Crab Plan Team Report

North Pacific Fishery Management Council Crab Plan Team (CPT)
Alaska Fisheries Science Center (AFSC) Seattle, WA September 10-13, 2018

The NPFMC Crab Plan Team met at the AFSC in Seattle WA from September 10-13, 2018.

Participants

Crab Plan Team members present

Bob Foy, Chair (NOAA Fisheries /AFSC – Kodiak)
Ben Daly, Vice-Chair (ADF&G –Kodiak)
Diana Stram (NPFMC)
Miranda Westphal (ADF&G – Dutch Harbor)
Cody Szuwalski (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 staff attending

In person: Toshide Hamazaki, Sara Cleaver, Scott Kent, Anne Hollowed, Gary Stauffer, Steve Minor, Scott Goodman, Lenny Hertzog, Matt Robinson, Edward Poulson, Madison Shipley, Angel Drobnika, Heather McCarty, Anne Vanderhoeven, Jocelyn Runnebaum, Jamie Goen, Stephani Zador, Gretar Gundmundsson, Ron Felthoven, Jeremy Rusin, Christie Lang, Nick Sagalkin, Craig Lowenberg, Jie Zheng, Craig Cross, Jennifer Bell, Justin Leon, Landry Price, Jon Richar, Wes Jones, Bo Whiteside, Lance Farr, Casey McManus, Joshua Songstad, Shannon Carroll, Ray Nomura, Dean Fasnacht, George Stensen

Webex: Nicole Kimball, Laura Slater, Tyler Jackson, Julie Dissen, Andy Nault, Paul Wilkins, Erin Fedewa, Elizabeth Siddon, Chris Siddon, Jim Ianelli, Christian Asay, Nikolai Sivertstol, Steve MacLean

Administration

The CPT reviewed the agenda for the meeting (CPT Agenda) and adjusted some timing to accommodate presentations on Tuesday. The CPT discussed a new process of minutes whereby they would be completed during the meeting for review by all before COB Friday in order to facilitate providing both the SAFE report and the CPT report to the SSC the following week.

The CPT welcomes Cody Szuwalski to the team.

2018 Eastern and Northern Bering Sea Surveys Update

Christie Lang (AFSC) summarized results from the 2018 NMFS survey. The 2018 survey was conducted from June 3 through July 31, covering the 375 standard stations, and including six special projects. General findings of the survey were: continuation of the recent warming period, with average bottom temperatures increasing compared to 2017 and surface temperatures declining slightly, in both Bristol Bay and the rest of the Eastern Bering Sea; a minimal cold pool retracted to northwest of St. Matthew Island; and a decrease of total mature male biomass when summed across all crab stocks.

Bristol Bay red king crab

BBRKC mature male and female biomass declined by 43% and 54% from 2017, respectively, with biomass of legal-sized males below the 20-year average; juvenile male biomass increased by 26%, and juvenile females declined by 56%. Survey densities of mature male and female RKC were highest in the central and southern sections of Bristol Bay and along the Alaska Peninsula. The centers of spatial distribution for both mature males and females continued the trend since 2012 of shifting northward.

Estimated mature male biomass of 13,226 ± 3,589 t represented 82% of total estimated male biomass, with estimated abundance of 4.6 ± 1.2 million mature male crabs. Shell condition of legal-sized males was 35% new hardshell crabs and 65% oldshell and very oldshell crabs. Estimated mature female biomass of 12,282 ± 5,437 t represented 96% of total estimated female biomass. Clutch condition of mature females indicated that the molt-mate cycle was not delayed given the warmer water observed in 2018, with 96% of mature females exhibiting extruded clutches of uneyed embryos. In response to a question, Bob Foy noted that survey results regarding the occurrence of barren females was typical of previous years. Length-frequency graphs showed no strong evidence for new recruitment in recent years, with the most recent peak in juvenile male and female abundance that occurred in 2011 not evident in any subsequent year.

Pribilof Islands red king crab

Pribilof Islands red king crab estimated biomass declined by 75% from 2017 for mature males, increased by 74% for mature females, and increased by over 1,400% for juvenile males; no juvenile females were collected. Size-frequencies by shell condition for legal-sized male red king crab were similar to 2017, with 55% of the legal-sized males sampled being new hardshell condition, and 45% oldshell or very oldshell condition. Biomass and abundance estimates for this stock are based on small numbers of crabs sampled and are highly uncertain.

Pribilof Islands blue king crab

Pribilof Islands blue king crab biomass estimates decreased from 2017 by 40% for mature males and 47% for mature females, while estimated biomass for juvenile males increased by 109% and decreased by 76% for juvenile females. Spatial distributions of both males and females were similar to previous years, as were length-frequency distributions.

St Matthew Island blue king crab

Estimated biomass of mature male blue king crab decreased by 6% from 2017 in the St. Matthew Island Section; no significant change was estimated for female and juvenile abundances. Mature

males were more evenly distributed throughout the high-density area south of St. Matthew Island, with no single survey station dominating (as has frequently occurred).

Bering Sea Tanner crab

Biomass estimates for Tanner crab east of 166° W long declined by 43% for mature males relative to 2017, declined by 70% for mature females; juvenile male estimated biomass declined by 41% and increased by 527% for juvenile females. West of 166° W long., estimated mature male biomass declined by 1% compared to 2017, and declined by 14% for mature females, while juvenile biomass estimates increased for juvenile crabs, by 62% and 212% for males and females, respectively. Across both districts, 91% of sampled legal-sized males were of oldshell or very oldshell shell condition. In contrast to a pronounced lack of newshell crab in the eastern district sampled in recent surveys, a pulse of newshell male abundance was observed in 2018, most of which were juveniles.

Clutch condition of sampled mature females in the eastern region indicated 72% with newly extruded embryos; 24% exhibited eyed embryos, had not produced a new clutch, or were barren. In the western region, 89% of mature females sampled exhibited newly extruded embryos. Clutch fullness on the eastern region was 4% 1/2 full, 27% 3/4 full, and 36 % full; western region clutch fullness was 19% 1/2 full, 35% 3/4 full, and 24% full.

Bering Sea snow crab

Estimated biomass of mature male snow crab increased by 60% relative to 2017 and increased by 56% for mature females; biomass estimates for juveniles increased by 143% and 26% for males and females, respectively. Mature females were distributed evenly through the historical area of concentration, while mature males were somewhat more concentrated to the northeast of the Pribilof Islands relative to 2017. Mature male abundance and biomass estimates for 2018 increased relative to 2015-2017, but remain below the average for previous 10 years, while pre-recruit abundance and biomass are the highest on record since 1980. The CPT discussed the increased survey abundance of mature males, and it was noted that this likely represented migration from outside the survey area.

Length-frequency distributions over the last four years showed succession of a large juvenile cohort that is expected to support strong recruitment in the next few years.

Of legal-sized males sampled, 81% were in new hardshell condition and 18% in oldshell or very oldshell condition. Among mature females sampled, 67% were in new hardshell condition and 33% in oldshell or very oldshell condition, and 95% were brooding new embryos, and 67% of all brooding females held clutches that were 75% or more full.

Northern Bering Sea Survey

Christie briefly reviewed results from the Northern Bering Sea survey. The 2018 NBS excluded Norton Sound. Bottom temperatures in the survey area were high, particularly in the southeast portion of the survey area and nearshore north of St. Lawrence Island, with cold water occurring in the western portion of the survey area. Snow crab catch in the survey indicted total estimated biomass of male and female snow crab was predominantly immature crab, with fewer mature males and increased mature females in the survey compared to 2017.

St. Matthew Island pot survey

Ben Daly (ADF&G) gave a presentation on the 2018 St. Matthew Island pot survey. ADF&G has historically conducted pot surveys in the Aleutian Islands, Pribilof Islands, St. Matthew Island, and Petrel Bank. Various biological characteristics are assessed during these pot surveys including size composition, depth distribution, abundance index, and size-at-maturity estimates. Tag and release studies are often coupled with the surveys. The St. Matthew survey was conducted on a triennial basis starting in 1995 but shifted to an annual survey during 2015-2018 due to data needs for the assessment, and to allow data collection of data on a much finer spatial and temporal scale.

The St. Matthew pot survey is divided into four strata. Ninety-six standard stations are found in strata 1 and 2 and are surveyed every year. Twelve of these stations are outside of the NOAA survey location and the remaining 84 overlap in the NOAA survey locations. These 96 stations are included in the assessment and used to determine trends. Stations in strata 3 and 4 are sampled sporadically as time and resources allow. Strata 3 stations are nearshore where females are commonly found. Strata 4 is to the north of the island and corresponds with station R24 from the NMFS trawl survey; Station R24 in the NMFS trawl survey can have a disproportionate effect on the overall abundance estimate depending on catch during the trawl survey. Strata 4 was added to the pot survey, so this area could be looked at in a finer resolution but was not sampled in 2018.

The survey uses commercial 7' x 7' king crab pots with no escape rings or panels, although biotwine is used in all pots to prevent ghost fishing in the event a pot is lost. Four pots are deployed at each station and an average CPUE per station is derived. Soak times range from 30-36 hours and sub-sampling never occurs for blue king crab. Temperature loggers were also deployed in one pot at each station. In addition, three pots outside of the survey were deployed with temperature loggers that can be used as reference points to the survey stations. These pots have been deployed in the same place for the past five years.

In 2018 the P/V *Stimson* was used for the pot survey due to no viable bids from the fleet. The core 96 stations were sampled plus six additional stations to the east of the core 96. The six additional stations were sampled in an area where catch was observed by the NOAA survey to assess the area at a finer spatial scale. Strata 3 consists of near-shore stations where females are normally found; in 2018 no females were found, which is unprecedented. Total male CPUE in 2018 was the lowest since 1994 in the survey for all sizes. Although there tends to be higher abundance in the nearshore stations, the trend at these stations was still downward. In recent years both the NOAA survey and the pot survey have shown a negative trend in abundance. Females also had a low CPUE during the 2018 pot survey.

Daly stated that satellite tagging on Tanner crab was also completed in the Pribilof Islands during the 2018 pot survey. This study was conducted to help understand the movement patterns of large males (industry-preferred size) inside and outside of the Pribilof closure area. About half of the mature males in recent years have been found in this closure area. In 2017, ten mrPAT tags were deployed on Tanner crab. These tags are set to pop-up on a specified date and transmit via satellite location and temperature data. Three of these tags successfully transmitted data on December 1 when they were released to the surface after being deployed for 95 days. These crabs were shown to move 42-191 meters per day as a minimum straight-line estimate. Five tags, which released on May 1, did not transmit any data. This could possibly be due to hardware corrosion from prolonged water exposure. In 2017 approximately 450 floy tags were also deployed. In 2018 eleven mrPAT tags were deployed and three miniPAT tags (these tags include depth, temperature, and tracking data). These tags were set to release at different times of the year in hopes of determining how long

the tags can withstand being submerged. In addition to the satellite tags, approximately 1,000 floy tags were deployed in the 2019 survey.

There were questions as to whether these satellite tags change crab behavior. Daly stated that crab observed in controlled tanks with these tags did not seem to change behavior, however the full effects are unknown. There was also a question on what the fleet should do if they encounter one of these tags. ADF&G stated that the satellite tags are deployed in the closure box, so it is unlikely they will be encountered by the fleet. Floy tags can be cut off and location information recorded and given to ADF&G.

Crab Catch overview

Ben Daly (ADF&G) presented a summary of the 2017/18 BSAI crab catch and fishery performance. In general, restrictions on confidentiality (less than 3 vessels participating in the fishery in one statistical area) prevented some catch data from being presented spatially for the Aleutian Island golden king crab (AIGKC) and Pribilof Islands golden king crab (PIGKC) fisheries, but the majority of the data were available to look at the spatial distribution for the Tanner, snow, and Bristol Bay red king crab fisheries.

