



North Pacific Fishery Management Council

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SCIENTIFIC AND STATISTICAL COMMITTEE FINAL REPORT TO THE NORTH PACIFIC FISHERY MANAGEMENT COUNCIL April 3 - 5, 2023

The SSC met from April 3rd – 5th, 2023 in Anchorage, WA. Members present in Anchorage were:

Franz Mueter, Co-Chair <i>University of Alaska Fairbanks</i>	Sherri Dressel, Co-Chair <i>Alaska Dept. of Fish and Game</i>	Chris Anderson <i>University of Washington</i>
Amy Bishop <i>University of Alaska Anchorage</i>	Curry Cunningham <i>University of Alaska Fairbanks</i>	Martin Dorn <i>University of Washington</i>
Mike Downs <i>Wislow Research</i>	Jason Gasper <i>NOAA Fisheries—Alaska Regional Office</i>	Dana Hanselman <i>NOAA Fisheries—AFSC</i>
Brad Harris <i>Alaska Pacific University</i>	Michael Jepson <i>Independent Contractor</i>	Andrew Munro <i>Alaska Dept. of Fish and Game</i>
Chris Siddon <i>Alaska Dept. of Fish and Game</i>	Ian Stewart <i>Intl. Pacific Halibut Commission</i>	Patrick Sullivan <i>Cornell University</i>
Robert Suryan <i>NOAA Fisheries—AFSC</i>		

Members attending remotely were:

Alison Whitman, Vice Chair <i>Oregon Dept. of Fish and Wildlife</i>	Kailin Kroetz <i>Arizona State University</i>	Kathryn Meyer <i>Washington Dept. of Fish and Wildlife</i>
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Members absent were:

Robert Foy
NOAA Fisheries—AFSC

SSC General Comments

The SSC notes that this will be Jon McCracken's last Council meeting and thanks him for his many years as an analyst and staff lead on innumerable agenda items. The SSC wishes him the best in his future endeavors.

SSC Administrative Discussion

As part of the administrative report, Diana Evans (NPFMC) noted four publications or reports included under the B1 reports to the Council that may be of interest to the SSC:

- The [IFQ Program report](#) to the fleet
- A [summary of crab amendments](#) prepared by Council staff / NMFS
- A [summary of conservation and spatial management areas](#) in federal waters off Alaska
- A briefing on the Arctic Integrated Ecosystem Research Program, which produced a series of videos available on the NPRB [Arctic Program website](#).

B1 Plan Team Nominations

The SSC reviewed the nomination of Tyler Jackson to the BSAI Crab Plan Team. The SSC finds this nominee to be well-qualified and recommends the Council approve the nomination.

C1 Cook Inlet Salmon FMP Amendment

The SSC reviewed the Environmental Assessment and Regulatory Impact Review (EA/RIR) for the proposed Amendment 16 to the Salmon Fishery Management Plan (FMP), which describes the alternatives and options for the inclusion of salmon fisheries in the Exclusive Economic Zone (EEZ) waters of Upper Cook Inlet (UCI) within the FMP. The EA/RIR describes four alternatives, only two of which appear viable under both MSA and court orders following litigation of this issue. Alternative 2 describes the process and considerations for federal management of fisheries within the UCI EEZ waters with specific management measures delegated to the State of Alaska, while Alternative 3 describes full federal management of fisheries in the EEZ within UCI. The SSC thanks the authors for their responsiveness to past SSC comments and their careful consideration of methods for implementation and the potential impacts of the alternatives before the Council. Public comment was received from Ted Eischeid (Matanuska-Susitna Borough Fish and Wildlife Commission staff) and oral public testimony was received from Jim Sykes (Matsu Fish & Game) and Erik Huebsch (United Cook Inlet Drift Association).

The SSC highlights that this action necessitates a challenging blending of management paradigms and, as such, represents a compromise between standard practices in the escapement-based salmon management policy that has historically formed the basis for Alaskan salmon fishery management and specific regulatory requirements for harvest-based management under MSA. The SSC further highlights that either alternative will require significant coordination, data sharing, and collaboration between NMFS and the Alaska Department of Fish and Game to ensure the fishery meets MSA requirements.

