North Pacific Fishery Management Council

Simon Kinneen, Chair | David Witherell, Executive Director
1007 W. 3rd Avenue, Suite 400, Anchorage, AK 99501
Phone 907-271-2809 | www.npfmc.org

Crab Plan Team
REPORT

September 13-17, 2021
Online Meeting

Members in attendance:

Martin Dorn, **Co-Chair** (AFSC-Seattle)
Katie Palof, **Co-Chair** (ADF&G-Juneau)
Diana Stram, **Coordinator** (NPFMC)
William Bechtol (UAF Homer)
Ben Daly (ADF&G-Kodiak)
Ginny Eckert (UAF/CFOS-Juneau)
Erin Fedewa (AFSC-Kodiak)
Brian Garber-Yonts (AFSC-Seattle)
Krista Milani (NMFS-AKRO-Dutch Harbor)
André Punt (Univ. of Washington)
Shareef Siddeek (ADF&G-Juneau)
William Stockhausen (AFSC-Seattle)
Cody Szuwalski (AFSC–Seattle)
Miranda Westphal (ADF&G-Dutch Harbor)
Jie Zheng (ADF&G-Juneau)

Others in attendance:

Allie Conrad
A. Hopkins
Allie Conrad
Andrew Olson
Angel Drobnica
Anne Hollowed*
Anne Vanderhoeven
Andy Nault
Annika Saltman
Arne Fuglvog
Alan Haynie
Austin Ahmasuk
Bo Whiteside
Bob Foy
Brent Paine
Brett Reasor
Bridget Ferriss
Caitlin Stern
Casey McManus
Cassandra Whiteside
Chris Woodley
Chris Long
Chris Lunsford
Chris Siddon
Cory Lescher*
Dana Hanselman
Dana Rudy
Dawn Wehde
Doug Wells
Ebett Siddon*
Ernie Weiss
Erik Velsko
Frank Kelty
Franz Meuter
Gabe Lipchik
Gary Stauffer
George Steers
Gretar Gudmundsson
Toshihide Hamazaki*
Heather McCarty
Ian Stewart
Jamie Goen
James Riley
Jared Weems
Jason Anderson
Jeff Kauffman
Jeff Regnart
Jen Bell
Jen Gardner
John Gruver
Jon Warrenchuck
Jim Armstrong
Jim Ianelli
Jim Thorson*
John Hilsinger
John Gauvin
John Hansen
John Hilsinger
Joletta Silva
Jon Richar
Justin Leon
Kalei Shotwell*
Karla Bush
Kendall Henry
Kenny Down
Kerim Aydin*
Knut Knutsen
Landry Price
Leah Zacher
Lee Cronin-Fine
Leonard Hertzog
Lisa Hiruki-Raring
Lucas Henkel
Lyle Britt
Mike Litzow*
Madi Heller-Shipley
Maggie Mooney-Seus
Mark Caylor
Mark Fina
Mark Henkel
Mark Stichert
Mateo Paz-Soldan
Matt Robinson
Matthieu Veron
Maxime Olmos
Michael Martin
Mike Shelford
M. O'Neal

Nicole Kimball
Nikolai Sivertstol
N. Stone
Paul Peyton
Paul Wilkins
Peggy Parker
Rachel Alinsunurin
Ray Melovidov
Rick Laitinen
Ron Felthoven
Ruth Christiansen
Ryan Burt
Sarah Marrinan
Scott Callahan
Scott Goodman*
Sean Dwyer
Sherri Dressel
Stephani Zador
Stuart Hollowell
Tyler Jackson
Todd Loomis
Vicki Vanek
Wes Jones
Zachary Liller
Zoe Reed
*gave a presentation to the CPT

1 Administrative

The September 2021 Crab Plan Team (CPT) meeting was held online via the Adobe Connect meeting platform, and connection information was posted to the CPT eAgenda. The meeting began at 8:00 a.m. on Monday, September 13, 2021 with technical set up and overview of the meeting application. The CPT reviewed assignments and timing for meeting deliverables, including finalizing the SAFE introduction and this CPT Meeting Report. CPT Co-Chairs Martin Dorn and Katie Palof reviewed guidelines for the meeting, including how public comments would be addressed during the meeting. Martin Dorn indicated that he would be stepping down as co-Chair after this meeting and an election for new co-Chairs was held at the conclusion of the meeting.

2 Summer Trawl Survey

Mike Litzow (AFSC-Kodiak) from the Shellfish Assessment Program at AFSC presented the 2021 Eastern Bering Sea (EBS) and Northern Bering Sea (NBS) summer survey results (see 2021 Eastern Bering Sea Continental Shelf Trawl Survey Results for Commercial Crab Species, NOAA Technical Memorandum). The survey consisted of two vessels and was conducted in the EBS and NBS from May 31 through 22 August. Crab samples for eight special projects were also collected during this survey. In 2021, the cold pool (< 2°C) had reduced extent in the EBS shelf area and was only present north of St. Matthew Island. Mature male biomass of all FMP crab stocks declined to a low, or the lowest, in the 1975-2021 time series.

In the 2021 survey, snow crab legal male abundance declined by 69% from the 2019 estimate, preferred size males (≥102 mm CW) were down 56% from the 2019 estimate, mature female abundance declined 70% from the 2018 estimate, and immature male and female abundances were down 96% and >99%, respectively, from the 2018 estimates. Increased proportions of old shell males and females were observed. Preferred size males and mature males shifted northwest, but mature females showed little changes in distribution. Immature male and female abundances shifted north. High incidence of old shell crab gives an indication of snow crab population change. Prevalence of bitter crab syndrome in snow crab appears to be higher in recent surveys, and an increasing overlap with Pacific cod and other groundfish stocks was observed. The slope survey, which has not been conducted since 2016, covers <10% of EBS shelf area and accounted for < 0.1% of the 2018 EBS snow crab biomass, although differences in survey gear make direct comparisons of biomass estimates from the shelf and slope surveys difficult.

In 2021, the cold pool did not extend to the Bristol Bay area to influence the distribution of red king crab. Because June sampling indicated a significant proportion of females had not completed the molt-mate cycle, the female areas were re-sampled in August to estimate available female abundance and determine reproductive status. Mature female abundance declined 25% and mature male abundance increased 26% compared to 2019. Declining trends in immature male and female abundances occurred in recent years. Survey results indicated a northern shift of the center of distributions of mature male and female abundances.

Tanner crab mature male abundance decreased over 20% in 2021 compared to 2019 in areas both east and west of 166°W. However, pre-recruit male and mature female abundances increased significantly in both areas in 2021, compared to 2019. Legal male abundance declined ~30% in both regions from 2019 to 2021. High abundances of small size (pre-recruit) crabs were seen during the 2018-2019 and 2021 surveys but progression to exploitable sizes over the years was not detected.

For the other FMP stocks, the 2021 survey indicated a 42% decline from 2019 in legal male abundance of St. Matthew blue king crab, and the legal male biomass of both Pribilof Island red king crab and Pribilof Island blue king crab were below the 20-year mean.

The CPT appreciated the survey team's great effort to successfully complete the 2021 survey after last year's absence and making the raw data and VAST abundance estimates available to stock assessment authors in time for analysis before the September CPT meeting. The CPT noted the overall decline in FMP crab stock abundances in the EBS, northern shift of crab, and increased prevalence of bitter crab syndrome in snow crab stock.

3 Fishery summary 2020-directed and bycatch

Ben Daly (ADF&G) and Krista Milani (NMFS-AKRO) gave an update on BSAI crab catch and fishery performance for 2020/21. Ben reviewed directed fishery observer coverage levels, which vary based on the crab fishery. This year was complicated by COVID-19, although the data collection process was largely unchanged thanks to the efforts of the crab Observer Program. The 2020/21 observer coverage by boat and pot were comparable to past years. Krista addressed groundfish vessel coverage, outlining full coverage, partial coverage, and vessels not selected for groundfish observer coverage requirements. Observer deployments were limited to specific ports on partial coverage vessels due to COVID-19, although vessels in the full coverage category continued to carry observers. Krista showed trends in incidental catch in groundfish fisheries, noting that bycatch broken down by trip target code should be interpreted with caution because the code is assigned based solely on the majority species for the fishing trip. Overall, bycatch of AIRKC is low due to limited federal fixed gear fisheries in the area.

Ben presented 2020/21 retained catch for BBRKC, snow, and Tanner crab directed fisheries. BBRKC retained catch was low, although CPUE was up relative to 2019/20 and remains close to the average for the rationalized part of the time series. Most of the BBRKC harvest was in central Bristol Bay and fishing occurred more in traditional fishing grounds rather than west-central Bristol Bay, as was the case in 2019/20. About 75% of the catch occurred in the first week of the BBRKC fishery and anecdotal observations included high CPUE of newshell males, a lot of recruits, and some females in pots. BBRKC discard mortality rate (relative to the weight of retained catch) has been relatively high for the past three years, likely due in part to a higher ratio of sublegal size male crab encountered in pots (as also indicated by at-sea observer data). This likely contributed to a large decline in mean weight of retained catch in the 2020/21 fishery. Krista presented BBRKC bycatch in groundfish fisheries, noting a large decrease in the fixed gear category that could be due to limited observer coverage in the fall, lower Pacific cod TACs, or the use of crab excluders on cod pots. Trawl bycatch was close to average.