The 2017 Bristol Bay red king crab (BBRKC) TAC (6.6 million lb) was the lowest it's been since 1996, and there was a large drop in the fishery CPUE from the previous year. Overall, the spatial distribution of catch was similar to previous years. Fleet observations included the presence of one "school" of fast-moving crab on the grounds and an increase from previous years in the time it took to locate good fishing grounds. The observer CPUE (average of 17.2, SD of 9.9) was comparable to the commercial fishery CPUE.

The 2017 snow crab TAC (19 million lb) was the lowest since 1982, and fishery CPUE was similar to the last two years. Fishery CPUE has been declining since the 2007/08 season. Observer coverage was representative of the spatial distribution of catch. There was a large disparity in individual fishing vessel performance, and the fleet was split between the traditional fishing grounds and those much farther north in an area southwest of St. Matthew Island (SMI). There was strong fishing around SMI, but the catches from the traditional fishing grounds were spotty and inconsistent. While presence of sea ice was not an issue this year, frequent storms and long run times limited the vessels that could participate in the better fishing grounds southwest of SMI. The observer CPUE (average 125.6, SD of 84.3) was comparable to the commercial fishery CPUE. The relationship between the spatial distribution of fishing effort and sea ice extent was examined visually but no clear pattern was observed.

The 2017 Tanner crab TAC, ~2.5 million lb for the area west of 166W longitude, was similar to the mid-2000s. The area east of 166W longitude was closed to directed fishing for Tanner crab. The bulk of the catch for this fishery occurred in one statistical area, west of the Pribilof Islands, and the CPUE in the western area was the highest observed since 2005. Tanner crab fishing was generally good and consistent for all vessels. The observer CPUE (average of 64.3, SD 35) was comparable to the commercial fishery CPUE.

The 2017 AIGKC TAC (~5.5 million lb) was the same as 2016 for for both the eastern and western regions. The CPUE trended up for the western area after a five-year decline and trended down in the eastern area for the third year in a row. The spatial distribution of the harvest was consistent with previous years, with the addition of some fishery effort farther west than normal in the western area.

The PIGKC fishery is tracked by calendar year, and while the 59 t GHL was achieved, the fishery data are confidential due to only two vessels participating.

Overall observer coverage goals per State regulation *5 AAC 39.645*, calculated as the percentage of vessels covered, are currently being achieved. In the future, additional metrics will be examined to determine the extent of observer coverage, these include percentage of observer coverage by weight, pots, and trips.

The Crab Plan Team appreciated the information presented on fishery operations and the additional information about the extent of observer coverage. There was a question from the Plan Team on how legal retained and non-retained catch will be provided in the future. Daly mentioned that legal retention status information (i.e., legal retained, legal not retained) will not be collected by observers in the future. The topic of calculating discards using alternative methods such as "the subtraction method" was added to the agenda for the January meeting. The Plan Team also requested a seasonal pattern of harvest to be presented in the future, both the percentage of catch over time and the spatial distribution of the fleet throughout time. The Plan Team understands that this may be difficult due to confidentiality restrictions.

EBS Ecosystem report

Elizabeth Siddon lead on the EBS Ecosystem Considerations Report, reviewed 2017 crab-relevant biological information, current 2018 climate and oceanography, and 2019 sea surface temperature forecasts. Residual heat maintained above-average water temperatures (surface and bottom) in 2017. Winter sea ice extended over much of the southern shelf and resulted in a large, although narrow, 2017 cold pool. Cold conditions were observed overall but warm conditions were observed over the inner shelf near Nunivak Island, east of St. Lawrence Island, and into Norton Sound.

Across all commercial crab stocks, biomass trends, which are highly variable over time, continued declines in 2017. Potential causes for population fluctuations include interannual variability of benthic predators or seasonal variability of pelagic prey resources for crab larvae. The 2017 Northern Bering Sea bottom trawl survey showed increases of snow crab and red king crab abundance, but biomass for both species decreased due to lower mean sizes. Snow crab were concentrated along the 50 m isobath near the southwest corner of St. Lawrence Island; the same location where Pacific cod were abundant. Additionally, the 2017 Northern Bering Sea saw blue king crab abundance and biomass increased while the mean size decreased. The benthic habitat-fishing effects model shows cumulative effects of fishing and potential recovery over time. The 2016 model showed no effects in the northern Bering Sea region, Bristol Bay, or around the Pribilof Islands. The CPT asked about possible environmental impacts of Pacific cod redistribution on snow crab recruitment. Distribution maps for groundfish were provided by Lauth for the 2017 BS trawl survey hot topic article. The benthic habitat-fishing effects model will be updated with 2017 and 2018 data for publication in this year's ecosystem report.

Structural epifauna (sponges, sea whips, and sea anemones) abundances are based on standard bottom trawl survey data. Structural epifaunal declines are an indicator of seafloor habitat conditions over the area of the bottom trawl. In 2017, sponge and sea anemone abundance were similar to 2016 with both estimates much lower than the most recent seven years. Sea whip abundance decreased significantly from 2016. Between 2016 and 2017, overall biomass of motile epifauna (e.g., octopus, crab, sea stars, snails, brittle stars, cucumbers, and sea urchins) was above the long-term mean and has been increasing over time. This increase is driven mainly by increases in abundances for brittle stars, urchins, sand dollars, and cucumbers. King and Tanner crab

biomasses, which comprise part of the motile epifaunal guild, have decreased 28% and 21%, respectively. Overall structural epifauna is decreasing, which may be a potential red flag for crab habitat conditions. Additionally, brittle stars, urchins, sand dollars, and cucumbers biomass has increased significantly from 2009 and are possible competitors with crab for seafloor resources. Zooplankton (including large and small copepods and euphausiids) abundance varied seasonally. Large copepod abundance was low in the 2017 spring and fall 70m isobath rapid assessment survey and decreased from spring to fall. Small copepods were more prevalent (due to warm water) in the spring and increased from spring to fall. For both large and small copepods, abundances were below the 2016 estimates. The 2017 estimate of euphausiid abundance was low but comparable to 2016. There was an increase in productivity in the north near St Matthew Island, reflecting an ice edge bloom and increase productivity, which may translate into an increase in productivity to the seafloor.

Changes in the aggregated CPUE of fish and invertebrates in the bottom trawl survey over the entire time series is driven mainly by walleye pollock abundance. CPUE has remained stable since 2015 with the overall time series trending upwards. Length-weight residuals for groundfish and flatfish species are used as a proxy for fish health or condition. Reduced condition (negative length-weight residuals) for nearly all groundfish and flatfish species in 2016, may be a leading indicator of poor overwinter survival. The biomass of pelagic foragers (walleye pollock, herring, Atka mackerel, salmon, capelin, sandlance, eulachon, etc.) s at the long-term mean with respect to the most recent five-year mean in 2017. An increase in Pacific herring was offset by a decrease in capelin. Apex predator (Pacific cod, arrowtooth flounder, Pacific halibut, skates, sablefish, sculpin, etc.) biomass for 2017 was at its long-term mean. From 2016 to 2017, there was a 35% reduction for Pacific cod biomass and an 11% reduction in arrowtooth flounder biomass, which accounted for much of the reduction in overall biomass. Benthic forager (flatfish, rock sole, flathead sole, arrowtooth flounder, etc.) biomass is at the long-term mean with a neutral trend over the last five years. There was a dip in 2015 due to a decline in northern rock sole, which continues to decline. The overall biomass returned to the long-term mean due to an increase in “miscellaneous flatfish” (Bering flounder, longhead sole, dab, starry flounder, etc.) as well as flathead sole. Only 2 years in the last 11 (2008 and 2015) had favorable in-shore winds for mid-winter spawning.

Multi-species CEATTLE model estimates for age-1 natural mortality for walleye pollock, Pacific cod, and arrowtooth flounder peaked in 2016, dropped slightly in 2017 but remains elevated with regard to the long-term mean. The peak in mortality in 2016 reflects the maturation of the 2012 year-class of pollock preying on these species. Elevated natural mortality rates may reflect higher metabolic or energetic demand of predators under warm water conditions.

Jellyfish abundance continues to decline from the peak in 2011 and was among the lowest relative abundance since 1989, which may mean the end of the recent bloom (2009 to 2015). Large jellyfish blooms may have a predatory impact on juvenile forage fishes and may impact the transfer of productivity from the pelagic realm the benthos. It was suggested that consideration be given to an appropriate way to integrate the northern Bering Sea indices into the ecosystem analysis and include northern indicators in future ecosystem reports.

Coccolithophores blooms over the Bering shelf are happening more frequently and are related to strong stratification in the system. These blooms may have negative impacts for visual foragers such as seabirds. Coccolithophores are smaller in size, resulting in longer food chains. The 2017 coccolithophore index is the lowest on record and may indicate weak stratification over the shelf which may have benefited visual predators. In 2017 and 2018, there was a wide-spread seabird die-off in both the southern and northern Bering Sea, including red-legged kittiwakes, black-legged

kittiwakes, thick billed murres, common murres, northern fulmars, short-tailed shearwaters, puns, and auklets. Even though the conditions in 2017 would be considered moderate compared to warm years (2014, 2015, and 2016), foraging conditions have not improved, and die-offs continued through 2017 and into 2018. A seabird hot topic report on the status of Bering Sea seabirds will be included in the 2018 ecosystem report.

Climate conditions in 2017-2018 were similar to 2016-2017 with both winters featuring La Nina and weaker than normal Aleutian lows. Sea surface temperature (SST) anomalies in 2017-2018 tended to be positive (warm) with increasing positive anomalies in the Bering Sea. The PDO remained slightly positive in summer 2018. There is an estimated 70% chance of a weak to moderate El Nino for winter 2018-2019, meaning warmer temperatures for the region. Fall 2017 saw warmer than normal SST anomalies across most of the north Pacific that continued through the winter 2017/18. Positive temperature anomalies in the Chukchi and northwest Bering Seas contributed to the delay in sea ice onset last winter. Spring 2018 was relatively warm compared to the seasonal normal in the eastern Bering Sea and was the end of the La Nina. By summer 2018, there was strong warm anomalies in the Bering Strait. Sea level pressure anomalies which indicates wind forcing in the region. Fall 2017 suppressed storminess from the Aleutian Islands to the Gulf of Alaska, continuing into winter 2017/18 with strong wind anomalies from the SW over the Bering shelf that moved warm air from the south to the north and impeded sea ice formation. Spring 2018 saw warm, SW flow wind anomalies across the Bering Sea creating favorable conditions for upwelling in the coastal GOA. By summer the winds relaxed, and the stratification was weak due to a weak salinity gradient caused by lack of sea ice. Overall climate indices show the North Pacific atmosphere-ocean climate system was mostly on the warm side during 2017/18. The was the second fall/winter with a weak-to-moderate La Nina event. The positive PDO that began in 2014 ended in 2017, which is consistent with the transition from El Nino to La Nina. The NPI is strongly positive in 2018, which is common with La Nina but has a greater magnitude than expected. The NPGO is negative going from 2017 to 2018 and has been declining since 2012. The AO is near-neutral in 2017 and transitioned to positive in the spring/summer of 2018, reflecting low pressure in the Arctic.

The fish stock sustainability index (FSSI) is a performance measure for sustainability of North Pacific stocks selected for importance to commercial and recreational fishing. The FSSI is updated annually but may need further updating for 2018 depending upon crab stock status determinations. Preliminary improvement was shown for Alaska overall, and for the BSAI. This improvement is due to the determination that Pribilof Islands blue king crab is no longer subject to overfishing, although it remains in overfished status.