The SSC finds that this document is sufficient to inform the Council at final action. The EA/RIR has benefitted from a substantive revision to address several key issues highlighted during the October 2020 SSC review and additional considerations brought forward for specific alternatives and options. The document now describes the impact and implications for the management of saltwater recreational fisheries within the EEZ region, including several options for implementation. The document acknowledges that

recreational fishery removals within the EEZ are quite small in the context of total EEZ fishing mortality. The document has also been updated to describe several options for defining MSY and an OY range based on either (1) the history of catch, considering escapement goals, (2) the range of the sum of group-specific ACLs across years, or (3) the range between the average of the three lowest and three highest salmon harvests within the EEZ. The SSC notes that these alternative approaches for defining the OY range lead to very different results in some cases. Which of these approaches is most applicable requires additional consideration in the context of the purpose behind the OY definition.

The SSC also highlights that the definition of MSY within this context is not consistent with the way MSY is estimated in standard stock-recruitment analyses for (Tier 1) salmon stocks. However, it is consistent with the proposed status determination criteria (SDC), which are defined relative to the lower bound of the escapement goal range. With respect to the analysis of impacts among alternatives, the current document presents a clear description of the annual and multi-year processes and timelines for implementation and review of data and stock status, and the specific roles of NMFS, ADF&G, a potential Salmon Plan Team, the SSC and the Council. **The description and equations for the calculation of maximum fishing mortality thresholds (MFMT) and the minimum stock size thresholds (MSST), annual catch limits, and ABC appear reasonable and consistent with MSA requirements. However, the SSC highlights that it remains clear that these EEZ management measures require considerable development before implementation, with several specific decisions deferred to NMFS or a future Salmon Plan Team.** For example, the question of what to do when data are unavailable from specific escapement enumeration projects in a given year was highlighted in public testimony. The SSC feels it is reasonable to expect that some of these lingering questions will be addressed by the relevant bodies as this process moves toward implementation.

The SSC again commends the analysts on developing detailed and insightful profiles of the communities engaged in this fishery. The profiles are supported by data that are collected by the State of Alaska for salmon fisheries but are not common in other fisheries within Council jurisdiction. Nevertheless, the analysts were able to describe the impacts of the alternatives only in qualitative terms. The SSC notes that modeling tools exist to understand how permanent or in-season closures of the EEZ will displace effort, and capture associated changes in production efficiency, competition with other fleets, and accessibility of the resource to different harvesting communities. However, it is not clear if available data are sufficient to inform such models.

The SSC acknowledges that this comprehensive analysis does not mean that anyone will be satisfied with the outcome, as evidenced by public testimony. Neither of the alternatives before the Council are likely to address the objectives of fishery participants when they pursued federal management of the Cook Inlet EEZ waters, and in fact are likely to result in both increased data and reporting burden, and the potential for more restrictive management of harvest in EEZ waters.

The SSC provides the following additional recommendations for the EA/RIR:

- NMFS staff, or a Salmon Plan Team if created, should consider scaling the level of precaution represented in the ABC calculation as a function of past preseason forecast performance, which will depend on the forecast methodology used and the available data. The SSC suggests that this be noted in the document.
- In the specific case of Kenai River late-run Chinook salmon, for which the existing escapement goal is size-based (≥ 75 cm), careful consideration is necessary to ensure all calculations for potential yield, SDC, ABC, and other management quantities, are represented in the common currency of large-sized Chinook salmon. For example, in ABC calculations based on the escapement goal, average harvest fraction in State waters, and the preseason forecast, both the State waters harvest fraction and preseason forecast would also need to be in terms of large Chinook. The SSC suggests that a footnote be included to highlight this point for specific calculations throughout the document.

C3 Scallop Harvest Specifications

The SSC received a presentation on the 2023 Scallop Stock Assessment and Fishery Evaluation (SAFE) from Scallop Plan Team (SPT) co-chairs Sarah Rheinsmith (NPFMC) and Tyler Jackson (ADF&G), and Scott Miller (NOAA-AKRO). There was no public testimony.