Snow crab retained catch has increased in recent years due to higher TACs. Trends in CPUE were very similar in both retained catch and observer pots. The bulk of snow crab catch in 2020/21 was more northwest than in recent years and the weighted mean center of catch was ~100 miles north of the northmost centroid from past years and adjacent to the Russian border. About 50% of the catch occurred in March-April and observations from the fleet noted "poor fishing in nearly all areas except northwest of St. Matthew Island, areas of clean fishing in deep waters (90+ fathoms) and sea ice limiting the amount of area vessels could fish." Snow crab discard mortality rates (relative to retained catch weight) declined substantially after an all-time high in 2019/20, and average weight of retained catch was one of the lowest recorded in the time-series. Bycatch of snow crab in trawl gear during 2020/21 was notably less than the e larger catches in the past two years attributed to yellowfin sole trawling north of the Pribilof Islands. The

CPT suggested Krista explore size compositions and sex of crab bycatch by gear type. There were also several questions on BBRKC bycatch, and Krista noted that fish tickets indicate high BBRKC bycatch in pot cod fisheries thus far, though the fishery will likely close early. Discussion centered on dramatic shifts in the spatial distribution of snow crab catches, and concerns were voiced by industry representatives that future efforts should focus on snow crab tagging given observations from the fleet fishing near the Russian border.

The centroid of Tanner crab retained catch in 2020/21 was near the 166°W management boundary though is typically driven by area closures in East versus West subdistricts. About 45% of the harvest was caught by early November, with another pulse in late January to early February alongside snow crab. Captains reported low CPUE and that many vessels made only one trip due to poor fishing. Discard mortality rates (relative to retained catch weight) were low in the directed Tanner crab; total bycatch mortalities in the BBRKC and snow crab fisheries were also lower than in recent years. A decline in incidental Tanner crab catch during fixed gear fisheries was noted, while trawl incidental catch increased East of 166°W during yellowfin sole fishing.

AIGKC total harvest has been steady across the time series. The 2020/21 EAG CPUE was down relative to the prior season and CPUE in the WAG was one of the lowest since rationalization of the crab fisheries in 2005. As usual, spatial catch distribution was broader in the west than the east during 2020/21 (as is usual), and lower WAG catch rates extended the fishery season into spring months. Average weights for EAG have been declining for several years but may have reached a minimum in 2020/21, while weights in the WAG were lower than in 2019/20. Bycatch mortality rates (relative to retained catch weight) were fairly stable in both regions. However, there was a large increase in fixed gear bycatch for both WAG and EAG. Krista cautioned that there is no federal Pacific cod observer/EM coverage in the stock area so State pot vessels are assigned an extrapolation rate based on all observed/EM groundfish targeted with pot gear in the stock area, which may likely be a misrepresentation.

Four vessels participated in the 2020 Pribilof GKC fishery, which is conducted on a calendar-year basis; 95% of observer pot locations were in the Pribilof Island canyon area. Most of the retained catch occurred in March-April. Incidental catch of PIGKC in trawl fisheries declined from 2019.

Incidental catch of other BSAI crab stocks (i.e., SMBKC, PIRKC, and PIBKC) during 2020/21 was low due to closure areas, although yellowfin sole fisheries have been fishing heavily near the northeast corner of the Pribilof closure area boundary. NSRKC incidental catch declined from 2019.

Krista concluded by reviewing estimated fixed gear bycatch from sablefish and Pacific cod GHL fisheries that are in state waters and managed by ADF&G but have no observer or EM coverage requirements. As such, GHL fisheries receive extrapolated rates from vessels mostly fishing in federal waters even though some crab species may be more prevalent in federal waters than in state waters, and thus bycatch estimates are likely inaccurate. There was some discussion on this topic as the Alaska Region is recommending to discontinue extrapolating crab bycatch to some GHL fisheries. Jamie Goen (Alaska Bering Sea Crabbers) addressed concerns with adequate observer coverage given low crab abundances, and many stakeholders outlined concerns with increases in unobserved bycatch in State waters given continued expansions as a percent of the Federal BSAI cod TAC. The CPT flagged this as an important issue and expressed concern with losing both important bycatch data and the capacity to track bycatch trends. The CPT recommends observer/EM coverage in State waters be considered to refine bycatch estimates. Unfortunately changes to observer coverage in state waters would require an Alaska Board of Fisheries regulation change.

4 Ecosystem Status Report

Elizabeth Siddon presented the ecosystem status report for the Bering Sea. Crab-relevant information that was available from 2020 was presented along with 2021 data and preliminary forecasts for 2022. Since

the NMFS summer trawl survey was cancelled in 2020, there was limited data gathered during the year. The ecosystem status report (ESR) is divided into larval pelagic indicators and benthic adult indicators.

Environmental Processes: In the winter of 2019/20 wind speeds were near long-term average. March through May of 2020 had southerly winds over the shelf. Winds between April and June had a drift directory over the middle shelf. In 2015 and 2018, when winds had drift trajectories inshore, it resulted in above average recruitment for northern rock sole, a predator for larger juvenile crab in nearshore waters.

Sea ice was reduced with delayed formation in 2017/18 and 2018/19. During the 2019/20 season there was considerable cooling that allowed thin sea ice to build rapidly exceeding median ice extent in February and March, which retreated quickly in the spring. Although the ice extent exceeded the median, the ice was not thick and broke up quickly in the spring. Sea ice is a driver for cold pool extent, which was limited in 2018 and 2019. The 2021 cold pool extent is similar to other warm years of 2002-2005.

For 2020/21 climate and oceanography, the North Pacific Index (NPI) suppressed storminess in the fall, increased westerly winds over the shelf through the winter and spring, and was moderate in the summer which enhanced storminess. A moderate La Nina resulted in slightly warmer sea surface temperatures (which have been above the baseline since 2015); however, SSTs were below the threshold for a marine heatwave. This delayed sea ice formation in the fall, resulted in a rapid building of thin sea ice in the winter, and rapid ice retreat in the spring. More sea ice in the winter 2020/21 promoted cold pool development, but thin ice may have reduced ice algae and primary productivity. Low pH conditions persist on the outer continental shelf, although it was less severe over the outer southern shelf than in 2020.

Crab prey: It is difficult to obtain information on benthic infauna or epifauna that would represent prey for adults, so no current indicators exist for adult prey species. However, there is some information for crab larval prey in the water column. Satellite information shows temporal variability and spatial variability during the bloom season over the Bering Sea. These data can be aggregated by management area and larval period. There was a coccolithophore bloom over the middle shelf in 2018 and 2019 that increased in 2020. This typically lengthens the food chain but may be a less desirable food source with less energy transferred for crab larvae.

Crab competitors: For larval crab, other zooplankton are considered potential competitors. Direct measurements for zooplankton in the Bering Sea were not collected by surveys in 2020. However, information on seabirds was available from coastal communities that indicated zooplankton status. Patterns of seabird reproductive success and survival are correlated to prey availability. In the Pribilof Islands, 2020 was an average year for most fish-eating seabird species. Plankton-eating seabird species declined, indicating they were unable to find adequate food, their food was of lesser quality, or the birds were unable to see their prey due to the coccolithophore bloom. The continuous plankton recorder project now has data tracks through the Bering Sea for the last three years. For 2020, abundance of large diatoms was low, copepod size was small, and mesozooplankton biomass was low, again suggesting that zooplankton populations, which would be prey for larval crab, were less nutritious or unavailable. For 2021, small copepods remained consistent with previous years; large copepod abundances were low and euphausiids were very low in abundance.

For adult crab competitors, motile epifauna biomass is still above the long-term average, but declined from a high in 2018 and 2019. Benthic foragers are below the long-term average and remained low in 2019.

Crab predators: No information is available for 2021 at this time. Juvenile pollock and jellyfish, the main predators for larval crab, were at the long-term mean in 2019, along with Pacific cod and arrowtooth flounder which prey on juvenile crab. Overall, there was a northward shift for the fish community in 2019, which may increase predator overlap with northern crab populations.

The food habits of adult Pacific cod shifted with *Chionoecetes* crab becoming the dominant prey species in the Northwest outer domain in recent years (2016-2019). In the northern Bering Sea, *Chionoecetes* crab (primarily snow crab) was identified as the most dominant food source in recent years. Pacific cod in the northern Bering Sea are recorded to have good body condition, which indicates they are most likely not having trouble foraging for food. Bristol Bay Sockeye salmon had the fifth largest run on record in 2020. Sockeye salmon feed on zooplankton, which may include crab larvae such as red king crab.

Forecast for 2021/22: Sea surface temperature will continue to be warm in the fall of 2021 due to fewer storms and lower incursions of mild maritime air masses. During the winter of 2021/22, there will be decreased warmth over the southern EBS, returning to near-normal temperatures in the early spring of 2022.

Industry representatives expressed interest in collecting environmental data during the crab fisheries in the future.

5 Ecosystem Socioeconomic Profile: Snow crab update

Kalei Shotwell (AFSC-Juneau), Erin Fedewa (AFSC-Kodiak), Kerim Aydin (AFSC-Seattle), and Brian Garber-Yonts (AFSC-Seattle) provided an update on Ecosystem Socioeconomic Profiles (ESPs) since the last CPT meeting, with a focus on development of indicators for the snow crab ESP.

Kalei provided an overview of the progress in ESP development in Alaska and nationally. An ESP timeline was developed to schedule activities for stock assessment authors and generate data for ecosystem indicators. A draft Request for Indicators (RFI) is being developed with a January submission and a February review. The request identifies needs for ecosystem and socioeconomic information by stock. ESP teams will compile information in March and April with review for crab scheduled at the May CPT meeting. Crab stock-specific ESPs would be reviewed in May every five years. The report card would be updated annually.

Erin presented a draft Request for Indicators for the snow crab ESP. The draft RFI identifies a snow crab conceptual model to consider key ecosystem influences at multiple life stages: 1) pelagic larval stages, 2) early benthic juvenile stages, and 3) benthic adult stages. Using this information, a suite of 18 proposed ecosystem indicators are drafted.