The 2019 SST projections are based on the National Multi-Model Ensemble and are forecast out in three-month increments. Warm conditions are expected to continue across the North Pacific through December 2018. The positive (warm) anomalies are greatest in the northern Bering Sea. There is a 70% chance of El Nino developing from fall to winter. The Aleutian low is predicted to be deeper than normal in late winter 2018/19, which may result in warmer weather for Alaska enhanced by warm waters. The PDO may be ill-suited for characterizing the state of the North Pacific in early 2019 because the typical structure for the PDO is non-existent.

It was suggested that it may be informative to run the OSCURS model focused on crab centric distributions relative to larval advection, although the model may need to be rescaled for crab. It was also suggested that it may be useful to revisit the ecosystems considerations chapter for individual crab stocks with a spatial component by stock. This effort is continuing by new NOAA staff and will be discussed at the January CPT meeting.

Incidental catch

Buck Stockhausen raised the issue of tracking incidentally-retained catch of Tanner crab in the snow crab and BBRKC fisheries, as well as more generally for other crab stocks. Currently, the incidentally-retained catch of Tanner crab in non-target crab fisheries in most years is very small relative to that in the directed fishery; in the assessment model it is simply combined with retained catch in the directed fishery to account for total fishing mortality without considering potential differences in the size composition (due to different gear types) used in the non-target fisheries. Previously, datasets provided to the assessment author have not differentiated between incidentally-retained catch and directed retained catch, but such data exist. ADF&G stated that it is difficult to separate the incidental and directed retained catch in the fishticket database because the gear configuration is not noted on the fishticket. This is not an issue when the incidental catches are very small compared to the directed Tanner crab catch. However, in certain years, for example 2005 and 2015, incidentally-retained catches of Tanner crab in the snow crab fishery were relatively high; although the incidentally-retained catches of Tanner crab in BBRKC fishery remained small. The Alaska Board of Fisheries has set allowances for incidentally-retained catch for Tanner crab at 5% of the snow crab total catch weight per vessel trip. However, ADF&G stated that the industry has expressed interest in raising the amount of incidentally-retained catch that can be kept which could cause additional issues. If the Board of Fisheries raises the allowable incidentally-retained catch amounts to 50% or more of Tanner crab while snow crab fishing, it will be even more difficult to determine incidentally-retained catch from directed catch. Stockhausen raised the issue that combining the incidentally-retained catch with the directed retained catch could become problematic for projecting future catch and determining OFL if incidental retention levels increase. After lengthy discussion, the CPT recommended that the incidental catch size composition data should be provided for modeling purposes, if possible, and if the amount of catch becomes significant in the future, consideration should be made to using separate selectivity/retention functions for the incidental catch in the snow crab fishery and other fisheries.

St. Matthew Blue king crab (SMBKC)

Jim Ianelli (NMFS) provided a webex presentation of the St. Matthew blue king crab assessment. This assessment uses the General Model for Alaska Crab Stocks (Gmacs) framework, configured to track three stages of length categories: 90–104, 105–119, and >119 mm CL. This assessment considered five models:

1. 2017 Model - the 2017 recommended model without any new data added

2. BTS – Model 1 with 2018 bottom trawl survey (BTS) data

3. BTS and pot, “reference model” – Model 2 with 2018 ADFG pot survey data

4. VAST - a model using indices produced using VAST, a geo-spatial delta-GLMM model, fit to the BTS data; and not run in Gmacs

5. Fit survey - an exploratory scenario that revises the reference model by reweighting the NMFS trawl and ADF&G pot surveys by 2.0

Recent model configurations allow natural and fishing mortality to be apportioned across five discrete seasons. Diagnostic output includes “dynamic B_0,” the ratio of estimated spawning biomass to the spawning biomass that would have occurred without historical fishing mortality.

The VAST uses a spatial averaging process to estimate survey cell abundances given densities in the cells in the surrounding area. The CPT had substantial discussion over how the VAST model uses survey data estimates around St. Matthew Island, particularly discussing uncertainties over extrapolating densities across the island and averaging near the edge of the survey distribution area. The author discussed rescaling the VAST model estimates to be the mean of the reference model estimates. Per questions, the author further noted: (1) there is likely an edge effect where crab abundance is underestimated; (2) VAST been used in several west coast stocks; and (3) the VAST was configured with 50 "nodes" which defines the grid spacing for the region (there are about 56 tows per year). It was noted that the VAST approach may be less sensitive to high CPUE tows and, hence, reduce interannual variability. This contrasts with the design-based survey estimates used under the reference model, where big tows can skew estimates. A particular concern is station R24 which has shown high variability in annual survey estimates, and some estimates being relatively high; an aspect that the VAST model tends to smooth. There was discussion of how VAST treats data spanning the island. In particular, the effect of catches on one side (station R24 in this case) tend to be much higher than other areas around the island. After substantial CPT discussion, it was requested that the January CPT meeting include a presentation on the pros and cons of the VAST approach, potentially including input examples from west coast stock assessments where VAST survey estimates are applied. The CPT remained concerned that none of the assessment models provided a reasonable fit to recent survey data, with the surveys indicating a continued downward trend with high precision (low CV). While this may be an issue with a lack of recruitment, whether real or driven by environmental conditions that affect catchability, it is also notable that general abundance declines were not matched by increases in other survey areas, suggesting out-migration is not a factor. Thus, a continued lack of recruitment is likely indicated.

The assessment author noted that data from the most recent pot survey was just received and not analyzed using VAST model, but it would be useful to explore in the future. The CPT discussed the aspect of an "edge effect" from survey truncation at the St. Matthew Boundary, or across the island. Diagnostic figures suggest VAST outputs seem reasonable and generally stable across the spatial distribution of the population. Ultimately, the CPT felt the VAST model has potential, but still presents substantial uncertainties and is not adequately developed for application to SMBKC at this time. The CPT requested a presentation at the CPT January meeting on: (1) VAST, including scaling in the model; and (2) calculating estimates along boundaries.

The CPT noted the "fit survey" model, along with other models, poorly matched the most recent two years of data. The assessment author also noted the dynamic B_0 suggests the population would still be around 50% of B_0; and while stock is overfished, there is no evidence that overfishing has been occurring for this stock. The CPT suggested looking at harvest rates as a phase plot with Dynamic B_0 vs. F; because the reference model suggests the stock has been overfished since 2011 given that new data with a low CV that reduces population time series estimates. The CPT also noted that while we have four recent years of low estimates, historical pot surveys were less frequent (triennial) and potentially didn't adequately identify interannual variability. However, a declining trend is evident over recent years regardless of the assessment model examined, and while females seem to have moved farther from the island, a large number of males have not appeared in surveys farther outside of the core area, suggesting overall declines.

The CPT agreed that the reference model using the pot survey data is the best option at this time. In addition, the most recent year of assessment data is to be included when calculating reference points. However, the CPT will schedule a discussion for January regarding adding the final year when calculating reference points for Tier 4 stocks. The CPT recommends the reference model for the 2018/19 crab year. This stock is in Tier 4 and reference model indicates the stock is overfished.

The CPT further recommends using the full assessment period (1978/79-2017/18) to define the proxy for B_{MSY} in terms of average estimated MMB_{mating}. Projected MMB for 2018/19 under the recommended model is 1.31 t (2.89 million lb), The F_{MSY} proxy is the assumed natural mortality rate (0.18), and F_{OFL} is 0.043, resulting in a mature male biomass OFL of 38 t (0.085 million lb). The MMB/BMSY ratio is 0.35. The author recommended, and the CPT concurred with a 20% buffer on the OFL for the ABC which was consistent with the approach used last year. The ABC based on this buffer is 30.77 t (0.068 million lb). Given the low abundance estimate, the CPT discussed data that will be needed to develop a rebuilding plan.

Additional aspect for future consideration in January:

1. The CPT would like more information on the VAST scaling of abundance index / total abundance for SMBKC to be presented at the January meeting. The models tend to overfit the smallest size group to create sufficient recruitment for survey observations of larger size groups; catchability on middle size group is set at 1.0.
2. Recommendations for whether to add the final year when calculating reference points for Tier 4 stocks.
3. Discussion of pros and cons of VAST model, and how it might be applied to specific crab stocks (e.g., with and without an island). The CPT noted the groundfish group has procedures in place for routinely applying VAST model to Bering Sea data sets and could easily be applied to Bering Sea crab stocks.

SMBKC Rebuilding discussion:

Given indications that the stock is currently overfished, the CPT discussed the schedule and plan for developing a Rebuilding Plan for this stock. Diana Stram provided an overview of the timeframe for the notification from NMFS to the Council. This notification will be made once the overfished condition has been officially determined and entered into the National SIS database. It is anticipated that the NMFS letter will be received by the Council in late October, which starts the two-year timeframe for preparing and implementing a Rebuilding Plan amendment. The CPT will further discuss what to consider in a Rebuilding Plan in January. In anticipation of this discussion the CPT made a number of suggestions for consideration at that time. Issues noted are the following:

1) Because GMACs does not currently produce projections, either the GMACs code must be modified to allow for projections or the projection must be modeled outside of the GMACS framework.
2) There was substantial discussion of bycatch in directed crab vs. groundfish fisheries. Bycatch is primarily in fixed gear groundfish fisheries. Bycatch in directed crab fisheries has been negligible in recent years and low outside of the SMBKC directed fishery. However, it was noted there remains the potential for bycatch in the snow crab fishery.
3) NMFS and the State will work to coordinate efforts between state and federal accounting of bycatch in-season to avoid an overfishing determination.
4) It should be verified that the area used for the biomass estimation for SMBKC matches the area over which bycatch accrues toward the OFL.
5) Given discussed confidentiality issues with groundfish fixed gear bycatch, staff will look into confidentiality waivers. In the absence of such waivers, the CPT will need to resolve how to evaluate the data.
6) More information needed on bycatch by other gear types (non-pelagic and pelagic trawls).
7) Need more information on the closure area and rationale for it.

8) What are the requirements for consultation with the BOF for a rebuilding plan? (note Diana to provide an overview of this in January)
9) Additional data and discussion of potential increases in Pacific cod predation on BKC in the St. Matthew area

Council, NMFS and State staff will coordinate efforts to provide the CPT more information on these items as well as other considerations for developing alternatives for the rebuilding plan in January.

EBS Tanner crab

Final Assessment

William (Buck) Stockhausen (AFSC) presented the draft Tanner Crab assessment. This assessment again uses the TCSAM02 modeling framework that was recommended by the CPT in May 2017 and approved by the SSC in June 2017. The model is a size-structured model configured to model the seasonal timing of Tanner crab biology and the directed fishery. The model estimates growth parameters, maturity, natural mortality (with priors), recruitment, selectivity and retention curves for the Tanner crab fishery, and selectivity for bycatch fisheries. The NMFS Eastern Bering Sea bottom trawl survey is the primary index used to track Tanner crab population trends.

The assessment author provided twelve assessment models (the 2017 final model and 11 new models), some of which had been selected at the May CPT meeting for consideration, and others that were new to this assessment. A selection of models that featured in CPT discussion were:

- Model 17AM: 2017 assessment model.
- Model 17Amu: 17AM with revised catches for the directed fishery and bycatch in the snow crab fishery.
- Model 18A: 17AMu with 2017/18 fishery data and 2018 NMFS survey data.
- Model 18C0: Fitting male maturity ogives, survey biomass by sex, size compositions for males by shell condition and by maturity state and shell condition for females.
- Model 18C1: 18C0, but also fitting survey abundance by sex.
- Model 18C2a: 18C1a, but fixing sex-specific survey catchability and selectivity functions for 1982+ based on the Somerton and Otto (1999) underbag experiment.

