimated by available survey data. There is also concern that a high precision on low trawl survey estimates may be having an overly strong influence on the estimated trend.

The CPT recommended the following for the next assessment:
- **a retrospective analysis of the 2017 reference model, particularly noting the poor fit to pot survey data after 2013.**
- **continue to explore weighting options and evaluate whether Francis' weighting is appropriate given that only 3 length bins are considered.**

Norton Sound red king crab

Hamachan Hamazaki presented alternative model scenarios and sensitivity runs for the Norton Sound red king crab (NSRKC) stock assessment. One of the major modeling issues for NSRKC is overestimating abundance of large (>123 mm CL) crab. The current default model assumes M is higher for the last 2 length bins (crab >123 mm CL).

The observer program for Norton Sound red king crab places observers on vessels based on staff availability and whether the vessel will accept an observer. Observer coverage is not mandatory. The

boats are small and generally have to displace a crew member in order to have an observer. Observers get length measurements from crab in sampled pots. Observers are encouraged to select pots for sampling without bias, but there is no formal statistical protocol for pot selection. There is also a tendency for observers to participate in pot hauls closer to the city of Nome. **The CPT recommended the next assessment include a graphic on where pot-pulls have been observed.** Winter fishery discard data are now being collected and will be incorporated into the model when several years of data are available.

The CPT previously requested the model be run with removal of each data component to investigate the influence on results. Trawl survey abundance (NOAA and ADFG) is most influential and results in much higher biomass when removed. The Q for the NOAA survey is estimated while the ADFG survey Q is fixed at 1.0. Removal of other data components did not change results much. Trends and biomass levels were very similar. Fixing the survey Q for the ADFG survey determines the scale of biomass.

The logistic function for the summer fishery selectivity has one parameter in the default model. Alternative models were explored that fit a two-parameter logistic function.

The author discussed the problem with large crab "disappearing" and how to resolve this through increasing M at larger sizes. Past assessments have applied a higher M for crab >123 mm CL. The model includes 8 length classes and the author explored an approach of fixing M at 0.18 for 5 or 6 length classes, and using model estimated M for the remaining classes.

Model scenarios were;
  0. One mortality for the last 2 length classes - this is the default model.
  1. Two separate mortalities for the last 2 length classes
  2. Three separate mortalities for the last 3 length classes
  3. One mortality for the last 2 length classes, 2 parameter fishery selectivity
  4. Two separate mortalities for the last 2 length classes, 2 parameter fishery selectivity
  5. Three separate mortalities for the last 3 length classes, 2 parameter fishery selectivity

The author would recommend model 5 for the January 2018 meeting due to the likelihood improvement from using the 2-parameter logistic function as well as estimating 3 parameters for M. Adding more parameters for M may not justified, but the 2 parameter logistic results in the most improvement in the likelihood. Model 3 gives 12 likelihood points improvement with 1 parameter more than the default model. Improvement in the likelihood is mostly in the tagging data and trawl length composition with the 2-parameter logistic (Models 3, 4 and 5), however, not in summer length frequency data. Tagging data is used to estimate growth in the model. There was only a 3.5 likelihood unit improvement from model 3 to model 5 with 2 parameters added, and not much difference between alternative models and MMB biomass.

The author discussed an effort to recalculate trawl survey abundance using a standard core area, assuming zero crab in unsurveyed stations and removal of re-tow survey data (previously, re-tow data were averaged). The survey data with the new calculation will be used in next assessment cycle. The CPT commented that it may be better to decide on a core area and expand sampled stations to the whole area rather than assume unsampled areas are zero. If stations are on the edge of the core area it may be OK to put the values at zero. Another alternative would be to define several strata for the survey and expand samples within each strata.

The CPT recommends bringing forward the default model, model 3, model 4, and model 5 for the January 2018 assessment. The CPT also recommends conducting a likelihood profile on the estimated M parameters. The profile should be done manually instead of using the code in ADMB.

There are also 4 years of pot survey data that could be added to the model. **The CPT requests to see the pot survey data in January 2018, however, not necessarily added to the model as the January 2018 CPT meeting will be for OFL setting.** It was also noted that there was a 2017 NOAA trawl survey in Norton Sound, but this data will not be available in time to add to the model.