- Arctic Oscillation (climate model)
- Cold pool extent (BTS)
- Sea-ice extent/retreat (satellite)
- pH index (ocean model)
- Production (chlorophyll a, satellite)
- Intermolt duration (BTS)
- Settlement success (IBM)
- Hatch spring bloom overlap (BTS, satellite)
- Benthic prey biomass (BTS)
- Snow crab recruit condition (BTS)
- Snow crab area occupied (BTS)
- Temperature of occupancy (BTS)
- Snow crab center of distribution (BTS)
- Pcod consumption of snow crab
- Pcod-snow crab spatial overlap (BTS)
- Female snow crab size at maturity (BTS)
- Male snow crab recruit biomass (BTS)
- Snow crab disease prevalence (BTS)

These ecosystem indicators have either positive or negative effects on the stock. Several of these indicators are also used for Bristol Bay red king crab ESP.

Erin detailed one of these indicators specific to snow crab: disease prevalence. Bitter crab syndrome prevalence data are collected on the EBS survey using visual determination. Immature females showed a dramatic increase in visual bitter crab prevalence in 2019. A study (Pam Jensen, NMFS) used qPCR on the summer survey to cample 200 immature crab at six index sites to quantify the presence of the parasite *Hematodinium* sp., which causes bitter crab syndrome. Each index site included about 10 survey stations. Overall, Pam found increased prevalence over time at four index sites from 2014-2017. There is a trend for higher prevalence in northern sites, and this might be a result of the fact that the survey occurs later in the season at northern sites. The geographic distribution of bitter crab and temporal variability is not well resolved. There may be a relationship between bitter crab and temperature, but further studies are needed to define this relationship. The literature suggests that crabs that are molting or under stress may be prone to infection or may have been infected and are under stress during molting. In Southeast Alaska Tanner crab, the high prevalence of bitter crab disease is associated with stable abundance, suggesting that stock collapse is not always a consequence of high prevalence. Pam Jensen has retired, and NMFS no longer has staff or resources to study bitter crab syndrome.

Cold water (<2°C) habitat indicators were developed for juvenile snow crab, as cold water habitat availability has been proposed as a recruitment bottleneck. The CPT asked if the pattern of decreasing immature female biomass at bottom temperatures above 2°C represented selective survival or shifting geographic distribution due to movement. The CPT also asked if any studies put immature females in a range of temperatures in the lab setting; a Canadian study looked at habitat selection for different temperatures and saw a narrow range of 0-1.5°C. The CPT commented that Louise Copeman (NOAA AFSC, Newport) has been conducting lab experiments on snow crab thermal preferences, and results suggested snow crab did not have a different thermal regime than Tanner crab. Survival actually peaked at 5°C in lab experiments, so why snow crabs prefer a lower temperature is not clear.

Predator indicators in development include the spatial overlap of snow crab and Pacific cod. Erin presented four years of data from northern Bering Sea (2010, 2017, 2018 and 2019). CPT members asked why only four years were presented. Erin replied that over all years, she didn't see a pattern in spatial overlap; the CPT would like to see all years represented in the future.

Kerim Aydin provided an update on consumption of snow crab by cod using a data set of 50,772 Pacific cod stomachs collected in the EBS/NBS from 1985-2019 during the summer bottom trawl survey. Overall, there is an increase in total consumption by larger cod in the St. Matthew Island and the northwest middle domain survey strata, with a recent shift in cod diets in the northern EBS strata from pollock towards snow crab. These data are used to generate estimates of daily summer consumption of snow crab by Pacific cod in the EBS. Consumption of snow crab by Pacific cod increased starting in 2014, with record highs in 2015 and 2016. Larger Pacific cod (30-60 and 60-85 cm fork length) are predominantly those eating snow crab, and when there are more large cod, there is more snow crab in the Pacific cod stomachs. Other predators to consider include Alaska skate, Pacific halibut, plain sculpin, and great sculpin. CPT asked about the suitability of snow crab to Pacific cod. Cody replied that he's looking at the size ranges of crab and will extrapolate the predation data using these consumption rates. Because crab abundance varies between years, mortality rates may actually be more stable, and the predators may be eating as a function of availability, so more crab present leads to more crab eaten by Pacific cod. Cody is working on incorporating these data into his modeling efforts. Pacific cod eat more in warmer waters due to metabolic processes, and the data show higher consumption in warmer years.

Brian Garber-Yonts provided an overview of socio-economic indicators in development. There are five fishery performance indicators and three economic indicators. No community indicators are proposed.

- Center of gravity (snow crab fishery)
- Catch-per-unit-effort (snow crab fishery)
- Total potlifts (snow crab fishery)
- Number active vessels (snow crab fishery)

- Incidental catch of snow crab
- Ex-vessel value (snow crab fishery)
- Ex-vessel price/lb (snow crab fishery)
- Ex-vessel revenue share (snow crab fishery)

Erin presented the draft traffic light table for each of the indicators. The missing bottom trawl survey in 2020 had a big impact, as data are not available to develop indicators for that year.

The presentation concluded with the timeline for the snow crab ESP. The RFI will be put out in January 2022 with a draft ESP at the May 2022 CPT with a final ESP for snow crab in September 2022. New ideas on indicators could be incorporated. The CPT will discuss these indicators at the January 2022 CPT meeting.

6. Snow Crab Assessment

Cody Szuwalski (AFSC Seattle) presented the 2021 assessment of Eastern Bering Sea (EBS) snow crab to the CPT. The stock assessment is based on a size- and sex-structured model coded in ADMB in which crabs are categorized into immature or mature, and account is taken of a terminal molt. The model is fitted to biomass and size frequency data from the NMFS trawl survey, total catch data from the directed fishery, bycatch data from the trawl fishery, size frequency data for male retained catch in the directed fishery, and male and female bycatch in the directed and trawl fisheries. The model is also fitted to biomass estimates and size frequency data from the 2009 and 2010 BSFRF surveys. Updated data in the 2021 assessment include retained and total catch and length frequencies from the 2020/21 directed fishery, discard catch and length frequencies from the 2020/21 groundfish fisheries, and biomass and length frequencies from the 2021 NMFS bottom trawl survey. Results from the 2021 NMFS bottom trawl survey indicated a severe decline in snow crab abundance, and the major focus of the assessment was to develop an assessment model that dealt appropriately with this decline.

Cody reported on a Center for Independent Experts (CIE) review of the snow crab assessment in March 2021. The CIE reviewers were Yong Chen (University of Maine), Nick Caputi (Western Australian Fisheries and Marine Research Laboratories, Australia), and Billy Ernst (University of Conception, Chile). All reviewers had expertise in crustacean biology and assessment. The CIE reviewers made several recommendations for improving the snow crab assessment and supported further development of the implementation of GMACS for snow crab. Cody mentioned that he will work with a new postdoctoral scholar, Matthieu Veron, to add more functionality to GMACS and provide better documentation. The CIE reviewers flagged the retrospective patterns in the assessment as a serious concern, and suggested ways that it might be reduced. One possibility that was suggested is to model time-variation in natural mortality and catchability. This was explored in models presented at the May CPT meeting (and again in the current assessment, but with a different implementation).

The CIE reviewers also recommended greater attention be given to data weighting in the assessment. The current assessment explored both the McAllister-Ianelli method and the Francis method, but encountered problems with model convergence in both cases. Andre Punt noted that there can be issues with data re-weighting when there is model misspecification. Still, the direction of results for McAllister-Ianelli method seemed promising in that weights were reduced for data sets that are likely more uncertain, such as the length-composition data for bycatch. Therefore, the CPT recommends that there be further exploration of data-weighting in the snow crab assessment.

Finally, the CIE reviewers recommended development of spatial models to better represent snow crab population dynamics. Cody mentioned work on a spatial snow crab assessment model by postdoctoral scholar Maxime Olmos that should be ready to present to CPT during the January 2022 CPT meeting, and a snow crab management strategy evaluation with spatial operating models that will be starting soon.

The assessment author and the CPT discussed extensively the potential causes of the severe decline in snow crab abundance evident from the 2021 survey. This decline of snow crab in the 2021 survey is all

the more unexpected because the EBS trawl survey had been tracking one of the largest recruitment pulses on record for five years to the 2019 survey. It was noted that abundance of this recruitment pulse had declined markedly in the 2019 survey, but still remained very abundant compared to the historical record. There was no 2020 trawl survey due to the COVID-19 pandemic, creating what turned out to be a critical gap in the ability to track snow crab abundance.

Potential causes of the decline were grouped into those factors that increase the mortality of snow crab, and factors associated with movement of snow crab outside the area surveyed by the EBS shelf survey. The snow crab ESP presented evidence of increased consumption of snow crab by Pacific cod, and an increase in the prevalence of bitter crab syndrome in recent years. It was also noted that increased temperatures on EBS shelf are a potential stressor on snow crab, which could result in increased susceptibility to disease and mortality. How these factors impact snow crab on the population level remain to be determined.

The assessment author and the CPT also discussed the potential movement of crab outside the survey area. Preliminary estimates of snow crab biomass in the northern Bering Sea remained stable, indicating that migration into northern Bering Sea could not account for large decline further south. The concentration of the fishing fleet close to the international boundary far to the northeast of typical fishing areas is an important piece of information. Movement of snow crab to the Russian zone is a possibility, but there is no information available at present about snow crab in Russian waters. The possibility that snow crab migrated into the area covered by the slope survey was also discussed. The slope survey area is small in relation to the EBS shelf, and historically has not contained many snow crab. It should be noted that the net used by the slope survey is not designed to be effective in catching snow crab. The possibility that snow crab migrated to the slope cannot entirely be excluded, but a survey of the slope is needed to evaluate potential migration. It was noted that from a population perspective, snow crab that have migrated to other areas but do not return are functionally the same as snow crab that have died.