Total catch estimates (abundance and biomass) for Tanner crab in the directed fisheries, the snow crab fishery, and the BBRKC fishery were provided by ADF&G based on at-sea crab observer data for 1992/93-2017/18. The total catch in the directed fishery and the bycatch in snow crab fishery were nearly the same as the estimates previously used in the assessment after 1995 but showed much larger changes in 1992-1995 (estimates of total catch for 1990/91 and 1991/92 were considered unreliable; at-sea observer data was unavailable prior to 19990/91). Inclusion of these revised catch estimates in the assessment (Model 17Amu) had a large impact on estimated Tanner crab mature male biomass for the entire time series, shifting it upwards by approximately 70%. The CPT had several concerns about using the revised total catches. First, there was no opportunity review the new estimates, and it was unclear to the CPT whether observer coverage (the basis for the revised catch estimates) was adequate to support earlier estimates. Second, the revised catch time series was used only for Tanner crab and not for the other crab assessments in this cycle. The CPT would have preferred that revisions to catch estimates be done consistently for all crab stocks. Finally, it was not clear to the CPT what was driving the extreme sensitivity of the model to the revised catch estimates. Further analyses by the assessment author suggested that results were

being driven by the approach used to infer bycatch in the snow crab fishery prior to observer sampling, but further investigation is needed.

Addition of the new fishery data and survey data (Model 18A) indicated a continuing downward trend in biomass, consistent with the biomass trend in the survey data. There is some indication of relatively strong recruitment in the last two years that may increase biomass and fishery yields in the future.

Including maturity data in the model to estimate the maturity ogive (Model 18C0) had been recommended previously by the CPT, and was regarded as an improvement by the CPT. However, there were relatively poor fits to the maturity data, suggesting that refinements to this approach may be needed. This model also fit size-composition by shell condition (new shell and old shell), and the CPT was not convinced that the shell condition data were sufficiently reliable to be included in the model.

The assessment also presented models (Models 18C1, 18C2a, 18C3a) that were fit simultaneously to total survey biomass and total survey abundance. Usual stock assessment practice is to fit either biomass or abundance, and not both simultaneously, and it is not clear to the CPT what the advantage of this approach might be. Model variants (18C2a, 18C3a) that fixed survey catchability and selectivity to results of the Somerton and Otto (1999) underbag experiment, rather than using this information as a prior (as had been done in previous assessments), were not regarded as an improvement by the CPT.

Given the issues that CPT identified with the models presented, the CPT requested, and Stockhausen agreed to provide, an additional model run with the model using last year's configuration (model 17AM) fully updated with recent survey and fishery data, but without the revised fishery catch time series. This model run (18AM17) was highly consistent with last year's assessment, except for a slightly steeper downward trend in the last few years, reflecting the downward trend in the bottom trawl survey. The CPT regarded this model as the best alternative for setting the ABC.

BSFRF Tanner selectivity study and other research activity

Scott Goodman presented a BSFRF research update, focusing on Tanner crab surveys, a collaborative Tanner crab workshop, collaboration on the ADF&G Tanner crab harvest strategy update, and potentially shifting future research to crab movement, which includes tagging. Goodman summarized male and female Tanner crab selectivity data for 2013-2016 surveys conducted within days of the NOAA survey tows conducted in the same area. The selectivity of females was lower in the NOAA survey across size classes, and male selectivity was lower in the NOAA survey with the most dramatic difference observed in the lower size classes. Goodman went on to summarize the 2017 and 2018 BSFRF Tanner crab selectivity survey results. Tows were conducted side by side with the NMFS survey tows in the Tanner crab areas, with the goal of extending the spatial area covered relative to previous surveys. In addition to the NOAA side by side tows, the BSFRF survey conducted tows in three index areas, one of which was near Zhemchug Canyon. In the 2017 survey, side by side tows were conducted in 95 stations (representing 53% of the catch from the NOAA survey) and 156 BSFRF index area tows. In the 95 side by side tows, the total catch was 921,000 crab in the NOAA survey compared to 6,149,000 crab in the BSFRF survey. In the 2018 survey, 95 side by side tows were also conducted (representing 56% of the catch from the NOAA survey) and 155 BSFRF index area tows. In the 95 side by side tows, the total catch was 796,000 crab in the NOAA survey and 8,230,000 crab in the BSFRF survey. For males and females in

both the 2017 and 2018 survey, the CPUE ratio (NMFS:BSFRF) was less than 1 (implies lower selectivity in NMFS survey) for most size classes, and the CPUE ratio was less for females compared to males (i.e., lower selectivity for females than males in NMFS survey). The BSFRF survey size frequency data in 1 mm size bins showed distinct modes less than approximately 50 mm CW, which likely represent separate cohorts. Because crabs of this size range are generally not captured in the NOAA survey in large numbers, these observations of cohorts at small sizes are unique and valuable data coming from BSFRF survey. CPUE ratio (NMFS/NMFS+BSFRF) bubble plots for the 2017 and 2018 survey showed a ratio of less than 0.5 for both males and females across all sizes, but the discrepancy in the CPUE was more pronounced for females. Goodman discussed the next steps for the BSFRF selectivity research, which includes incorporating the selectivity data into the Tanner crab assessment model in an appropriate way (i.e., similar process as that for the snow crab model). Currently, the Tanner crab assessment model does not include the BSFRF selectivity data directly but has used it indirectly by comparing to the Somerton and Otto "underbag" experimental results to inform selectivity. When asked about future survey work, Goodman stated that future research may include smaller-scale projects such as additional juvenile sampling and understanding movement via tagging, but the specific future survey goals are under discussion. Goodman mentioned that BSFRF plans to continue collaboration with crab managers and stakeholders. There is an ongoing Tanner crab harvest strategy revision with ADF&G, BSFRF, and University of Washington participation. He also briefly discussed the collaborative, multi-agency Tanner crab science workshop that took place in Juneau, Alaska in December 2017. A draft workshop report, including paraphrased minutes, has been produced and is available to the public.

Tanner crab MSE and harvest strategy

Ben Daly presented an update on the revision of the State of Alaska's Bering Sea Tanner crab harvest strategy with the goals of providing historical context for the current harvest strategy and proposed harvest strategy revisions, discussing different harvest strategy scenarios that are being explored, and to solicit feedback from the plan team on additional harvest strategy scenarios of interest and management objectives that can be used to rate the stock sustainability and productivity under a given scenario.

In 1974, an exploitation rate of 40% on legal male abundance was considered low and was implemented with the intent of dampening inter-year variation in catch. This stock management strategy is known as multi-year class management and was discussed by Somerton in his 1981 doctoral thesis. Legal size limits for Bering Sea Tanner crab were established in 1976. Prior to 1976, the size of retained crab was determined by processors based on market considerations. Throughout the mid-1970s, 1980s and much of the 1990s, Tanner crab in the Bering Sea was managed by size, sex, and season (3S) strategy. Fishing was limited to legal size males only, and fishing during the molting and mating seasons was prohibited. The stock collapse in the mid- and late-1990s showed that the exploitation rate of 40% was likely too high.

After the 1998 collapse, a Federal rebuilding plan was implemented in 1999, which included a harvest strategy revision. The harvest strategy aimed to balance the tradeoff between in high average catch and catch variability and considered probabilities of overfishing and fishery closures. The harvest strategy was again revised in 2011 and 2017. Each of the revisions focused on revising the female threshold calculations, male exploitation rates, and the management boundary between the eastern and western portions of the stock.

In the 1999 harvest strategy revision female threshold was based on past fishery management and partly on the weak stock-recruit relationship. Effective spawning biomass (ESB; an assumption

about the number of females that are available for males to mate) was developed for Bristol Bay Tanner crab and was expanded to the Eastern Sub-district. However, it was recommended that mature female biomass be used instead of ESB for Tanner crab due to the complexity of the ESB calculation and for a number of years ESB equaled mature female biomass. In 2011, the Bering Sea Tanner crab harvest strategy was revised due to acceptance of terminal molt in Chionoecetes crab, and to better align with the Federal assessment process. The basic core elements of the harvest strategy remained but calculations were revised. The line of demarcation between the eastern and western port of the stock was changed from 168°W long. to 166° W long. The harvest strategy was again revised in 2017, and while the core components remained intact, the mature female threshold was modified to the updated time frame of 1982-2016 (fixed), included females in the Western Sub-district (west of 173°W long.), and updated the definition of female maturity based on abdominal flap morphology rather than a size cut off. Additionally, an "error band" approach was included to reduce the probability of closures based solely on female abundance.

Many of the changes and discussions regarding the Tanner crab harvest strategy have centered around the mature female threshold. Low female abundance is linked to low egg production and lower capacity to produce future recruitment. Since females are not targeted in the fishery, causes for female declines are not known but most likely linked to environmental conditions. Female abundance-linked closures are conservative measures in line with Board of Fisheries policy #5, which mandates maintaining adequate broodstock. Tanner crab recruitment is highly variable and episodic. Increases and decreases in male biomass lag females 1 to 2 years. Additionally, there is likely a mis-match in peak mating within a single cohort. Reducing the exploitation rate on males when females are in relatively low abundance is meant to preserve adequate male availability for the recruitment of future mature females.

The intent is to recommend a revised Tanner crab harvest strategy revision to the Alaska Board of Fisheries at the March 2020 Board of Fisheries meeting. The goals of a revised harvest strategy include: simplifying the harvest strategy and providing a more flexible approach to the selection of population estimates (raw area-swept vs model derived). Because of uncertainty of the role of a female harvest control rule in a male only fishery. Daly recommends including a range of scenarios from no female consideration to full female consideration. The following spectrum of harvest control rule (HCR) scenarios were presented to the crab team:

1. Male only ramps: exploitation rate based solely on MMB, with alternative fixed slopes
2. Female "floating dimmer": exploitation rate based on MMB/MMB_{avg} and female biomass, with the slope of the HCR ramp determined as a continuous function of the ratio of current-year to long-term average female biomass (MFB/MFB_{avg}) and bounded between a 5% and 20% exploitation rate on males.
3. Female "blocked dimmer": similar to Scenario 2, but with alternative fixed slopes determined by specified ranges of the ratio of current-year to long-term average female biomass.
4. Female ramp: exploitation rate on males based solely on mature female abundance (MFB/MFB_{avg}).
5. TAC is set equal to ABC (ABC modified to account for bycatch in the directed and groundifsh fisheries).
6. "Exploited legal male" only ramps: fixed exploitation rates of exploited legal males

In discussion of these five scenarios, the CPT seemed to prefer scenario 3 over scenario 2 due to reduced variability although it was noted that it was difficult to make comparisons because there aren't any metrics that are equal across all scenarios. Simulations are planned for each of the

proposed scenarios to evaluate their effects on potential harvest limits. It was noted that the lack of a stock recruit relationship for Tanner crab will limit the efficacy of simulations that are run and the effects on recruitment. There was discussion about defining "exploitable legal males" for scenario 6. Daly noted that shell condition must be considered when determining the portion of the population targeted in the fishery because generally "clean" crab are targeted. Ignoring shell condition in TAC setting could result in overharvest of newshell males. Assumptions about determining oldshell selectivity for the exploitable legal male was discussed. Daly mentioned that oldshell selectivity has approximated 25% in past snow/Tanner crab fisheries.

Madison Shipley will be conducting a Management Strategy Evaluation (MSE) for her master's thesis (University of Washington, with Andre Punt oversight and assistance from Stockhausen) and will compare multiple state harvest strategy scenarios. The specifics of the scenarios are still in development. Going forward Alaska Department of Fish and Game staff plan to work though CPT and industry recommendations and then have Shipley and Stockhausen work through an analysis prior to making recommendations to the Board of Fisheries. The current objective for her project is to provide as much guidance as possible within the timeframe set for the 2020 Board of Fisheries meeting.

