North Pacific Fishery Management Council

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SCIENTIFIC AND STATISTICAL COMMITTEE FINAL REPORT TO THE NORTH PACIFIC FISHERY MANAGEMENT COUNCIL September 30th – Oct 1st & Oct 4 – 6th, 2021

The SSC met remotely from September 30th – October 1st and October 4 – 6th, 2021.

Members present were:

Sherri Dressel, Co-Chair *Alaska Dept. of Fish and Game*	Anne Hollowed, Co-Chair *NOAA Fisheries – AFSC*	Alison Whitman, Vice Chair *Oregon Dept. of Fish and Wildlife*
Chris Anderson *University of Washington*	Amy Bishop *University of Alaska Fairbanks*	Curry Cunningham *University of Alaska Fairbanks*
Mike Downs *Wislow Research*	Jason Gasper *NOAA Fisheries–Alaska Region*	Dana Hanselman *NOAA Fisheries—AFSC*
Brad Harris *Alaska Pacific University*	George Hunt *University of Washington*	Kathryn Meyer *Washington Dept. of Fish and Wildlife*
Franz Mueter *University of Alaska Fairbanks*	Andrew Munro *Alaska Dept. of Fish and Game*	Matt Reimer *University of California, Davis*
Chris Siddon *Alaska Dept. of Fish and Game*	Ian Stewart *Intl. Pacific Halibut Commission*	Patrick Sullivan *Cornell University*

SSC General Comments and Administrative Discussion

Acknowledgements

The SSC congratulates Dr. Jeff Napp (NOAA-AFSC) on his retirement and acknowledges his many contributions to the advancement of sustainable fisheries in Alaska. The SSC also congratulates Dr. Jim Balsiger (NOAA-AKRO) on his upcoming retirement and extends its appreciation for his many contributions to Alaska fisheries research and management.

SSC Appointments 2022

During the Executive Session, the SSC noted the members that will be stepping down from the SSC in 2022 and members that may be stepping into SSC leadership positions. In response to these changes, the SSC discussed the areas of expertise from which the SSC could benefit in 2022. Based on these discussions, the SSC recommends that the Council consider appointing members with the following expertise: (1) a social scientist with a background in anthropology, sociology, human geography, or a related field, (2) an economist, (3) a scientist with a strong background in fish population dynamics and stock assessments.

Ecosystem and Socioeconomic Profiles

There was extensive discussion by members of the SSC regarding the most prudent pathway forward in the collection and use of socioeconomic data in the Ecosystem and Socioeconomic Profile (ESP) context, and in relation to the socioeconomic data and indicators used in SAFEs, Annual Community Engagement and Participation Overview (ACEPO), Ecosystem Status Reports (ESRs), risk tables, and new products being developed under the Climate and Fisheries Initiative (CFI) to address specific analytic needs, address needs related to National Standards 2 and 8 (among others), and help foster efficiency to reduce staff burden. In response, while clearly acknowledging the innovative and outstanding work that has been done to date, **the SSC suggests it may be prudent to undertake a comprehensive review of how socioeconomic information is incorporated in a range of evolving Council decision-informing products** to facilitate efficient reporting and future indicator development. The goal of such a review would be to explore the existing partitioning of information among related documents and products, to ensure redundancy is minimized, coordination is maximized, the social and economic information presented in each product aligns with its purpose, and data gaps are addressed to the extent practicable. The SSC suggests that expanded consideration of how socioeconomic information fits into the NPFMC fishery management process to inform both short-term tactical and longer-term strategic Council decisions may be valuable. The SSC suggests that a good model for such a review may be the recent national Socioeconomic Aspects in Stock Assessment Workshop (SEASAW)[1], a North Pacific region adaptation of which could draw participants from NMFS and Council staff, the Social Science Planning Team (SSPT), and the BS FEP LK/TK/S taskforce, among others.

There was some discussion of the capacity by NMFS scientists to produce ESPs for individual stocks on an annual basis given the time and personnel required. Kalei Shotwell (NOAA-AFSC) responded that the ESP team has addressed this concern by outlining a variety of products including partial ESPs that will reduce the burden of development.

[1] Chan, A.N., A.C. Haynie, P. Lynch, S. Sagarese, K. Shotwell, L. Pfeiffer, S. Crosson, M. Krigbaum, D. Lipton, J. Vieser, A. Mamula, J. Walter, R. Methot, K. Blackhart, M. Szymkowiak, E. Markowitz, S. Oakes, M. Downs, H. Townsend, T.T. Jones, D. Stram, and M. McPherson. *In Review*. The SocioEconomic Aspects in Stock Assessments Workshop (SEASAW) Report: Recommendations for Increasing Assessment Accuracy and Improving Management Advice. NOAA Technical Memorandum.

Technical Memorandum on Alternative ACLs for Data Limited Stocks

The SSC received a brief summary from Dana Hanselman on behalf of a subgroup of the SSC that drafted written comments in response to the "Draft NS1 Technical Guidance Subgroup 3 Tech Memo: *Managing with ACLs for data-limited stocks in federal fishery management plans - Review and recommendations for implementing 50 CFR 600.310(h)(2) flexibilities for data limited stocks*." The Tech Memo provides a brief summary of the literature with relevant references for developing data-poor management approaches.

Along with some suggested improvements, the draft SSC comments from the subgroup provide feedback to the Tech Memo authors about how the technical guidance might affect management of data-poor stocks in Alaska. The SSC recognizes that the guidance may ultimately have little effect on NPFMC management because data-limited stocks in this region are largely non-target stocks. However, as noted in the draft SSC comments, technical guidance will be helpful for assessing and perhaps revising some of the approaches to managing data-poor crab (Tier 5) and groundfish stocks (Tier 6).

The SSC supports submission of the draft response, but recommends inserting the following paragraph before the last summary paragraph to encourage the authors of the Tech Memo to include additional case studies from each region:

"The Tech Memo could benefit from some specific examples that illustrate how data-limited approaches have been implemented to evaluate stock status based on indicators and how these are used in the context of control rules. This would help inform each Council about data-limited approaches in other regions and would provide specific case studies that could serve as models for other regions. As an example, we provide a brief case study from the North Pacific region: *'Case study - Sharks in the Bering Sea and Aleutian Islands (BSAI): Groundfish stocks off Alaska are managed under a tier system, with the most data-limited stocks assigned to Tier 6. The BSAI shark complex, mostly consisting of Pacific sleeper shark and salmon shark, is one example of a Tier 6 stock and is a bycatch only stock. The OFL for this stock is based on the maximum historical catch observed between the years 2003–2015. Catches prior to 2003 were not included due to concerns regarding the accuracy of catch estimates. While catch data are available, sleeper sharks taken in the survey and fisheries are believed to be juveniles, so the effect of these catches on spawning stock biomass cannot be evaluated. Under the Tier 6 control rule, the ABC is set at or below 75% of OFL. The stock is assessed on a biennial cycle. Although bycatch of salmon sharks has increased since 2010, recent catch levels for the complex have been well below the ABC. This stock complex represents a challenge to catch-scalar approaches because a full accounting of catch biomass for the sleeper shark portion of the complex is difficult. This is due to large sharks not being brought on board or dropping off the long-lines before they can be observed or their size can be estimated. Sleeper sharks likely have a significant discard mortality, so research is underway on how to manage this complex in numbers instead of biomass and determining better methods of estimating unobserved average weights.'"*

B1 Plan Team Nominations

The SSC reviewed the nomination of Dr. Philip Joy (ADF&G) to the Bering Sea Aleutian Islands (BSAI) Groundfish Plan Team (GPT), Mr. Jared Weems (ADF&G) to the Bering Sea Fishery Ecosystem Plan Team (BS FEP), Dr. Mike Litzow (NOAA-AFSC) to the BSAI Crab Plan Team (CPT), and Ms. Caroline Brown (ADF&G) to the Social Science Planning Team (SSPT). **The SSC finds these nominees to be well qualified and recommends the Council approve their nominations**.

B4 Alaska Fisheries Science Center Report

NOAA Climate and Fisheries Initiative

The SSC received a presentation from Anne Hollowed (NOAA-AFSC) about the NOAA Climate and Fisheries Initiative (CFI). The goal of the CFI is to build a nationwide, operational ocean modeling and decision-support system that addresses four core requirements: (1) operational delivery of ocean forecasts and projections for use by NMFS and others; (2) operational capability to turn ocean forecasts into climate-informed management advice; (3) capacity for continuous validation and innovation through observations and research; and (4) increased capability to use climate-informed advice to reduce risks and increase the resilience of resources and the people that depend on them.

This national effort of sharing, modeling, and infrastructure can both improve NPFMC applications and management, and how the Council and its advisory bodies can share expertise in a bi-directional community of practice. The CFI will be built with input from coastal communities and the plan includes numerous provisions to foster communication. This effort will develop climate informed management portfolios that include climate-enhanced adaptive management (based on climate-enhanced stock assessments); infrastructural improvements; and climate-smart long-term strategies to anticipate climate induced species interactions and responses, reduce conflict, and support overall dynamic management.

Products of the CFI, including reliable ocean modeling products informed by a suite of existing and expanded surveys (funded through a separate initiative), will open the door for the NPFMC to be able to look at species-specific, climate-enhanced assessments that are not relying on a single season or location (e.g., ocean conditions in spawning areas or season) and can be used to avoid bycatch and protected species interactions. The short-term forecasts will also improve rapid responses for planning and prediction, alerting constituents, triaging impacts, and enabling adaptation. NPFMC is already benefiting from some pilot applications of climate enhanced models in the Bering Sea. The CFI will facilitate the operationalization of these pilot projects. In addition, the CFI provides for the expanded support for development of these tools in the Gulf of Alaska (GOA) and Arctic.

Initial funding in 2021 is for pilot projects and development of the Arctic Grid, followed by a substantial build phase in 2022 that includes: data portal teams, model teams, Fisheries and Climate Support System (FACSS) Teams, skill assessments, and model design specifications. The SSC was pleased to see this integrated investment in climate-readiness and looks forward to

following the progress of the initiative. **The SSC suggests clarifying how these efforts map onto existing Council decision-informing analytic products (e.g., map of information flow).** This would improve public understanding and tracking of products from this initiative.

The SSC is excited to see this level of investment in climate-informing products relevant to management as it will improve linkages between climate change and sustainable management.

Climate Regional Action Plans

The SSC received presentations from Martin Dorn (NOAA-AFSC), Kalei Shotwell (NOAA-AFSC), and Jim Thorson (NOAA-AFSC) on the draft Regional Action Plans (RAPs), 2022-2024. Public testimony was provided by Lauren Divine (Aleut Community of St. Paul Island) and Heather McCarty (Central Bering Sea Fishermen's Association).

In 2015, the NOAA Fisheries Climate Science Strategy (NCSS) was published as a guide for efforts by NOAA Fisheries to address information needs across seven science objectives that address the Nation's challenges in sustaining and managing large marine ecosystems (LMEs) in the face of a changing climate. RAPs for the Eastern Bering Sea (EBS) and GOA were developed with a focus on monitoring, process studies, and modeling. During the initial implementation of the RAPs, it was envisioned that research on climate change and fisheries would evolve over time and thus periodic updates of the RAPs would be required. Upon completion of the NCSS 5-year review, NOAA Fisheries leadership concluded that an update of the RAPs was both timely and necessary and the GOA RAP (2.0), EBS RAP (2.0) and a new RAP for the Arctic were developed.

The purpose of the RAPs is to identify and describe planned and proposed climate-science research activities at AFSC during the years 2022 – 2024. They also highlight new initiatives and projects that require additional funding but could be implemented quickly to build on the portfolio of climate-related research. **The SSC was excited to hear about the ongoing and new research.** Specifics for each RAP will be provided below, but the SSC commends the RAP working groups for each LME for the considerable effort that went into these documents and thoughtful assessment of current needs and knowledge gaps.

Across all three RAPs, there was a strong emphasis on key gaps that derive from a lack of monitoring. While it was made clear that these documents are not intended to task or direct budgets, **the SSC strongly supports prioritizing fisheries independent and dependent surveys, and that these data are consistently collected and enhanced**.

Similarly, the SSC was pleased to see emphasis on new and ongoing studies that focus on nutritional ecology and trophic interactions for fish. All three RAPs highlighted a need for predator-prey information to understand mechanistic linkages, and **the SSC supports the efforts to stabilize funding for laboratory studies and efforts exploring the impacts of climate change on food habits, bioenergetics, foraging and energetic quality.** The SSC looks forward to seeing how these can improve understanding and predictive capabilities for thermal thresholds, and predator prey interactions (e.g., in the GOA for the Atlantis and ECOPATH models).

The importance of both the monitoring data and interaction information is critical for investigating and identifying impacts of climate change and ecosystem tipping points. Many of these projects are only feasible under the Scenario 2 (increased) funding.

All three RAPs provided a balanced portfolio of research projects across five categories: Monitoring, Management Oriented Synthesis, Socioeconomics, Process Studies, and Marine Mammals. While the SSC recognizes that NOAA is not the agency tasked with managing seabirds, **the SSC recommended that the RAPs provide some information on inter-agency collaborations and efforts that feed into ecosystem-based approaches for sustaining and managing the LMEs in light of climate change (e.g., seabird productivity and diet, ESRs).** The SSC was also pleased to see international and inter-survey calibration efforts (e.g., DFO and NWFSC) for species that cross international borders

Specific focus was placed on envisioning a collaborative research environment with Alaska Native communities in each of the RAPs. The new AFSC Tribal Research Coordinator will assist this process, with the goals of strengthening working relationships and partnerships to promote sharing information, supporting data collection, developing collaborative research projects, and identifying mutual priorities to co-produce research. **The SSC is supportive of these efforts and stresses the need for NOAA, the Council (e.g., through its relevant committees and task forces), and related agencies to coordinate, thereby allowing for an efficient use of resources in communities for co-generation of knowledge, cooperation, and research.**

Finally, similar to the CFI, the **SSC suggests the RAPs consider including and clarifying how these existing and proposed new projects and efforts map onto existing Council decision-informing analytical products (e.g., map of information flow).** This will assist in clarity for public understanding of how information flows from various sources, documents, and efforts into decision-making processes.

Eastern Bering Sea Regional Action Plan

The EBS RAP 2.0 updates 51 current and new (started after 2016) climate research activities likely to occur in the next three years and provides an evaluation of remaining key scientific gaps. This list is not the full scope of climate research conducted in the EBS but represents NOAA's contribution to scientific research relevant to the NCSS through projects that receive federal funding or engage federally-funded researchers. The RAP as a whole highlights many areas of advancement and improvement of the EBS climate-ready strategy.

Of the existing activities, the majority are focused under the research themes of Monitoring, Management Oriented Synthesis, and Socioeconomics, with additional activities classified as Process Studies and Marine Mammals. Most new projects were integrated and based on a foundation of ecosystem-based management (EBM) and thus fell under the Management Oriented Synthesis category.

Five projects were highlighted as important for including ecosystem advice in tactical decision making and included ESPs, Risk Tables, FEP Task Force Teams, Human Integrated Ecosystem Based Fisheries Management (HI-EBFM), and the Fisheries Integrated Modeling System (FIMS). From the Process studies category, it was highlighted by the CPT that new projects focusing on

shifting spatial distributions will be key (e.g., tagging, collaboration with Russia)**.** The potential predictive nature of the framework laid out by the RAP is particularly exciting.

Twenty-five key gaps still remain—with the majority falling into the Monitoring category. Given the strong emphasis on integrated research, the authors found it difficult to prioritize across projects but did note that three main foci emerged: Infrastructure, Decision Support Pathways, and New Technology that would accelerate progress towards a fully integrated climate portfolio in the region. Highlighting a few gaps:

- Ship time and increased survey frequency was a recurring theme for both fisheries and protected species like marine mammals (e.g., cetaceans haven't been surveyed in the Bering Sea since 2006). Increased survey effort is needed to address the distinct lack of data on phytoplankton bloom timing, seasonality, and phytoplankton and zooplankton species composition (measurements are strongly linked to overall fisheries production), impacts of climate change on habitat use and prey resource distribution, and spatial and temporal gaps in coverage. Improving coverage and adding novel biogeochemical sampling will also require development of new tools and technology.

- Another key gap was understanding human community adaptations and non-market values of the Bering Sea ecosystem, but funding is limited. Additionally, there is a need for improved communication of risks of climate change to fishing dependent communities (KGMOS 2). The SSC is excited about the diverse tactics highlighted for addressing the gap with understanding human community adaptations and non-market values of the BS ecosystem and the addition of the AFSC's new Tribal Research Coordinator to assist in facilitating two-way dialogue, with initial focus on the northern Bering Sea (NBS) (see note about coordination above).

The SSC appreciates the SMART metrics of progress as this allows for more accountability and transparency of how these activities will be achieved. However, the "T—Timebound" component was inconsistently applied across metrics (e.g., at least one workshop on climate-related community priorities in a western Alaska community, and with fisheries stakeholders, but did not indicate a target completion date). This could be improved in future drafts.

The CPT also highlighted, and the **SSC agrees, that it would be helpful in the text to note where research or key gaps are specific to groundfish or crab, or both**.

Four national initiatives were advanced in FY22 that can address these needs, including CFI, NOAA Fisheries Survey Infrastructure, PMEL Expansion of Moored Observatories in the NBS, and PMEL funding request to OAR for eDNA Moorings and Shipboard Measurements. Full funding of these projects would provide for key surveys for the NBS and climate decision support for fishery-dependent communities and managers by growing teams that provide flexible responses to challenging monitoring needs. Under Scenario 1, these initiatives are not funded and the authors project that slope surveys will be discontinued or infrequent, juvenile fish surveys will be biennial or severely reduced, and near coastal regions will not be surveyed.

Some programs will continue on temporary funding (ACLIM, MAPP, MOM6, eDNA research), but data and sample processing may be slowed. If the initiatives are funded (Scenario 2) many of the key gaps will be addressed, though some programs (e.g., food habits long-term data program, marine mammal monitoring and assessments, and euphausiid dynamics) will still be limited.

Arctic Regional Action Plan

At present, the NPFMC Arctic Fishery Management Plan (2009) prohibits commercial fishing (excluding salmon and halibut) until sufficient information is available to support the sustainable management of a commercial fishery. This is the first RAP for the Beaufort and Chukchi Seas. The report details several previous and on-going research programs in the high Arctic including large-scale integrated surveys (RUSALCA, DBO, AEis, AIES) that may serve as baselines for assessing future changes, and several marine mammal surveys that look at abundance, migration, and trophic interactions.

Several studies were highlighted including focused sampling in the Beaufort Sea that found snow crab were associated with cold, high salinity water offshore of the shelf break (Logerwell et al. 2011), and results from uncrewed surface vehicle surveys of the Chukchi shelf that showed age-0 gadids are advected to the Chukchi shelf from the northern Bering Sea and then advected farther north after a period of growth (Levine et al. 2021). Several projects focused on predator-prey interactions (e.g., examining the trophic role of ice seals in the Chukchi and Beaufort Seas that aim to estimate prey requirements and seasonal/spatially explicit consumption). There was also emphasis on spatial distributions and movement ecology (e.g., northward distribution shifts including developing survey designs for large-bodied fishes and crabs).

The Arctic RAP identified 11 on-going and expanded research activities that are important for ecosystem monitoring, synthesis and management responses in the US Beaufort and Chukchi Seas. The targeted portfolio spans trophic levels and human components of the ecosystem and would occur from 2022-24. Table 1 in the report details each of these activities, the research type and NCFSS objectives it meets. Priorities were fairly evenly distributed across all five research types (Monitoring, Process Research, Marine Mammals, Management-Oriented Synthesis, and Socio-economics).

The authors suggested development of a LK/TK/S Taskforce for the Arctic Region as one potential pathway for improving communication. It was also a goal to refresh the Arctic ESR to regularly communicate Arctic science to the NPFMC. **The SSC is supportive of the development of a LK/TK/S Taskforce but suggests coordination with existing NOAA efforts and relevant Council entities (see comment above).**

The CPT acknowledged and the SSC supports 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.