The assessment author examined several model scenarios for this assessment. The issues that were addressed in these models included whether to use empirical availabilities for the BSFRF survey area, whether to include empirical selectivities in the model, whether to reweight the length frequency data sets, and finally, and most importantly, whether to estimate higher natural mortality separately for 2018 and 2019. Several models resulted in $F_{35\%}$ harvest rates using mature male biomass that were very high, resulting in essentially complete removal of the exploitable component of the stock. The assessment author therefore evaluated alternatives to $F_{35\%}$ harvest rates, including $F_{MSY}=M$, and the assumption of functional maturity at 95mm, based on Canadian studies indicating that only males greater than this size were capable of successful mating.

Many of the model runs that Cody presented were for models that did not converge adequately. The status quo model did not converge with the new survey data, which meant that all of the models considered by the CPT focused on models that differed from those examined in May 2021. Cody and CPT focused primarily on three models with good convergence characteristics. These models were:

- Model 21.1a: this model was as close as possible to last year's model when updated with the most recent data but included empirical availability curves for the area covered by the side-by-side experiments with the BSFRS survey vessel. Model 21.1a did not fit the recent survey biomass estimates and estimated higher biomass than was observed in 2021 (positive residual).
- Model 21.2: this model builds on model 21.1a but adds estimated mortality events in 2018 and and 2019, includes tighter priors on natural mortality and the probability of maturation to ensure model convergence. This model achieves adequate fits to the recent survey biomass estimates.
- Model 21.3b: this model builds on Model 21.2, includes the mortality events in 2018 and 2019, and adds empirical selectivity to incorporate the side-by-side BSFRF information directly in the model. Model 21.3 estimates an F35% that is essentially infinite, and so consequently Model 21.3b, which uses >95mm as a definition of functional maturity, was put forward. This model was considered a

potential path forward for the snow crab assessment but introduced several new features that could not be fully evaluated.

The assessment author recommended Model 21.2 which included empirical availabilities and higher natural mortality in 2018 and 2019 and continued with the $F_{35\%}$ harvest rate based on mature male biomass. The CPT also recommends Model 21.2, to determine stock status and set the OFL and ABC for 2021/22. The CPT recommended this model for the following reasons: 1) fitting the recent survey trends including the decline in 2021 was considered a priority, 2) the CPT regarded an increased mortality event as the most plausible cause of stock decline; and 3) the additional modeling developments using empirical selectivity and different proxies of reproductive output have not yet been fully evaluated.

The CPT recommends that the ABC be set less than maximum permissible ABC. The buffer between the ABC and OFL implemented by the SSC in 2020 was 25%, which reflected an additional 5% to account for the lack of a 2020 NMFS bottom trawl survey. Previous assessment issues identified by the SSC include the ability to estimate M (and its impact on biomass estimates), and the strong retrospective patterns in the assessment remain concerns, but the rationale for the additional 5% buffer is no longer relevant because a survey was conducted in 2021. However, the CPT identified additional uncertainties associated with the assessment this year, including uncertainty regarding the appropriate metric for reproductive output, whether natural mortality will return to baseline following the presumptive mortality event (as is assumed in the calculation of F35%), and the fact that the model changes necessary to deal with the extreme 2021 survey data resulted in models that were not vetted at the May CPT meeting. Therefore, the CPT recommends continuation of the 25% buffer.

The CPT recommends that the EBS snow crab is a Tier 3 stock so the OFL will be determined by the F_{OFL} control rule using $F_{35\%}$ as the proxy for F_{MSY}. The proxy for B_{MSY} ($B_{35\%}$) is the mature male biomass at mating (153.42 kt) based on average recruitment over 1982 to 2020. The CPT compared the MMB that was determined for February 15, 2021 (26.74 kt) with the MSST (76.71 kt) from the assessment conducted in 2021 to determine whether the stock is overfished. Given the estimated MMB for 2021 is below the MSST, the stock meets the criteria in the BSAI Crab FMP for an overfished stock. The projected MMB at the time of mating when fishing at the OFL for 2022 (0.33 B_{MSY}) is above the criteria for a directed fishery closure based upon the control rule in the FMP (0.25 B_{MSY}).

CPT encourages further development of a GMACS model for snow crab. Although a GMACS model for snow crab is under development, this work was put on hold for this assessment in order to not introduce too many new aspects of the assessment that needed review. The CPT recommends that this work be restarted, and that snow crab GMACS models be brought forward next year for consideration. Research needs for snow crab that became evident from this year's assessment include looking at population level impact of predation by cod and of bitter crab disease, investigating an appropriate threshold for defining MMB, investigating the potential movement of snow crab into the Russian portion of the Bering Sea and slope habitats, and the development of pop-up satellite tags for snow crab to investigate seasonal movement patterns.

7. Tanner Crab Assessment

William (Buck) Stockhausen (AFSC-Seattle) presented the draft assessment for eastern Bering Sea Tanner Crab to the CPT. The OFL and ABC for 2020/21 were 21,130t and 16,900t, respectively. The TAC for the eastern management area was zero because MMB failed to meet the threshold for opening the fishery, while the TAC for the western management area was 1,070 t, which led to a retained catch of 655 t. The total catch mortality for 2020/21 was 925 t.

The estimates of male and female biomass from the 2021 NMFS EBS survey were slightly higher than the corresponding estimates from 2019 (there was no 2020 NMFS survey) but the industry preferred male (125mm) biomass estimate was substantially lower than in the 2019 survey. Overall, there has been a declining trend in male biomass since 2014. The CPT notes that the recent survey length-frequencies have

included high densities of small crab but that several of these cohorts have not remained in the population. This may be one reason (along with the lack of a 2020 survey) for the retrospective pattern in recruitment evident in the assessment results.

Buck presented the results of four models. Input data sets used in the 2020 assessment were updated with the most recent information on bycatch and size composition data from the 1990/91 to 2020/21 crab and groundfish fisheries, revised and new male maturity data, and size composition and index data from the 2021 NMFS trawl survey. One of Buck's objectives was to find a model for which no parameter estimates were on bounds. The model presented to the May CPT, which formed the basis for the CPT-recommended model at the May 2021 meeting, achieved this goal, but the addition of new data led to additional parameter estimates that were on bounds, and led to the development of a new model (21.22a). Buck had intended to use the Dirichlet-multinomial (D-M) likelihood for multiple length-composition data sets, but the estimates of the associated over-dispersion parameters hit their upper bounds (implying that the effective sample sizes are larger than the input sample sizes).

The four models included in the assessment were:

- Model 20.07u, model 20.07 (the model used for the 2020 assessment) with updated 2020/21 data;
- Model 21.22, with σ_R, the extent of variation in recruitment, estimated, with retention assumed to be 100%, with normal rather than lognormal likelihoods for the fisheries, with the size-composition data for the BSFRF survey treated as Dirichlet-multinomial instead of multinomial, and with alternative selectivity forms for the fisheries and survey,
- Model 21.24, model 21.22 but with growth estimated outside the model – this was another model suggested by the CPT in May 2021; and
- Model 21.22a, model 21.22 reparameterized to avoid any parameters on bounds, and with a N(0,1) prior on the log-scale recruitment deviations (to force the parameter for 2020 recruitment from its lower bound).

Model 21.22a was preferred by Buck to model 21.22 because no parameter estimates were on bounds and because the fit of model 21.22a to the data was not markedly poorer than model 21.22 (It was noted that there was an error in Table H of the draft assessment report). Also, model 21.22 attempted to estimate the extent of variance of recruitment, but this parameter cannot be estimated reliably in the models that treat the recruitment deviations as penalized parameters. Model 21.24 was selected as a candidate model by the CPT in May to reduce the conflict between male growth and maturity by pre-specifying growth based on analyses conducted outside of the assessment. However, this model led to poorer fits to several data sources, in particular the NMFS trawl biomass indices for males and females. Overall, the models differed markedly in terms of the estimates of biomass and recruitment for the years before survey data are available but this is unsurprising. The models exhibited retrospective patterns for recruitment but not for mature male biomass. Given the relative performances of the various models, the CPT endorsed model 21.22a and requested that the author expand the justification in the report for the selected model.

Buck implemented an MCMC algorithm to quantify uncertainty and hence compute the p-star ABC. The MLE estimates and the medians of the posterior distributions for the quantities of management interest were quite similar (MMB: 42.78 kt vs. 42.57 kt; B_{MSY}: 36.27 kt vs 35.94 kt; F_{MSY}: 1.19 vs. 1.17 yr^{-1}; and OFL: 27.2 kt vs. 27.14 kt.). The CPT agreed to base management recommendations on the results from the Bayesian posterior and agreed with continuing with the 20% buffer between the OFL to the ABC used last year owing to (a) the lack of survey data for 2020, (b) the severe decline in recruitment for 2019, (c) the poor fit to terminal year survey biomass, (d) the observation that recruitment pulses at small sizes to the survey have not led to large year-classes to the modelled population, and (e) the poor fits to the data for large crab.

Buck identified the following tasks for future work (which were endorsed by the CPT):

- The ability to conduct multi-year projections should be added to the model.
- A delta approximation method should be incorporated in the model to estimate the uncertainty associated with the OFL and ABC as an alternative to MCMC.
- The analysis to create a standard approach for using BSFRF/NMFS side-by-side trawl data to inform NMFS survey catchability in assessments needs to be completed; the 2018 BSFRF data should be obtained and included in the analysis.
- A model in which the model simulation (i.e., projection) starts in 1982 should be created.
- Nonparametric approaches to determine selectivity should be explored.
- EBS Tanner crab should be implemented in GMACS. This could occur once the model for snow crab has transitioned to GMACS.

Additional recommendations for future work:

- Indicate important time periods (e.g., start of NMFS survey data, selectivity time blocks, etc.) on relevant plots for better reference
- Further examine weighting schemes, including scenarios in which the input sample sizes are larger in the D-M weighting scheme.
- Continue to investigate the use of VAST estimates of survey biomass and size-composition in the assessment.
- Simplify the model structure.
- Develop a model for EBS Tanner crab that incorporates important aspects of State management for Tanner crab, perhaps using the "fleets as areas" concept to reflect the State's two-area management.