The CPT discussed various aspects of the MSE. B_{msy} over time depends on how many recruits come into the population over time. In the absence of a stock-recruit relationship it is necessary to look at variety of possible relationships as a function of male biomass. The current harvest strategy is workable, but functions in a way that makes TAC setting difficult. The CPT cautioned employing too many conservative triggers without analysis to see how each measure impacts performance. Additionally, dismissing hard bounds when you haven't seen any results is premature. It was reminded that historical thresholds were determined by experts and they were determined for specific reasons and shouldn't be dismissed outright. Stable markets were discussed as markets will shut off at certain levels and economically it's better to smooth harvest over time.

It was recognized that scenario 4 would provide information about how important females are and if the stock assessor is modeling females correctly. It was recommended that if females are used as a fishery scalar, females in the harvest strategy would need to be lagged 1-2 years due to correspond to observed differences in abundance trends. Scenario 5 is not the best option because the ABC accounts for all mortality in the stock and makes no accommodation for legal sized male crab or industry preferred size retention. For this scenario, it was recommended to use only the male ≥125 mm CW portion of ABC, rather than the entire ABC for TAC. Part of the harvest strategy may include a 50% maximum exploitation on legal males as a precautionary measure.

Bristol Bay red king crab (BBRKC)

Final assessment

Jie Zheng presented the stock assessment for Bristol Bay red king crab, which provided results from six model scenarios. Results from two model scenarios, Scenarios "2b-old" and "2b", were given to provide continuity from the 2017 assessment. Scenario "2b-old" was identical to the 2017 assessment model and included fits to discard catch biomass and size compositions in the directed fishery. Scenario "2b" used the same model and data but included corrections to two errors that were found in the model code following the 2017 assessment that resulted in: (1) NMFS survey size compositions being overweighted at small sizes and (2) the BSFRF survey biomass being underweighted. As shown by Jie, these corrections had little overall effect on model results, but did result in moving estimates of NMFS survey catchability away from the upper bound of 1, where it

had been estimated in the 2017 assessment. These two scenarios provided a bridge to the four model scenarios considered as candidates for status determination and OFL setting. These models were:

- Scenario 18.0 – this scenario replaced the fits to discard catch biomass and size compositions from the directed fishery with fits to total catch biomass and size compositions. Size-dependent functions reflecting sex-specific total catch selectivity and the proportion of males retained at length were estimated, replacing size-dependent functions reflecting male retained and discard catch selectivity. Retention is 1 at full-selection.
- Scenario 18.0a – this scenario assigned equal effective annual sample sizes in the model likelihood to male and female size compositions (in previous models, effective annual sample sizes could differ by sex, but this was incorrect from a technical standpoint).
- Scenario 18.0b – this scenario is similar to 18.0, except that only one size-specific logistic function reflecting retained proportions-at-length is estimated, while an annual logistic-scale factor is estimated reflecting changes in the extent of high-grading in the directed fishery after 2004. A penalty is placed on the arithmetic scale value of these parameters to avoid overfitting the data.
- Scenario 18.0c – this scenario is similar to 18.0, except that (1) one logistic function for male total catch selectivity in the directed fishery is estimated, with annual deviations in the length-at-50%-selected parameter, (2) one logistic function for retained catch proportions in the directed fishery is estimated with annual deviations after 2004 in the length-at-50%-retained parameter, and (3) annual logistic-scale factors reflecting annual changes in the extent of high-grading are estimated after 2004 (as in 18.0b). An autoregressive penalty is placed on changes to the annual parameters in (1) and (2) to avoid overfitting.

Jie noted that the male catch data from the directed fishery used in Scenario 2b (and 2b-old) will no longer be available following this assessment because at-sea crab observers will no longer be making a determination whether or not the observed catch would be discarded or retained. Consequently, Scenario 2b would no longer be carried forward as an alternative. The CPT noted that applying equal effective sample sizes when fitting size composition data, as in Scenario 18.0a, is the technically correct approach and should be carried forward.

Results for all model scenarios were very similar, and generally fitted the input data well. A major exception to this was, in all scenarios, that the models could not follow the substantial decline in observed NMFS survey biomass from 2017 to 2018, leading to substantial over-predictions of survey biomass for 2018. It was also noted that Scenario 18.0c fit size compositions somewhat more poorly than the other scenarios and that it differed from those in estimates of total catch back-projected from 1989 to 1975. The CPT recommended Scenario 18.0a for status determination and OFL setting on the basis of parsimony (it had fewer parameters than 18.0b and 18.0c) and was technically correct in the manner in which annual effective sample sizes were applied to size composition data (in contrast to 18.0).

The CPT expressed concern over the inability of any of the scenarios presented to adequately predict the drop in NMFS survey biomass for 2018 and noted a tendency for the model to overpredict MMB in the retrospective analysis. The CPT noted that the model has had difficulty dealing with rapid changes in survey biomass in the past, which has led to uncertainty and discussions as to whether such fluctuations have resulted from changes in natural mortality ("kill 'em") or availability ("hide 'em"). As a result of this uncertainty, and in view of the extremely unusual environmental conditions in the EBS this year (no cold pool), the CPT recommended increasing the ABC buffer on OFL from 10% to 20%—and noted that this buffer equaled the buffer

used for other Tier 3 stocks that were also considered to have increased uncertainty (i.e., snow crab and Tanner crab).

The CPT requested that the author consider a scenario based on 18.0a in which the asymptote to the retention function is estimated after 2004, rather than fixing it to 1 as it now is.

BBRKC Gmacs

GMACS (Generic Size-structured stock assessment Model for Alaska Crab Stocks) has been in development with the goal to implement it for all Bering Sea and Aleutian Islands crab stocks. GMACS is currently being used to assess SMBKC and André Punt outlined progress on the BBRKC GMACS model. The GMACS BBRKC model and the current BBRKC assessment model by Zheng and Siddeek were compared and found to return different results. The code for both models was then compared and modified to align parameter values, outputs, and likelihoods. The models are now similar in most ways but have different penalties. They now result in close, but not identical, results. André does not plan to replicate all features in the current assessment model within GMACS.

This exercise resulted in discovery of errors in the current BBRKC assessment model, which have been corrected in the September 2018 assessment. An additional potential change to the current BBRKC assessment model as a result of the comparison with GMACS is changing how the size-transition matrix is calculated to make this more accurate. The current BBRKC model uses a discrete approximation to the cumulative gamma function. GMACS employs the correct cumulative gamma function available in ADMB.

The exercise also resulted in discovery of errors in GMACS: incorrect accounting for discard, errors in discard rates, and incorrect input sample sizes. These were corrected. A long list of additional changes were made to add features and options. The next steps in model formulation include checking the ability to calculate reference points and exploring issues with why GMACS cannot obtain a positive definite Hessian matrix, which is problematic and suggests that some part of the code may be non-differentiable.

The CPT discussed the future development of GMACS. Essentially André (BBRKC) and Jim (SMBKC) have become the programmers for GMACS, but neither have the time to continue in this capacity, and the sustainability of GMACS is not clear. Including a post-doc is a short-term solution (funding will be available, but no one has applied for the position), but the lead time will likely be very long for anyone to come up to speed because GMACS is so complex. A postdoc could participate in documentation.

The CPT recommended that Jim and André combine their two model variants, as they have diverged and now there are two versions of GMACS. The SMBKC GMACS model is much simpler. There is a need to test the BBRKC model further, and André will work on this with the goal to implementing the model for the BBRKC SAFE next year, 2019/20. For this to happen, model review will need to happen in January 2019. Andre thinks they are very close to achieving this goal and will meet with Jim as soon as they are able.

The CPT discussed the plan to use GMACS for other stocks. The general modeling structure is pretty much there. It would be straightforward to use the model for AIGKC or other king crab stocks. The ability to set a variety of features such as selectivity patterns, mirroring, population dynamics, time stanzas, mortality, and so forth, exists. GMACS is set up so that additional pieces can be added. For

the Tanner and snow crab stock assessments, GMACS will need to be modified for these species that have a terminal molt. The assessment authors (Buck Stockhausen and Cody Szuwalski) can be guided in the process, but it will take a sizeable amount of time. The links between the model and the data need to be clear, as the data matrices are not simple. There is not yet any code for data input manipulation.

BBRKC EFP

Cory Lescher, a graduate student at APU, presented an overview of his proposed master's thesis work using an exempted fishing permit (EFP) for sampling crab PSC in the winter flatfish fisheries (yellowfin sole and rocksole) to investigate bycatch and viability (handling mortality) of trawl bycatch of BBRKC. The EFP is intended to (1) investigate whether current methodology for estimating trawl bycatch (PSC) of red king crab (RKC) gives an adequate representation of what is caught, or over or under estimates the number of bycaught RKC at the haul level; and (2) conduct a pilot study examining potential vitality metrics that could help predict the post-discard mortality of bycaught RKC crab.

The first part of this study will examine at how well current sub-sampling practices generate data that are representative of whole haul census sampling of crab. The second part of study is to assess the crab using vitality metrics and then hold them in on-deck, plumbed seawater tanks. Mortality rates determined over the course of holding will be used to determine which vitality metrics could be used to predict delayed discard survival

There are two exemptions requested of the NMFS for this study. The first is an exemption to regulations to hold crab for whole-haul sampling and collection of basic biological data prior to discards and the second exemption is to hold crab in tanks on deck for 72 hours to conduct viability studies. The proposers are requesting up to 400 crab as a target for the viability portion of this study. These crab will be all discarded after whole haul sampling and viability assessments on deck.

The intent of the whole-haul accounting of red king crab is to help inform the efficacy of the estimates generated by the sub-sampling procedure as compared with a true census of crab. This may help with informing potential improvements in PSC rate estimation for NMFS and industry management for crabs and other rare PSC species.

Four objectives of the study are:

> Objective 1: Collect RKC basic biological catch composition data including sex, size, shell condition, clutch assessment, vitality metrics
>
> Objective 2: Two parts a) whole haul versus sub-sample estimation; b) analyze RKC distribution on the belt (throughout the tow) and vessel specific differences
>
> Objective 3: Haul characteristics and environmental variables. Are there haul-specific characteristics that may be influencing PSC? The proposers will look at haul time and location, tow duration, fishing depth, towing speed, target catch, total catch as compared against environmental variables such as sea surface temperature.

The proposers will look at haul time and location, tow duration, fishing depth, towing speed, target catch, total catch and catch per unit effort (CPUE) as compared against environmental variables such as seafloor water temperature and ambient air temperature (for on-deck pilot study).

Objective 4: Vitality Pilot study. This is an effort to determine methods that can be reliably used to quantify delayed discard mortality rates that are representative of the fishery, and that can be used to evaluate stressor-level impacts on survival. To that end, this study will evaluate the potential to use vitality metrics as predictors of survival. Here a subset of crabs will be held up to 72 hour on-deck.

The fisheries to be included in the study are flatfish fisheries in the A season (yellowfin sole and northern rock sole). For objectives 1-3 the proposers will be examining at data from haul level, trip level, and vessel level. This is a pilot project with a maximum of 5 vessels and 2-3 months fishing.

The proposers anticipate that the viability pilot study will enhance understanding of the variables that influence discard mortality and metrics that can be used to evaluate discard survival, leading to better field and laboratory studies in the future.

Concerns were raised that there may be an impact on the regular observer activities as well as potential issues with biasing observer sampling by whole hauling and tank studies concurrent with sampling, working with observer program to ensure accounting.

During his presentation Cory noted that all whole-haul sampling will occur downstream of the observer sampling stations and that the EFP team is working with the observer program to ensure that regular duties would not be disrupted and to ensure appropriate RKC accounting will occur. Under the EFP sea samplers will be trained to count king crab (whole haul) and conduct biological sampling. The EFP team (Cory and Noelle Yochum will conduct the RKC vitality sampling). Cory noted that video footage of the catch on the sorting belt in the factory will be recorded for every haul and could potentially provide additional information and examination of other species after the study.