Gulf of Alaska Regional Action Plan

The most notable progress from the initial GOA RAP 1.0 was that AFSC and UW received funding for robust modeling efforts in the GOA. Based on the ACLIM project, this multi-model approach includes an ECOPATH model, multispecies models, and an Atlantis ecosystem model for the

GOA. It will include fleet dynamics, a marine mammal project looking at heatwave impacts on Steller sea lions, a sociological study of adaptive capacity in fishing communities, and coupled regional economic models for southwest Alaska. This RAP will be conducted over three years, 2022-2024. **The SSC is very supportive of this effort and looks forward to seeing these models incorporated into the Council process.**

The targeted portfolio spans trophic levels and human components of the ecosystem and would occur from 2022-2024. Some other highlighted projects in the GOA RAP 2.0 included: development of new methodologies for efficient and rapid assessment of key metrics (fish condition, relative abundance) to reduce lags in use in fisheries management (Monitoring); experimental studies on the effects of increasing temperature and ocean acidification (Process Research); climate vulnerability analysis for the GOA (Management-Oriented Synthesis); heatwave impacts on Stellar sea lions (Marine Mammals); and a coupled fleet-community-adaptation model (Socio-economic). The RAP team identified a number of projects that would fill key gaps and are important for addressing NCSS objectives but require additional funding (detailed in Executive Summary and Table 5.1).

As with the EBS, the GOA RAP utilized SMART metrics for tracking progress; the SSC appreciates this approach but suggests authors ensure that metrics have clear timeframes identified where appropriate.

C1 BSAI Crab SAFE

The SSC received a detailed report on the September 2021 BSAI CPT meeting from Martin Dorn (NOAA-AFSC, CPT co-chair) and Katie Palof (ADF&G, CPT co-chair), with a presentation on the EBS snow crab assessment by Cody Szuwalski (NOAA-AFSC). Oral public testimony under the C-1 agenda items was received from Scott Goodman (Bering Sea Fisheries Research Foundation; BSFRF), Jamie Goen (Alaska Bering Sea Crabbers; ABSC), Cory Lescher (ABSC), Siri Dammarell (Brekkaa Fisheries), Rick Shelford (Shelford's Boat Ltd.), Casey McManus (F/V Cornelia Marie), Frank Kelty (City of Unalaska), Leonard Herzog (self), Gretar Gudmundsson (F/V Provider), and Heather McCarty and Mateo Paz-Soldan (St. Paul Island). Written testimony was provided by Scott Goodman (BSFRF), Amos Philemonoff, Sr. (ACSPI) , Jamie Goen (ABSC), Jake Jacobsen (Inter-Cooperative Exchange), Maria Painter (Katrina EM, Inc.), and C. Braxton Dew (self). Testimony, including testimony regarding the trawl survey, is characterized in the EBS snow crab and Bristol Bay Red King Crab (BBRKC) sections.

Trawl Survey

The SSC received an excellent presentation on the 2021 EBS and NBS bottom trawl survey from Mike Litzow (NOAA-AFSC). Written testimony on the trawl survey was provided by Jamie Goen (ABSC), Lauren Divine (Aleut Community of St. Paul Island), and Scott Goodman (BSFRF). Oral public testimony was provided by Scott Goodman (BSFRF) and Cory Lescher (ABSC). The SSC wishes to commend AFSC survey staff for completing the bottom trawl surveys in 2021 under the ongoing challenges of COVID. Further, the SSC is impressed with the rapid turnaround of the survey data that were included in the October crab assessments. The SSC thanks the survey team for their efforts on this front, and the assessment authors for their efforts to turn around updated

models so quickly. Additionally, the SSC is encouraged to see the connections between the information presented in the survey and the assessments – a great example of this is the snow crab assessment.

The combined abundance of all BSAI commercial crab species was down from 2019. Declines were prevalent across all species and for most sex and size classes within a species, with only some exceptions. **The SSC finds these trends in survey biomass extremely concerning.** This also points to the continued importance of the large-scale, annual fishery independent surveys as a critical tool for monitoring population trends.

EBS snow crab legal male abundance, preferred size male abundance, and mature female abundance declined from 2019, by 69%, 56% and 70%, respectively. Immature abundances of both males and females were down more than 95% from 2019. Several of these abundance estimates were the lowest values in the bottom trawl time series. There was an increased proportion of old shell males and females, and a decline in clutch fullness, though this last result was not unusual for old shell crab. Collectively, however, the SSC notes that these represent a serious decline in the reproductive potential of the EBS snow crab stock. Dr. Litzow presented three hypotheses for the survey results, including movement outside the survey area, a mortality event, or issues with the survey (see snow crab above). The SSC agrees that problems with the survey or observation error are unlikely explanations. While clear mechanisms are currently lacking, increased mortality is a plausible explanation for the observed drops in abundance. The SSC notes that, if recent high temperatures are implicated in the decline since 2019, that further declines are possible given that environmental conditions on the EBS shelf remain warm. It is unlikely that northward movements into the NBS can explain the decline as catches of snow crab in the NBS have not correspondingly increased to compensate for the EBS declines. The slope has not been surveyed since 2016, but changing EBS shelf temperatures may increase the importance of these two habitats to snow crab.

BBRKC survey results were mixed. There was a decline in mature female abundance from 2019 (25%) but an increase in mature males (26%). Immature abundances have remained low for the last three surveys (2018, 2019 and 2021).

Survey results for Tanner crab showed signs of positive recruitment, with pre-recruit male abundances increasing in both the eastern and western areas since 2019. Mature males continued to decline over the last several surveys, but mature females increased in both areas, significantly so in the eastern area (331%).

There were indications of northward shifts in distribution for several species. Mature female BBRKC abundance in the northern district increased dramatically, and centers of distribution were shifted to the north for BBRKC females and males, and for mature male snow crab. Immature snow crab CPUE has also continued to shift north.

The SSC offers the following comments regarding the BSAI bottom trawl survey results for crab in 2021:

- To further elucidate the cause of the observed decline in snow crab, the SSC suggests that additional flexibility in the EBS survey footprint may be warranted given the exceptional

circumstances. There is no slope survey planned by AFSC at this time, but expansion of the EBS shelf survey to deeper waters may provide additional information to explain the decline. Pot survey stations that overlap both the shelf and slope survey areas may also be an avenue to obtain information. **Long-term, the SSC continues to advocate for enhancement of fishery-independent surveys to properly monitor distributional changes in managed species**.

- The SSC acknowledges the joint efforts of BSFRF, NOAA, and ADF&G to tag BBRKC and notes that this project has been informative to BBRKC management. The SSC would like to encourage expansion of these efforts to snow crab to help differentiate between movement and population declines.

- A holistic look at the various stresses to which snow crab are being subjected would be worthwhile, including thermal induced metabolic stress, food conditions, and predation.

- The SSC notes that, when showing time series, points between the 2019 and 2021 surveys should not be connected to indicate the missing survey in 2020.

- Providing detailed survey information for the overfished crab stocks with multi-year harvest specifications is key to successful monitoring between assessment cycles. The SSC wishes to see more details on the survey results for these stocks in the future.

- Finally, it would be helpful to include landmarks in the center of distribution maps to aid in interpretation.

BSAI Crab SAFE and Harvest Specifications

The SSC reviewed the SAFE chapters and information provided by the CPT with respect to the stock status information from 2020/2021 and relative to total catch during the 2020/2021 season (Table 1). The SSC notes that PIGKC is on a calendar year cycle, where stock status is reviewed relative to 2020. In addition, Table 2 contains the SSC recommendations for 2021/2022 catch specifications, with maximum permissible ABCs for 2021/2022 shown in Table 3. **The SSC endorsed all of the OFL and ABC recommendations of the CPT (Table 2).** St. Matthew blue king crab and Pribilof Islands blue king crab are overfished. EBS snow crab mature male biomass (MMB) was below MSST and is pending overfished determination by NMFS. None of the other crab stocks were overfished or approaching overfished status. None of the crab stocks were subject to overfishing.

Table 1. Stock status in relation to status determination criteria for 2020/21 as estimated in October 2021. Hatched areas indicate parameters not applicable for that tier. Values are in thousands of metric tons (kt).

Chapter	Stock	Tier	MSST[1]	B_{MSY} or $B_{MSYproxy}$	2020/21[2] MMB	2020/21 MMB/ MMB_{MSY}	2020/21 OFL	2020/21 Total Catch	Rebuilding Status
1	EBS snow crab	3	76.7	152.4	26.74	0.17	95.4	26.2	**Below MSST***
2	BB red king crab	3	12.12	24.2	13.96	0.58	2.14	1.57	
3	EBS Tanner crab	3	17.97	35.94	56.34	1.57	21.13	0.96	
4	Pribilof Islands red king crab	4	0.87	1.73	6.43	3.7	0.86	0.51	
5	Pribilof Islands blue king crab	4	2.05	4.10	0.18	0.04	0.00116	0	**overfished**
6	St. Matthew Island blue king crab	4	1.67	3.34	1.12	0.34	0.05	0.001	**overfished**
7	Norton Sound red king crab	4	1.03	2.05	2.27	1.11	0.13	0.09	
8	AI golden king crab	3	6.03	12.05	16.21	1.34	4.80	3.44	
9	Pribilof Islands golden king crab	5					0.093	0.052	
10	Western AI red king crab	5					0.056	<0.001	

[1] As estimated in the 2021 assessment.
[2] For Norton Sound red king crab, MMB on 2/1/2021 is estimated using the current assessment in January 2021.
*NMFS will make the determination of stock status as it relates to overfished status.

Table 2. SSC recommendations from the final 2021 SAFE in October 2021. Stocks for which specifications are rolled over between assessments (Pribilof Islands golden king crab and Western Aleutian Islands red king crab) or were set in February or June 2021 are also included. Biomass values are in thousand metric tons (kt). Tier designations in this table are based on the projected stock status in 2021/2022. Stocks for which the SSC recommended different harvest specifications from the CPT are bolded. Harvest specifications for SAFE Chapters 1 – 4 and 6 are set in October and Chapters 5 and 8 – 10 are set in June, in the year according to the assessment frequency cycle (see current SAFE Introduction for assessment cycle). Chapter 7 (Norton Sound Red King Crab) is set in February.

SAFE Ch.	Stock	Tier	F_{OFL}	B_{MSY} or $B_{MSYproxy}$	B_{MSY} basis years[1]	2021/22[2] MMB	2021/22 MMB / MMB_{MSY}	γ	Natural Mortality (M)	2021/22 OFL	2021/22 ABC	ABC Buffer
1	E. Bering Sea snow crab	3b	0.37	153.42	1982-2020	50.6	0.33		0.27 (imm. mal), 0.28(mat. mal)	7.5	5.6	25%
2	Bristol Bay red king crab	3b	0.17	24.2	1984-2020	14.95	0.62		0.18	2.23	1.78	20%
3	E. Bering Sea Tanner crab	3a	1.17	35.94	1982-2020	42.57	1.18		0.31 (mat.fem) 0.23 (imm. males and fem) 0.30 (mat.males)	27.17	21.74	20%
4	Pribilof Is. red king crab	4a	0.21	1.73	2001-2019	6.43	3.72	1	0.21	0.86	0.65	25%
5	Pribilof Is. blue king crab	4c	0	4.10	1980/81-1984/85 & 1990/91-1997/98 [MMB]	0.18	0.04	1	0.18	0.00116	0.00087	25%
6	St. Matthew blue king crab	4b	0.05	3.34	1978-2019	1.12	0.34	1	0.18	0.05	0.04	25%
7	Norton Sound red king crab	4a	0.18	2.05	1980-2020 [MMB]	2.27	1.11	1	0.18 (0.58 >124 mm)	0.29	**0.17**	**40%**

[1] For Tiers 3, 4 where B_{MSY} proxy is estimable, the years refer to the time period over which the estimate is made. For Tier 5 stocks it is the years upon which the catch average for OFL is obtained. MMB on 2/1/21 as estimated using the current assessment for Norton Sound red king crab.
[2] MMB on 2/1/2021 as estimated for Norton Sound red king crab and on 2/15/2021 for all other stocks, using the current assessments.

Table 2. SSC recommendations from the final 2021 SAFE in October 2021. Stocks for which specifications are rolled over between assessments (Pribilof Islands golden king crab and Western Aleutian Islands red king crab) or were set in February or June 2021 are also included. Biomass values are in thousand metric tons (kt). Tier designations in this table are based on the projected stock status in 2021/2022. Stocks for which the SSC recommended different harvest specifications from the CPT are bolded. Harvest specifications for SAFE Chapters 1 – 4 and 6 are set in October and Chapters 5 and 8 – 10 are set in June, in the year according to the assessment frequency cycle (see current SAFE Introduction for assessment cycle). Chapter 7 (Norton Sound Red King Crab) is set in February. CONT.

SAFE Ch.	Stock	Tier	F_{OFL}	B_{MSY} or $B_{MSYproxy}$	B_{MSY} basis years[1]	2021/22[2] MMB	2021/22 MMB / MMB_{MSY}	γ	Natural Mortality (M)	2021/22 OFL	2021/22 ABC	ABC Buffer
8	Aleutian Is. golden king crab[3]	3a	0.61 (EAG) 0.57 (WAG)	12.05	1987/88-2017/18	14.82	1.23		0.21	4.817	**3.372**	**30%**
9	Pribilof Is. golden king crab	5	-	-	See intro chapter	-	-	-	-	0.093	0.070	25%
10	W. Aleutian Is. red king crab	5	-	-	1995/96-2007/08	-	-	-	-	0.056	0.014	75%

[3] AIGKC OFL and ABC calculated by combining two separate assessment models for the EAG and WAG, as presented in the current assessment

Table 3. Maximum permissible ABCs for 2021/22 and SSC-recommended ABCs for stocks where the SSC recommendation is below the maximum permissible ABC, as defined by Amendment 38 to the Crab FMP. Stocks for which specifications are rolled over between assessments or were set in February or June 2021 are included. Values are in thousand metric tons (kt). Harvest specifications for SAFE Chapters 1 – 4 and 6 are set in October, and Chapters 5 and 8 – 10 are set in June, in the year according to the assessment frequency cycle (see current SAFE Introduction for assessment cycle). Chapter 7 (Norton Sound Red King Crab) is set in February.

SAFE Ch.	Stock	Tier	2021/22 Max. ABC	2021/22 ABC
1	EBS Snow Crab[1]	3	7.5	5.6
2	Bristol Bay RKC[2]	3	2.18	1.78
3	Tanner Crab[3]	3	27.14	21.74
4	Pribilof Islands RKC[4]	4	0.857	0.648
5	Pribilof Islands BKC[5]	4	0.00104	0.00087
6	Saint Matthew BKC[2]	4	0.05	0.04
7	Norton Sound RKC[2]	4	0.288	0.17
8	Aleutian Islands GKC[2]	3	4.793	3.372
9	Pribilof Islands GKC[5]	5	0.092	0.070
10	Western Aleutian Islands RKC[5]	5	0.056	0.014

Basis for P* calculation of Max ABC,
[1]P* was not used to calculate the Max ABC for this stock therefore Max ABC = OFL
[2]CV on OFL
[3]MCMC
[4]CV on terminal year biomass
[5]Tier 5 (90% OFL)

Eastern Bering Sea Snow Crab

The SSC received a presentation of the 2021 snow crab stock assessment from Cody Szuwalski (NOAA-AFSC), with additional information regarding the CPT discussion and their subsequent recommendations from Katie Palof (ADF&G, CPT co-chair) and Martin Dorn (NOAA-AFSC, CPT co-chair). The SSC acknowledges the highly compressed time-frame in which crab assessments are required to be produced and the hard work of the survey scientists, assessment analyst, and the CPT in trying to develop the most reasonable approach given challenges with the assessment model and marked declines in survey estimates for all size and sex classes of snow crab. Specifically, the **SSC recognizes that this snow crab assessment represents the best scientific information available (BSIA) under very unexpected circumstances**.

The SSC received extensive public testimony, both oral and written. Oral testimony was provided by Scott Goodman (BSFRF) highlighting the economic importance of crab stocks, the BSFRF's 2021 and ongoing support for the Bering Sea trawl survey, the need for an annual northern Bering Sea trawl survey and new deeper survey stations, and the importance of achieving model stability for snow crab, likely through transition to the GMACS framework. Cory Lescher (ABSC) commented on the need for deeper stations on the trawl survey to address unknown crab biomass on the slope in the absence of a full slope survey. Siri Dammarell (Brekkaa Fisheries, small business owner) commented on the economic effects of crab fishery reductions, and in 2020 – 2021 catches occurring at different depths (115 – 125 fa) and in different areas than in historical years. Jamie Goen and Cory Lescher (ABSC) also identified the concerns over the current model and large impacts of the potential changes in the crab fisheries. Rick Shelford (Shelford's Boat Ltd.) reported fishing deeper (103 – 180 fa) than in recent years with high catch rates of legal male crab, noting 30% of his quota caught outside the standard survey area. Casey McManus (F/V Cornelia Marie) reported fishing deeper and farther north than in recent years. Frank Kelty (City of Unalaska) commented on the potential loss of information if the fishery is closed entirely. Leonard Herzog (self; F/V Tempo Sea, BSFRF Board member) commented on the benefits of even a small fishery and the importance of determining functional vs morphological maturity. Gretar Gudmundsson (F/V Provider) commented on the applicability of management boundaries relative to the current biological distribution. Mateo Paz-Soldan (City of Saint Paul Island) and Heather McCarty (Central Bering Sea Fishermen's Association; CBSFA) noted the severe community consequences of crab reductions.

Written testimony was also received from Scott Goodman (BSFRF), Jamie Goen (ABSC), Amos T. Philemonoff, Jr. (Aleut Community of St. Paul Island), and Jake Jacobsen (Inter-Cooperative Exchange). The BSFRF letter notes confidence in the 2021 NMFS survey results, highlights the need for research on snow crab movement into deeper waters and into the NBS, supports prioritizing the development of a GMACS-based model for snow crab, stresses the need to understand changing snow crab distributions relative to existing management boundaries, and reiterates BSFRF's desire to ensure continuing support for ongoing crab research. Alaska Bering Sea Crabbers supports BSFRF comments and specifically highlights the need for further development of the GMACS platform, including a spatial modeling approach to better account for snow crab outside of the current survey area, encourages industry efforts to reduce bycatch and expresses support for at least a small snow crab fishery. The Aleut Community of St. Paul Island supports the switch to a GMACS model, the addition of deeper survey stations in the 2022 survey,

and new ways to reduce bycatch of crab in all fishing sectors. The Inter-Cooperative Exchange highlights the impacts of likely reductions in snow crab catches on the industry's ability to engage with the Council and is actively looking for ways to work on solutions.

The SSC recognizes the critical economic importance of this fishery, the broad impacts of an abrupt change in stock trend and status, the concerns over model stability, the lack of comprehensive survey data covering the entire crab range (i.e., waters deeper than the shelf survey and the NBS) to inform the model, and uncertainty about whether distributional shifts or changes in mortality explain recent observed trends. The SSC responded to the recommendations brought forward in public testimony as detailed below.

The SSC notes that the snow crab stock is currently estimated to be at the lowest mature male biomass in the NMFS trawl survey time-series, resulting from a large and unexpected decline from the previous observation in 2019. In tandem with the downward aggregate crab biomass trend from the trawl survey, this appears indicative of major changes in many of the crab stocks and ecosystem in the Bering Sea.