8. Overfishing updates: WAIRKC, PIGKC, PIRKC, PIBKC, AIGKC

Ben Daly (ADF&G-Kodiak) provided an overview of the catch in relation to overfishing limits (OFL) for WAIRKC (2020/21), PIGKC (2020) and AIGKC (2020/21). Total catch was below the OFL for each of the three stocks, so overfishing did not occur for WAIRKC, PIGKC, or AIGKC. Updated summaries for these stocks are contained in the introduction to the final SAFE report. WAIRKC and PIGKC are on a triennial assessment cycle and stock assessments were last completed by the CPT in May 2020. The OFL and ABC for WAIRKC and PIGKC will remain in effect until the next assessment cycle, which will be in May 2023. AIGKC is on an annual cycle and was last assessed in May 2021 However, at that time, the fishing year (July 1 to June 30) had not yet been completed and overfishing could not be determined until the September CPT meeting.

Industry expressed concern over the sensitivity of the AIGKC assessment to catch per unit effort, particularly in core vs non-core areas. The assessment author stated that this will be looked at during the January 2022 CPT meeting.

CPT also noted that the AIGKC stock assessment author should be projecting future catch to the end of the season when conducting the stock assessment if the fishery is still ongoing. The CPT had a discussion about which data should be updated in the SAFE summary tables for AIGKC. Although the model was rerun once the full data set was received, results from that model should not be used to make changes to the values in the SAFE summary tables. Council staff clarified that the ABC/OFL was approved by the Council in June and cannot be updated when additional data become available. The summary table should only be updated with the final catch information and the ABC if the SSC changed the buffer from the CPT recommendation.

Cody Szuwalski (AFSC-Seattle) provided an overview of the catch in relation to the OFL for the 2020/21 PIRKC fishery. Total catch was below the OFL for this stock therefore overfishing did not occur. This stock is on a triennial cycle and was last assessed at the September 2019 CPT meeting. The OFL and ABC for this stock will remain in effect until the next assessment for this stock in September 2022.

William Stockhausen (AFSC-Seattle) provided an overview of the catch in relation to the overfishing limit for the 2020/21 PIBKC fishery. Total catch was below the OFL so overfishing did not occur. PIBKC is overfished and the status has not changed since 2002. This stock is on a biennial cycle and was last assessed in May 2021. However, at that time, the fishing year (July 1 to June 30) had not yet been completed and overfishing could not be determined until the September CPT meeting. The OFL and ABC for this stock will remain in effect until the next assessment for this stock in September 2023.

9. SMBKC update on bycatch and multi-year OFL

Katie Palof (ADF&G-Juneau) presented information on the SMBKC stock. This stock is overfished and a rebuilding plan has been in place since 2020. The stock was on an annual cycle and was last assessed by the CPT in September 2020. The SSC recommended and the Council approved an OFL and ABC for the 2020/21 crab year. The CPT recommended that this stock be moved to a biennial cycle during the January 2021 CPT meeting, a move supported by the SSC. As a result, the stock will not have a new assessment in 2021. However, the Council will still need to approve an OFL and ABC for the 2021/22 crab year. Katie recommended carrying over the same OFL and ABC from the 2020/21 crab year to the 2021/22 crab year, noting there was no attempt to rerun the assessment model, that the directed fishery remained closed, and that bycatch amounts remained low. The CPT agreed that carrying over the OFL and ABC from the previous year was appropriate.

Katie also provided an overview of the catch in relation to the OFL for the 2020/21 SMBKC fishery. Total catch was below the OFL for this stock, so overfishing did not occur. The next assessment for this stock will be in September 2022.

10. NSRKC proposed model runs

Toshihide (Hamachan) Hamazaki presented responses to CPT and SSC comments for the assessment for Norton Sound red king crab, summaries of current research, and two versions of the stock assessment model with updated data.

Two key requests arose from Hamachan's responses to the CPT's management-related comments. First, participants in the industry reiterated the request to plot the market size crab so they can understand how many of the crab in the legal size are actually marketable. This request is not a change to the model, rather it is a spreadsheet exercise using the output of the model. Second, Hamachan suggested that a total OFL would not be presented going forward because no discard estimates would be available in the future due to cancelled ADFG surveys. The CPT emphasized that our goal is to provide OFLs based on total catch and requested Hamachan to bring forward methods to use historical data to estimate discard rates. A simple method of doing this would be to use the previous ratios of discard to retained catch to calculate discard from retained catch. A more complicated method could involve models that predict discards from covariates such as retained catch, depth, and season.

The CPT previously requested that Hamachan examine several ecologically-motivated questions, including revisiting natural mortality and growth assumptions, investigating size at maturity, and female clutch fullness. Requests around *M* and growth arose from concern around how to address the discrepancy in model output and observations of large crab. Hamachan's presentation emphasized that the growth increments of tagged crab are well-fit, given fishery selectivity and *M* has been estimated repeatedly in the past, but estimates of *M* were higher than the currently used value and not adopted. Size-at-maturity from other stocks was not helpful for NSRKC, due to differences in apparent growth rates. Consequently, Hamachan did not recommend any changes to the current biological assumptions of the model.

No summer commercial fishery occurred during 2021, the winter fishery was very small, and the total harvest was 0.007 million pounds. The ABC was 0.35 million pounds, so overfishing did not occur. Poor weather reduced the ADFG survey area in 2021 and 80% of crab were caught at only three stations. Other

on-going research was discussed, and included laboratory explorations of size-dependent mortality, identifying the size at which males are functionally (rather than biologically) mature, and satellite tagging of crab to identify movement into and out of Norton Sound. Based on preliminary data analysis, it appears that large male crab are not moving out of Norton Sound.

Hamachan presented two models with updated data for consideration: Models 21.0 and 21.1. Model 21.0 is Model 19.0 with discards estimated using the proportion method, a revised methodology for standardizing CPUE, and two retention probabilities estimated for both the summer and winter commercial fisheries. Model 21.1 is Model 21.0 plus $M = 0.18\text{yr-}1$ for all size classes. Some of the larger changes in model output appears in estimated selectivity for the winter pot fishery and the associated retention curve. Large differences in estimated abundance occurred when assuming a size-invariant natural mortality (Model 21.1 had generally lower estimates of abundance). Although the CPT was not opposed to the modeling changes presented in Model 21.0, they were not supplied with the appropriate documentation to evaluate the changes appropriately. Further, the CPT requests that 'bridging' analyses be conducted to demonstrate the successive changes made between models. Changes need to be made (and presented) one at a time so that the resulting effects can be clearly understood. Bridging analyses need to start with (and present) last year's accepted model.

11. ABSC Survey update

Cory Lescher from Alaska Bering Sea Crabbers (ABSC) presented the summary of a pilot survey of skippers participating in the 2020/2021 Bristol Bay red king crab (BBRKC) or eastern Bering Sea snow crab fisheries. The long-term objective of the survey is to establish a time series of fishery-dependent observations that represent local knowledge from skippers' firsthand observations on the fishing grounds. The primary goals for this pilot survey are to capture skipper observations of perceived crab abundance, fishing areas, tagged crab information, and fishery interactions. The questions for the poll consist of two types: skippers' observations and information that ABSC would like to know. About 20 skippers participated in each fishery poll, which is not representative of the entire fleet, but results may be valuable as a baseline for the future surveys.

The poll results are summarized in pie charts with the current year results relative to the last three years. For overall abundance of the stock, a very large majority of the skippers thought BBRKC increased, and about equal number of the skippers thought snow crab either increased or decreased. For pre-recruit abundance, a large majority indicated this was above average for BBRKC, and a slight majority thought below average for snow crab. For female abundances, a majority indicated average abundance and a quarter or so thought above average for BBRKC, and a slight majority thought average and the rest thought below average for snow crab. When questioned about the use of the designated at-sea king crab pot gear storage area box, replies indicated that only about 20% used it. For a question about the potential to further reduce handling/discard mortality in the fishery, the answers were almost three-way tie: yes, no, and not sure, with "no" answers slightly more than the other two. For a question asking whether any tagged crab were encountered during the fishing season, almost all answers were yes. For tag type encountered, there were 46 spaghetti, 7 acoustic, and 3 harness tags.

Cory pointed out that there was great feedback from the NOAA, ADF&G, CPT, BSFRF and skippers prior to the survey who thought the pilot survey was successful. He hoped to continue the survey annually with more skipper participation in the future to make the survey more representative of the fleet. Cory and the ABSC will continue to distribute their post-season surveys to the fleet and anticipate that the results can be incorporated into or used to inform risk table discussions. This local fisherman knowledge is an important resource, particularly in contrasting their observations with other data sources. The CPT expressed support for the survey and hoped the survey could continue annually with a greater participation of skippers. The CPT also discussed the discrepancies between the poll results and NMFS survey results, especially for snow crab. The NMFS survey in 2021 shows a large decline of snow crab while the poll suggests that abundance is stable. Also, the NMFS survey shows about a 25% decline of

BBRKC female abundance, while the poll suggests that they are stable or increasing. Cory thought that movements of crab, movements of fishing vessels, and fishing locations might cause the discrepancies.