CPT members suggested increasing sample sizes across strata (e.g., flatfish catch size and tow duration) to get better information on vitality. The CPT was concerned that the scale of project is too small to adequately inform viability (80% mortality) estimates used for catch accounting and stock assessment, and therefore the EFP application should to be sure to caveat that this is a pilot study with not every tow sampled for viability nor every trip. This project, however, does not aim at estimating a new delayed discard mortality rate for this fishery. Rather, in acknowledgement of the difficulty of generating representative rates for this species, this study aims to determine an appropriate method for estimating survival rates in a future study. In particular, this study will look at the potential to use vitality metrics as predictors of survival. The CPT noted that the RAMP measures of viability have had mixed results for RKC.

Some discussion was held regarding industry motivation with these data. John Gauvin explained the cooperative motivation in learning about sampling variance between vessels which will help with managing limits within individual cooperatives. . A secondary motivation with respect to viability is the potential for better information on the how haul characteristics and handling procedures (on deck and in the factory) influence RKC vitality. The hope is this may lead to improved RKC survival in the future.

The CPT appreciated the presentation, supports the work proposed in the EFP and looks forward to updates on results as the study gets underway.

AIGKC

Ben Daly (ADF&G) presented the updated catch for the Aleutian Islands golden king crab (AIGKC) fishery for the 2017/18 fishery. The total catch was 2,942 t (6.487 million lb) and the 2017/18 OFL was 6,048 t (13.333 million lb), therefore overfishing did not occur in this fishery for the 2017/18 season.

He then presented work that the state has done revising the harvest strategy for AIGKC to reflect the adoption of the assessment model. Co-authors for this work were MSM Siddeek, Steve Martell, Jie Zheng, and Mark Stichert.

Currently, the state manages AIGKC as two stocks, the eastern area (EAG; east of 174° W longitude) and the western area (WAG; west of 174° W longitude). The current ADF&G harvest strategy for AIGKC has TACs set in state regulation 5 AAC 34.612 for each area. The EAG TAC is 3.31 million lb and the WAG TAC is 2.98 million lb. This regulation also has a part that allows ADF&G to modify the harvest levels based on information available.

The department is working on harvest strategy revisions to allow the TAC to respond to population fluctuations as estimated by the assessment model. At the January 2018 CPT meeting the state presented a draft of harvest strategy scenarios and at this meeting simulations were presented that compared harvest strategies and their effects on stock sustainability and productivity. The goal of this analysis is to submit a recommended harvest strategy to the Board of Fisheries for the March 2019 meeting to be implemented in the 2019/20 fishery.

There are three core elements to the harvest strategies considered here: (1) a threshold for opening/closing the fishery, (2) an exploitation rate on mature male abundance, and (3) a maximum allowable exploitation rate of legal male abundance. The threshold for opening the fishery was determined by relating the current year point estimate of mature male abundance (MMA) to the long-term average. This threshold would be set as 25% of the long-term average of MMA, this was calculated separately for the EAG and WAG using 1985 to 2017 mature male abundances.

Five scenarios were presented related to the exploitation rate on MMA. Each scenario started when the MMA in the current year was at least 25% of the average MMA, with the range in exploitation rates starting at 2.5% to 7.5%. The scenarios ramped up as the current year's MMA was increasingly close to the average MMA maxing out at 100 % MMA/MMA_{avg}. The slope of the ramp increased with increasing maximum exploitation rates to a maximum exploitation rate ranging from 10% to 30% depending on the scenario.

The maximum allowable exploitation on the legal male abundance was capped to provide protection against over harvesting legal males when they are in relatively low abundance. Caps for legal males of 25% and 30% were evaluated for each of the five scenarios, creating a total of ten scenarios. An exploitation rate of zero was used as a control.

The methods for the simulation structure were presented and there was much discussion on how these may be adjusted in the future (see recommendations below). The simulations summarized here use the 2018 base model (scenario 18_1) to project abundances for 30 years and each of these is done for 100 random replicates. These random replicates were summarized to calculate projected: MMB, MMA, legal male biomass (LMB), ABC, total catch, retained catch, retained CPUE

index, number of annual recruits, and the probability of the annual total catch exceeding the annual ABC.

The structure of the simulations started with randomizing 2017 abundance and recruitment, then implemented the state harvest control rule (HCR) which sets the exploitation rate based on the scenario options. Once the harvest rate is chosen it is converted into F, population characteristics are estimated under this F (total catch [which is the TAC], MMA, MMB, LMB, stock depletion, retained CPUE index), total catch is removed from the simulated population, the population is projected to the next year with additional recruits, and then the ABC is estimated. After looping over 30 years and repeated 100 times, summary statistics calculated were the mean and standard errors of MMA, MMB, LMB, ABC, stock depletions, total catch, retained CPUE, number of recruits (for S-R model), and the probability of overfishing (TAC being above the ABC).

Initial conditions of recruitment were considered under two different methods, either a random draw of estimated annual recruits or annual recruits generated from a Ricker stock -recruit model. The randomization of recruitment takes a random draw from years 1987 – 2012, which is selected via a uniform random distribution with an additional lognormal annual deviate. The Ricker relationship uses MMB and an 8-year lag to spawning and the mean size of the recruiting size-class in the model. This relationship was performed separately for the EAG and WAG. The necessity of an autocorrelation parameter was evaluated with an ANOVA. Initial abundance (N) was randomized by deviations related to the standard error of the terminal year of MMA.

The results were similar for both the EAG and WAG and indicate that the probability of catch exceeding the ABC was higher under the Ricker S-R relationship and was higher for larger harvest rates. This probability decreases for some scenarios with a higher cap on legal biomass. MMB and MMA fell below their long-term average only for the 30% HR. LMB and CPUE decrease with higher harvest rates, and recruitment trends declined with the 30% HR scenario. Overall, a harvest rate of less than 15% would be safe, if the desired goal of management is to maintain the population where the MMB and MMA were above their long-term averages. A harvest rate of 20% is considered more risky and a rate of 30% is too high.

The CPT is concerned that these simulations are not incorporating error correctly and are assuming perfect data. Additionally, this is not a full management strategy evaluation and the results should be treated with caution. Additionally, there was concern over how variability is being incorporated in the random draw of recruitment. The current method for recruitment variability would be appropriate if a shrinkage estimator was applied to the recruitment estimates. The plan team also suggested that the ABC could be part of the harvest control rules and not evaluated after it was implemented.

Recommendations:

- One of the approaches for generating recruitment includes random selection from a range of historical years with an added lognormal variate. The standard deviation of the lognormal variate was 0.2 but should reflect the CV of the associated recruitment (or zero if the standard errors for the associated recruitments are very small).
- The estimated stock-recruitment relationship is (not unexpectedly) uncertain and it is not clear that the equilibrium matches that in the stock assessment. Many stock-recruitment relationships can fit the associated data and one way to ensure that the stock-recruitment relationship matches current policy would be to select its parameters, so the unfished equilibrium matches that in the assessment and the slope at

the original is such that F_{MSY} equals $F_{35\%}$. Alternatively, a hockey-stick stock-recruitment relationship where the kink equals the lowest observed MMB could be adopted.

- The management system for AIGKC involves a check that TAC calculated using the state harvest strategy is not less than the ABC, but this constraint is not imposed in the simulations. The evaluation framework should be modified so that the ABC is first calculated, along with its retained component and the outcome of the state harvest strategy reduced if this outcome is greater than retained component of the ABC. The CPT previously evaluated control rules this way (Punt et al. 2012; ICES J. Mar Sci. 69: 624-634)
- The projections account for some sources of process error but ignore observation, implementation, and model errors. Thus, the projections are based on perfect information about stock status and abundance. Approaches exist to allow for observation and implementation error in this context. Punt et al. 2008 [Fish Res. 94: 251-266] provides an example of how to apply an MSE without including a full stock assessment in the simulations.

Snow crab

Background and data

The 2018 survey estimate of mature male biomass is the highest since 1998, and substantially larger than the estimates of mature male biomass from the 2016 and 2017 surveys. The increase in mature male biomass is attributed to a large recruitment that entered the population in 2014/15. In addition to new survey and catch data, the assessment includes new growth data for 70 male and female juvenile crab. Unlike the 2018 updated model scenarios for EBS Tanner crab, the data on total catch in the directed snow crab fishery and bycatch in other pot fisheries have not been revised to reassign the target fishery.

Assessment

The assessment of EBS snow crab has shown instability and retrospective patterns. Instability is evident from "jitter" analyses, in which the initial values for the estimated parameters of the model are perturbed and the model refitted. Only a relatively small (<50%) proportion of the jittered model runs led to positive definite Hessian matrices, and of these only a small proportion (<10% for most model configurations) led to the lowest value for the objective function. A lack of stability suggests that either (a) the objective function surface is flat so that many parameter combinations lead to the same value for the objective function, or (b) different starting values for the parameters do not lead to the same final estimates, suggesting a complex objective function surface.

Retrospective analysis involved removing one, two, three, etc. years of data and refitting the model. A retrospective pattern occurs when the results from the assessment change in a consistent direction (e.g., adding data consistently leads to higher estimates of mature male biomass for past years). Models presented to CPT in May suggested that the combination of estimating mature female natural mortality and the new growth data greatly reduced model instability, however the addition of new catch and survey biomass data for this assessment resulted in a return of the problems with model stability.

The assessment author considered nine models (the 2017 final model and eight new models):

- "New Data": The 2017 final model with the new data.

- "Fix fem M": Fix mature female M at 0.23 yr^{-1} as in the 2016 assessment rather than estimating it with an informative prior.
- "Loose prior M": Estimate all natural mortalities with a looser prior on M.
- "Looser prior M": Estimate all natural mortalities with an even looser prior on M.
- "Sep devs": Estimate separate recruitment deviations for females and males.
- "Sep devs + Loose prior M": Estimate separate recruitment deviations for females and males with a loose prior on M.
- "Sep devs + Looser prior M": Estimate separate recruitment deviations for females and males with a looser prior on M.
- "Sep devs + Loose prior M + Growth": Estimate separate recruitment deviations for females and males with a loose prior on M and assume a linear relationship between growth increment and pre-molt size.

Estimating separate recruitment deviations for males and females was not put forth by CPT in May 2018 as a candidate model but reflects a way to better fit the survey estimates of biomass. The additional models in which the priors on M were adjusted were designed to explore the impact of an informative prior for M on management quantities. Instability and retrospective patterns were present in all models fit to new data, although the retrospective pattern was reduced for some of the model configurations.

The CPT has concerns regarding all of the model configurations:

- The models that do not estimate separate recruitment deviations for males and females lead to the most severe retrospective patterns.
- The "Sep devs + Loose prior M + Growth" model has some desirable properties but exhibited very poor convergence diagnostics based on the jitter analysis.
- The "Sep devs", "Sep devs + Looser prior M", and "Sep devs + Loose prior M + Growth" models led to female growth curves with a "kink". However, the kink occurs close to the point where the probability of females molting to maturity is high, so this may be acceptable/realistic.
- There is no obvious basis for the variances for the looser and loose M priors.

The CPT selected the "Sep devs" model given its better fits, because there is a lack of justification for the looser M priors, and because the estimates of natural mortality from the models with loose and looser M priors are high compared to earlier estimates.

Although having separate recruitment deviations for males and females led to better fits, the biological basis for this is not clear, although spatial variation in the distribution of small animals in surveys by sex could be indicative of differences in mortality by sex among years and hence recruitment.