Aleutian Island golden king crab

Shareef Siddeek presented AIGKC model scenarios for the May 2018 stock assessment; OFL and ABC for 2018/19 will be finalized at the May CPT meeting. This model is the only FMP crab stock that only includes fishery data (i.e., no survey data are available). The model results shown by Siddeek included fishery data from the 2016/17 season. In general, fishery data is available for inclusion in the model as early as mid-June. The CPT noted that, while fishery catch data is available for finalizing OFL/ABCs at the September meeting, fishery survey data collection occurs in the summer and fall, which means the survey data could not be included in the assessment at the September meeting. However, finalizing OFLs in September would allow industry to know well in advance what TACs would likely be for the following season. The CPT noted that survey data could be included by the January meeting, and Siddeek confirmed that if survey data are added to the assessment, it could be completed no earlier than the January CPT meeting. Siddeek noted that for this cycle, he plans on completing the assessment for the May 2018 meeting, but can adjust timing in subsequent years.

2016/17 CPUE in EAG is reduced compared to 2015/16, but still high overall. 2016/17 CPUE data in the WAG is slightly less than that in 2015/16. Siddeek presented responses to May 2017 CPT and June 2017 SSC comments. For most scenarios, knife edge maturity was determined outside the model, as requested by the CPT. Natural mortality for the combined EAG/WAG data was estimated in the model at 0.22 yr^{-1}. However, based on the individual region data likelihood components, an M value of 0.21 yr^{-1} was selected for all scenarios.

Siddeek used chela height and carapace length data (WAG: NMFS 1984; EAG: 1991 ADFG pot survey) to determine the maturity breakpoint by the breakpoint analysis. He found that the best two lines in ln(carapace length) vs. ln(chela height) space that minimized the distance among all points from one of the lines, with one line defining the linear (in ln-space) chela height vs. carapace length relationship for immature crab and the other defining the relationship for mature crab. Individuals were then classified as immature or mature based on which line each was closest to for logistic curve fitting. The mean size at maturity determined by breakpoint was similar between EAG and WAG (less than 1 mm difference between estimates of size at 50% maturity). The 50% maturity estimated from the breakpoint was at 108.53 mm CL for the ADFG pot data and 109.51 mm CL for the NMFS data. The CPT had many questions about the maturity categorization for the logistic curve fitting, but not the above bent point estimates. There was concern that the defined maturity based on vertical distance to regression lines for logistic maturity curve fitting was arbitrary. Some small crab were assigned as mature in the analysis, which was a concern and many questions arose by the CPT because some small crabs were assigned as mature despite having small chela heights (this is not realistic). Members of the CPT suggested excluding small crabs from the analysis because there is likely a minimum size for maturity; however, others

suggested small crabs should be assigned as immature because it is unlikely that small crabs with large claws exist. Another approach would be to use one line for discrimination between mature and immature, as with Tanner and snow crab, with crab falling above the line classified as mature and crab falling below the line as immature. Or the discrimination line could include a kink.

Siddeek also used a 1,000 iteration bootstrap analysis to estimate uncertainty in the maturity breakpoint. 111 mm CL was used for knife-edge maturity in the assessment model because 111 mm is the lower limit of the next 5 mm size bin, which is larger than the estimated break point. A logistic curve was fitted to the arbitrary designation of maturity, but the CPT noted that the slope of the logistic curve looked too shallow (i.e., it should be steeper because the small mature crab should be classified as immature). It was also suggested to analyze the ratio of log(CH) to log(CL) vs CL, which would likely make the kink in data easier to see. Siddeek agreed that this analysis could be done.

The CPT recommends the following: 1) Reconsider what crabs are mature vs immature via breakpoint analysis using the methods suggested above; 2) Repeat the breakpoint analysis using log(CH):log(CL) vs CL, rather than the logCH vs. logCL; 3) Because it was based on an inappropriate analysis, there is no need to show models with a logistic maturity curve, unless an improved approach can be found.

A retrospective analysis was shown under equilibrium and non-equilibrium initial conditions; however, the two approaches yielded only very small differences once the model was informed by data. The patterns for recent years are similar between the two initial conditions.

Based upon this analysis the CPT recommends 4) It is appropriate to use only the equilibrium abundance as a starting point.

In response to a CPT request, an analysis was done using CPUE from the core area and compared the results from the entire area. The core area and the whole area CPUE input did not change the predicted CPUE and overall abundance estimates very much. The spatial effect was explored by standardizing the observer and fish ticket CPUE data using finer ADFG statistical area. Area effect was picked up, but requires further analysis.

Based upon this analysis the CPT recommends: 5) Moving forward, do not look at the core data; 6) Continue analysis of spatio-temporal variation of the fishery using a program like VAST.

Siddeek presented a table with the various model scenarios tested using equilibrium and non-equilibrium start points (i.e. 6 pairs for 12 total). He also presented results from 100 jitter runs: the model rarely converged to any value other than the (presumed) global minimum. The Francis iterative re-weighting process appeared to work well and was used for most scenarios. McAllister/Ianelli weighting was used for 2 model scenarios and the biomass and CPUE results were similar to that of Francis weighting. Recommendation: 7) Show a scenario with the McAllister and Ianelli re-weighting for comparison when choosing preferred model.