12. BSFRF Update

Scott Goodman gave a brief update on Bering Sea Fishery Research Foundation (BSFRF) research projects and workshop plans. BSFRF research activity, field work, and meetings have been ongoing during remote work conditions. Scott reviewed the list of BSFRF board members and science advisors, noting that Gordon Kruse has recently joined as a science advisor. Scott gave an overview of current research initiatives. In addition to topics that Scott covered in more detail during the presentation, he noted several ongoing efforts: improving accessibility of BSFRF data; direct support of NMFS Bering Sea trawl survey (BSFRF-funded biologists Cory Lescher and Charlie Heller staffed EBS survey legs 2 and 3); collaborative research with other Bering Sea fishery sectors on crab bycatch; collaborating on research surveys of supporting groups (e.g., crab skipper survey, gear instrumentation); continued development of management strategy evaluation approaches; and exploring options to engage with NPRB. In addition to currently ongoing efforts, Scott emphasized that BSFRF is placing a high priority on developing new "out-of-the-box" research that may provide information in the near term that addresses the current outlook for crab stocks, and obtaining supplemental research funding to offset the expected decline in funding available from crab industry stakeholders given declining crab fishery allocations.

Scott outlined BSFRF's crab workshops during 2021, noting that the scope of topics is limited to research, crab biology and management, excluding economic issues. The first of two workshops was held in January, focused on snow crab and so-sponsored by BSFRF, ADF&G, and NMFS. Materials and recommendations from the workshop are in preparation for release and are intended to guide decisions on next steps in research initiatives. The focus of a second workshop planned for October 2021 is being reconsidered in light of current stock conditions and will take into consideration the outcomes of Council and ADF&G crab management decisions for the 2021/22 crab season. Plans for the workshop will be announced soon. Scott also reviewed the agenda for the annual BSFRF Science Symposium on September 17, immediately following the September CPT meeting, which includes presentations from CPT members Ben Daly and Cody Szuwalski, and Leah Zacher from the Kodiak Lab.

Scott updated the CPT on the progress of three of BSFRF's ongoing research projects. He provided an overview of the BBRKC tagging and movement study, which is funded by BSFRF, NMFS, and ADF&G, summarized the research questions regarding spatial and seasonal distribution and movement trajectories of male and female red king crabs, and presented preliminary results from 2020 satellite pop-up tag data showing movement trajectories for legal males during July to October 2020. Scott noted the shift in tag technology over the course of the study, beginning with acoustic tags in 2019 and 2020, employing a saildrone during 2019 and 2021, and shifting to satellite tags in 2020 through 2022. Scott gave a brief update on the Bycatch Reduction Engineering Project (BREP), collaborating with ABSC and Natural Resource Consultants, Inc. to test pot gear modifications to reduce crab bycatch in cod and halibut fisheries, noting the use of cameras to observe crab escape from modified pots in the field, and briefly reviewed BSFRFs work on providing specimens for the crab growth research at the AFSC Kodiak lab. A brief discussion with CPT members followed, inquiring about the shift to satellite tags and potential for their use in research on snow crab movement.

13. Ecosystem and Socioeconomic Profile: BBRKC

Erin Fedewa (AFSC-Kodiak) and Brian Garber-Yonts (AFSC-Seattle) gave a presentation on the Bristol Bay red king crab (BBRKC) Ecosystem and Socioeconomic Profile (ESP) update. Erin provided an overview of the 2021 report card format including the indicators and associated analyses, recent recommendations, and plans for the next full ESP. The last full ESP was conducted in September 2020. Since then, there have been no new indicators, but existing indicators have been updated, including

changes to data sources and the addition of 2021 survey data and model estimates. For bottom temperature and cold pool extent indicators, the NOAA EBS trawl survey data replaced the Regional Ocean Modeling System (ROMS) bottom temperature hindcasts that had been used in the absence of a 2020 survey. Other changes include an ocean acidification indicator in which a ROMS-estimated ocean acidification index is presented as pH values instead of aragonite saturation states to simplify interpretation. While predation on larval BBRKC is a consideration, a lack of predator consumption data necessitates using predator biomass data as an index.

Erin presented both the indicator time-series and a "traffic light table'' that showed the current status of each indicator (low, neutral, or high relative to 1 SD of the long-term mean) and the proposed impacts/relationships on BBRKC (red, grey, blue colors). It was noted that the simplistic traffic light approach only accounts for directional effects, and it is recognized that responses could be nonstationary in nature, or approach thresholds. Erin highlighted a smaller cold pool extent (optimal for embryo development and overlap with the hatch and spring bloom), warmer temperatures (shorter advective distance and higher rates of local retention), and larger areas occupied by mature female red king crab despite declines in abundance (may decrease the likelihood that crab are in the BBRKC closure area and thus increase bycatch rates during groundfish fisheries). Erin noted that some indicator effects on the BBRKC population may be delayed by several years and discussed ecosystem considerations for current conditions.

Socioeconomic indicators were briefly discussed: five have been discontinued due to redundancy with what is presented in the stock assessment and to emphasize those indicators that are most closely associated with the health and condition of the stock. There was some brief discussion about the socioeconomic indicator time-series, and the associated traffic light indicators. All six indicators show low or neutral relationships with the current stock status.

Planned ESP developments will address 2020 CPT/SSC recommendations including improving interpretability of plots to emphasize lags, addressing proposed directional effects on stock, and assessing indicators for potential redundancy. Other developments will include the creation of Request for Indicators (RFIs) as a means for others to propose new indicator contributions. Ecosystem and socioeconomic indicators will next be updated in September 2022. The CPT is pleased with ESP progress overall and supports the continued development of the ESPs for BBRKC, snow crab, and other BSAI crab stocks. There was much discussion about potential distribution shifts to the northwest as highlighted in the ESP, with the 2021 bottom trawl survey data showing increased presence of female RKC just north of the Bristol Bay management area. It was noted that future research directions outlined in the 2022 BBRKC report card should emphasize RKC spatial distribution and movement, the effectiveness of trawl closure areas, and identifying essential spawning habitat.

14. BBRKC stock assessment

Jie Zheng (ADF&G-Juneau) presented the draft 2021 stock assessment for Bristol Bay red king crab (BBRKC) to the CPT. The 2020/21 OFL was 2,140 t while the ABC was 1,610 t. ADF&G set the TAC at 1,200 t and 1,260 t was retained in the directed fishery. Total catch mortality was 1,570 t, which was less than the OFL, so overfishing did not occur. Based on the CPT's recommended model (Model 21.1), MMB on Feb. 15, 2021 (13,960 t) was above MSST (12,120 t), so the stock was not overfished in 2020/21.

Mature male (>119 mm CL) area-swept abundance in the 2021 NMFS EBS trawl survey for BBRKC was estimated at 6.3 million crab, a 26% increase from the previous (2019) survey. Immature male abundance was 3.5 million, slightly down from 2019, while immature female abundance increased somewhat to 1.4 million. However, the estimated mature female (> 89 mm CL) abundance for red king crab in Bristol Bay was 6.4 million crab, a decline of 25% from 2019. This is below the threshold (8.4 million mature females) in the State's harvest strategy for opening the BBRKC fishery, so the directed fishery will be

closed for 2021/22. It should be noted that females, originally sampled in June, were resampled in August per standardized survey protocols based on the fraction of mature females in June without newly-extruded egg clutches. The density of mature females was essentially unchanged between June and August (503 crab/nmi vs. 508/nmi, respectively). Although this so-called "re-tow" protocol is generally triggered in years with cold bottom conditions (delaying egg hatching and subsequent extrusion of a new clutch), the cold pool was evident only north of St. Matthew Island in 2021. The CPT expressed its appreciation for the NMFS EBS survey personnel, AFSC Shellfish Program biologists, and stock assessment authors for the extra effort it took to be able to incorporate the BBRKC female resampling data into the assessment this year.

Immature male and mature female red king crab were found by the survey in the Northern District (north of Bristol Bay and south of Nunivak Island) in high abundance compared with previous years. These crab were outside the BBRKC stock boundary and were not included in the assessment. Several members of the public expressed concern that these crab were not included. The CPT recognized the potential need to expand the stock boundaries in the future to accommodate a northward expansion of the stock under warming environmental conditions. Implications of a recent modeling paper on larval transport and settlement of BBRKC by Daly et al. (2020) in light of a northward shift were discussed, although Ben Daly pointed out the limitations of such modeling studies.

Jie presented the results from six models: 19.3d, 19.3e, 19.3g, 21.0, 21.1, and 21.2. The first four were models requested by the CPT and SSC in May and June 202, respectively, while the remaining two were added by the authors. All models were implemented using the GMACS framework. Model 19.3d was the model on which the other models, incorporating minor modifications, were based. Model 19.3d was the same as the 2020 assessment model (19.3), except for including updated/standardized observer data from the directed and Tanner crab bycatch fisheries, changes in the fishing effort to cover a large majority of the stock to 166° W, additional bycatch length compositions from the Tanner crab fishery, and revised input sample sizes. Model 19.3e was identical to model 19.3d except that sex-specific survey "q's" were estimated, rather than a single "q" applied to both sexes. Model 19.3g was fit to VAST estimates of NMFS survey biomass rather than area swept estimates while model 21.0 estimated a single value for natural mortality that was applied to both sexes and the entire model period (model 19.3d fixed *M* for males in all years except 1980-84 and estimated a multiplicative offset for females). Additionally, the same survey selectivity was applied to both sexes (estimated survey selectivity functions were sex-specific in model 19.3d, while "q" was the same for both sexes). Model 21.1 estimated *M* in the same way as model 19.3d, but like model 21.0 only estimated a single survey selectivity function that applied to both sexes. Finally, model 21.2 was identical to model 21.1 except for estimating a separate male *M* for 2018 and 2019.