Recommendations for the next assessment

- Examine the possibility and implications of skip molting.
- Consider moving to the "GMACS catch equation" as is now the case for the assessment of EBS Tanner crab.
- Explore parameter correlation matrices to better understand possible reasons for model instability. In addition, examine how the values for each likelihood component change among jittered solutions with similar objective function values.
- Consider a model in which growth differs for animals that are about to mature.

- The level of recruitment is likely correlated with immature M. This should be explored in future analyses.
- Further explore the basis for the existing priors for M; for example, from the estimated ages post terminal molt.

- Consider including the chela height data in the same manner as for EBS Tanner crab.
- Explore alternative options for weighting the growth data to achieve a more expected fit to the data (i.e., linear).

Snow crab PSC

Steve MacLean from the North Pacific Fishery Management Council (NPFMC) presented (over Webex) the Council's proposed action and the current action plan regarding Bering Sea snow crab prohibited species catch (PSC) limits which trigger the C. Opilio Crab Bycatch Limitation Zone (COBLZ). In 2016, the Council proposed that C. opilio PSC limits be reviewed, citing the rationale that recent changes in model estimates for snow crab have significantly improved since the PSC limits were originally specified in 1997.

Diana Stram (NPFMC) provided some background and historical context of the proposed action within the Council process, as this action was distilled through the Council process after several discussion papers over the last ten years. She noted that the C. opilio stock is distributed broadly within the COBLZ, however there is also a band south of the COBLZ where C. opilio are found. The COBLZ is a trawl-specific fishery area closure, which is closed to trawling by fishery category when a category reaches its apportionment of the snow crab PSC limit inside the area. Recently, only the yellowfin sole fishery has been closed out of the COBLZ due to reaching its limit.

The Council will undertake initial review of this analysis in December 2018, and Council staff is both seeking input from the CPT to guide the analysis, as well as seeking feedback on the current alternatives to bring to the Council's attention if they choose to revise the purpose and need statement or the alternatives (below).

In 2016, the Council proposed the following three alternatives:

1. *No action*
2. *Revise C. opilio PSC limits to be based on the stock assessment model estimate. Remove the minimum and maximum C. opilio PSC limit for trawl vessels in the COBLZ and reduce the C. opilio PSC limit to (Option 1: 0.10%, Option 2: 0.075%, Option 3: 0.05%) of the total abundance of C. opilio.*
3. *Revise C. opilio PSC limits to be based on the stock assessment model estimate. Reduce the maximum and/or minimum C. opilio PSC limit for trawl vessels in the COBLZ by (option 1: 10%, Option 2: 15%, or Option 3: 50%).*

The Council currently sets PSC limits based on model estimates of survey abundance of C. opilio, and that under both action alternatives, the PSC limit would be based on the model estimate of total C. opilio abundance. Alternative 2 would remove the current minimum and maximum (min (floor)= 4.5 million, max (ceiling) = 13 million) and change the multiplier from the current 0.1133% to one of three options (Option 1: 0.10%, Option 2: 0.075%, Option 3: 0.05%). Alternative 3 would base PSC on total C. opilio abundance, and leave the multiplier the same, but would reduce the floor and ceiling by 10%, 15%, or 50%. In drafting alternatives for this analysis, the Council chose to focus on changing the floor and ceiling as well as the multiplier but did not indicate an interest in modifying the COBLZ area nor extending PSC limits to fixed gear at this time.

The initial analysis will investigate potential economic and environmental impacts. This includes exploring historical data to see how frequently these fisheries would be constrained by these modified limits, and how the fleet would potentially respond to these changes (for example, if fleets may move outside of the COBLZ to complete their fishing seasons if constrained, and whether vessel traffic through a walrus protection area could increase). Thus far, it is unlikely that there would be significant environmental impacts due to the proposed action. Mr. MacLean described his plan to use data beginning in 2008 due to the passage of Amendment 80, and confidentiality issues with that data may exist.

Feedback and recommendations from the CPT were as follows:

The CPT noted that the analysis should consider the pros and cons of the use of total abundance as an appropriate measure to inform and index the PSC limit. The analysis should consider the exploitation rate on males and females, as well as by size, to determine the historical impact of bycatch on the population numbers and size/sex categories. The analysis should also consider the exploitation rate on a population level by the proportion of the population impacted. CPT members questioned the rationale for a floor noting that it would not protect the stock at low levels. Team members suggested the analysis consider how often the limits (by fishery category) have been constraining both with and without the floor imposed.

The CPT discussed the importance of considering crab size in the PSC limit. Some discussion focused around what is intended to be measured as PSC, i.e., is the concern surrounding legal-size snow crab or all sizes? Previously, a lack of information on the size composition of snow crab bycatch did not allow for assessing whether small or immature crab were being differentially exploited in trawl fisheries. A subset of the stock may be more vulnerable to trawl bycatch due to size selectivity, and an understanding of this size selectivity may be useful in informing an appropriate PSC limit. If the subset of the population that is vulnerable to trawl bycatch increases, then the fleet would likely see bycatch overall increase. Additionally, the CPT recommends that while crab PSC is currently calculated in numbers, a PSC limit in biomass should also be considered. Managing PSC by biomass would accommodate issues such as large numbers of incoming immature crab which would be subject to high levels of natural mortality in the absence of fishing mortality and are not equivalent to mortality of adult crabs. The CPT recommends that consideration be given to investigating crab PSC limits in both abundance and biomass.

The CPT also highlighted the benefit of flexible PSC limits due to changes in the Bering Sea ecosystem. Additionally, PSC limits should reflect the status of the stock. When looking at a lower level of snow crab abundance, the PSC limit may need to be more constraining than during levels of high abundance. Other biological or physical variables may also trigger changes in PSC limits. For example, if predators shift, PSC limits may need to be adjusted accordingly.

Norton Sound red king crab (NSRKC)

The author summarized two model run alternatives, in conjunction with the 2017 base model (Model 0). Model 1 estimated a summer retention curve; Model 2 estimated a winter retention curve. The observer data from 2012-2018 were used to inform summer retention and 2016-2018 data were used to inform winter retention curves. The author suggested that Model 0 should be used due to perceived issues with the observer data. The CPT considered Model 1 to be an improvement over Model 0 because of better fits to the data and, all else considered, estimating parameters for which informative data exist is preferable to specifying them (the author agreed).

Differences among the models were not large—estimated discards of sublegal crab was larger for the baseline model.

Catches were lower than last year, resulting from a combination of lower quotas and environmental conditions. The winter fishery was opened a month later than usual, but the ice receded much earlier than usual as well, resulting in a shorter season. The fishery was opened a month later out of concern for cold weather effects on crab and the prospect of better ice conditions (the winter fishery is performed through the ice). Questions were raised about the impact of delaying the fishery on the estimates of the OFL. The author replied that he did not believe it would impact the model output greatly.

The summer fishery is larger than the winter fishery, but CPUEs were still low; catch rates were relatively high at the start of the season but dropped suddenly after two weeks. The catch was historically highest in western Norton Sound, but this year eastern Norton Sound was more productive. This year only 20 legal crab were caught in the survey of Norton Sound (an all-time low), which corroborates the difficulty in catching quotas. In contrast with low legal abundance, there were ~5x as many sublegal crab than have ever been observed (though this estimate was also driven by 3 stations).

VAST was applied to the available survey data, but the output was not thoroughly scrutinized, and convergence was not achieved. Considerable discussion was had concerning (1) the suitability of VAST for NSRKC data, (2) the possibility of combining two surveys (ADFG and NMFS) with such small temporal overlap, and (3) method of scaling the biomass index in the VAST (e.g., dividing by the arithmetic or geometric mean). Some slight modifications have been made for the ADFG survey stations (e.g., station 135 was dropped because it has reported only 2 crab since 1996), but it is projected to be performed annually for the foreseeable future.

The impact of size-specific natural mortality and calculations of the OFL was also discussed at length, with emphasis placed on the importance of considering a change in natural mortality in calculations. The impact of an assumed knife-edge cutoff maturity on estimation of management quantities (and calculation of derived management quantities) was also discussed.

There was also some discussion on attempting to perform the final decisions for NSRKC at the September meeting. This action was not adopted at the 2018 September meeting, but this may be revisited. The traditional rationale for making management decisions in January for NSRKC was that fishing was still underway in September. However, in the recent past, the fishery has been closing in August.

CPT recommendations for January:

- Limit the January discussion to Tier 3 vs. Tier 4. The CPT does not need to see all of the model description again.
- A key concern is determining if Tier 3 status is appropriate for NSRKC. A thorough examination of the understanding (based on NSRKC-specific studies) of the processes that determine $F_{35\%}$ is needed to make this determination.
- The CPT suggests comparing the calculated OFLs when the increased natural mortality on the plus group is included when computing a Tier 4 OFL to support the decision between Tier 3 vs. 4 status. A relevant question is what would happen if the stock was fished at *M* uniformly, as there is no assumed selectivity in Tier 4 rules. The basic thrust of these questions is to ensure that the OFLs presented for Tier 3 and Tier 4 are fair comparisons.

- A summary slide of the pros and cons of Tier 3 vs. Tier 4 for this stock would be useful.
- Perform sensitivities to the assumed knife-edge cutoff for maturity. Search out data to inform the appropriateness of the assumptions about maturity.

Crab PSC accounting

Jason Gasper (AKR) and Jennifer Cahalan (PSMFC/AFSC) gave a presentation on Prohibited Species Catch (PSC) monitoring and assessment within the observer program and Catch Accounting System (CAS), and system elements related to crab PSC and discards and total catch estimation. The presentation began with an overview of the history of PSC management and accounting in the NMFS Alaska Region, noting accounting and estimate methodology changes in 1991, 2009, and 2017, and a functional overview of the CAS system. Jennifer reviewed haul-level sampling coverage target rates for 2017, by gear group and fleet segment, under full and partial coverage. For full coverage vessels (required to have a minimum of one observer on board at all times), from 8% (pot gear) to 100% (pelagic trawl gear) of gear hauls are subject to observer sampling. Under partial coverage (as specified in the Observer Program Annual Implementation Plan), which applies to vessels in the partial coverage and electronic monitoring (EM) strata, target coverage rates range from 92% for pot gear on partial coverage vessels and 8% on EM vessels, to 18% on non-pelagic trawl vessels (all partial coverage). CPT members inquired about how target coverage rates are determined for respective vessel strata; in developing the Annual Deployment Plan (ADP), rates are set in a process of allocating observer resources, subject to a spending limit, in order to achieve efficient data collection and statistical objectives, noting that vessel coverage within the EM strata is limited under regulation to 40%. The ADP is presented to the Council annually at the October meeting, with input incorporated into the final ADP released by NMFS in December; an annual review report on prior-year ADP implementation is published by NMFS in June. Jennifer noted that the draft ADP for 2018 has been released, and reviewed rates proposed by vessel strata (for BSAI and GOA overall) as well as realized rates for 2017, and outlined general procedures for crab bycatch estimation, based on discard rates calculated from observer sample data. CPT members inquired about EM deployment and procedures specific to particular gear groups and management areas, and estimation procedures related to conversion of observer crab count data to rate weight in rate-based estimation. Jennifer clarified that sampling procedures include collection of crab data on 100% of sampled hauls, including those in the EM strata, and that EM data is remotely uploaded to data servers and reviewed the next day by EM observers at PSMFC.