The SSC had a limited set of models to compare, none of which were previewed in June, which severely constrained the standard approach to model selection. It was unexpected and unfortunate that model 21.1 (last year's model with this year's data) did not converge and therefore could not serve as the normal starting point and/or fallback if new models were not determined to be satisfactory. Converged models considered by the author, CPT and SSC included:

- 21.1a: 20.1 + this year's data + empirical availability specified for the BSFRF data
- 21.2: 21.1a + increased natural mortality in 2018–2019 + tighter priors on M and maturity smoothness
- 21.3: 21.1a + increased natural mortality in 2018–2019 + empirical selectivity

As the base model did not converge, the SSC also considered last year's accepted model fit to last year's data as an option to fall back on (notated as model 20.1 in the SAFE). However, in light of the very large observed change in biomass since 2019, which was not reflected in the 2020 stock assessment, the SSC did not consider using 20.1 for advice even with an increased buffer. **The SSC identified significant concerns with all three models (21.1a, 21.2, and 21.3)** and noted that, if a careful Tier 4 calculation had been available, it might have been used. Major concerns with the three models considered fell into several general categories:

- *Technical issues*: The current model structure appears unstable – simply adding one year of data should not generally result in an unconverged model. Different data weighting approaches should have resulted in model convergence. These behaviors, and the very poor retrospective patterns, are indicative of major model misspecification. Under normal circumstances, the SSC would likely have rejected these models and reverted either to the base model or to the previous year's assessment with a reasonable buffer applied, but the lack of a base model that included the new data and the inability of the previous year's assessment to reflect the decline seen in the 2021 survey estimate necessitated updating from the base model or previous model in some way.

- *Mortality/distribution*: The analyses are based on the hypothesis that there has been a major mortality event for snow crab in 2018 and 2019. Although plausible, the SSC notes that a distribution shift into deeper waters and to the north and west, including transboundary movements, may also be contributing to observed trends. Current approaches are limited in exploring these factors by the lack of NBS data in the stock assessment and the lack of data from deeper waters and from Russian waters. At least in the short term, the management response might be the same, but looking farther ahead, delineating between these hypotheses will be critical. If distribution is playing a role, revisions to the data included in the model and/or to the way in which the population dynamics are modelled will be required. The SSC agreed that increased predation, increased disease prevalence, and changes in cold pool extent / bottom temperature are plausible mechanisms for increased mortality, but that the timing of these changes does not seem to closely align with the elevated mortality as currently modelled. There are significant implications for the projected 2022 status if there was a mortality event and it continues. Although more investigation is needed, only additional survey data will ultimately help reduce these uncertainties. The SSC highlights the critical nature of the missing survey in 2020 – the drop in biomass could have been detected earlier, and a second data point would now be providing support (or not) for the 2021 estimate. Simulations of missing one year of data could not have reasonably included this kind of surprise, and this is a good illustration that efforts to predict the cost of missing 2020, while valuable, cannot substitute for an actual survey.

- *Maturity*: The definition of male snow crab maturity is extremely important to the calculation of the appropriate level of fishing mortality for this stock. The SSC identifies the need to model the biology as accurately as possible, and the current models include quite different estimates for the proportion of mature snow crab at intermediate lengths.

- *Selectivity/availability*: The fully nonparametric selectivity used for the NMFS trawl survey appears to be overparameterized (i.e., Figure 44 in the SAFE). Parameters associated with the BSFRF data were identified by the author as contributing to the large gradients observed for some models. The CPT noted that there had been no review of the new approach to empirical availability and selectivity in earlier meetings, and that additional investigation would be helpful.

The SSC was unable to identify a better alternative than the model supported by the author and CPT (21.2). Therefore, the SSC recommends using the OFL, ABC and stock status from model 21.2. That places this stock in Tier 3c, below the minimum stock size threshold in 2020/21, and projected to be in Tier 3b in 2021/22. Importantly, this is based on the assumption that there are no additional years of elevated natural mortality beyond 2018 – 2019. The SSC also supports the CPT recommended buffer of 25% from the maximum ABC. Following the CPT's basis for this buffer, the SSC noted that the buffer implemented by the SSC in 2020 was 25%, which included an additional 5% to account for the lack of a 2020 NMFS bottom trawl survey. Previous assessment issues included in the buffer were concerns over the ability to estimate M (and its impact on biomass estimates), and the strong retrospective patterns in the assessment. The SSC agrees that the additional 5% buffer is no longer needed because a survey was conducted in 2021, but concurs with the additional uncertainties identified by the CPT: 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. The SSC notes that the large observed drop in the 2021 survey estimate is captured by the model and therefore already included in the result, and so does not warrant further adjustment via the ABC buffer at this time.

Given the concerns with this year's available models, the SSC highlights that next year's model, which should include major revisions to the current approach, could result in a different status and/or perception of recent stock trends.

The SSC recommends that, for the 2022 assessment, the authors provide a Tier 4 calculation, using the NMFS trawl survey MMB, as the base model. This is intended to provide a stable calculation as an available 'fallback' in case challenges with the full Tier 3 assessment cannot be resolved. The SSC does not anticipate moving this stock to Tier 4 in the long term.

The SSC recommends extending the NMFS trawl survey into deeper waters, by adding stations to the standard EBS and NBS designs. A short-term experimental pot survey spanning between the shelf and slope depths (150 - 300m) could also provide insight on snow crab depth distribution and comparison to trawl survey observations, but the SSC cautions that starting a new survey time-series would be far less informative than extending an existing effort. The SSC recognizes that a model-based estimator may be necessary to incorporate additional data with standard designs and suggests **planning of these efforts should include survey and assessment leads to ensure that data can be used effectively.**

Other recommendations follow the author and CPT priority research topics, and those identified by the CIE review, including improving the approach to data weighting, using geostatistical modelling, and addressing the poor retrospective patterns. **Generally, the SSC recommends revisiting many aspects of the assessment, aiming for a broad reduction in complexity and/or reparameterization such that this assessment can provide more stable management advice. Specific recommendations include:**

- Implementing the assessment in GMACS, after adding the ability to accommodate a time block on natural mortality to that framework. **This should be made a critically high priority for the next assessment**. **Further, the SSC requests that a 'cross-over' model (perhaps 20.1 or another converged analysis) be provided as a link between historical models and a full implementation in GMACS.**

- Further evaluation of the hypothesis of elevated mortality in 2018 – 2019. This should include developing a clear justification for the choice of years, preferably quantitatively linking hypotheses to known data sources (e.g., Pacific cod abundance), possible new sources of mortality (e.g., large increases of sablefish in the EBS while Pacific cod have decreased) or covariates (e.g., temperature) that will allow objective assignment of years and the potential for prediction of such events in the future. **A combination of both mortality and distribution shifts should also be considered in the next assessment.**

- Revisit the characterization of maturity. Consider under what conditions (e.g., lower density, environmental conditions) smaller crab may or may not be reproductively successful. The SSC recommends caution in applying knife-edge maturity schedules based

on functional maturity studies from other areas that are not well supported, and instead expanding the considerations to include reproductive potential (e.g., clutch fullness or other metrics). Also consider whether smaller crab, especially in the NBS could be contributing to spawning output.

- To fully use all of the information, but not double count the data, fit the GMACS model to total survey abundance (or possibly biomass), not just the mature components, and use compositions by size, sex, and maturity.

- Move to a model-based estimator (e.g., VAST) for the NMFS trawl survey index; this could simplify the current use of two time-periods reflecting survey design and allow inclusion of data from the NBS as well as any additional stations that can be added in deeper waters in future trawl surveys. To respond to dynamic crab distributions under continued environmental change in the Bering Sea, the use of a modelling approach to the survey index may be increasingly important.

- Continue using the BSFRF data as a prior on the NMFS trawl survey selectivity, but simplify that parameterization from the current fully non-parametric approach. Although the SSC has previously encouraged including the BSFRF data directly in the assessment, the convergence issues reported for parameters associated with this source of information suggest removing the BSFRF data from direct model fitting or adjusting how they are treated within the model. It may also be helpful to analyze the BSFRF information as pairwise data rather than pooled, with a specific consideration of whether this would reduce the strange selectivity peak at 50 mm.

- To improve understanding of the effect of each specific piece of information (e.g., catch, survey index, fishery size compositions, etc.) on model results and performance, bridging analyses should include additional steps as each new data set is added (rather than the entire year in one 'jump').

- Do not report 'results', especially management quantities, for models that did not converge.

- The SSC noted public comments reflecting observations of higher abundances of large crabs in deeper waters, beyond those indexed by the Bering Sea shelf survey, and suggests that these local knowledge-based observations are extremely helpful. The SSC requests two items be reported in future assessments: 1) The temporal trend in the depth distribution of observed fishery CPUE, and 2) the same information for shelf trawl survey catches. This may be helpful in identifying whether the survey and fishery encounter crab at the same depths, and if not, could provide some indication of what portion of the crab stock is unavailable to the shelf survey. This summary could be either stratified spatially, or not, at the discretion of the authors. Evaluating this match or mismatch between crab depth distribution and the survey footprint over time could also provide a foundation for beginning to assess whether variation in survey catchability (based on the standard survey footprint) may be correlated with oceanographic processes.

    - Further, the SSC suggests that a genetic study including Russian waters would be helpful for assessing the potential for a transboundary snow crab stock.

- The SSC also noted a pause in the development of snow crab ESP community/social

indicators and provided recommendations in the ESP section under SSC General Comments and Administrative Discussion, above.

Finally, the SSC recognizes a fundamental problem with the timing of the snow and other crab stock assessments relative to data availability and the review process. The SSC notes that two weeks is insufficient time for assessment analyses that encounter major technical challenges and/or unexpected changes in the input data such as the large drop in the 2021 survey. Specifically, for snow crab in 2021 there was not time to: 1) do a more detailed bridging analysis from last year's model, 2) complete the jittering analysis needed to fully evaluate convergence, 3) include the NBS survey data, and 4) evaluate mortality and movement hypotheses proposed as models. The SSC recognizes that the North Pacific region realizes a great benefit from using the current year's survey results in the stock assessments, but that it is necessary to have a schedule that will allow sufficient time to produce and review quality assessments even when there are unexpected changes in population dynamics and quickly changing environmental conditions. **The SSC therefore recommends a major revision to the timing of the snow crab assessment and review process (and possibly also for tanner crab and BBRKC); this could require a delay in setting the specifications or initiating the fishery.**

Bristol Bay Red King Crab

The BBRKC assessment was presented by Martin Dorn (NOAA-AFSC, CPT co-chair). Written public testimony was provided by Braxton Dew (self), Maria Painter (self), Jake Jacobsen (Inter-Cooperative Exchange), Jamie Goen (ABSC), Scott Goodman (BSFRF), Mateo Paz-Soldan (City of St. Paul Island), and Heather McCarty (CBSFA). Braxton Dew submitted a copy of a complaint submitted to Public Employees for Environmental Responsibility. The complaint focused on possible methodological problems with NMFS historical survey trawl estimates. Maria Painter and Jake Jacobsen's letter requested that the SSC consider the possibility of unreported mortality associated with trawl fisheries and the need for emergency closures. In oral testimony presented in addition to their written testimony, Mateo Paz-Soldan, Heather McCarty, and Jamie Goen all noted the catastrophic impact of reductions in crab abundance and associated constraints on fishing on crab dependent coastal communities. Ms. Goen, in written and oral testimony, noted the northward movement of the stock and proposed an expansion of the closure area to the north. Scott Goodman offered written and oral testimony that described future tagging research and stressed the importance of research on mature female crabs both because of their current northward movement and to learn more about larval drift. Oral testimony was also received from Rick Shelford (Shelford's Boat Ltd.), Gretar Gudmunson (F/V Provider), Casey McManus (F/V Cornelia Marie), and Siri Dammarell (Brekkaa Fisheries). Mr. Shelford testified to the presence of a large biomass of males in the northern part of the region and the challenges of the survey grid being too wide to detect aggregated crabs. Mr. Gudmunson was concerned about the arbitrary borders delineating the stock when most of the females are now at the northern border or across it. Mr. McManus testified to the good fishing in the northwest corner they experienced with very large males in the catch. Ms. Dammarell concurred with the other testifiers on the potential negative impact to their business and testified that crab caught on their vessel were large and clean.

In past years, the SSC has requested model runs to explore the mechanisms underlying the sharp decline in BBRKC abundance in the early 1980s. The results of these runs have informed current management of this valuable resource. The SSC notes that the PEER complaint is awaiting a

formal response from NMFS, therefore the SSC will reserve further comments on the specific allegations in the complaint until a response from the agency is provided. With respect to potential unobserved mortality due to trawling, the SSC encourages Ms. Painter and Mr. Jacobsen to review the upcoming catch-in-areas analysis associated with the EFH update to assess time trends in the trawl gear footprint.

The 2021 BBRKC stock assessment was updated with NMFS trawl survey data through 2021, directed pot fishery catch and bycatch data through 2020 (i.e., completed 2020/21 fishery), and updated/standardized observer biomass estimates in the directed pot fishery and Tanner crab fishery from 1990 to 2020. Fishing effort data used to estimate red king crab bycatch in years before the observer data in the Tanner crab fishery were changed from east of 163^0 W to east of 166^o W, which covers the large majority of the Bristol Bay red king crab stock. Five more years of length composition data with relatively small observed sample sizes from the Tanner crab fishery were also added (occurred in May 2021). Groundfish fisheries bycatch data were updated during 2014-2020. **The SSC agrees with the author's use of these new data in the assessment.**

The SSC thanks those individuals who participated in the survey and in data processing. This was another challenging year for data collection and the SSC is thankful for the extra time and effort it took to process the information in time for use in the current assessment. Results from the 2021 NMFS trawl survey revealed that male biomass estimates in 2021 were slightly higher than those in 2018 and 2019, but the survey female biomass estimates were lower. The "re-tow" protocol was triggered in 2021. This protocol is usually triggered in years with cold bottom conditions (delaying egg hatching and subsequent extrusion of a new clutch). However, in 2021 the cold pool was evident only north of St. Matthew Island. Given that the cold pool was distributed to the north and ocean conditions were warmer than past years when re-tows were required, **the SSC requests that, in addition to temperature effects on the timing of the molt-mate cycle, the authors explore other potential drivers (e.g., prey quality or quantity) that could underlie the incomplete molt-mate cycle observed in 2021. Based on NMFS trawl survey female biomass estimates, the State of Alaska closed the BBRKC fishery.** The SSC appreciates the added work it took to "re-tow" stations in 2021 and process the data in a timely manner.

The SSC reviewed the CIE reports from Drs. Ernst, Chen and Caputi. The SSC appreciates the thoughtful comments and suggestions provided by the reviewers and the author's attention to some of the issues raised in the reviews. As noted in the reviews, understanding the movement of BBRKC out of the historical management area remains a concern and the **SSC supports the CPT recommendation for research to resolve spatial movements of BBRKC in the future**. The SSC received data and public testimony that the stock boundaries are perhaps becoming less representative of the true stock distribution. The SSC recommends that authors should carefully consider assessment implications of the stock boundaries given the evidence of crabs outside of the managed area. The SSC suggests that the authors should still be able to use data from outside stock boundaries, even if not used in the input survey abundance estimates. For example, the abundance seen outside stock boundaries could be treated as covariate informing catchability within the model. This analysis seems particularly important for females that are increasingly outside of the current stock boundaries and are at low abundance, triggering the State closure. The SSC recommends that the authors formulate separate survey abundance time series inside and outside of the defined area that could prove useful in the assessment model (e.g., informing catchability). If this is not an option in the stock assessment, then it highlights the need for ESRs

or ESPs to track movement of these crabs both through survey results and developing indices from local knowledge.

The SSC appreciates the author's responsiveness to the SSC's June 2021 request to see Models 19.3d, Model 19.3e and 19.3g. The SSC also appreciates the inclusion of a simplified version of model 19.3d that estimates one natural mortality parameter across sex and time, and one shared catchability and selectivity curve for the NMFS trawl survey to make several selectivity parameters better defined (21.0). The results of model 21.0 that estimates a single M over time and for both sexes seem to fit the survey and fishery length data in the 1980s well for males, but severely over-predicts large females. It would be useful to investigate if there is a mechanism for higher natural mortality or fishing mortality for females only during that early time period while following the CPT recommendation of looking at model 21.0 with constant but separate Ms by sex. Since Model 21.0 estimates a very high level of fishing mortality, but does seem to account for the decline in large females, there may be a fishery selectivity issue in that period. If the modelers choose not to continue to use historical data prior to 1985, this suggestion may not be useful.

The SSC agrees with the author and CPT rationale for selection of Model 21.1 as the base model for the 2021 assessment. Model 21.1 shares survey selectivity curves between sexes and thus has six fewer parameters than 19.3d and has similar fits to the data. The SSC appreciates this more parsimonious approach. The SSC carefully considered model 21.2 because this model addressed issues associated with the retrospective performance of the model. Although Mohn's rho drops from 0.347 for model 21.1 to 0.223 for model 21.2, the SSC agrees with the author and the CPT that the drop in productivity was not pronounced and the model adds a special mortality period without additional rationale. The SSC also supports the CPT recommendation to consider constant M scenarios with a sex-specific M for 2022. The SSC supports continued exploration of the use of VAST estimates for this assessment, particularly if their use will inform mechanisms underlying shifting distributions outside of the current management area. **The SSC supports the BSFRF collaborative work with ADF&G and NMFS to tag BBRKC.** This work, in conjunction with VAST model explorations and BBRKC diet studies, is expected to inform the mechanisms underlying observed shifts in distribution into the Northern District.

Results from model 21.1 place the stock in Tier 3b. The SSC accepts the recommended 2021/22 OFL and a 20% buffer for the ABC (Table 2). **The analysis shows overfishing was not occurring and the stock was not overfished**. Key justifications for the 20% buffer include continued concerns regarding shifting spatial distributions to the north. The SSC appreciates the authors' response to CPT recommendations regarding the evaluation of whether the stock was approaching an overfished condition. The SSC agrees with the CPT that the ratio of MMB/BMSY for each realization in the MCMC should be used to determine if the probability of the stock falling below $0.5*B_{MSY}$ when fished at F_{OFL} was greater than 0.5. Based on the revised results using the CPT analytical approach, **the SSC agrees 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 SSC reviewed the ESP and offers the following general comments and recommendations. The authors dropped five indicators that were perceived to be redundant or already in the model. The SSC appreciates the authors' efforts to reduce redundancy in the selection of socioeconomic indicators, but noted the lack of community/social indicators (see the ESP topic under SSC General

Comments and Administrative Discussion, above). The SSC requests that the authors check the inverse correlation between summer cold pool extent in Bristol Bay and summer bottom temperatures in Bristol Bay and consider whether they are related to differing hypotheses (i.e., if they are related to the same hypothesis they may be redundant, but if they are related to different hypotheses, or the same hypothesis at a different scale, they may not). The SSC suggested that in future assessments the authors should consider utilizing information from either Regional Ocean Modeling System (ROMS) output or survey temperatures adjusted to a mean collection date within a VAST modeling framework. This would allow for the exploration of thermal effects on distribution.

The SSC provided specific comments on two of the indicators selected for inclusion in the ESP. The SSC requests that the authors compare satellite derived estimates of spring chlorophyll-a with comparable estimates derived from the ROMS model. The SSC notes that subsurface phytoplankton blooms could be missed by satellite derived estimates. The SSC requests that authors ensure that the Pacific cod biomass reflects the area where predator and prey distributions overlap during relevant life stages (size). Finally, the SSC requests that the authors consider whether including red king crab recruitment biomass as an indicator is redundant because this information is already included in the model.

Tanner Crab

The SSC received a presentation of the 2021 EBS Tanner crab assessment from Katie Palof (ADF&G, CPT co-chair) and Martin Dorn (NOAA-AFSC, CPT co-chair), including CPT discussions and resulting recommendations. No public testimony was provided.

The 2021 NMFS summer EBS trawl survey revealed a decrease in abundance of both mature male and legal male Tanner crab in both the east and west areas when compared with 2019 survey estimates, while the abundance of pre-recruit male and mature female crabs increased over this same time period.

The Tanner crab stock has been assessed with a size-structured model since 2012, which is currently informed by abundance and size compositions from the NMFS EBS trawl survey, landings and discards from the directed fishery, and bycatch in the BBRKC, EBS snow crab and groundfish fisheries. In recent years this assessment has struggled with striking an optimal balance in model complexity, resulting in persistent issues with parameters estimated at or near bounds and retrospective patterns in recruitment. However, the authors have made a concerted effort to address these issues and the SSC commends their efforts in this area and responsiveness to past SSC comments.