Siddeek showed trends in standardized and non-standardized CPUE indices for 1995/96-2004/5 and 2005/06-2016/17 for EAG and WAG. The GLM picked up year, captain, gear, soak, and area effects. When the CPUE likelihood was removed from the model optimization, the predicted CPUE indices did

not fit the input CPUE indices in the EAG for the past 6 years very well. The fit was worse for the WAG; however, the *trends* in the WAG fit well, but the absolute values were a worse fit compared to EAG. The CPT noted there is likely a conflict between the CPUE data and the size composition data, which results in different patterns of recent recruitment depending on which data set is considered reliable. The group asked the fleet if they could explain fishing behavior and observations of crab populations on the fishing grounds. It was noted that this conflict between CPUE and size composition data may be a problem moving forward, and warrants further evaluation.

The CPT recommends: 8) Consider interaction terms, specifically area x year interaction for CPUE standardization; 9) Consider scenarios with catchability and/or total selectivity breaking at a third point in 2010 (or a better year); 10) Provide a comparison between the previous CPUE standardization and any new standardization methods that are applied.

Siddeek suggested that the length comp data is driving recruitment estimation in the model, but it was suggested (Steve Martell) that the length comp data and CPUE data are contradictory about what is driving the recruitment estimation in the model. Siddeek showed model fit to retained catch and the bycatch. In general, scenarios fit these data reasonably well overall. The relationship between full fishing mortality and MMB was shown, and the relationship did not change much when adding the 2016/17 fishery data.

The CPT recommends: 11) Include last year's model as a scenario for consideration; 12) Overall model recommendation for May 2018: base model from last year (equilibrium initial abundance, knife edge maturity, both CPUE analyses with any significant interaction terms).

Economic Assessment

Brian Garber-Yonts presented the *Economic Status Report Summary: BSAI Crab Fisheries, 2017* document, provided annually to the CPT (and appended to the SAFE Report) as a summary of key economic status and performance indicators for BSAI FMP crab fisheries in advance of the 2017 update of the BSAI Crab Economic Status Report (Crab Economic SAFE) forthcoming in January 2018 for presentation to the SSC at the February Council meeting. He divided the summary into three sections: changes in volume and value of production, employment and income in the harvesting and processing sectors, and IFQ leasing activity, with results reported for the 2012 through 2016 calendar years. The results for 2016 fisheries are preliminary. The author noted that all information is reported on a calendar year basis, not crab fishing year.

The total volume of ex-vessel landings sold to processors during 2016 was 64 million pounds (29 thousand metric tons), a 30% decrease from the previous year. Processing sector total finished production volume during 2016 was 42.3 million pounds (19.2 thousand metric tons), a 30% decrease from the previous year. There were eight processors in 2016, a decrease by one processor from the 2015 year. Revenue dropped off in snow and Tanner crabs due to reductions in fishing, but remained relatively unchanged for the other fisheries. The reduction in harvest as a result of fishery closures, combined with offsetting price increases, produced an aggregate 3.6% decrease in total ex-vessel revenues in 2016, totaling $259.3 million for the year, and with aggregate first wholesale revenues declining by 3.9% from the previous year to $349 million.

Over 98% of total allowable catches were landed in 2016 and interannual variation in catch levels were due to stock assessment results rather than changes in fishing capacity. The total 2016 landings of 39.6 million pounds (17.6 thousand t) in the Bering Sea snow crab (BSS) fishery represented the largest decline (35%) from the previous year of all crab fisheries. Landings in the Bering Sea Tanner (BST) fisheries decreased 30% from the 2015, to 10.6 million pounds (4.7 thousand t), and landings of 8.4 million pounds (3.8 metric tons) in the Bristol Bay red king crab (BBR) fishery represented a 14% decline from 2015. The 5.6 million pounds (2.5 metric tons) landed in the Aleutian Islands golden king crab (AIG) fisheries during 2016 represented a relatively modest reduction of 3.4% from 2015.

These declines in landings were reflected in the finished production in the processing sector, a 30% decrease aggregated over all active crab fisheries in 2016. This was driven in large part by the 35% decline to 25.9 million pounds (11.8 thousand t) of finished production in the BSS fishery, and a 30% decline in finished volume in the BST fisheries to 7.2 million pounds (3.2 thousand t).