Jennifer reviewed the partial coverage hierarchical sampling regime, describing the randomization procedures at each sampling level (trip selection, haul selection, catch sample selection within haul, and sampling of individual fish—noting that observers have discretion regarding sample selection method at the catch and specimen level and adhere to randomization as much as possible given operational constraints onboard active fishing vessels. In addition to catch monitoring, observers also monitor vessel interactions with seabirds and marine mammals, participate in special studies, salmon monitoring and genetic sampling, data enter sampling data and record all daily activity in logbooks, and transmit data and reports daily. An overview of sampling procedures was presented for each vessel and gear type (Fixed gear: longline CV/CP, Pot CV/CP; Trawl CV: pelagic and nonpelagic; and Trawl CPs/Motherships: pelagic and nonpelagic), including the target haul-sample rate by vessel strata/gear type, sample collection logistics (location on the vessel, catch sampling rate and basis (weight per haul, hooks per set), and measurements captured. In response to a question about discard handling, Jennifer clarified that on all vessels, observer samples are drawn before any catch sorting or discard handling by crew is allowed. For PSC crab species, observers collect additional data for all intact specimens captured in a sample, including weight, species, sex,

egg presence (females), carapace measurements, procedures associated with tagged crab; for non-intact crab parts in a sample; a more limited set of variables are also recorded where possible.

Estimation procedures conducted by observer program staff are limited to expanding sample data to haul-level bycatch and discard count and weight values by species; in response to a question from the CPT regarding PSC limits specified in numbers of crabs, Jennifer noted that haul-level count estimates for crab species are reported directly to CAS, not converted from haul-level weight estimates using average crab weight statistics. Estimation procedures for deriving fishery-level PSC and discard rates and quantities are conducted within CAS, and Jason Gasper provided an overview of PSC accounting methods. Extrapolating fishery-level PSC count estimates from CAS catch and haul data for unobserved hauls using estimated discard ratios employs a hierarchical post-stratification framework that integrates data on the basis of maximizing similarity of haul characteristics between the respective data streams (in terms of individual vessel, vessel strata (vessel/processing sector and gear type), and date and area of hauls. The post-stratification hierarchy ranges from the highest level of integration at the trip level, achieved for full coverage vessel strata with the highest sampling rates, to the lowest integration, where average discard ratios are extrapolated to aggregated catch-by-haul data only on the basis of year and crab stock area (i.e., excluding similarity on the basis of vessel or within-season timing). Jason presented figures reporting 2017/18 estimated total crab catch (metric tons) by species, which includes PSC and discard, reported in aggregate and by proportion of total crab catch by gear type (hook-and-line, jig, pot, and trawl). Statistical tables were also shown reporting the relative weights that each post-stratum level contributed to the 2017/18 PSC estimates, by gear-type and overall, for each crab species. The sample weights ranged from a high of 1.0 for the trip-level post-stratum used in the blue king crab PSC estimate (which are only encountered in the full coverage trawl fisheries), to 0.76 for the Year (cross sampling stratum)-level post stratum used in the golden king crab PSC estimate. CPT Member Dorn inquired about the implied difficulty in estimating golden king crab PSC, which Jason and other commenters explained is due to the high proportion of total groundfish catch in areas where golden king crab are encountered that is landed using pot gear, which has a relatively low observer sampling rate (both historically and under the AIP), or in GHL fisheries with no observer coverage. Jason noted that the post-stratification sample weighting details by gear and crab species are included in the PSC data files distributed to the CPT via the AKFIN data dashboard and invited assessment authors and others to contact him directly for more information regarding these details and referred CPT members to CAS system documentation and other published and /or ongoing studies related to PSC estimation methods. Beginning in 2019, variance estimates will be included in crab PSC data files (as currently included in groundfish PSC data files). Noting that crab PSC estimates are calculated on a calendar-year basis, such that current-year PSC estimates in files downloaded from AKFIN are subject to change until finalized at end of year, Jason asked the CPT to provide input regarding a preference for crab PSC estimates based on crab-year; no direct response was provided, but members discussed the potential for alternative spatial aggregations to improve post-stratification results for estimating golden king crab PSC. The CPT agreed that the presentation was informative and useful, and asked to receive a brief annual presentation at its September meeting to update the CPT and focused on results (rather than methodological details) of crab bycatch data collection and PSC estimation.

PIRKC

Cody Szuwalski (AFSC) presented a brief update on Pribilof Islands red king crab (PIRKC) survey and catch data. This stock has been moved to a biennial assessment cycle, with full assessments conducted every two years. The last full assessment was conducted during 2017/2018, so 2018/2019 is an 'off' year for PIRKC. The PIRKC fishery was closed in 2017/2018, so no catch was

retained. Bycatch of PIRKC in the crab fisheries observed by the Alaska Department of Fish and Game was 168 kg (derived from a single female caught in the snow crab fishery). Total bycatch of PIRKC in the fixed gear fisheries was estimated at 131 kg by NMFS AKRO from groundfish observer sampling. The NMFS estimate of bycatch from the trawl gear fisheries was 269 kg. Applying a handling mortality rate of 0.2 for fixed gear and 0.8 for trawl gear to these bycatch estimates produced an estimated bycatch mortality of 275.0 kg (0.275 t). The estimated ABC for 2017/2018 was 362 t, so overfishing did not occur in 2017/2018 for PIRKC. Fishing mortality due to bycatch has been small in recent years. NOAA bottom trawl survey trends for males and females have been stable in recent years, but with high variance.

PIBKC

William Stockhausen (AFSC) presented a brief update on Pribilof Islands blue king crab (PIBKC) survey and catch data. PIBKC has been moved to a triennial assessment cycle, with full assessments conducted every three years. The last full assessment was conducted for 2017/18, so 2018/19 is an "off" year for the assessment. The PIBKC fishery was closed in 2017/18, so no retained catch was taken. Total bycatch of PIBKC in the crab (pot) fisheries was estimated by ADFG from crab observer sampling. A single BKC was captured in the Tanner crab fishery for a total expanded bycatch of 64 kg for all crab fisheries, while total bycatch in the groundfish fisheries was estimated by NMFS AKRO from groundfish observer sampling at less than 0.5 kg in the fixed gear fisheries (pot and hook-and-line) and 397 kg in the trawl gear fisheries (pelagic and non-pelagic trawl gear). Applying handling mortality rates for 0.2 for fixed gear and 0.8 for trawl gear to these bycatch estimates yields an estimate of 0.330 t (330 kg) total catch mortality, which is below the OFL of 1.16 t (and ABC, 0.87 t) for 2017/18. Thus, overfishing did not occur in 2017/18. Total bycatch mortality has remained very low over the past 20 years. NOAA bottom trawl survey data indicate male and female biomass remain at extremely low levels.

ADF&G pot surveys

Ben Daly discussed the timing of the ADF&G Westward Region crab pot surveys. The Aleutian Islands golden king crab pot survey in recent years has been conducted in collaboration with industry and has been conducted yearly since 2015 in the eastern portion of the Aleutian Islands. It is planned to be extended to the western area in the near future. The Pribilof Island pot survey has not been completed since 2011 due to low abundance of crab in the area and limited funding. The Petrel Banks (AIRKC) pot survey was last completed in 2016 and has been conducted when interest in opening the fishery is high. The St. Matthew blue king crab pot survey was conducted on a triennial basis starting in 1995 but shifted to an annual survey from 2015-2018 due to data needs for the assessment and to allow data collection on a finer spatial and temporal scale than available in the NOAA trawl survey. Norton Sound red king crab trawl surveys are operated by a different region of ADF&G than the other surveys (Western region of ADF&G) and have occurred on a triennial schedule. However, beginning in 2018 the Norton Sound survey will be every year.

ADF&G Westward Region has limited capacity and can currently conduct one pot survey each year. Daly was asking for feedback from the CPT on priorities for future surveys, including whether or not the St. Matthew Island pot survey should continue yearly. This survey includes 96 core stations and takes 21 charter days, at a charter cost of approximately $10,000 per day.

Data from the St. Matthew Island survey are used in the SMBKC assessment and complement the NOAA trawl survey. The pot survey occurs in areas that overlap with the trawl survey as well as some nearshore stations not surveyed by the trawl survey. It also provides finer scale information

to inform stock abundance. For example, one trawl location (R24) has been a hotspot that historically has caused challenges for the stock assessment.

The CPT briefly discussed the challenges of pot surveys; one important challenge is finding a charter vessel. ADF&G would prefer to charter with the crab fleet and will work on reducing Captain license requirements that may have been limiting bids in 2018. Currently the St. Matthew Island survey is conducted in August and corresponds with the timing of the NOAA trawl survey and inclusion the same years St. Matthew BKC assessment. Ideally the pot and trawl surveys would occur around the same time of the year, but this timing is not ideal for the crab fleet as they are tendering for salmon in August. There was some discussion that it might be valuable to do some surveys at different times of the year to assess the movement of the crab and other biological factors.

The CPT discussed ways to maximize information with limited resources. CPT research priorities could inform potential process studies to be implemented alongside or instead of surveys, such as tagging. Other ideas include an abbreviated St. Matthew Island survey (in nearshore stations or in the hotspot areas) to save costs or allow for surveys in other areas, such as the Pribilof Islands. Other suggestions included process studies of Bristol Bay red king crab, environmental studies to understand the effect of the changing environment on crab stocks, data or studies to help inform the SMBKC rebuilding plan (such as genetics) and surveying the Pribilof Islands golden king crab stock.

Other business

The CPT discussed agenda items and timing for planning the January CPT meeting to be held in Nome, AK January 22-25, 2019. Tentative topics and relative timing include the following:

Agenda Item	**Timing**	**Presenter**
NSRKC final assessment Research and fishery issues	 1.0 4.0	Hamachan Justin Leon, Jenefer Bell
Snow Crab PSC limit analysis (T)	2.0	Steve Maclean
SMBKC rebuilding plan discussion -GMACs/projection framework planning -other considerations (catch etc) -timing/alternative development	3.0	-Andre, Jim -Council, NMFS RO staff
BBRKC Ecosystem status card	1.0	Erin Fedewa
Assessment and catch issues: (a) Dockside data sampling and incidental catch/effort reporting, CIF data (b) Catch estimation and observer data (determining effort, estimating discards via subtraction method, future assessment data needs)	1.0 2.0	Miranda Westphal Ben Daly

Agenda Item	Timing	Presenter
(c) Standardizing the method of total catch estimation from observer data for different assessment models (Tanner, snow, AIGKC, and BBRKC)	3.0	Stock assessment authors
VAST presentation and applicability to crab assessments-note need to lay out issues by assessment (islands etc), paper in prep flow chart	2.0	Jim Thorson (Webex) others?
Basis for BMSY and whether or not to include most recent year MMB (Tier 4) or recruitment (Tier 3). (Table and consistency)	0.5	CPT & assessment authors
AIGKC model scenarios for June assessment	2.0	Siddeek et al.
Snow crab assessment with new catch data model runs; data weighting issues	Already above in catch issues	Cody
BBRKC assessment with new catch data runs	2.0	Jie
Tanner crab assessment: BSFRF survey integration, male maturity ogives, data weighting issues, etc. etc. etc.	2.0	Buck
Shell condition error overview (Kodiak Lab)	0.5	Bob
GMACs testing and long-term planning- multiple sessions planned -intro to GMACs -return with results -BBRKC ready for May?	4.0	Andre/Jim
Economic SAFE report	1.0	Brian
Projections AIGKC and SMBKC rebuilding	1.0	Ben/Andre/Jim
Chionoecetes mating dynamics research update	1.0 (if limiting bring in May)	Laura Slater

The CPT discussed logistics for the Nome meeting. Diana and Shannon will work with ADF&G staff in Nome to find appropriate meeting space with sufficient internet for hosting the meeting and webex. The CPT encourages presentations from the Nome fishing community in conjunction with this meeting.

Upcoming CPT meetings:

January 22-25, 2019; Nome, AK

April 29-May 3, 2019; Anchorage, AK

September 16-20, 2019; AFSC Seattle, WA

Public Comment

The CPT received the following as public comment from Braxton Dew prior to the meeting.

Public Comment Trawl Survey