Four models were presented by the assessment authors, including:

- **Model 20.07u** – The model used in 2020 for assessing stock status with updated data from 2020/21.
- **Model 21.22** – A CPT- and SSC-recommended alternative that directly estimates the extent of recruitment variation, explored alternative functional forms for fishery and survey selectivity, fixed directed fishery retention at 100%, and utilized alternative likelihoods for fishery catches and BSFRF survey size compositions.

- **Model 21.22a** – An updated version of 21.22 that reparameterized the selectivity function for male crab in the NMFS EBS shelf survey as half-normal rather than logistic, fixed several survey and fishery selectivity parameters, and constrained rather than freely estimating the extent of recruitment deviations.

- **Model 21.24** – A CPT- and SSC-recommended alternative to 21.22 where growth is estimated outside of the model.

The SSC notes that Model 21.22 successfully converged with no parameters hitting bounds in May 2021, but when confronted with updated 2020/21 data encountered parameter bounding issues for five model parameters and exhibited several jittered model runs that did not converge to the maximum likelihood estimate. The reparameterized and constrained version of Model 21.22, Model 21.22a, exhibits adequate performance with no parameters hitting bounds and reasonable fits to most data inputs. However the SSC notes that this assessment model continues to underestimate periods of high survey biomass. **The SSC supports the use of Model 21.22a for 2021/2022 harvest specification.**

The authors implemented MCMC sampling to quantify uncertainty in model estimates for quantities of interest. The SSC notes that trace plots for model parameters indicate significant autocorrelation in MCMC chains and rather poor mixing, both of which are undesirable for Bayesian inference. The authors have attempted to address this with a long MCMC burn-in period and extensive thinning (saving 1/10,000 iterations); however, these remedies do not appear to have fully addressed this issue. The SSC suggests that there are likely still model considerations with respect to misspecification and complexity which may be resulting in these MCMC sampling challenges that need to be addressed. However, the SSC notes that the distributions are unimodal, and are extremely similar to the MLE estimates, so **the SSC supports the CPT recommendation to base management recommendations on the Bayesian posterior probability distributions at this time and suggests continued work to address model structural concerns.**

Based on Model 21.22a, the 2021/22 mature male biomass is estimated at 118% of B_{MSY}, thus qualifying this stock under Tier 3a. **The SSC accepts the 2021/2022 OFL (Table 2)**, based on the Tier 3a OFL control rule.

The CPT recommended continuation of the 20% buffer between OFL and ABC for 2021/22 that was adopted in 2020. **The SSC supports the CPT recommendation of a 20% buffer between OFL and ABC**, reflecting uncertainty due to the lack of survey data for 2020 and the resulting severe decline in recruitment for 2019, the observation that recruitment pulses observed at small sizes in surveys have not subsequently resulted in large year classes in the modelled population, and the poor fits to the data for large crab.

A wide range of recommendations for future model development were identified by the assessment author and endorsed by the CPT, with several additional recommendations from the CPT for future work. The SSC broadly supports these suggested areas of future model development and research, highlighting in particular:

- Efforts to simplify the model structure.

- Continued investigation of the use of VAST estimates of survey biomass and size composition to inform the assessment.

- Implementation of the EBS Tanner crab model in GMACS.

The SSC reiterates its suggestion from October 2020 to prioritize development of a projection model for crab that doesn't assume the entire OFL is removed, which is especially important for the EBS Tanner crab stock where exploitation is routinely below the OFL.

With respect to the treatment of selectivity within this assessment the SSC supports continued exploration of alternative ways to approximate temporal variation, given known, among-year differences in the location of fishery prosecution, including through direct comparison of random walk and time block specifications where appropriate. However, the SSC suggests balancing model complexity exploration of the extent to which survey or fishery selectivities may be shared among time periods or sexes is warranted, drawing particular attention to NMFS survey selectivity.

The SSC highlights that determining the right level of model complexity is a challenging task, and appreciates when authors explore the use of simpler alternatives to explore the degree of explanatory power gained by adding specific model variations that increase complexity of the model with the hope of capturing process nuances. The SSC recommends incorporating this approach as a regular practice in framing the degree of complexity subscribed to for a particular assessment. The 1998 NRC report Improving Fish Stock Assessments recommended having alternative model formulations at hand, which can be used to provide a reality check regarding model complexity, but also provide better understanding of contributions to model fit, as well as levels of uncertainty and the reliability of predictions.

The SSC continues to support the investigation of model outputs that better inform State management, especially males of industry-preferred size to ensure proper scaling.

Pribilof Islands Red King Crab

PIRKC is a Tier 4 stock that was moved from a biennial to a triennial assessment schedule earlier this year, with the next full assessment now to be completed in 2022. The SSC recommends harvest specifications for 2021/2022 be retained from the last assessment in 2019, as specified in Table 2 in the SSC report, as well as to continue to apply a 25% ABC buffer. The stock is not overfished, and the total catch in 2020/2021 was below the OFL so overfishing did not occur.

St. Matthew Blue King Crab

With the decision to move SMBKC to a biennial assessment cycle earlier this year, the CPT recommended that harvest specifications for 2021/2022 be retained from last year's assessment (Table 2). The SSC concurs with this recommendation. SMBKC is a Tier 4 stock. SMBKC is overfished and under a rebuilding plan that was put in place in 2020. The total catch in 2020/2021 was less than the OFL, so overfishing did not occur. The next full assessment for SMBKC will be completed in 2022.

Overfishing Determinations

PIBKC was assessed in June 2021 as a Tier 4 stock and harvest specifications for 2021/2022 were set at that time. The CPT provided an update on the total catch, which is below the OFL and so overfishing did not occur. PIBKC continues to be overfished.This stock is on a biennial schedule.

In June, the SSC supported moving the PIBKC assessment to the September/October meetings, so the next full assessment will occur in September/October 2023. The SSC also received overfishing status updates for AIGKC, PIGKC and WAIRKC. Catch for each of these three stocks was below the OFL, so overfishing did not occur in 2020 for PIGKC and in 2020/2021 for AIGKC and WAIRKC. AIGKC is assessed annually in June but the harvest was not complete at the time specifications were adopted. The SSC concurs with the CPT that the AIGKC assessment author should be projecting catches to the end of the season in the assessment model if harvest is not complete by the time of the assessment. PIGKC and WAIRKC are assessed on a triennial schedule, where the OFL and ABCs from their respective 2020 assessments will remain in effect until updated assessments are presented in 2023.

Norton Sound Red King Crab Model Runs

The SSC received a presentation on proposed Norton Sound Red King Crab (NSRKC) model runs for February. The SSC thanks the authors for their responses to the SSC comments and suggestions. In addition to the base model (19.0), two new models were presented, 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 with three time blocks, and two retention probabilities estimated for both the summer and winter commercial fisheries. Model 21.1 is Model 21.0 plus M = 0.18 for all size classes. The change in natural mortality in 21.1 results in a lower overall biomass trajectory, as expected with a lower M. The SSC requests that authors examine and describe differences among models caused by standardizing CPUE into three separate blocks.

The SSC supports the CPT recommendations to bring forward both Models 21.0 and 21.1 in February, in addition to the base model, 19.0, with updated data. Better documentation in the future is necessary to compare changes in models. Stepwise changes in models are necessary, including changing retention probabilities and the CPUE separately, and other bridging analysis models.

The draft assessment suggests that the model would be better fit with a higher M, and the authors should attempt to estimate overall M rather than fix all length classes at the lower value. The SSC recognizes that the author brought forward alternative models 19.4 and 19.5 in 2020, but suggests this be evaluated again with more description for further contrast with Model 21.1. The rationale that it may result in a higher OFL should not prevent exploring a higher value for M if that may be the best description of the dynamics. **If feasible for February, the SSC would like to see a variant of 21.0 with an estimated natural mortality.** The SSC still hopes to see a GMACS version of the model, but recognizes this may not be possible by February. A verbal update on the status of the GMACS model would be helpful for the SSC at that time.

The SSC looks forward to learning about the mortality and maturity studies being done at the Kodiak lab as well as results from the recovered satellite tags when they are fully analyzed.

The authors noted that the State observer program was cut due to lack of funding since the last assessment, which will present a serious challenge for calculating discards and total OFL for future assessments. Alternatives should be explored including local knowledge. **The SSC agrees with the CPT that the OFLs should be based on total catch** and requests that the authors bring forward methods to use historical data to estimate discard rates.

The SSC had requested that the authors determine why the standard errors were all the same for the CPUE index since 2000. Appendix B (Table B-5) shows they are now slightly variable for that time period, but they are much lower than the earlier years in the model. The authors explain that the log SDs are "exponented (sic) back to normal space." This is not typically how log-sds should be used, so further clarification of the CPUE index in Appendix B and how the year effects are extracted would be helpful.

Risk Tables

Risk Tables were taken up under both C1 CPT report and C6 Joint Groundfish Plan Team (JGPT) report. Please refer to C6 JGPT Report for the SSC responses to the Plan Teams' review of Risk Tables.

C4 BSAI Pacific cod Trawl CV LAPP

The SSC received a presentation from Jon McCracken (NPFMC), Darrell Brannan (Brannan & Associates LLC), and Mike Downs (Wislow Research). Written testimony was received from Amos Philemonoff, Sr. (Aleut Community of St. Paul Island), Phillip Lestenkof (Central Bering Sea Fishermen's Association; CBSFA), Heather Mann (Midwater Trawlers Cooperative), and Jon Warrenchuk (Oceana). Oral public testimony was received from Heather McCarty (CBSFA) and Lauren Divine (Aleut Community of St. Paul Island); Jon Warrenchuk (Oceana) was unable to testify due to technical difficulties but referred to his written testimony.

The SSC expresses its appreciation to the Council for specifying a preliminary preferred alternative (PPA) to allow the analysis to focus on the most relevant permutations of the elements and options. The SSC commends the analysts' responsiveness to the guidance and discussion following the previous meeting, especially as they reflect the Council's PPA; the section detailing responses to previous SSC and AP minutes made it easy to identify where information was added to the document.

The revised draft uses the PPA to paint a clearer picture of how various options and elements will work together to achieve the stated purpose and need. In particular, the analysis benefits from the more nuanced distinction between consolidation and specialization in the harvest of Pacific cod, as well as a clearer description of how these co-ops will interoperate with existing co-ops that the same vessels and processors have for other fisheries. Finally, the revised draft provides a more complete characterization of experiences with ex-vessel price effects and market power effects in the presence of various mitigating measures. **The SSC recommends this draft as sufficient to inform decision making by the Council at final action**.

As the analysis indicates, key decisions about the structure of this LAPP will need to be made with incomplete information, as the industry structures and program designs of prior experiences do not closely match those of the proposed program. The SSC had a lengthy discussion of the evidence supporting the need for, and efficacy of, the market power balancing measures. The SSC notes that, globally, empirical evidence for significant shifts in ex-vessel prices following introduction of harvest quota is mixed at best, raising the question of whether theoretical predictions of imbalances bear out in reality. However, many of these cases have market power mitigation

measures in place, so this may instead provide evidence that existing measures are sufficient. In the North Pacific, and globally, there is experience with catch share programs that are working well, where processor-centered cooperatives (only) are used to balance market power between harvesters and processors and support community stability. There is also experience with a program where processor allocations of harvest quota (only) are generally considered successful. **The SSC cautions that available experience does not provide evidence that layering considerable harvest quota allocations on top of processor-centered cooperatives will result in an appropriately strong market power mitigation measure.** This may particularly adversely impact non-AFA vessels and vessels without established processor-centered cooperatives, whose initial bargaining power is identified as weaker in the analysis.

The SSC strongly encourages the Council to identify the measures on which this LAPP will be evaluated and authorize a collection program for the data necessary to populate metrics Council and NFMS staff identify for quantifying those measures. In contrast to the long-term strategic social and economic data collection planning being undertaken by the SSPT, a targeted tactical data collection program is required to track compliance with National Standard 8 and to evaluate the effects of this program against its specific purpose and need as it goes into effect. Based on past experience, the SSC is concerned that key information needed to evaluate distributional aspects of the program may be lost among inter-cooperative records and not captured in current data streams. Public testimony revealed a particular need for data necessary to track impacts on small communities engaged in harvesting and processing. The SSC notes the reliance of this analysis on the quantifiable experience of the West Coast Trawl IFQ program, made possible by a data collection program that provides insight into harvester-processor relationships and captures information on costs from both harvesters and first receivers who benefitted from the program.

The SSC observes that the specification of the PPA helped focus the latest iteration of the analysis, leading to a presentation that was more focused, concise, and accessible. Even in the absence of a PPA, the SSC recommends future analyses be framed around answering key questions raised about the effects of the action (even if they are not explicitly stated) to keep the document as focused and concise as possible. For example, the recap of the previous literature on the effect of quotas on market power could be better focused around the questions of 1) does quota lead to price increases, and if so, under what conditions? 2) Do processor-centered cooperatives affect this? And 3) do processor allocations of harvest quota affect this?

C5 Annual Observer Deployment Plan

The SSC received a presentation on the 2022 Draft Annual Deployment Plan (ADP) from Jennifer Ferdinand (NOAA-AFSC FMA) and Geoff Mayhew (PSMFC, NOAA-AFSC FMA). There was no public testimony. The draft ADP presented the proposed deployment of observer and electronic monitoring (EM) resources to vessels in the partial coverage and EM programs, which constitute about 10% of total observer effort. The presenters noted that the Fishery Monitoring Science Committee (members from AFSC, AKR, IPHC, and PSMFC), three Council advisory groups (Partial Coverage Fishery Monitoring Committee, the SSC, and the AP), and the Council all provide input to the ADP process.

The analysts reviewed the June 2021 Council's ADP recommendations and provided a brief overview of the 2021 ADP with emphasis on changes relevant to the 2022 plan including expansion to coverage of all ports and expected reductions in deployment costs associated with minimal COVID quarantining between trips.

The analyses in the draft 2022 ADP focused on projecting 2022 fishing effort and determining how to allocate observer effort to sampling strata while remaining within budget. Fishing effort was projected to be approximately the same as 2021 (+/- 11%) using methods in Ganz and Faunce (2019; NOAA/AFSC-TM 395) with modifications for COVID-19. Four partial coverage allocation strategies were explored using simulation methods to compare sampling rates and numbers of sea-days. The Equal Rates strategy applied relative weightings to the size (effort) within each deployment stratum such that fishing trips with gear types that have more trips in the year get proportionally more monitored trips and all logged trips get the same selection probability. The Minimum + Optimization (status quo) strategy applied the equal rates algorithm up to a minimum coverage rate (15%) and then applied an algorithm for additional monitored trips aimed at optimizing estimation of discarded groundfish, Chinook salmon PSC and halibut PSC with every logged trip in a stratum assigned the same selection probability. In response to the Council's June 2021 motion the analysts also examined the Minimum + Trawl Optimization strategy which applied the equal rates algorithm up to a minimum coverage rate (15%) and then assigned all additional monitored trips to trawl vessels. Finally, an Adjusted Minimum + Optimization strategy was explored in which the strata-specific minimum coverage rates were calculated to ensure a 95% probability of achieving the 15% coverage threshold and then applied an optimization algorithm for additional monitored trips for estimation of discarded groundfish, Chinook PSC and halibut PSC.

To determine the degree to which these strategies were likely to generate data representative of unobserved fishing, the analysts assessed the proximity of observed trips to unobserved trips, EM trips, and trips in the zero-selection pool (vessels < 40ft) using a similarity index. Proximity scores were assigned at 4 levels: covered trips, within 15 days and the same NMFS reporting area, within 45 days and the same FMP, and greater than 45 days and within the FMP.

The analysts indicated that the preliminary budget for 2022 was sufficient to support baseline observer coverage. Among the four partial coverage allocation strategies examined, NMFS recommended using the Adjusted Minimum + Optimization strategy for 2022 and 2023. **The SSC commended the analysts for the clarity and increasing sophistication of the ADP analyses and recognized the extensive efforts by the Observer Program to maintain critical data streams under very challenging conditions presented by the COVID pandemic in 2021. The SSC supported all the NMFS recommendations for implementation in the 2022 ADP noting that Adjusted Minimum + Optimization strategy generally performed well relative to the Council's recommendations while also maximizing the probability of achieving the baseline 15% coverage. This strategy was also recommended by the Fisheries Monitoring Science Committee.**

The SSC briefly discussed the NMFS plan to develop an integrated evaluation of the partial coverage category which will account for upcoming changes to the trawl components of partial coverage (BSAI Pacific cod Limited Access Program and transition of Trawl EM to a regulated program) and a new contract for observer coverage in the partial coverage category.

The SSC supports the NMFS recommendation that this effort be conducted holistically with a target date of being fully implemented by 2024.

The SSC emphasized the importance of fishery-dependent data in the management process and points out that our discussion of the impacts of EM expansion on the collection of biological samples can be found under the C6 Joint Plan Team section of the SSC report.

C6 BSAI and GOA Groundfish Harvest Specifications

The SSC received a series of presentations from Grant Thompson (NOAA-AFSC, BSAI GPT co-chair) and Jim Ianelli (NOAA-AFSC, GOA GPT co-chair) that included items from the September 2021 JGPT, BSAI Groundfish Plan Team (BSAI GPT), and GOA Groundfish Plan Team (GOA GPT) meetings.

General Comments

In response to the AI Pacific cod author's and BSAI GPT teams request for guidance on data weighting, **the SSC encourages the Plan Teams and stock assessment authors, perhaps through a working group, to build on previous efforts to develop standard practices for data weighting in stock assessments.**

Joint Plan Team Report

The SSC received a presentation from Grant Thompson (NOAA-AFSC, BSAI GPT co-chair) on the September 2021 JGPT meeting. Dan Goethel (NOAA-AFSC) gave a presentation on the sablefish assessment.

Electronic Monitoring Workshop

The SSC received a report from the JGPT about the AFSC Electronic Monitoring workshop held on July 8, 2021. The purpose of the meeting was to provide a forum for assessment authors to discuss the different EM programs and resultant data collections and pipelines that inform AFSC stock assessments. **The SSC appreciates the work of the participants and supports continued efforts such as these to improve sampling programs and data pipelines used in the assessments.** The workshop concluded with four recommendations: at-sea observers should be deployed in a way that is representative of fishing effort; the Plan Team process (or some other) should be developed so assessment authors can provide coordinated feedback to NPFMC advisory bodies regarding stock assessment data needs; metrics should be developed and shown in stock assessments to help inform on EM program performance and potential impacts; and continued development of methods to accurately estimate catch weight of at-sea discards in the EM strata based on only catch numbers and observer-data derived estimates of weight per fish.

The SSC concurs with the JGPT recommendations to continue work related to the four recommendations from the workgroup. The JGPT also provided the following specific advice:

1. *A process for soliciting and delivering feedback from assessment authors should be developed, making sure to include NPFMC advisory bodies and committees as well as pertinent agency Divisions in the delivery.*

2. *An iterative process will likely be needed to determine the important metrics for assessment authors to report, and whether every assessment should be required to report those metrics.*

The SSC appreciates the JGPT comments and recommends that a working group of assessment authors be formed. This group should work closely with and advise the Fisheries Monitoring Science Committee (FMSC) on sampling issues and performance metrics as they relate to observer deployment**.** The FMSC is a natural nexus for integrating assessment author advice into the Annual Report and Deployment Plan, both of which are provided to the NPFMC and its committees (e.g., PCFMAC and FMAC). Integration of metrics, as described in the JGPT comment, could also be considered by the workgroup as needed, noting that overlap between deployment metrics and other sampling related metrics likely exists. The SSC also highlights that an evaluation of integrating and improving cost-efficiencies for the partial coverage category has been started (see the C5 Draft ADP section in the SSC Report). Coordination between FMSC and a working group of assessment authors would provide a diverse range of expertise that may benefit the evaluation. Finally, this workgroup would also have ancillary benefits by improving coordination among data users and suppliers.