Average BBR ex-vessel price increased 32% per landed pound to $10.67 and average first wholesale price increased 26% to $18.27 per finished pound, while AIG prices increased to $5.38 per-pound (+23%) ex-vessel and to $9.38 (+28%) first wholesale. Prices in the BST fishery increased to $3.02 ex-vessel (+15%) and $6.31 (+17%) at first wholesale, and in the BSS fishery to $2.73 average ex-vessel (+33%), and $5.97 average first wholesale (+36%) per-pound. In looking at the ratio of ex-vessel to first wholesale, weighted average price, shows that wholesale prices relative to ex-vessel prices for Aleutian Islands golden king crab and Bristol Bay red king crab have increased over the past 4 years with no notable changes seen in the other fisheries.

The number of vessels operating in the rationalized (CR) fisheries in 2016 declined from 82 to 80. The active fleet in the BBR and BSS fisheries were similarly reduced, to 63 and 68, respectively, while 46 vessels participated in the BST fishery, 11 fewer compared to 2015. The active fleet in the AIG fishery remained the same at 6. There were an estimated 1,218 crew positions in aggregate across all 80 vessels in CR fisheries in 2016, 114 fewer than the previous year, of which 69 were due to the smaller fleet in the BST fishery. Due to overlapping vessel participation, it is not possible to break out crew participation by fishery. Revenue-share payments to crab vessel crew members as a group totaled approximately $36 million in 2016, with an additional $16 million paid to vessel captains, both declining by approximately 5% from previous year. Crab processing labor input at processing plants that received IFQ and CDQ crab landings in 2016 is estimated at 788 thousand labor hours, declining 33% from 2015, with the number of plants active over all CR fisheries reduced from 9 to 8. Aggregate processing labor income generated across all CR fisheries during 2016 was $9.6 million, 29% less than the previous year. Median plant-level hourly wage rate increased by 11 percent from 2015, to $11.93 over all CR fisheries.

The BSAI Crab Rationalization Economic Data Report provides detailed IFQ and CDQ Leasing information on quota lease volume (in pounds) and cost reported for crab vessels by fishing quota type category, including total quantities summed over all reporting vessels, and average values (both median and mean) for volume and cost of leased quota per vessel, and average lease price paid ($US per pound) and average lease rate (lease price as percentage of ex-vessel price) per vessel for 2012 through 2016. In general for 2016, 5.8 million pounds (69% of the total catch) was leased in the Bristol Bay red king crab fishery, 27.5 million pounds (69% of the total catch) was leased in the Bering Sea snow crab fishery, 9.9 million pounds (94% of the total catch) was leased in the Bering Sea Tanner crab fisheries.

The Crab Plan Team would like to explore the idea receiving an overview of the full Economic SAFE at the meeting in January if available to provide comments to the SSC. Production of economic performance reports similar to those produced by Ben Fissel for groundfish stocks for use in stock assessment documents was discussed, and the CPT asks that the author give a better idea of what information would be available at different times of the year.

New Business

Model Numbering Convention: Upon the request of the SSC, the CPT discussed options for model numbering conventions brought forward in the May CPT report. After discussion of the pros and cons of various approaches, **the CPT recommended moving forward with the modeling convention adopted by the Groundfish Plan Teams.** This policy is the following:

Naming conventions in groundfish SAFE guidelines: When a model constituting a "major change" from the original version of the base model is introduced, it is given a label of the form "Model *yy.j*," where *yy* is the year (designated by the last two digits) that the model was introduced, and *j* is an integer distinguishing this particular "major change" model from other "major change" models introduced in the same year.

When a model constituting only a "minor change" from the original version of the base model is introduced, it is given a label of the form "Model *yy.jx*," where "*x*" is a letter distinguishing this particular "minor change" model from other "minor change" models derived from the original version of the same base model.

The distinction between "major" and "minor" model changes is determined subjectively by the author on the basis of qualitative differences in model

January CPT Meeting agenda items: **The CPT recommends the following non-exhaustive list of items for the January Plan Team agenda.**

1. Chela height issue with respect to survey data
2. Discussion of weighting and lambdas in Tier 3, perhaps using snow crab as example
3. Francis weighting in all assessments. Uncertainties in application within various assessments
4. Terminal year of recruitment and how to address
5. Discuss the MCMC posterior draws. How implemented and for which stocks is this valuable. Issues of bimodality as with snow crab in the 2017 assessment
6. Dynamic *B0* for all applicable assessments and how to implement and interpret
7. NSRKC assessment OFL and ABC
8. ADFG harvest strategies uncertainties considered in TAC setting process for all stocks
9. Potential Alaska Board of Fisheries proposal for AIGKC harvest strategy change (T)
10. Format of SAFE Chapters discussion
11. Preliminary results of AIGKC genetic work
12. Use of acoustic bottom typing to inform bottom trawl sampling efficiency for snow crab
13. Overview presentation of the full Crab Economic SAFE

The meeting adjourned at 6pm.