All six models fit the fishery catch and bycatch biomass data well. Model 21.0 fit the NMFS survey area-swept biomass estimates much more poorly than the other models. Estimates of biomass from model 19.3g were substantially higher than those from the other models during recent years because the VAST estimates of NMFS survey biomass tended to be higher than the corresponding area-swept estimates. Model 21.2 had the best overall likelihood, but at the cost of estimating a different *M* during 2018 and 2019. Models 19.3d, 19.3e, and 21.1 fit the data in almost identical fashion, but model 21.1 was more parsimonious (6 parameters fewer than model 19.3d, 7 fewer than model 19.3e). Authors' preferred model was Model 21.1, based primarily on parsimony considerations. The CPT agreed with the authors' arguments and also selected Model 21.1 as the recommended model for status determination and OFL setting. One implication of this model choice is that survey selectivity and catchability are assumed to be the same for males and females in this stock, which is different from the assessments for snow crab or Tanner crab. The CPT and author discussed reasons why these might be the same for BBRKC but different for the *Chionoecetes* stocks. It was noted that *Chionoecetes* females have a different response mechanism to the trawl gear (they bury themselves in the sediment) whereas red king crab do not. It was also noted that using the resampling data for females would probably tend to minimize differences

between the sexes that might otherwise accrue from differences in behavior and habitat use during molting for females early in the summer.

The OFL for 2021/22 from the recommended model (21.1) was 2,230 t, with a projected MMB on Feb. 15, 2022 of 14,950 t. B_{MSY} for this model was 24,200 t, so the stock was in Tier 3b (MMB/ B_{MSY} =0.62).

The CPT recommends decreasing the buffer used to set ABC from 25% used last year to 20%. CPT discussion on this topic centered on the components that were used to determine the buffer used last year and any additional concerns raised, or previous concerns allayed, this year. Last year, the CPT identified a base buffer of 20% as consistent with recurring concerns for this stock (cold pool distributional shifts, declining trends in mature biomass, lack of recruitment, retrospective patterns) and the base buffer used for other Tier 3 stocks. An additional 5% was added to the base buffer last year to reflect concerns regarding the missing 2020 survey and its impact on the assessment model. The CPT found that, unlike the Tanner crab assessment, the missing survey appeared to have no follow-on effects for the BBRKC assessment this year. Further discussion on the base buffer concluded that the main concerns it reflected remained in effect (changes in the cold pool, lack of recruitment, declining trends in mature biomass), but that the drop in mature female abundance this year below ADF&G's threshold for opening the fishery was already included in these concerns. The CPT noted that improvements to the model could lead to a reduction in the buffer, and that it recognized Jie's work to construct a more parsimonious model this year, but retrospective patterns still remained a concern and the improvements, taken together with the remaining concerns, were not sufficient to recommend reducing the buffer below 20%.

The Regional Office had previously requested that Jie provide the probability of approaching overfishing. The criteria in the NMFS National Standard 1 Guidelines for approaching overfishing status is whether the stock is projected to be below the MSST with greater than 50% probability in the next two years. He first presented MCMC results as plots of the median projected MMB and confidence limits projected from 2021 to 2031 under four fishing mortality scenarios (F={0, 0.5, 1.0, 1.5}*$F_{OFL2021}$) with random selection of recruitment from 2013-2020 estimates. The CPT suggested that it was more appropriate to evaluate summary statistics for the projected ratio of MMB to B_{MSY} in order to evaluate whether the stock was approaching an overfished condition. Because B_{MSY} would be the same for all years in a given MCMC realization, but would have its own distribution across the MCMC realizations, it would thus be necessary to evaluate MMB/B_{MSY} for each realization to determine if the probability of the stock falling below 0.5*B_{MSY} when fished at F_{OFL} was greater than 0.5. The CPT also requested that the author provide the results as plots of the cumulative probability distribution of MMB/B_{MSY} for 2021/2022 and 2022/23 in order to more easily evaluate the probability of the ratio being less than 0.5. Jie presented this revised analysis to the CPT on the day following his initial presentation. Results indicated that the stock was not approaching an overfished condition because the probability that MMB/ B_{MSY} was less than 0.5 in 2021/2022 and 2022/23 was much lower than 50%. The CPT expressed appreciation to the author for his extra effort to provide these results so rapidly. The importance of describing the uncertainty captured in the projections (e.g., uncertainty in estimated parameter values and in future recruitment) was also discussed, particularly in relation to the uncertainty not taken into account in these projections (e.g., uncertainty in fixed parameters and future environmental conditions).

Jie also reported on a Center for Independent Experts (CIE) review of the BBRKC assessment in March 2021. The CIE reviewers were Yong Chen (University of Maine), Nick Caputi (Western Australian Fisheries and Marine Research Laboratories, Australia), and Billy Ernst (University of Conception, Chile). All of the reviewers had expertise in crustacean biology and assessment. The CIE reviewers made a number of recommendations for improving the assessment. Among their recommendations, several are noted here. The reviewers considered retrospective patterns in the assessment to be problematic and suggested it was necessary to identify the sources of these patterns, as well as to consider incorporating time blocks for parameters such as M or survey catchability to reduce these patterns. Jie noted that conflicts between the NMFS survey and BSFRF survey data contribute to the large retrospective patterns and pointed out that one model (21.2) presented to the CPT in this assessment used an additional time

block for natural mortality. The CIE reviewers also suggested evaluating potential changes in survey selectivity in terms of changes in the stock distribution with time, as well as potential changes in the stock area itself. Jie told the CPT that he recognized the importance of examining red king crab north of Bristol Bay and that a tagging study could supply useful information on movement and connectivity between the Bristol Bay stock and red king crab to the north, while limited genetic and larval transport studies existed to further inform stock structure.

The CIE reviewers recommended performing a sensitivity study to examine the impacts of changes to size-at-maturity for both sexes to assessment results; Jie informed the CPT that he would update the estimates of female size-at-maturity, but that this would not affect the State's harvest strategy because the size-at-maturity for females in the harvest strategy is written into regulation and male maturity does not enter into it. The reviewers also suggested evaluating changes in spatial patterns of commercial catch, effort, and CPUE relative to survey results, as well as potential impacts of survey timing and availability, and using standardized fishery CPUE as an index of abundance in addition to the survey index. Jie explained to the CPT that he had started to, or planned to, work on several of these suggestions for May 2022. Another suggestion the CIE reviewers put forward was to run a model using data that started in 1985 to avoid the early 1980s high mortality period; Jie indicated that a similar model had been run in the past but that he planned to do this again for presentation at the May 2022 CPT meeting. Finally, the reviewers suggested conducting new tagging studies to update the outdated tag-return data used in growth estimation in the assessment; Jie enthusiastically endorsed this suggestion.

The CPT concurred with most of the CIE reviewers' recommendations but noted in particular that standardizing fishery CPUE could be very tricky and that it should have a low priority given that the NMFS survey already provides an independent measure of abundance. The CPT also made its own recommendations for future work:

- When projecting the stock to determine whether it is approaching an overfished condition, identify the uncertainties included and ignored in the projection. It is particularly important to distinguish those that are captured in the projection (i.e. those associated with the model) and the additional uncertainties that form the basis for the ABC buffer.
- When projecting MMB, label figures with the date to which it is projected (e.g., Feb. 15, 2022), not just the year (which can lead to confusion).
- Consider a model with constant *M*, but estimated separately for males and females (i.e., similar to Model 21.0, but with sex-specific *M*'s) for May 2022.
- Consider a model in which the data starts in 1985 (as suggested by the CIE reviewers).

15. Risk tables: Comment on SSC report

Anne Hollowed, SSC co-Chair, provided an update on the development of risk tables. A February 2021 SSC workshop addressed continued development of risk tables, with a draft summary report presented at the June 2021 SSC meeting, and potential report acceptance by the SSC and Council in October 2021. The report summarized eight workshop sessions focused on components related to risk tables. Workshop objectives were to: examine the value and status of risk tables; evaluate consistency across stocks, compare existing OFL/ABC determinations to a risk table approach in terms of scientific uncertainty, and discuss future options. Anne is seeking further input in advance of the October SSC/Council meeting. Preliminary SSC recommendations are that risk table development is going well, and that the SSC supports their continued use to identify uncertainty external to stock assessments. A major benefit of the approach is to promote linkages among assessment authors, ecosystem/process researchers, and the public, while providing a basis for relating assessment and stock concerns. For clarity, the SSC defined "risk" as the probability that ABC exceeds the true, but unknown, OFL. Risk tables are intended to guide and inform a consistent policy for change from the maximum permissible ABC given uncertainty external

to the stock assessment. The SSC generally agreed with workshop recommendations and suggested that risk tables be developed for stocks with full assessments, recognizing that stocks (e.g., some crab stocks) with biennial or triennial assessments would not need risk tables in off-cycle years. However, risk assessments could be revisited in the event of a dramatic stock status change. Recognizing species and spatial-temporal differences, the SSC does not support adopting fixed levels of ABC reductions across larger aggregates, but instead establishing risk scores according to a given stock or stock complex. In addition, linkages of a single risk factor (e.g.., temperature) shared among risk categories should be identified across appropriate risk categories. The focus remains on identifying information external to the assessment and related to the biological status of the stock. Thus, skipper surveys could be included as LK/TK, although the process to incorporate such data needs further work.

A discussion of the CPT history of identifying uncertainty ensued. The CPT stressed that many of the existing recommendations for a buffer approach to the maximum allowable ABC, including using P* as a buffer for OFL, are already being applied during CPT consideration of risk. Thus, a risk table application won't likely change the current CPT process and decisions on establishing buffers but may better clarify concerns over stock status and stock trends that are not captured in the existing assessments. Such an approach could better organize our existing process and may also better inform the SSC, Council and public of the rationale for CPT considerations. For example, in reviewing buffers, a risk table consideration will more formally bring environmental considerations into our deliberation process. The CPT noted a risk assessment table should be better quantified, although this is difficult. A statistical framework was proposed (i.e., Thompson's workshop discussion 7 - Comparing P* and Decision-Theoretic Approaches), but the SSC decided against its adoption at least for now.