The EM workshop also noted that information about whale depredation, seabird interactions, and marine mammal presence is not currently detectable in EM videos. **These issues are currently of management interest and the SSC encourages further work to obtain these data and/or evaluating new methods to estimate interactions using available fishery and survey information.**

Essential Fish Habitat

The SSC received an overview of the JGPT discussion on Component 1 (EFH descriptions), the plan for Component 2 (fishing effects models, FE), and the stock assessment author reviews of the Component 1 species distribution models (SDMs). The SSC appreciates the detailed review by the JGPT and stock assessment authors. The SSC received public testimony from Jon Warrenchuck (Oceana).

The SSC was pleased by the progress made on the SDMs and generally positive response from stock assessment authors.

The JGPT highlighted a number of concerns regarding the EFH review process and timeline for completion of SSC review in June 2022. Principally, the JGPT noted that the current timeline may preclude a sufficient iterative review process with the stock assessment authors and/or review bodies (e.g., JGPT, SSC), including review of the updated EFH descriptions including responses to comments made during the stock assessment author and Plan Team reviews, as well as the incorporation of new performance metrics not available during the stock assessment author reviews. The SSC notes it also expressed strong concerns during its April 2021 meeting about the timeline providing adequate opportunity for scientific review, and recommended splitting review of components 1 and 2 into two SSC meetings (October 2021 and Spring 2022).

Component products from the EFH process are hierarchical. The SDMs (Component 1) are an integral component of the FE model (Component 2), which, in turn, inform multiple products, from EFH conservation and enhancement efforts (Component 6) and future EFH cumulative

impact analyses to indicators of habitat disturbance levels in the annual Ecosystem Status Reports. This hierarchy complicates reviews because changes to one component can influence another, thus requiring an iterative process for review. Unfortunately, scheduling conflicts prevented the SSC from reviewing Component 1 during this October 2021 meeting.

The SSC is scheduled to review draft EFH results for both Components 1 and 2 in February 2022. An iterative review process, as noted by the JGPT, provides the SSC and NPFMC with well-vetted scientific information. The SSC is concerned that the current timeline may preclude important review opportunities for stock assessment authors and opportunities for the EFH team to respond. Specifically, stock assessment author input on the fishing effects model results or EFH descriptions will likely not be available prior to SSC review in February. Additionally, should the SSC request further work after its February review, adequate time for additional EFH work and consultation with stock assessment authors prior to SSC re-review (if requested) would be required. For example, issues identified with Component 1 may result in both SDMs and fishing effects models needing to be re-run and stock assessment authors to be consulted if important changes in output occur. The degree to which the schedule is of concern likely depends on whether there are issues of concern, and if so what level of concern, identified during the SSC February review. **Given these concerns, the SSC recommends the EFH authors provide an updated workplan that includes an update on what has been reviewed to date and a timeline for key review and decision points for the remainder of this review cycle.** The timeline should also consider stock assessment author input on updated EFH descriptions as noted by the JGPT. Having the detailed schedule would help the SSC understand whether gaps exist prior to final Council review and also, depending on the February review, allow for adjustment in the review timeline if needed.

Beyond the 2022 EFH cycle, the current review processes may need adjustment to accommodate the needs of key review bodies and individuals. **The SSC recommends that the EFH team consider improvements for the process prior to final Council review of EFH for this cycle. The current EFH roadmap may need to be modified to better accommodate scientific review.**

SSC February Review

The SSC notes the scope of the EFH work is complex and, due to the postponement of EFH on the SSC's schedule from October to February, the SSC will be reviewing model analysis associated with Components 1 or 2 together. **The SSC requests the EFH authors provide the EFH materials as early as possible to maximize review time for the February meeting**. In addition, following SSC recommendations from its April 2021 meeting, the SSC offers the following specific suggestions to facilitate review:

General

- An overview of SSC recommendations from the 2017 EFH process and the degree to which these were addressed for the current EFH review cycle.
- A summary of major EFH elements that have already been peer reviewed (e.g., the fishing effects model and research outlined in the initial June 2019 work plan).
- The SSC appreciates reviews by stock assessment authors and notes this scientific review is critically needed to inform EFH methods and products. **The SSC strongly recommends**

the EFH team incorporate author comments into the full review for February 2022. The SSC also encourages the EFH team to work closely with stock assessment authors to address comments prior to the February 2022 review.

- A summary of detailed comments made by assessment authors and EFH team responses as appropriate

SDM Modeling

- Table showing the current EFH levels and proposed changes under the new methodology.
- Information on the importance of habitat covariates in the SDM for each species and life stage. The purpose of this request is to evaluate whether habitat covariates statistically influence the distribution and abundance of North Pacific groundfish and crab life stages.
- A clear description of the data used for each model ensemble: e.g., description of data sources, data transformations, new data sets not previously considered, and input data time periods.
- Description of how complexes are being treated in the analysis: e.g., are the species distribution maps based on the entire complex or only certain species within the complex.
- Description of the ensemble modeling methods and a summary of member model fits, including a description of the probability thresholds used to characterize species presence and absence.
- Consideration of using a Precision Recall (PR) AUC and F1 scores as an alternative to ROC AUC. While AUC is a common metric to assess classification performance, it may not represent the minority class well for imbalanced datasets. For example, species that are patchy in distribution, such as rockfish, may occur in a few relatively small areas, resulting in a low number of positive classes where the species is present.
- A table showing species and life stage-specific ensemble fit metrics (i.e., Spearman's rho, AUC, Deviance Explained) and including PR AUC and F1 metrics.
- Providing maps that allow comparison of new results with 2017 results and total changes in area values (e.g., total % change and km^2).
- Maps showing the regions used to extract spatial outputs (core EFH) for the fishing effects analyses and clear description of thresholds.
- Information on any important temporal and spatial trends in the input data used to train the models. The intent of this request is to evaluate the degree to which model outputs reflect current species distributions versus historical distributions (i.e., are the data relatively stationary or are there important trends).

Fishing Effects Modeling

- A reference table for the reader summarizing any important changes in habitat distribution and fishing effects. For those species/life stages with important changes to core areas, maps

should be provided highlighting changes.

- Description of updated data inputs, new data sets not previously considered, and any methodological changes to the model or treatment of input data.

VAST Bottom Trawl survey

The SSC received the JGPT report on work being done by the AFSC Groundfish Assessment Program (GAP) on model-based indices; specifically the Vector Autoregressive Spatio Temporal (VAST) model. The report detailed work being done by GAP over the past year, including model comparisons for GOA Pacific ocean perch and EBS Pacific cod, and ongoing development of the Cold Pool Extent Index (CPI). The report also outlined near-term work on (1) producing indices, (2) reviewing and documenting methods, (3) further investigating variation in survey timing (CPI Index only), (4) developing goodness of fit diagnostics, (5) developing recommendation/rejection criteria with stock assessment authors, and (6) formalizing the bridging step between different years' models.

The GAP proposed a priority list for further development of model-based indices and requested JGPT input on priority ranking and for additional stocks to prioritize. **The SSC supports the prioritization approach and appreciates the opportunity to offer input on establishing priorities for VAST development.** Given the high demand for VAST products, the SSC believes this prioritization may help acknowledge limited staff resources while organizing workload and development processes. The SSC generally concurs with the JGPT recommendations, with several concerns noted below and pending review of the priorities by the CPT. The SSC also endorses the JGPT recommendation to consider BSAI northern rock sole and Greenland turbot for model-based indices.

The SSC also offers the following advice:

- The SSC's December 2020 minutes highlighted that a statistically rigorous model selection process that includes species-specific diagnostics and tuning is a priority. The SSC is concerned that tuning and providing diagnostics for only one model a year per area and species will not be adequately responsive to inform management advice. To this end, the SSC requests GAP consider development processes that would align species-specific work with assessment cycles, need, and complexity of tuning.

- Consider creating a central repository for VAST code used in the assessments. The Tier 4 and 5 working group had a similar recommendation and perhaps a similar structure could be used for both repositories.

- Regular review of the priorities by the Plan Teams, noting that priorities are inter-related and new developments may influence progress on multiple priorities.

- Future prioritization of apportionment scenarios considering a VAST approach

- The SSC also expressed support for continued development of multi-model inferences, as described under JGPT recommended priority #4, and continued work to better understand differences between VAST error estimation and design-based estimation (priority #3).

Age Composition Estimation

The SSC received a report from the JGPT on work being done by Jim Thorson (NOAA-AFSC), Andre Punt (UW), Pete Hulson (NOAA-AFSC), Jim Ianelli (NOAA-AFSC), and Meagan Bryan (NOAA-AFSC). Simulation methods were used to evaluate how changes in the sampling intensity for compositional data influence effective sampling sizes and assessment uncertainty. The simulation method consisted of a bootstrap method to select and predict input sample sizes; multinomial approaches to weighting age and length data; and prediction of OFL assessment variability using an age-structured operating model. The authors are also investigating the relationship between changes in input sample sizes and costs associated with ABC uncertainty.

The authors requested input from the Plan Teams on identifying for which Bering Sea stocks this analysis might be useful, whether this type of analysis should become a routine part of assessments, and if AFSC should have a more formal process to evaluate ageing effort across stocks. The JGPT supported further work on this analysis, expanding the analysis to include species in the Bering Sea, and developing a streamlined process to inform collection and ageing efforts across stocks. **The SSC concurs with the JGPT recommendations and believes, with further work, the information could be useful for guiding both survey sampling efforts and age reading efforts. Regarding the question posed by the workgroup about a review timeline, the SSC agrees with the JGPT that this type of analysis would not need to occur on an annual basis and some elements may be incorporated into the survey planning process.** However, ongoing dialog with GPT and assessment authors about potential impacts from changes to the sample size should be part of the planning process.

The SSC also cautions that this approach is conditioned on a stable assessment model configuration. Changes to data weighting, sex-specific dynamics, spatial approaches or other model structure could require more information and therefore a different number of age samples**. The SSC recommends including an evaluation of the potential for future changes in assessment methodology and stability (e.g., removing data weights).**

The SSC also offers the following suggestions for future work:

- The study investigated several changes to nominal sample sizes, including changing the number of tows sampled (sampling costs), the number of ages collected and/or read (sampling and reading costs). The marginal costs (i.e., the cost of reading or obtaining an additional sample) are likely different between these sampling adjustments and future work on these tradeoffs would be informative.

- A definition and/or set of performance standards and decisions that define "optimal" in terms of nominal sample collections.

- Monetary cost associated with the P* analysis was focused on the ABC as a catch limit; however, the SSC notes that the ABC may not be fully utilized for some species. Future work should consider whether the TAC is fully utilized. Further, the level of P* was not defined, and P* is not utilized in groundfish. For direct application in the NPFMC, increased variability or stability in ABCs might be a better metric.

- The study used three case examples to illustrate a range of data rich to data poor

assessments. An area of future investigation is whether case examples and P* evaluation could be generalized broadly to the tier system levels, including the evaluation of cost tradeoffs of sampling intensity and OFL/ABC uncertainty.

- The SSC notes this type of analysis could be useful for evaluating fishery data collection priorities. However, future work would need to incorporate changes in deployment methods that influence sampling methods as well as onboard sampling constraints. Additionally, data acquisition costs are likely different than those on a standardized survey.

Random Effects - Tier 4/5 Considerations

A workgroup consisting of AFSC stock assessment scientists (Cole Monnahan, Jane Sullivan, Cindy Tribuzio, Grant Thompson, and Pete Hulson) authored a report detailing Tiers 4 and 5 assessment methodologies and differences in estimating ABC, including differences in model coding and combining data sets. Grant Thompson (NOAA-AFSC, BSAI GPT co-chair) provided an overview of the report and JGPT recommendations. This workgroup is a continuation of the Survey Averaging Workgroup that explored several estimation methods in the context of Tiers 4 and 5 assessments and, ultimately, recommended the random walk model (ADMB-RE) that is adopted for many of these assessments. A framework was created in 2015 for implementation of both the ADMB-RE methodology and a multispecies model; however, the framework has not been consistently implemented among assessments. A workgroup with the following three goals was formed to better understand how the framework is being used among assessments:

- Collate and summarize information on different model software versions used and how zeroes are dealt with implicitly or explicitly.

- Examine the range of approaches for combining estimates when there is more than one survey for a single species assessment, or a complex with more than one species.

- Examine the way uncertainty is calculated given multiple surveys/species, and how increasing survey reductions would increase uncertainty and the implications for a P* approach to explicitly account for it.

The report outlined several important findings: the random effects methodology has evolved for individual stocks; zeroes are generally ignored, and internal software treatment of the zero is unclear; important differences exist in combining multiple indices; modeling approaches for complexes differ considerably; and the uncertainty of combined lognormal estimates is a challenge.

The SSC appreciates the detailed report from the workgroup and found it provides a very useful cross-assessment review of methods and issues for Tiers 4 and 5 assessments. **The SSC concurs with the JGPT recommendations supporting the workgroup plan**. **The SSC highlights the differing methods for zero treatment and recommends evaluation of methods to include zeros for assessments.** Recent developments with the REM and REMA methods and VAST may offer alternatives for both the treatment of zeros and calculation of variance**. The SSC also supports the workgroup's recommendation for SAFE reports to be explicit about the treatment of zeros and method for variance calculation**. Finally, the workgroup highlighted the need for code versioning and creating a central repository.

The SSC is supportive of efforts to improve the reproducibility of assessment results and improvements to workflow pipelines.

Risk Tables

The SSC's Risk Table discussion centered around the June 2021 Council motion, recommendations from the groundfish and crab Plan Teams, and revisiting the SSC's own June 2021 comments to provide final recommendations and subsequent edits/revisions to the *Risk Table Workshop Report, Preliminary Guidance and SSC Recommendations* (Appendix A, pg. 33 of the June 2021 SSC Report).

The SSC discussed all three considerations from the Council's motion: positive stock trends, where the initial recommendation for reduction from maxABC should come from, and that reductions to maxABC in previous year(s) should not influence the current year's decision unless relevant risk factors for a stock continue to be present. The Council's motion asked the SSC to consider whether positive stock trends should be included as 'concerns'. The SSC continues to support including the term "unusual" and including both increasing and decreasing stock trends in the Population Dynamics category of the Risk Table template (Table 1, Appendix A of the June 2021 SSC Report). While increasing stock trends certainly provide positive indications for the stock, rapid changes in stock abundance and highly atypical recruitment patterns often are also highly uncertain. The SSC agreed that positive trends in the Assessment, Ecosystem or Fishery performance should not be included, as the default is that conditions are positive or neutral, and the default option is for no reduction from maxABC. Therefore, **the SSC recommended no changes to the language in the Risk Table template.**

The SSC considered multiple options for where the initial proposed amount of reduction from maxABC should come from (e.g., stock assessment author, Plan Teams, or SSC), or whether an intermediate approach where the stock assessment author would simply suggest whether they thought a reduction was warranted or not (but not provide an estimate of the magnitude) was better. The SSC consensus was to recognize the importance of the stock assessment authors' expertise to provide a starting point for the magnitude of proposed reduction. **The SSC recommended maintaining the status quo, where authors are encouraged (but not required) to provide a recommendation on a reduction from maxABC, if warranted, and the Plan Teams and SSC would then evaluate and modify the reductions based on the information available for the stock**.

The last item of the Council's motion, consideration for reductions from maxABC to be based on current year information unless relevant risk factors for a stock continue to be present from previous years, was widely agreed upon and will be incorporated directly into the final recommendations.

The groundfish and crab Plan Teams were asked by the SSC to explicitly provide feedback on: the inclusion of Risk Tables for Tiers 4-6 stocks, how to treat stock complexes, and moving from 4 to 3 scoring levels**. The SSC agreed with the JGPT recommendation that Risk Tables should not be mandatory for Tiers 4-6; however, stock assessments must include compelling rationale for why a Risk Table would not be informative**. **The SSC also agreed with the JGPT recommendation to leave the decision concerning which species (or multiple species) to focus**

on for stock complexes up to the author. Again, the stock assessment authors' expertise was deemed the most important factor. There was also **agreement that reducing the number of scoring levels from 4 to 3 would be helpful, but the JGPT asked to postpone this until next year's assessments as many authors had already begun working on Risk Tables for the upcoming season; the SSC agreed with this request.**

Following direction from the Council, the CPT postponed working on Risk Tables until the recommendations for groundfish stocks were further along. However, the CPT reiterated the general utility of having rationales for concerns that were not captured in the stock assessment organized in one place. They also suggested that Risk Tables for crab stocks in Tiers 4 and 5 would likely be helpful (at least to start) to provide information for a more informed decision moving forward. Similarly, the CPT mentioned the difficulty of making recommendations for implementing Risk Tables for crab without actually producing draft risk tables; they suggested that it would be helpful to produce them for one or two stocks as an exercise. **The SSC agreed and suggested that drafting Risk Tables for a historical stock assessment of BBRKC and snow crab for the upcoming January or May CPT meetings could provide a useful illustration of how Risk Tables could be used in relation to the current use of buffers without using the Risk Tables for setting harvest specifications at this time.**

The SSC had a number of additional suggestions/comments/ideas that were posed during the June 2021 meeting (e.g., having a point of contact for fishery/community performance, what is the definition of "commonplace", etc.). The SSC recommended that these and any other considerations be reviewed and revisited regularly (as requested by the Council's motion) as the Council, SSC and others continue to gain experience utilizing Risk Tables.

Sablefish

The SSC received a presentation on the JGPT report by Grant Thompson (NOAA-AFSC, BSAI GPT co-chair) and an update on the sablefish assessment by Dan Goethel (NOAA-AFSC). Linda Behnken (Alaska Longline Fishermen's Association) provided public testimony.

The SSC commends the authors for their thorough responses to previous SSC comments and suggestions. The proposed model changes address the previous poor retrospective performance and evidence of degrading fits to important data sources. The authors recommend Model 21.10 which includes the following five key model changes to address these issues:

1) Updated weight and growth for the recent time period (1996 – present) to reflect the full extent of available data;

2) Updated age- and length-based maturity estimated via a general additive model (GAM) that accounts for skipped spawning using histological information from recent maturity studies;

3) The catchability priors are removed;

4) A recent time block (2016+) for estimation of fishery and survey selectivity and fishery CPUE catchability allows the model to better fit recent indices and compositional data; and

5) Data reweighting (i.e., the Francis method) to create consistency between input and effective sample sizes, which also improved fits to abundance indices, and reduced retrospective patterns, and retroactive downgrades in recruitment estimates and associated ABCs.

The SSC reviewed the incremental changes to model performance associated with these changes, and appreciated efforts by the authors. The SSC requests that the authors present a bridging exercise where specific impacts of assuming a 2016 time block for fishery catchability are separated from that of assuming a recent shift in fishery and survey selectivity in the context of new data available for this assessment.

With respect to changes in length-at-age and weight-at-age, the SSC agrees with the JGPT that for the current time the updated weight and growth data from 1996 – present should be used in the model. The SSC also agrees with the JGPT that additional work is needed on time blocks and if time blocks are brought forward, length-at-age and weight-at-age blocks should be consistent.

The SSC thanks the authors for their exploration of methods to incorporate the effects of skip spawning on the maturity schedule. The SSC requests that the authors include a figure with the updated author-preferred maturity curve with and without skip spawning, and the status quo maturity curve. The figure should include uncertainty estimates in the fitted relationship to inform sizes where additional sampling should occur and to provide for comparison with previously applied curves. The analysts have only two years of information from a limited geographic region in the GOA to inform skip spawning across the entire coast of Alaska. These two years differ substantially in the amount of skip spawning observed. The SSC agrees that additional data are needed to fully inform this option and the SSC supports the recommendation by Williams and Rodgveller for expanded data collection in 2022. The SSC recommends that future analyses of maturity and skip spawning include ageing imprecision, which may affect the perceived importance of length and age vs. only age on the biological process of maturity.

The SSC agrees that selection of a new post-2016 fishery CPUE catchability and selectivity time period is justified given the observed changes in distribution, gear and fisher behavior. The SSC requests that the author justify why longline survey selectivity and catchability would change at the same time as the fishery. The SSC notes that the proposed mechanisms for shifting selectivity at the youngest ages may already be changing again as the recent strong cohorts leave these ages. Therefore consideration of what selectivity to use for short- and longer-term projections may be increasingly important. The SSC requests consideration of alternative methods for constraining time varying selectivity as an alternative to ad hoc time blocks, in order to avoid future bias if/when selectivity changes occur.

The SSC recommends that the following models are advanced in 2021: 16.5, 21.10, a model that includes the features of 21.10 without the skip spawning option, and a model that addresses possible alternative treatment of longline survey selectivity and catchability.

The SSC inquired about how the authors would advance this assessment toward the 5-year survey average apportionment approach in the final SAFE. The SSC notes that a 50% step (from the 2021 apportionment toward the 5-year average) would be consistent with the SSC's recommendation of a 25% step in 2021 and the intent of moving to full use of the 5-year average approach in the

future. The SSC recommends presenting an alternative using a 100% step (the 5-year average) for comparison and to guide future consideration of the method.

The SSC repeats its previous request to update information on whale depredation. Given that whale depredation is incorporated into the assessment, the ecosystem driver should be regularly updated, especially as the fishery is undergoing rapid change in the prevalence of pot gear which should not be subject to depredation.

The SSC was concerned that the CPUE data from the commercial fishery may not be available from the 2020 fishery. The SSC notes that this information is an important part of this assessment and requests that the author explore how this information could be processed more quickly.

BSAI Plan Team Report

The SSC received a presentation from Grant Thompson (NOAA-AFSC, BSAI GPT co-chair) on the September 2021 BSAI GPT meeting. Items where the SSC had comments or recommendations in addition to, or different from the BSAI GPT are listed below.

BSAI Preliminary Groundfish Harvest Specifications

The SSC recommends approval of the preliminary 2022/2023 BSAI groundfish specifications as provided by the BSAI GPT. The SSC supports the BSAI GPT's recommendation to approve the Halibut DMR Working Group recommendation for proposed halibut DMRs for 2022/2023.

The SSC received public testimony from Chad See and Jim Armstrong (Freezer Longline Coalition; FLC).

EBS Pollock

The SSC received a brief presentation from Grant Thompson (NOAA-AFSC, BSAI GPT co-chair) on the 2021 EBS pollock stock assessment and supporting analyses. The SSC appreciates the responses to previous requests and the update on the detailed analyses underway. Although not presented, the SSC appreciates the update on the pollock fishery in 2021 relative to recent years, noting the sharp drop in A season herring CPUE (relative to 2020), the increase in B season chum CPUE, the mixed trends in pollock CPUE and the increased numbers of smaller pollock in the fishery catch. The SSC also appreciated the analysis of various climate-enhanced stock assessment models, but noted that none of those models seemed to be enough of an improvement to warrant use as a tactical model.

The SSC looks forward to additional progress on requests from last year, including: the genetic analyses, treatment of data weighting and variance parameters, movement of pollock along the U.S.-Russia EEZ, combined acoustic-trawl model-based index analyses, and young-of-year pollock density. **The SSC provides a clarification that it is requesting a description of the method used for projecting selectivity when calculating the OFL/ABC and looks forward to a retrospective analysis on the performance of this projection method relative to the subsequently estimated selectivity in the next assessment.** This request was motivated by the large change in F_{OFL} observed from the 2019 to 2020 assessments.

The SSC requests an evaluation be provided in December of which Tier classification is most appropriate for this assessment, noting the use of an informative prior on the SR relationship, and the historical use of Tier 3 OFL/ABC calculations rather than basing these quantities on the estimates of B_{MSY} and F_{MSY}, consistent with the Tier 1 classification of the assessment. The SSC recommends that if the assessment is considered in the appropriate Tier, buffers should be based on the use of the Risk Table rather than the continued use of Tier 3 calculations for a Tier 1 stock. The SSC also notes that this stock may be a candidate for the infrequently used Tier 2 classification. This tier uses the SR relationship for stock status and OFL, but uses the SPR ($F_{40\%}$) approach for ABC, which would more explicitly highlight the uncertainty in the SR relationship.

EBS Pacific Cod

Grant Thompson (NOAA-AFSC, BSAI GPT co-chair) presented the EBS Pacific cod assessment as part of the BSAI GPT report. The SSC thanks the author for his continuing efforts to address the complexities associated with Pacific cod and in particular his efforts to explore a model ensemble approach for this stock. The SSC notes that this year's preliminary model runs benefited from a thorough CIE review and include many of the specific reviewer recommendations. **The SSC highlights the tremendous value of these CIE reviews, which provide independent examinations that often bring new ideas and valuable outside perspectives to the table.**

Public testimony was provided by Chad See and Jim Armstrong on behalf of the FLC. The FLC appreciates the thoroughness and responsiveness of the Pacific cod assessment authors, but has concerns about the current suite of models. Specifically, the FLC urges further efforts to include data from the fishery such as CPUE and age composition data, and is concerned about potential reductions in survey effort as the survey should cover the entire extent of the stock. Finally, FLC suggests that, in the long run, the Pacific cod stocks off Alaska could benefit from a more integrated approach to modeling across EBS and GOA stocks. Written testimony by FLC also expresses concerns about the current suite of models in the ensemble, which do not fully reflect the large-scale movements of Pacific cod under changing environmental conditions, may add little to an improved understanding of stock dynamics, and lack a full discussion of the biological underpinnings for the different models considered. The FLC also highlights the significant economic impacts of potential reductions in the ABC.

The SSC broadly shares these concerns, as noted in specific comments below.

The suite of models brought forward for consideration benefited greatly from a thorough CIE review, which prioritized technical questions about the ensemble approach, but still leaves many questions about the use of fishery data and about the impacts of movements of Pacific cod, within and beyond the survey area, unresolved. The SSC was encouraged that the CIE strongly supported the use of an ensemble modeling approach for this stock, which can be an appropriate approach to addressing the structural uncertainty associated with this assessment. Therefore, the SSC continues to support the ensemble modeling approach and notes that the CIE reviewers placed the highest weight on model 19.12a, the current base model and a strong candidate for quota setting in December should the SSC fail to agree on a suitable ensemble. With respect to the treatment of spatial structure and movement within this model, the SSC highlights the complexity in doing so and the careful considerations necessary. The SSC references its minutes from December 2020 on

this topic, but welcomes future research in this area. Furthermore, the SSC feels that inclusion of a bottom trawl survey index, which incorporates both EBS and NBS data, has been a beneficial step toward a more comprehensive treatment of this stock outside of traditional management boundaries. The SSC offers some specific recommendations regarding data issues, the current suite of models and the ensemble approach below.

In response to a previous SSC request, the authors produced VAST estimates of survey abundance using three alternative model configurations that evaluated the consequences of dropping the cold pool covariate (configuration #2), greatly reducing the number of knots (#3) and using the Tweedie distribution to model CPUE with fewer parameters as an alternative to the current default Poisson-linked Delta-gamma distribution (#4). Preliminary results suggest that estimates are generally similar and that alternative configurations in #2-4 did not result in model improvements over the current approach (#1), based on the AIC. The SSC notes that the model-based estimates of uncertainty for the EBS, NBS, and EBS+NBS indices were lower when the Tweedie distribution was assumed (#4), which may be a concern. However, the use of the AIC may not be appropriate to select among different VAST models (Thorson et al. 2021, Fisheries Research) and the alternative models have not been fully evaluated due to lack of time. In particular, there was no assessment of any remaining spatial-temporal autocorrelation that may affect model choice. **Based on these comparisons, the SSC supports continued use of the current VAST estimates of survey biomass in the assessment.**

The preliminary assessment includes a new fishery CPUE index based on a VAST model to address the public and the SSC's desire to utilize fisheries data better. The advantage of the VAST framework for CPUE standardization is that it can, at least to some extent, account for the bias in a conventional fishery-dependent CPUE index that arises from the fishery targeting localized, high-density areas that may not reflect average CPUE at a larger scale. The VAST index was fit to winter (January-February) longline CPUE data only and was extrapolated to the entire EBS survey area. The SSC notes that there is no basis for the extrapolation into shallower areas of the shelf that, although sampled by the survey, have never had fishery effort. Although this is reflected in large uncertainty in the estimates, the SSC is concerned that this could introduce biases in the estimates as the estimated proportion of CPUE in the shallow areas changes. Moreover, the index does not utilize CPUE data from any of the other gear types or seasons and has not been fully reviewed and considered by the BSAI GPT or the SSC. Although the CIE reviewers supported the index, the SSC has concerns about the index as currently constructed, and requests that a more thorough exploration of a VAST-based fishery CPUE index be conducted that should make use of more of the available CPUE data, or that a stronger justification for the selected component of the fishery be provided. Despite these concerns and due to limited time before the November Plan Team meetings, **the SSC leaves it to the author to bring forward a model with the best currently available fishery CPUE index** as part of the ensemble**.** In the longer term, t**he SSC strongly supports continued development of the VAST modeling approach to fishery-dependent CPUE standardization for this and potentially other assessments**. Moreover, **the SSC reiterates comments from December 2020 regarding the importance of including fishery age compositions in future models and highlights the need for fishery age and size composition data from the NBS**.

For this preliminary assessment, as recommended by the CIE reviewers for use in an ensemble approach, the authors brought forward five models updated with available 2020 data:

- 19.12a (2020 base model)
- 19.12 (19.12a + time-varying survey catchability; the 2019 accepted model)
- 21.1 (19.12a + dome-shaped survey selectivity)
- 21.2 (19.12a + VAST-based fishery CPUE index)
- 21.3 (19.12a + internal estimates of additional survey SD)

The SSC appreciates the input from the CIE reviewers and agrees that using the accepted base model to explore the impact of changing one aspect of the model at a time provides a good basis for an ensemble approach for this year's assessment. While the model set does not fully reflect the structural uncertainty associated with this stock and its complex fishery, each of the models addresses a specific concern that has been highlighted previously for this assessment. It is noteworthy that all of the models brought forward had good retrospective performance.

The author discussed some of the advantages and disadvantages of allowing for time-varying catchability (19.12) and notes that this approach has good support in the literature. It provides a sensible approach to address the potential for variations in catchability associated with a variable portion of the stock being available to the survey and other processes. **Therefore, the SSC supports bringing this model forward for consideration in an ensemble.**

With respect to model 21.1, the SSC notes that the model to some extent addresses one of the concerns about a proportion of the population, in particular larger fish, not being available to the survey. The model estimates a considerably higher biomass due to the dome-shaped survey selectivity, which would imply that the survey still misses many of the larger Pacific cod. This can no longer be attributed to larger fish moving into the NBS, as NBS biomass is now included in the model, but could result from large fish moving deeper or into Russian waters. The SSC noted one additional concern with the model, specifically that the asymptotic length for Pacific cod in this model is considerably lower than in the other models. **The SSC supports bringing this model forward as an ensemble member, but recommends that the author explore whether the low asymptotic length in the model is consistent with the data and, if warranted, consider a different weight for the model.**

Model 21.2 suggests that the impact of including the new fishery CPUE index is fairly small, but the model is responsive to previous requests for including fishery information in the model to the extent possible. **The SSC supports inclusion of the model in the ensemble, using the best available fishery CPUE index as noted above.**

Model 21.3 allows for additional survey CV that is estimated within the model and results in substantially lower biomass estimates in recent years and a different recent stock trajectory that appears inconsistent with either the survey CPUE or recent fishery CPUEs. The SSC was concerned about the resulting residual pattern and, more importantly, about the model estimate of 'extra SD', which implies that the true (log-scale) standard deviations for the survey biomass index are on average more than 3 times larger than the log-scale standard deviations estimated by the VAST model. The SSC discussed imposing an upper bound on the "extra SD" in the model, noting that authors routinely impose bounds on the implied uncertainty for other quantities such as age

composition estimates. However, while such approaches have been vetted through the review process, there is currently no accepted standard for imposing a bound on "extra SD". **Because of these concerns, the SSC recommends excluding model 21.3 from consideration as part of the ensemble in November.** The SSC also noted that three of the four model alternatives de-emphasize the trawl survey abundance index in some way (time-varying catchability, adding an additional abundance index, and increasing the survey SD), so excluding model 21.3 makes the ensemble set more balanced.

In addition to supporting the ensemble modeling approach, the CIE reviewers suggested some revisions to the model weights that the authors adopted in this assessment. Specifically, weights were expanded from two [0,1] to three levels [0,1,2], some old criteria were dropped and new ones were added. The CIE reviewers judged all models to be less plausible than the base model based on model performance and model structure. **The SSC concurs with the proposed weights and accepts the revised criteria,** but encourages the assessment authors to consider modifications to the weights if warranted (see discussion of Model 21.1 above) and to consider bringing forward a set of alternative weights based on the approach and the criteria used in the proposed 2020 ensemble.

In summary, the **SSC requests that the author bring forward model 19.12a as the base model and models 19.12, 21.1 and 21.2 (in addition to 19.12a) as part of a multi-model ensemble for consideration in December.** For the ensemble, the SSC requests the CIE proposed weighting scheme (without model 21.3) with possible adjustment to the weights by the author and Plan Teams. At the authors' discretion, the SSC also welcomes an alternative weighting scheme based on last year's assessment.

The CIE reviewers addressed the question as to "whether to apply the sloping harvest control rule before or after ensemble averaging of SSB and other reference points" (December 2020 SSC minutes), but did not come to a definitive conclusion. The assessment authors explored the question through a simplified simulation approach and concluded, based on those explorations and literature, that the "before" approach is better because in the authors' view it accounts for both within-model and between model variability more appropriately. **The SSC supports the rationale provided for this assessment cycle but encourages further consideration of this issue by the authors and BSAI GPT in the future.** The SSC notes the need for further refinement of the ensemble approach in the longer term to address, among other issues, the use of means vs medians in model averaging and approaches that consider differences in the level of uncertainty in each model when assigning model weights.

The assessment includes preliminary results from a new tagging study that are very informative and show that fish tagged in the NBS may remain in the NBS into December before moving south or west and offshore, with movements to the outer shelf and into Russian waters. It is noteworthy that most of the tags that released during the spawning season were located along the outer shelf (including in the vicinity of Zhemchug Canyon and near the Pribilof Islands), but none of the tags released in the known major spawning area off Unimak Island. One tag popped up in the western GOA, supporting the idea that Pacific cod can undergo very large migrations. Although few tags lasted through the following year, those that did suggest that at least some fish stayed in or returned to the NBS in the following summer. The SSC is pleased to see these analyses and encourages further development of the migration model to integrate this and future tagging work.

Unresolved spatial movements of Pacific cod were raised in public testimony as a major concern and the SSC shares these concerns. The SSC notes that some previous research on estimating movement rates between the EBS and NBS has been presented in previous assessments. However, with the recent transition to using VAST model estimates for a combined EBS and NBS biomass index, the need for resolving movements into and out of the NBS has diminished. Nevertheless, the new tagging study clearly shows that some component of the Pacific cod stock moves between US and Russian waters and the GOA, and is therefore potentially vulnerable to exploitation in Russian fisheries and GOA fisheries and potentially unavailable to the EBS and NBS surveys. The SSC notes that several Pacific cod tagged in the NBS were located in Russian waters during the spawning season, suggesting the possibility that Pacific cod spawning in Russian waters may move into the NBS during summer. The SSC was encouraged to see a combined analysis of Russian and US survey data using the VAST modeling framework (Figure 2.1.6 in the report) and a time series of Russian catches, which increased substantially in the last two years of the time series (2017/18). **The SSC would like to see more details on the VAST analyses at a future meeting to evaluate their possible use in the assessment model as a means to addressing transboundary concerns.** The SSC also highlights the need to further develop a spatial model for Pacific cod as a research priority, reiterating comments from their October 2020 minutes.

The SSC appreciates the ongoing work on the Pacific cod ESP as it continues to evolve and inform the stock assessment, and acknowledges the efforts of the ESP team. The SSC looks forward to the updates in November that will include information for the current year. The SSC agrees with the assessment authors that there is no need for the ESP to duplicate information that is also used in the assessment (such as fishery CPUE). See the section under General SSC Comments and Administrative Discussion for the SSC's discussion on ESPs.

Finally, the SSC was intrigued by the suggestion brought forward in public testimony for a more integrated Pacific cod modeling approach across the GOA, AI and EBS and highlighted this idea as a topic for further discussions by the Plan Teams and SSC.

AI Pacific Cod

The Aleutian Island Pacific cod stock has been managed under Tier 5 since the stock was first separated from the EBS in 2013. The SSC has been looking forward to the development of an age-structured assessment model for consideration to move the stock to Tier 3. This year, the assessment authors propose bringing forward three alternative models in November, in addition to the previously developed 'base model" (model 19.0). The alternatives include model 19.0a, which uses a natural mortality of M=0.4, between that derived from the data (M=0.56) and the assumed mortality in the Tier 5 assessment (M=0.34), and model 19.0b, which uses a different maturity ogive from Stark (2007). Model 19.0c is identical to 19.0 but does not include fishery length data. **The SSC concurs with the BSAI GPT to bring forward results from age-structured assessment models 19.0, 19.0a and 19.0b, in addition to a Tier 5 assessment, for consideration in November**. The SSC agrees with the BSAI GPT that model 19.0c should be used for a sensitivity analysis only to assess the influence of the fishery length information on model fits. This might help reconcile differences between survey and fishery data to support the use of the fishery length data.

The SSC appreciates the thorough exploration of natural mortality and agrees that a model with a

natural mortality of M=0.4, corresponding to the mode of previous estimates of M across a range of Pacific cod stocks, is a reasonable starting point for model 19.0b.

The author of the assessment requested input from the BSAI GPT on data weighting and the BSAI GPT noted that all stock assessment authors would benefit from additional guidance on data weighting. See the General Comments section under C6 BSAI and GOA Groundfish for the SSC's recommendation regarding data weighting.

Impact of Altering Survey Design and Density on Survey Indices

The SSC received a summary of a study titled "Designing for change: the impact of altering sampling design and density on survey indices" by Jason Conner (RACE, NOAA-AFSC), Stan Kotwicki (RACE, NOAA-AFSC), Kotaro Ono (Institute of Marine Research, Norway), and Lewis Barnett (RACE, NOAA-AFSC). The impetus behind this study was a recommendation from a CIE review of the Bering Sea bottom trawl survey and because survey effort may be reduced or altered for various reasons including insufficient funding, logistical challenges, shifts in species distributions, and evolving management concerns. The SSC appreciates the efforts of the research team to analyze the effect of different sampling densities on the mean CPUE and standard error estimates for different survey designs as well as an exploration of alternative standard error estimators.

Currently, the survey employs a fixed starting point systematic design, which can be less expensive and provide more precise estimates if assumptions are met. There is, however, no unbiased estimator of the variance. Therefore, the current practice is to estimate variance of the mean using the simple random sample formula, which likely overestimates true variance. This study simulated three sampling designs: systematic (current), stratified random, and simple random sample and tested four different sampling densities (current, 75%, 50% and 150%) for four representative species. These species were arrowtooth flounder, walleye pollock, Pacific cod, and yellowfin sole, which have different life history characteristics (e.g., depth and temperature affinities) and therefore distributions.

The mean CPUE estimates were relatively unbiased for all sampling designs, densities, and species examined. The conventional estimators of standard error performed well with the simple random sample and stratified random sample designs; and, as expected, uncertainty increased as sampling density decreased. When applying the simple random sample estimator to the systematic sampling results (current practice), the estimates of standard error had a positive bias that was sometimes substantial. Two "local" standard error estimators (ST4 and LO5) were also computed for systematic sampling design simulations and performed better than the approximation currently used. **The SSC agrees with the conclusions to continue to use a systematic survey design at present and recommends continued evaluation of a standard error estimator that produces less-biased estimates than the current practice of using the simple random sample estimator.**

The SSC recommends the authors consider doing similar analyses on additional species and comparing results from these simulations with model-based VAST estimates that are available for the particular species examined. The SSC also recommends that these analyses be extended to evaluate the potential impacts on stock assessment in the context of one or more actual assessments.