In May 2021, the CPT tentatively explored application of risk tables to some crab stocks. However, the CPT was subsequently asked to not proceed with risk tables until after the SSC/Council October meetings and finalization of the risk tables report. Contingent on the October decisions, the CPT would like to begin exploring a risk table approach on a trial basis during the next assessment cycle. Eventually we might anticipate use of risk tables for all full assessments, including Tier 5 stocks, as an opportunity to provide a more rigorous decision process for our ABC and OFL recommendations.

16. AFSC update on climate science regional action plans: EBS and Arctic

Anne Hollowed presented a report on the Alaska Regional Action Plan (RAP) 2.0 for the Eastern Bering Sea. This is an update to the original Regional Action Plan that was developed in 2017, with the goal of evaluating scientific gaps and communicating climate-related projects, activities, and research in response to the NOAA Fisheries Climate Science Strategy. The RAP author list is composed of subject matter leads for five key focus areas. These include: management-oriented synthesis, socioeconomics, process studies, marine mammals, and monitoring. The subject leads worked with the writing team to develop text for the report, focusing 'key action synthesis' on three broader themes: invest in technology, infrastructure, and pathways to management including communication. Once the plan was developed, the next step was to present it to groups, such as the CPT, to allow for feedback on the RAP, specifically on the research focuses suggested in the document.

The appendix of the RAP provided a summary for the five subject areas of projects that were continuing from the 2017 report, those that were added post-2016, and a 'gap' category – which includes projects seen as needed but not established yet. For the five subject areas, 'monitoring' had the largest number of gap projects, while management-oriented synthesis had the largest number of post-2016 projects, suggesting that this area had been a focus on development since the initial RAP publication. The other subject areas had a balance of projects in the three categories.

The RAP highlighted four emerging opportunities that could be used to develop projects to fill some of the gaps acknowledged in the report. These included: NOAA's Climate Fisheries Imitative (CFI), FY22

NOAA Fisheries Survey Infrastructure, Expansion of Moored Observatories to the Northern Bering Sea, and OAR eDNA Moorings and Shipboard Measurements (2022-2023). Anne provided a synthesis of how these emerging opportunities would lead to a process and feedback loop to develop an end-to-end ocean modeling and decision support system. This involves 1) advancing ocean ecosystem, and climate understanding (science and development); 2) operational ocean, climate, and ecosystem prediction systems (operations and infrastructure); 3) and climate ready decision making (extension and engagement). The goal would be for this to be an interactive feedback loop between these three areas that would allow for ecosystem foresight, improved rapid response to changes, and climate smart decision support tools.

With increased support and funding, the RAP report to the CPT focused on feedback for key gap projects in both the infrastructure and fisheries and climate decision support subject areas. The key gaps in infrastructure included: ecosystem data collection, expansion of summer acoustic surveys to inner domain, HABs, mechanisms underlying spatial shifts (NBS survey), ocean biogeochemical sampling in the NBS, climate-mediated demographic vulnerability, predator-prey, survey frequency for pinnipeds, and baseline information for cetaceans. The key gaps in pathways for fisheries and climate decision support included: CFI implementation across NOAA new hires, communication, understanding human community adaptions, and non-market conservation of BS ecosystem.

CPT discussion focused on the potential predictive nature of the framework laid out by the RAP, and the need for understanding spatial distributional shifts for crab stocks specifically. CPT recommendations/ suggestions include: support for tagging studies or studies to better inform the seasonal distributions of crab stocks and how they would be affected by changing climate, advanced technology for tagging smaller crab, an increased ability to look at distributional changes into the Russian zone of the Bering Sea, and clarifying in the RAP document the importance of gap projects for crustacean species along with fish species.

Jim Thorson (NOAA) presented the Arctic Regional Action Plan, summarizing that the document can be used to prioritize funding, identify collaborations, and identify key science gaps. The Arctic RAP is new this cycle and includes the Chukchi and Beaufort seas regions. The Arctic RAP was divided into two sections, similar to the EBS RAP: 1) inventory of previous and on-going ecosystem monitoring programs, and 2) recommended future activities with the goal of developing a targeted portfolio of monitoring, process research and synthesis efforts.

Jim detailed future activities outlined in the Arctic RAP for the remainder of the talk. One recommended future activity is to bridge knowledge to inform Arctic management through collaborations and interdisciplinary partnerships. Another future activity highlighted is communications to support science with Arctic communities that would include education efforts, radio and television interviews, and the use of NMFS communication platforms. The Arctic RAP also outlines an LKTC task force for the region, and expanded involvement with Distributed Biological Observatory to add beam trawls, benthic respirometry, and eDNA efforts. Predicting HAB's and juvenile snow crab population dynamics using satellite-based ocean color was also highlighted as a future research activity, and the CPT expressed interest in updates regarding efforts to link snow crab abundance estimates to satellite indicators and fatty acid diatom markers. Overwintering of gadids is a future research activity that will focus on predicting impacts of summer warming on condition and overwintering survival. Marine mammal future research includes cetacean monitoring in the Chukchi Sea and developing a better understanding of the trophic role of ice seals. Jim also outlined updates to the Arctic Ecosystem Status Report as a high priority, as the document was last updated in 2015 and could be helpful for understanding snow crab dynamics. In addition, future efforts to expand Arctic ecosystem modeling would include, for example, updating the Chukchi Sea food web model and developing a Beaufort food web model. The CPT recommended collaboration with DFO whenever possible when developing a Beaufort Sea food web model. Lastly, the Arctic RAP recommended a combined bottom trawl and acoustic trawl survey to detect northward distribution shifts.

The CPT acknowledged the efforts of the Arctic RAP authors and look forward to additional climate-related research and synthesis to improve our understanding of snow crab dynamics and predictive capabilities in light of dramatic snow crab declines in 2021.

17. SAFE guidelines update (postponed)

18. GMACS update- priorities for January

Katie Palof solicited feedback on GMACS progress and planning. Cody Szuwalski identified a new (started ~Aug 2021) post-doc, Matthieu Veron, who will be adding new features to GMACS, producing documentation, and helping to get the crab stocks into GMACS. Matthieu will start by getting up to speed with the code and documentation and will start working on a GMACS model for NSRKC.

There was discussion about which stock should be prioritized to focus on getting into GMACS next, and the CPT agreed that NSRKC would be a good candidate. Shareef Siddeek and Andre Punt have been working on getting the AIGKC assessment in GMACS and are very close to mirroring the status quo model. They are struggling with some likelihood functions and CPUE calculations, but Andre is optimistic that progress is going well (e.g., can replicate the N matrix and retained catch size compositions). But further progress will take time and additional fine tuning is still needed. An AIGKC-GMACS update will be presented to the January 2022 CPT meeting.

There was discussion about the plan for implementing the snow crab assessment in GMACS. Cody mentioned that assessment priorities are in flux, given the overfished stock status, and that GMACS is on hold until the snow crab rebuilding plan is scoped out. There was concern about slowed progress in GMACS for snow crab, but it was recognized that the snow crab assessment in GMACS is close and encouraged further progress with the transition to GMACS.

There was discussion about how to determine when an assessment is "ready" to fully transition to GMACS. The metric in the past has been matching numbers-at-length between the status quo model and the GMACS model. The CPT noted that presentation of the status quo and GMACS model side by side is needed to illustrate any differences between the two models.

There was discussion about the utility of an R visualization package and whether the CPT should define a standard set of figures or guidelines to improve SAFE formatting/visualization/standardization. An R visualization package would help speed up the process for putting the SAFE chapters together, given the compressed timeline. R markdown is one pathway mentioned as a possibility to move towards a more standard format for SAFE chapters. Martin Dorn mentioned that he could work with Buck Stockhausen in developing an R visualization package, and Andre noted the importance of incorporating projections. It was noted that keeping track of the likelihoods in the status quo models is important to ensure they are correctly incorporated in GMACS.

The CPT discussed the uncertainty regarding the in-person vs. virtual status for the January 2022 CPT meeting. If virtual, in-depth GMACS coding work may not be an effective use of time given difficulties in coding collaboratively during virtual meetings. Regardless of virtual/in-person meeting status, the CPT agreed that progress updates should be provided, as ongoing GMACS discussion is important. It was suggested that the CPT plan for an in-person meeting (with asterisks) and then drop topics if the meeting ends up being virtual.

19. New business/Officer elections

Officer elections:

Katie Palof was re-elected to serve another term as co-Chair of the CPT. There were no nominations for the other co-Chair position, so that position is considered vacant for now. The AFSC plans to put forward a candidate for co-chair in time for the January CPT meeting.

Proposed 2021 meeting dates:

Jan 10-14, 2022 Anchorage (CPT is interested in a meeting in Dutch Harbor when the snow crab fishery is active).
May 16-20, 2022 Juneau (tentative).
September 12-16, 2022 (tentative).

January CPT meeting draft agenda:

- NSRKC final SAFE.
- AIGKC proposed model runs.
- Economic SAFE.
- Risk table future directions.
- Stock assessment TOR and standardized output files and plots.
- Survey improvements/updates - review BBRKC resampling protocols (Kodiak Lab).
- Snow crab stock status update and planning for rebuilding analysis.
- Snow crab ESP indicators update
- Alternatives to MMB for F35% based on functional maturity for *Chionoecetes* spp.
- ACLIM management scenarios for Bering Sea crab stocks
- Research overviews:
    - Overview of research on ocean acidification on Bering Sea crab stocks (multiple presentations, incl. Chris Long, Andre Punt, Mike Dalton)
    - Spatial assessment model for snow crab (Maxime Olmos)
    - Temperature effects on survival, intermolt duration, molt increment, and growth rates of early benthic snow crab and Tanner crab (Louise Copeman, AFSC-Newport)

January modeling workshop potential topics:

- GMACS (Katie)
- BSFRF side-by-side trawl selectivity analysis (Buck)
- Best practices for modeling mortality events/time varying mortality (Cody)