The SSC noted that if the goal is to get an analytical variance, it would require paired random starts, so it was unclear what the objective of suggesting switching to a random start was. **However, if this is pursued, the SSC agrees with the BSAI GPT recommendation to add someone from the GAP to the analysis team to provide input into the feasibility of employing a random start to the systematic survey design and evaluate the benefits over the current practice.** A team member from GAP could also assist in evaluating alternative standard error estimators as well as their implementation.

Finally, the SSC recognizes that analyses such as those presented, provide a useful means of approximating the increase in error with reduced sampling, which may be necessary at times. However, **the SSC emphasizes continued support of existing survey efforts to collect the data needed to inform science and management of fisheries in the North Pacific.**

Performance of Model-Based Indices Given Alternative Sampling Strategies

The SSC received a summary of a pair of analyses to investigate the "performance of model-based indices given alternative sampling strategies in a climate adaptive survey design" by Meaghan Bryan (NOAA-AFSC) and James Thorson (NOAA-AFSC). Written testimony was provided by Chad See (FLC) and oral testimony was provided by Chad See and Jim Armstrong (FLC).

The first analysis was in response to the BSAI GPT's request to investigate "the ability of VAST to predict large unobserved areas by omitting some data from the EBS Bering Sea trawl survey in a cross-validation type exercise." The second analysis was in response to questions about the frequency and density of the NBS survey. The SSC commends the authors on their thorough efforts to investigate the performance of model-based indices given alternative sampling strategies.

Empirical data were used in the first analysis to mimic an unbalanced survey design, in which data from large survey areas in the EBS were arbitrarily dropped. Then VAST was used to produce estimates for four species (walleye pollock, Pacific cod, yellowfin sole, and snow crab) using these reduced datasets. Results of this analysis indicated that the scale and trends of density estimates of the reduced data scenarios were generally similar to estimates with all survey data. The reduced survey footprint, however, resulted in greater uncertainty with larger standard errors in density estimates, especially in areas central to the distribution of a species – as would be expected. The SSC appreciates the authors' responsiveness to the BSAI GPT's request and found this analysis to be helpful in providing some indication of the predictive ability of VAST under spatially unbalanced survey designs.

In the second analysis, survey density estimates for EBS, NBS, and both regions combined were simulated and three different survey scenarios were run (annual full surveys, annual surveys with 50% reduced sampling in the NBS, and biennial full surveys in the NBS). The results indicated that annual surveys with reduced sampling produced estimates with less bias and smaller mean absolute errors than if surveys were biennial but with no reduction in sampling density. **The SSC suggests that the authors consider whether the reduced number of knots used in their estimation model was sufficient** because the number of knots used to estimate indices for some species are much greater (e.g., for Pacific cod 750 knots are used).

Both the empirical and simulation analyses are reasonable approaches to assess the performance of model-based indices given alternative sampling strategies. The SSC notes that the combination of these analyses helps to provide a comprehensive view of how well a spatio-temporal model, such as VAST, estimates densities when survey data are missing from large portions of the survey or survey frequency is reduced. Thus, they help to quantify the potential impacts of various decisions on survey design. **The SSC agrees with the authors' conclusion that the effects of reduced sampling density and frequency should be considered when developing future survey strategies.**

Understanding the impact of missing large portions of the survey area on stock assessment and management decisions would be an additional benefit to these analyses. **The SSC recommends extending these examples to the stock assessments**. Furthermore, it would be useful to evaluate how much increased uncertainty is acceptable (i.e., at what point does it impede our ability to make effective decisions based on sound science?).

The SSC concurs with the BSAI GPT's recommendation that, if resources are limited and reductions in the northern Bering Sea survey are necessary then the preference is to conduct annual surveys with reduced sampling density over biennial surveys. In other words, it would be preferential to estimate indices with some data annually rather than to extrapolate with no data. The SSC notes that this recommendation may not apply if the species of interest is longer-lived and poorly sampled already with a full sampling density.

The SSC notes that reduced survey coverage and reduced survey frequencies will likely increase uncertainty in stock assessments and projections and may necessitate larger buffers between overfishing limits (OFLs) and acceptable biological catches (ABCs). Therefore, **the SSC reiterates its strong support for maintaining the current surveys and routinely sampling in the NBS to support analyses and obligations of NOAA and the Council.** Finally, the SSC also suggests that consideration should be given to the loss of ancillary data collected on surveys (e.g., temperature, sea bird surveys, etc.) when reductions in survey density, footprint, or frequency are contemplated.

BSAI Greenland Turbot

Grant Thompson (NOAA-AFSC, BSAI GPT co-chair) provided the BSAI GPT summary of conclusions and recommendations from the CIE review of the BSAI Greenland turbot assessment. The BSAI GPT report highlighted that all three CIE reviewers agreed that the most recently accepted model is suitable for management advice, and made recommendations for improvements regarding concerns they had with the assessment. Several areas of focus for future work were recommended by the CIE: a re-evaluation of the model's selectivity methods, including the time blocks used for the survey selectivity; exploration of estimating catchability (rather than fixed); sensitivity analysis on catch data used in the early part of the time series and the model estimate of recruitment in the 1960s and 1970s; age remaining otoliths to help inform the model about recruitment; and generally improving model parsimony. The SSC is appreciative of the thoughtful review by the CIE authors and work done by the assessment authors to improve this assessment.

The SSC supports the authors' and BSAI GPT's recommendation to explore the issues raised by the CIE in the next full assessment scheduled for 2022. Additionally, the CIE reviewers had

concerns about the model being able to uniquely identify some parameters, an issue likely related to the parameterization of selectivity and catchability. For the next full assessment, the **SSC requests authors provide an analysis to evaluate convergence on new model formulations and the base model.**

Blackspotted/Rougheye Rockfish Genetics and Spatial Issues

The SSC received a summary of the presentations given to the BSAI GPT on a recent blackspotted rockfish genetics study and the timeline of spatial management issues in the BSAI for this species. In addition, a summary of the BSAI GPT's discussions and recommendations were provided. The SSC appreciates these updates and continued discussion on concerns related to the spatial management of the BSAI blackspotted-rougheye rockfish (BS/RE) complex.

The genetic study of blackspotted rockfish did not detect any stock structure, which aligns with a previous genetic study, despite using a newer and more powerful genetic technique (whole genome sequencing). According to the authors, this result was not surprising given several factors, including large population size (millions), long generation time (~50yrs), a pelagic larval dispersal stage, and a variable environment on evolutionary time scales (~10K years, glaciation). **The SSC extends its appreciation to the authors for their informative study.** The SSC discussed whether the lack of evidence for genetic stock structure provided by this study reduced the level of conservation concern, as it pertains to this species complex in the western Aleutian Islands (WAI). Despite not detecting genetic stock structure, **the SSC continues to be concerned about the disproportionate spatial harvest, including catch in excess of the WAI/CAI subarea MSSC in recent years, and the potential vulnerability of this rockfish complex to localized depletion.**

As noted in the December 2020 SSC report, the SSC recognizes its role in bringing species that are facing potential conservation concerns to the Council's attention in accordance with the Spatial Management Policy. Therefore, **the SSC reiterates its recommendation to the Council to consider moving to Step 2 of the Spatial Management Policy. The SSC recommends reconstituting a spatial management working group to develop a white paper that addresses how the Spatial Management Policy can be used to address conservation and management concerns for BSAI BS/RE.** The white paper would explore potential options for management response and identification of a suite of tools that could be used to achieve conservation and management goals as outlined in December 2020. In particular, the SSC recommends the white paper focus on new information and industry avoidance efforts. **The SSC also recommends that the white paper explore what level of depletion would be cause for conservation concern given the lack of genetic structure.** The SSC did not come to a consensus regarding the utility of a workshop at this time and suggests the development of a white paper as an intermediate step to identify if there is sufficient new information to warrant another workshop.

The BSAI GPT discussed potential research projects to help understand the demography of blackspotted rockfish and recommended that the AFSC evaluate the cost and benefits of a tagging study as well as a larval dispersion study to better understand stock replenishment rates in the Aleutian Islands. Some members of the SSC questioned whether a tagging study would bring new information to bear on this issue. However, **the SSC concurs with the BSAI GPT recommendation to evaluate the cost and benefits of these additional studies** and suggests that the tagging study has a higher priority than the larval study.

The SSC looks forward to updates on the various recommendations made to the assessment authors from December 2020.

Finally, the SSC notes that 2022 is a full assessment year for the BSAI BS/RE rockfish stock complex and that this should be taken into consideration if changes to the structure of harvest specifications are recommended (e.g., separate WAI and CAI ABCs).

GOA Plan Team Report

The SSC received a presentation from Jim Ianelli (NOAA-AFSC, GOA GPT co-chair) on the September 2021 GOA GPT meeting. Items where the SSC had comments or recommendations in addition to, or different from, the GOA GPT are listed below.

GOA Preliminary Groundfish Harvest Specifications

The SSC recommends approval of the preliminary 2022/2023 GOA groundfish specifications and halibut DMRs as provided by the GOA GPT. The SSC supports the GOA GPT's recommendation to approve the Halibut DMR Working Group recommendation for proposed halibut DMRs for 2022/2023. The SSC notes that the GOA GPT agreed that the GOA non-pelagic trawl CP sector now has sufficient sample size to calculate the GOA trawl CP DMR instead of using the BSAI DMR.

The SSC received no public testimony on the GOA Plan Team Report.

GOA CLIM

The SSC received the GOA GPT report on GOA CLIM. Please refer to section D2 for the SSC's comments related to ACLIM and GOA CLIM.

GOA Pollock

The SSC received a brief presentation on updates to the GOA pollock assessment. Foremost, the SSC thanks Martin Dorn for his many years of excellent pollock assessments and welcomes Cole Monnahan for assuming the lead authorship and quickly getting up to speed on the assessment model. The SSC also again thanks the survey teams that, through great effort, were able to have a successful survey season during COVID-19.

The SSC appreciates the efforts of the authors to respond to GOA GPT and SSC comments from past years back to 2018. A 2018 PT request asked the authors to conduct a "leave-one-out" analysis with the various survey indices. Dropping the synoptic summer acoustic-trawl (AT) survey had less influence than the focused Shelikof winter survey. This could be explained by the summer AT survey being similar in timing and spatial domain to the bottom trawl survey or because of its shorter time series. Clearly, the bottom trawl survey was the most influential index. Removal of the ADF&G and Shelikof surveys mostly impacted recent estimates of stock trajectory.

An additional analysis was provided by the authors that removed all of the indices but one, which showed the most dramatic changes when only the Shelikof survey was considered, resulting in much higher and more uncertain survey biomass estimates. The SSC encourages further explorations of the spatial and temporal coverage among the surveys, including whether they are providing complementary information or contradictory information and whether tradeoffs are

associated with their inclusion, such as whether they are informative about population abundance versus tracking spatial and temporal variability. The SSC also looks forward to Dr. Monnahan adapting the geostatistical methodology he developed for the EBS to combine the acoustic and trawl surveys for the GOA as time allows.

The SSC notes that the logit parameterization seems like a good solution to constrain Shelikof catchability to be less than 1, but the increased variability in annual q should be explored to determine whether results are biologically plausible. The SSC also requests the authors verify that, under the logit parameterization, the probability of catchability being between 0 and 1 is uniform, particularly if the model uses a fully Bayesian framework in the future.

The SSC supports the authors using the latest maturity information for the November assessment as well as continued investigations into weight-at-age trends. There were no proposed new models to evaluate, so the SSC expects only minor incremental improvements will be included in the November assessment.

GOA Pacific Cod

The SSC received a presentation from Jim Ianelli (NOAA-AFSC, GOA GPT co-chair) on the GOA Pacific cod stock assessment, including exploration of alternative model structures incorporating a new data source to inform recruitment, ecosystem linkages with key demographic processes, expansion of the recent time block for natural mortality, and a model tuning and data re-weighting exercise. In addition to the status quo model (19.1), the authors present and describe eight exploratory model variants that include:

- An index of age-0 Pacific cod abundance from a beach seine survey sampling bays on Kodiak Island and along the western Alaska Peninsula (Model 21.1 and all following variants).
- Sea surface temperature linked growth (Models 21.1b, e, g; 21.5a, c).
- Marine heatwave linked natural mortality (Models 21.1c, e, g).
- Heatwave index at time of spawning linked to recruitment (Models 21.1d, e, g; 21.5a, c).
- Expansion of the recent time block for natural mortality from 2014 – 2016 to 2015 – 2020, with age-invariant natural mortality estimated separately for this block and all other years (Models 21.5a, c).
- Re-weighting of sample sizes for age and length compositions using the Francis TA1.8 method (Francis 2011) and survey index variances tuned to the root mean square error (Models 21.1g, 21.5c).

Inclusion of the age-0 beach seine index reduced uncertainty in recent recruitment estimates and estimated variance in reference points, but at the cost of the model's ability to fit both the NMFS bottom trawl survey and longline survey indices. The addition of SST-linked growth improved fits to composition data, but at the cost of a reduced ability to fit abundance indices. Addition of heatwave-linked natural mortality provided the greatest improvement in overall model fit based on the total objective function value and improved the model's ability to explain recent declines in the longline survey index, length composition data, and the beach seine index, with only a

moderate increase in the retrospective pattern, but substantial impacts to harvest recommendations. Inclusion of heatwave-linked recruitment resulted in a moderately improved fit to the NMFS bottom trawl and longline survey indices and a reduction in recruitment residuals, but the overall impact on model estimates was minimal.

Iterative exploration of the natural mortality time blocks identified the 2015 – 2020 period as best supported by the data, resulting in an improved fit to the NMFS longline survey in the recent period and a reduced ability to explain biomass estimates from the NMFS bottom trawl survey. However, the authors note this model exhibited an increased retrospective pattern in SSB. Tuning of sample sizes for composition data and index variances resulted in reduced model weight on all three survey indices and a reduction in effective sample sizes for age and length compositions. There was also a substantial and potentially implausible increase in the estimated catchability for bottom trawl and longline survey indices with a commensurate reduction in estimated biomass.

The SSC notes that the authors regard the model variants presented as exploratory in nature and wish to continue exploring their development, but are "reluctant to recommend any of them for management of the stock at this time". The SSC thanks the authors for their diligence in investigating candidate environmental linkages within this assessment, with each based on a clearly-articulated a priori hypothesis.

The SSC supports the authors' recommendation to bring forward Model 19.1 for the November assessment, and encourages the authors to explore a tuned version of this model that does not fit to the age-0 beach seine index. The SSC further supports the authors presenting several additional research models at their discretion:

- Model 21.1e that includes the age-0 beach seine index and environmentally-linked growth, mortality, and recruitment.
- Model 21.1g a tuned version of 21.1e.
- Model 21.5c which includes environmentally-linked growth and recruitment, the updated natural mortality time block, and is tuned.
- A possible model variant described in the GOA GPT presentation as 21.6 which includes the age-0 beach seine index and is tuned.

The authors requested feedback on model evaluation criteria to guide selection. The SSC highlights retrospective performance and model fit as key criteria given that the total likelihood and AIC are not comparable among all models with differing input data and data weighting. The SSC further supports reporting of comparisons of the estimated value and variance for key model parameters. The SSC also recommends the authors continue to describe results of incremental model changes in terms of benefits and costs in the ability to fit the range of data inputs. Additionally the SSC recommends exploration of prior distributions for parameters describing environmental effects on growth, natural mortality, and recruitment that penalize estimates toward zero, or no effect, in the absence of strong evidence from the data for these links. The SSC suggests that this may present a way to consider ecosystem-linked parameters in a synergistic way that avoids the dichotomy of comparing models that either include or exclude these relationships.

With respect to the treatment of natural mortality within this assessment model, the SSC supports further research to identify potential model misspecification as highlighted by the apparent conflict between the age-0 beach seine index and other surveys that index the age 3+ component of the stock. This may include exploring whether age-specific natural mortality should be assumed, either in conjunction with heatwave-linked or time-blocked natural mortality, or in isolation.

Finally with respect to the age-0 beach seine index, the SSC encourages the authors to consider whether the model-based estimates of uncertainty are accurately reflecting the true uncertainty in juvenile Pacific cod abundance, given the spatial extent of sampling relative to the distribution of juvenile Pacific cod in the GOA. The SSC requests expanded documentation of the structure of the model used to generate the age-0 index, but recognizes that a peer reviewed article on its development is forthcoming.

The SSC also recommends further discussion of the tagging results presented to the GOA GPT, noting that alternative hypotheses regarding mortality vs. movement are critically important in understanding the recent dynamics of this stock.

GOA Pacific Cod ESP

Development of the ESP for GOA Pacific cod began in 2020 and was finalized for the September 2021 GOA GPT meeting. The SSC thanks the ESP authors for advancing this valuable product, and highlights the important role of the ESP in this context in closing the gap between the single-species stock assessment and ecosystem research and supporting ecosystem-enhanced model development.

The GOA GPT requested clarification on past SSC requests for inclusion of socioeconomic information within this ESPs and whether this information should be used to inform stock trends and "red flags." Other discussions on the role of specific types of socioeconomic information in the BBRKC and snow crab ESPs occurred under other agenda items at this meeting. See the section under General SSC Comments and Administrative Discussion for the SSC's discussion on ESPs.

GOA Other Rockfish

The SSC received a summary on the spatial management of GOA demersal shelf rockfish (DSR) and Other Rockfish complexes. Specifically, the GOA GPT recommends separating DSR rockfish from the Other Rockfish complex in WGOA/CGOA/EGOA (currently separate in eastern Yakutat/Southeast Outside), thereby creating a GOA-wide DSR complex. The justification is based on several factors including life histories of the various rockfish species and gear selectivity, which has been further supported by a recent study on methods for identifying species complexes. The SSC appreciates this update from the GOA GPT.

The proposal of a GOA-wide DSR complex was first raised in 2015. In 2017, a discussion paper was produced and the GOA GPT and SSC approved Alternative 3a. At that time, both the GOA GPT and the SSC recommended the Council consider taking this issue up under Step 2 of the Spatial Management Policy. This recommendation was made again most recently in 2019.

The SSC concurs with the GOA GPT and recommends that the Council consider taking up this issue of separating DSR from Other Rockfish GOA-wide – thus moving to Step 2 of the

Spatial Management Policy. As part of the next steps, the SSC suggests that a white paper be written, potentially an update of the 2017 discussion paper, to identify economic and management implications and tools to achieve management and conservation goals. Issues that the white paper might address include:

- How would separating DSR from Other Rockfish impact setting harvest specifications?
    - Would an FMP amendment or other regulatory change be needed?
    - How would separate DSR assessments (as outlined in the GOA GPT September 2021 minutes) produce harvest specifications? GOA-wide, or regionally?
    - Should a combined assessment with two tiers (e.g., skates assessment) be considered?
- How would these specifications align with state management of the DSR complex?
- Are there conservation concerns with the proposed assessment structure? Do other tools need to be considered for appropriate management and conservation?
- Are there any economic or other management impacts (e.g., catch accounting) to be considered?

GOA Pacific Ocean Perch

The SSC reviewed the assessment authors' summary of 2021 CIE recommendations for the Pacific ocean perch (POP) assessment. There was no public testimony.

Pacific ocean perch in the GOA are assessed on a biennial stock assessment schedule. An off-cycle full assessment was conducted in 2020 in anticipation of a CIE review that occurred in 2021. The SSC reviewed several model changes in December 2020 and accepted an updated model. The 2020 model included a revised aging error matrix, updated fishery age compositions and a prior on trawl survey catchability and natural mortality. In 2021, the authors do not plan any substantial changes to the assessment. **Therefore, the SSC recommends that the approved model from December 2020 should serve as the base model for the 2021 assessment**.

The SSC learned that the authors consider the 2020 model an intermediate step to additional changes resulting from the CIE review. The authors provided a summary of the CIE reviewer recommendations including: 1) the feasibility of incorporating hydroacoustic information into the assessment, 2) examining catchability and selectivity, 3) examining the VAST model for POP abundance and apportionment, 4) examining data weighting for compositional data, 5) re-evaluating the plus age group; and 6) examining how fishery-dependent ages are being collected. The author intends to evaluate the majority of these recommendations before the next full assessment in 2023. The SSC appreciates the author's compilation of CIE recommendations and requests that the authors develop responses to these recommendations. The SSC looks forward to the opportunity to review proposed model changes in 2022 prior to the next full assessment in 2023. The SSC also reiterated its request from December 2020 that the author explore whether the prior on M is still constraining.

GOA Flathead Sole

The SSC received a presentation from Jim Ianelli (NOAA-AFSC, GOA GPT co-chair) on the proposed update to the 2017 GOA flathead sole stock assessment. **The SSC supports the author's and GOA GPT recommendation to proceed with the partial update for 2021, as the survey index remains high and there is no indication of a conservation concern at this time.**

GOA Northern and Southern Rock Sole

Jim Ianelli (NOAA-AFSC, GOA GPT co-chair) presented the proposed models for the 2021 northern and southern rock sole assessment.

The northern and southern rock sole assessment is implemented using a statistical catch-at-age model configured in Stock Synthesis 3. The model is run separately for each species. The data used in the assessment model includes fishery catch, the GOA trawl survey biomass, fishery and survey size composition, and survey conditional age-at-length.

The SSC reviewed CIE reports from Drs. Anders Nielsen and Sven Kupschus. The report from Dr. Colin Millar was not posted. **The SSC appreciates the careful reviews by the CIE for this assessment**. The key recommendations from the CIE reviewers include:

- Improved modeling of growth
- Investigate the possibility of estimating catchability to relax the assumption that survey biomass is an absolute index
- Develop model-based indices and use as input, partially to address concern about assuming that the survey biomass is an absolute index
- Encourage research of untrawlable habitat to improve understanding of the relative abundance of the rock soles in these habitats
- Provide justification for the 50/50 catch split between northern and southern rock sole
- Model catch with uncertainty
- Use annual proportions from FMA observer data

In addition, the reviewers recommended the inclusion of jitter runs in future assessments.

The authors explored regional patterns of growth using the 'fishmethods' package. Results revealed spatial trends in growth between the Central and Western regions of the GOA. The authors explored a two-area model for northern rock sole only and concluded that the split-area modeling approach was not a viable option at this time. The SSC supports this conclusion and recommends continued work on these models along with an exploration of the potential mechanisms for observed differences in growth patterns.

For the September GOA GPT meeting, the authors updated the fishery length composition as well as correcting the minimum sample size. The authors explored a series of model changes. These

model investigations included: the use of an updated aging error matrix, estimation of catchability, incorporation of model-based (VAST) survey biomass estimates, and two methods for data weighting.

The SSC commends the assessment authors for their timely responses to CIE recommendations. The SSC supports the GOA GPT recommendation that the following models are brought forward in November:

- 17.1 (last year's model)
- 17.1d (last year's model with updated aging error matrix)
- 17.1f (last year's model with updated aging error matrix and VAST)

The SSC agrees that if this full suite of models is not feasible for 2021, then remove the subset containing VAST estimates. The SSC agrees with the author that freely estimating catchability (17.1e) is not recommended for use in 2021. The SSC encourages the author to consider Francis re-weighting (17.1h and 17.1j) once issues regarding area effects on growth are resolved.

D2 ACLIM Report and GOA CLIM Update

The SSC received a report from Kirstin Holsman (NOAA-AFSC) and Alan Haynie (NOAA-AFSC) on the ACLIM 2.0 project and a brief overview on the new GOA CLIM model from Jim Ianelli (NOAA-AFSC, GOA GPT co-chair) with some additional discussion by Martin Dorn (NOAA-AFSC, CPT co-chair, GOA CLIM co-PI) during the GOA GPT presentation. Time constraints did not allow for a detailed presentation on the new GOA CLIM project. The SSC looks forward to a future presentation on GOA CLIM, which has already made much progress in a short amount of time and represents an exciting new development for evaluating fisheries and management options in the GOA under a changing climate.

Several recent events in the North Pacific, such as the drastic decline of Pacific cod in the GOA and of snow crab in the Bering Sea groundfish survey, have revealed the vulnerability of Alaska's marine ecosystems to warming climate conditions. While multiple factors may have contributed to these declines, the marine heatwave of 2014 – 2016 in the GOA and unprecedented warm conditions in the Bering Sea over the following years were undoubtedly a major driver of these stock-specific declines and of the broader ecosystem changes that are yet to be fully documented, let alone understood. **The SSC considers efforts like ACLIM and GOA-CLIM to provide the backbone of a system that will help build more resilient fisheries and identify pathways of adaptation for those engaged in Alaska's fisheries, for affected communities, and for the Council to better prepare for inevitable surprises in the future.** The SSC notes, in particular, potentially transformative changes in the NBS and Bering Strait region associated with the northward expansion of many commercially important species. These changes are already raising new transboundary issues and could lead to new resource conflicts between the shifting fisheries footprint and historical use patterns of marine resources in the region.

These ongoing climate-driven changes require new, more proactive and strategic approaches to prepare for future surprises, in addition to reacting to the latest emergency. **The SSC highlights the need to find the right balance between efforts to improve and adapt existing single-species models, which may fail to adequately account for rapidly changing conditions, with developing new approaches that are more robust to changes in growth, natural mortality, spatial distribution or other consequences of a changing climate.** The SSC is encouraged by and impressed with the ACLIM 2.0 and GOA CLIM efforts and offers some thoughts for consideration by the investigators on these projects.

The investigators of the CLIM projects are seeking feedback from the SSC and the Council on potential management measures that can be evaluated by analysts in proposed simulations and management strategy evaluations (MSEs). The ultimate goal of the simulations and MSEs is to identify management approaches that are climate resilient and provide the Council with better tools to prepare for inevitable future changes and surprises. While a detailed review of the status of these projects was not possible in the time available, the SSC suggests some general actions that the analysts may want to consider. These actions are not specific to one region but include examples that mostly focus on the Bering Sea as the ACLIM 2.0 project is more mature at this stage, while the GOA CLIM project is developing a new modeling approach using the Atlantis end-to-end model that has not previously been applied to Alaska's marine ecosystems.

The SSC discussion focused on a few broad categories of management actions and offers some suggestions regarding specific measures that could be considered in simulations, realizing that the ACLIM and GOA CLIM investigators have likely already considered most of these measures in their internal discussions and discussions with stakeholders:

1) **EBFM measures**. Under the MSA, the Council currently uses a broad ecosystem-based fishery management measure in the form of the Optimum Yield (OY) range, which is typically referred to as the 2 million ton cap on groundfish removals from the Bering Sea (corresponding to the upper limit of the OY range). While the cap has been binding in the EBS for most of its history, catches in the GOA have never been constrained by an upper limit on the GOA groundfish OY; further, the basis for the OY has been questioned in previous analyses. Therefore, one of the goals of the GOA CLIM group is to re-estimate an appropriate OY range under current environmental conditions, which would allow analysts to conduct more meaningful analyses for assessing the impacts on future harvests in the GOA under different OY ranges. Analyses for the Bering Sea suggest that the use of EBFM measures like the cap can forestall some of the negative impacts from changing climate conditions (Holsman et al. 2020, https://doi.org/10.1038/s41467-020-18300-3) and we suggest that similar analyses could be conducted by GOA CLIM. In ACLIM 2.0, the analysts propose an examination of a lower (1.6 MT) and a higher cap (2.4 MT) for the eastern Bering Sea groundfish complex in the future. The SSC suggests that a re-estimation of the OY range in the Bering Sea under current climatic conditions may be fruitful as well. The analysts could consider a broader range of upper limits on removals such as no cap (as in Holsman et al., 2020), a new, revised cap based on best available information from single and multi-species models, a reduced cap to account for enhanced climate risks, and possibly a cap that is linked to current or recent estimates of overall system productivity (for example based on a combination of primary productivity estimates, food web complexity and transfer efficiency).

2) **Gear considerations**. Given the use of spatially explicit models in the suite of models considered, the SSC suggests some exploration of the current, complex system of gear restrictions. Given that changes in the NBS are of particular concern, the SSC suggests some consideration in the simulation analysis of different gear restrictions in this region, which could include lifting restrictions on bottom trawling or placing additional limits on fishing gears in the NBS. Impact analyses from these modifications would need to consider both impacts on commercial fishing as well as impacts on subsistence resources, including marine mammals. Other gear considerations relevant in both the Bering Sea and GOA include changes in size selectivity of fishing gear that may result from changes in regulations or changing interactions between fisheries and projected decreases in the maximum size of many fish species under the metabolic theory of ecology or temperature-size rule.

3) **Spatial considerations.** Spatial (and temporal) closures of certain areas to some or all gear types have been used throughout Alaska to protect vulnerable habitats and life stages. As the distributions of many species shift, the analysts may want to consider the potential for additional closed areas such as new Habitat Conservation areas where there was little fishing in the past (such as in the NBS) and the use of dynamic management areas whose footprint adapts to changing distributions of species. One example of the latter may be dynamic red king crab savings areas or management boundaries as BBRKC expand beyond their historical range. These savings areas might be tied to trigger points associated with the center of distribution of the stock.

4) **Transboundary issues**. An important consideration in any simulations for the Bering Sea will be the possibility of future regulatory changes or international arrangements to deal with transboundary stocks such as walleye pollock, Pacific cod, and snow crab. These could include scenarios about catch-sharing agreements or other considerations to account for catches of these and other species on both sides of the Russia–United States maritime boundary.

5) **Control rules**. The SSC strongly supports considerations of dynamic control rules in MSEs, including ideas that link control rules to perceived changes in stock dynamics or to environmental or biological thresholds. The SSC had no specific suggestions for the best way to proceed at this time but is interested in exploring these ideas further.

6) **Catch allocation**. The SSC also supports efforts by the analysts to consider broad re-allocations of catches among species or species groups (such as gadids vs flatfish) under the OY cap. The SSC suggests that the analysts may also want to consider scenarios that re-allocate catches to different species or groups based on considerations of which species may be more resilient to climate change. The resilience of species to future changes could be explored through appropriate simulations.

7) **Bycatch issues**. Considerations of modified bycatch limits for salmon, crab and other vulnerable species is another fruitful area for further research and the SSC supports efforts to explore the effects of modified or new bycatch control rules through MSEs.

8) **Broadening of management approaches**. The SSC suggests that the ongoing discussions about future socio-economic pathways under the CLIM projects offer an excellent

opportunity to more broadly evaluate the current management framework through exploring other approaches. While these specific approaches may be controversial and represent a fundamental shift in how fisheries in Alaska could be managed, they could offer additional contrast for exploring alternative pathways of adaptation within a research framework. These could include issues such as full retention requirements, "balanced harvesting" approaches (i.e., harvesting species and individuals at a rate corresponding to their productivity), access rights considerations, and others.

Finally, the **SSC highlights the excellent suite of products and tools that have already been produced by the ACLIM and GOA CLIM projects.** These products and tools have tangible benefits for the research community and will undoubtedly elevate current and future research efforts to better understand and adapt to the ongoing changes in Alaska's marine ecosystems. The SSC also appreciates the efforts of the analyst to share climate data, developing tools, and research results in an open and reproducible framework.

D3 October preview of Ecosystem Status Reports

The SSC received presentations by Elizabeth Siddon (NOAA-AFSC), Bridget Ferriss (NOAA-AFSC) and Ivonne Ortiz (UW-CICOES) on the Ecosystem Status Reports (ESR) for the EBS, the GOA and the AI. Overall, data loss due to COVID in 2021 was limited in the GOA and AI, and moderate in the EBS with most loss due to survey cancellations, survey reductions (smaller footprints), and lab/data processing delays. Though preliminary, the presentations were informative and highlighted the great strides that the authors and editors of the ESRs have made in producing documents that are insightful and of benefit to the management of Federal fisheries off Alaska. The SSC appreciates the consistent high quality of the ESR presentations and looks forward to seeing the final products in December. Public testimony was provided by Chris Tran (Aleut Community of St. Paul Island).

The NPI was strongly positive in winter 2020 – 2021, the AO was negative in winter and positive in spring and summer 2021, while the PDO was negative. Water temperatures were warmer than average offshore and cooler inshore.

Eastern Bering Sea

In 2021, there was a decoupling of the winds in the NBS (strong winds from the north) and the southeastern Bering Sea (moderate to strong winds from the south). As a result, there was widespread and thick sea ice in the northern Bering, and reduced sea-ice extent and thickness in the southeast. Over the southeastern shelf, the advancement of sea ice stalled at the end of January, resulting in a relatively small cold pool, similar in size to those occurring in the warm years of the early 2000s. In 2021, air temperatures, as measured at St. Paul Island, were again quite warm, continuing the period of temperatures above the 100-year mean observed since 2012. This period of above average air temperatures is also reflected in total annual cumulative SSTs being high since 2012, particularly in the southeastern Bering Sea. The winter SSTs in 2021 were slightly below the long-term mean in the north, and somewhat above the long-term mean in the southeastern Bering Sea. Summer SSTs were above average throughout the eastern Bering Sea, though less warm than in 2019. The inner shelf south of St. Matthew Island was closer to the long-

term mean than were the middle or outer shelf regions. There was no indication of a marine heatwave in the NBS, but in the southeastern Bering Sea, temperatures briefly achieved heatwave status.

Red Flags

The presentation noted several red flags related to population declines or die-offs occurring in the EBS. In 2021, there was a 25% decline in BBRKC mature female biomass and a sharp, 69% decrease in legal male snow crab in the survey. There were also seabird die-offs in the NBS and the AYK Chinook and chum salmon returns were low. There is apparently no "smoking gun" as to the causes of the precipitous declines in snow crab and sustained period of low production of BBRKC, but several hypotheses related to changing ocean environmental conditions will be explored and presented by the ESR authors at the December Council meeting including: cumulative impacts of thermal exposure and metabolic demands, changes in stratification and vertical distribution of prey resources, and prey switching and lack of functional redundancy. **The SSC looks forward to the synthesis of more indicators in the full ESR in December and emphasizes the need for mechanistic studies, especially as they relate to the benthos in the EBS, to understand the impacts of climate change.**

Aleutian Islands

Sea surface temperatures in the western, central, and eastern Aleutians were some of the highest on record, particularly in late summer and early fall. Marine Heatwave conditions were briefly present in spring in the western and central Aleutians, and from mid-/late summer through at least September throughout the Aleutians. The long-term yearly averages of SSTs in the Aleutians have been above the long-term average starting in 2013.

Red Flags

Harmful Algal Blooms (HABs) again occurred in the Aleutians, with paralytic shellfish toxins at 76x the regulatory limit in blue mussels from Unalaska. This was less than the level in 2020 (140x the regulatory limit). There were higher concentrations of mercury detected in Steller sea lion pups (SSL; reflecting their exposure *in utero*) and fish from the western AI relative to samples from the central AI. Additionally, the percentage of SSL pups with mercury concentrations above the threshold associated with adverse effects in pinnipeds (>20µg/g) has doubled in 8 years at Agattu Island. A new set of invertebrates are to be analyzed.

Gulf of Alaska

In winter, northerly winds were weaker than usual inshore and stronger offshore. These winds may have resulted in onshore advection at depth of nutrient-rich water from the basin. The spring bloom over the shelf, at least between the Seward Line and Kayak Island, was the largest spring phytoplankton bloom in 24 years. This bloom may have been driven by nutrients advected onto the shelf by the offshore transport of inshore surface waters. There was an eddy just east of the Seward line and near its outer end, which may have also contributed to the strength of the bloom. It is not known at this time what effect the bloom had on the overall ecology of the GOA.

Red Flags and Noteworthy

In July 2021, over 300 seabirds died on Middleton Island, including at least 250 black-legged kittiwakes, 70 glaucous-winged gulls, and two herring gulls. Both the seabirds and their prey (mussels, large species of crustacean zooplankton and forage fish) tested negative for biotoxins (saxitoxin and domoic acid). It is believed that botulism type C was the most likely cause, but analyses are still on-going. The possibility that the botulism came from a freshwater pond on the island where the gulls bathed was mentioned. In 2021, NOAA conducted the first large whale survey since 2015. During the survey, four North Pacific Right Whales were seen, two over Barnabas Trough and two southeast of the Trinity Islands near the shelf break. North Pacific right whales are extremely rare, with about 100 for the North Pacific as a whole, of which about 30 are thought to reside in the eastern North Pacific, including the EBS. Right whales in the northwestern Atlantic forage for copepods that are aggregated near the bottom. In the Atlantic, right whales are vulnerable to ship strikes and entanglement in pot lines and gill nets.

SSC Member Associations

At the beginning of each meeting, members of the SSC publicly acknowledge any direct associations with SSC agenda items. If an SSC member has a financial conflict of interest (defined in the 2003 Policy of the National Academies and discussed in Section 3) with an SSC agenda item, the member should recuse themselves from participating in SSC discussions on that subject, and such recusal should be documented in the SSC report. In cases where an SSC member is an author or coauthor of a report considered by the SSC, that individual should recuse themselves from discussion about SSC recommendations on this agenda item. However, that SSC member may provide clarifications about the report to the SSC as necessary. If, on the other hand, a report is prepared by individuals under the line of supervision by an SSC member, then that SSC member should recuse themselves from leading the SSC recommendations for that agenda item, though they may otherwise participate fully in the SSC discussion after disclosing their affiliations with the authors. The SSC notes that there are no financial conflicts of interest between any SSC members and items on this meeting's agenda.

At this October 2021 meeting, multiple SSC members declared an association with various agenda items. Mike Downs is a contributing author to C4 BSAI Trawl LAPP. Jason Gasper is on the halibut DMR working group (under C6 JGPT Report) and a contributing author for C5 Observer Annual Deployment Plan. Dr. Gasper was also on the original working group that developed the NS1 Technical Memorandum on Data Limited Stocks. Dana Hanselman is a co-author on the sablefish assessment, under C6 JGPT Report, and supervises Chris Lunsford who is the supervisor of most of the sablefish authors. Dr. Hanselman also directly supervises Wes Larson, who was a contributor to the genetic analysis of blackspotted rockfish in C6 BSAI GPT Report. Dr. Hanselman is married to Kalei Shotwell, who is a contributing author on multiple ESPs (C6 JGPT Report, BSAI GPT Report, GOA GPT Report) and the Bering Sea Regional Action Plan (B4). Brad Harris is a member of the EFH Fishing Effects modelling team and is on the BS FEP team. Anne Hollowed supervises Martin Dorn, the CPT co-chair, and crab assessment authors Cody Szuwalski and Buck Stockhousen. Martin Dorn is also the lead author for the GOA RAP and GOA CLIM. Dr. Hollowed also supervises groundfish assessment authors Grant Thompson (BSAI GPT co-chair and EBS Pacific cod lead author), Jim Ianelli (GOA GPT co-chair and EBS pollock lead

author), Paul Spencer (BSAI Blackspotted-Rougheye assessment author) and Steve Barbeaux (BSAI GPT co-chair and GOA Pacific cod lead author). She is also the secondary supervisor for multiple roundfish assessment authors (C6 BSAI GPT and GOA GPT Report). Finally, Dr. Hollowed is also the lead author of the BS RAP, the lead PI on the ACLIM project and was involved with the development of the CFI. Andrew Munro is in the supervisory chain for Toshihide Hamazaki (NSRKC assessment author). Chris Siddon is married to Elizabeth Siddon, a lead editor for the EBS ESR and supervises Katie Palof (BSAI CPT co-chair and SMBKC lead author) and Jie Zheng (lead BBRKC assessment author and NSRKC co-author). Finally, Ian Stewart is a member of both the Halibut DMR working group and the BS FEP team.