The scallop stock is assessed by ADF&G with input from the NMFS and the SAFE Report is compiled by the Council's SPT. The SPT meets and recommends specifications annually, but the stock is assessed biennially. This is an off year, so a SAFE Executive Summary was presented along with updates on the 2023 stock status, 2022 dredge survey, ADF&G survey dredge transition, retained-not-landed meats, changes to the FMP regarding assessment timing, age structured model development, and socioeconomics. **The SSC provided extensive comments during the 2022 SAFE review and appreciates the concerted effort by authors to address these.** The SSC supports the author's work plan for the 2024 SAFE.

Estimated total fishing removals (retained and discarded) for the 2021/22 and 2022/23 seasons were 311,978 lbs (141.5 t) and 345,690 lbs (156.8 t) of shucked meats, respectively. These estimates are less than 30% of the OFL, therefore, **overfishing did not occur in 2021/22 or 2022/23. In the absence of stock-size estimates, the status of the scallop stock relative to overfished is unknown.**

Consistent with all the scallop assessments since 2011/12, the SPT recommended that the 2022/23 OFL be set equal to the Optimum Yield (1.284 million lbs; 582 t) as defined in the Scallop FMP and the 2022/23 ABC be set equal to the maximum ABC control rule value (90% of OFL or 1.156 million lbs; 524 t). **The SSC supports the SPT's OFL and ABC recommendations and notes that scallop management via GHs continues to be very conservative.**

ADF&G conducted a dredge survey in 2022 of weathervane scallop beds within the northeast and Shelikof Districts of the Kodiak Registration Area, and the Kamishak District of the Cook Inlet Registration Area. The abundance and round weight biomass of exploitable-sized scallops (≥ 100 mm shell height) increased from previous surveys in all districts. Trends in meat weight biomass followed abundance and round weight biomass in all beds, except within the Kamishak District, which was likely due to sampling error. Abundance and round weight biomass of scallops <100 mm shell height also increased among all districts.

The ADF&G scallop surveys use an eight-foot wide New Bedford style dredge, with a ring bag consisting of four-inch diameter rings that is fitted with a 1.5-inch mesh liner to retain small scallops and epi-benthic faunal samples. Two new survey dredges were purchased in 2021. During 2022 initial test tows were conducted to troubleshoot (e.g., to determine whether or not to retain the bail rollers) the new dredges and a series of systematic calibration tows are planned for 2023.

Scallop adductor meats that are shucked as part of the retained catch, but subsequently discarded due to the meat not being marketable (poor color, texture), being damaged during shucking, or otherwise lost during processing, are referred to as "retained-not-landed" (RNL) meats. RNL meats do not count against the GH and constitute a source of unquantified fishing mortality. Since RNL meats are directly related to market quality, an index of RNL meats may provide insight to the portion of the biomass which is commercially viable. The analysts presented a brief overview of methods being explored to estimate the quantity of RNL meats in the fishery and indicated further investigation was necessary. **The SSC concurred with the SPT that collecting RNL meat data via the observer program would be valuable, if feasible, and recommended work on estimating RNL be a priority.**

Staff provided a summary of ongoing efforts to revise the Scallop FMP to remove language requiring that specifications be set annually and allow for a biennial or triennial schedule. **The SSC reiterates its support for such an amendment.**

Updates to the catch per unit effort (CPUE) standardization index and Stock Synthesis evaluation for the Kodiak Shelikof scallop bed were provided as well. The current CPUE standardization employs a general additive model (GAM) with multiple variables including depth, bed, longitude, month, vessel, and season.

Due to concerns about overfitting, the analysts proposed to use a general linear model (GLM) that includes smoothed terms for continuous variables with fixed degrees of freedom and employs model-selection criteria that include both AIC and an approximate R-squared statistic. This approach is currently used for Aleutian Islands golden king crab. Based on previous SSC recommendations, the analysts are developing an age-structured scallop population dynamics model. The model uses Stock Synthesis and focuses on the Kodiak Shelikof District. Six model scenarios were examined, including the best model from the 2022 analysis (22.1a) and five new models (23.x) that include discard mortality. The SSC appreciates this work and concurs with the author and SPT recommendation to carry forward models 23.0a3 and 23.3 for review in the next full assessment. This is based on overall fit to the data and retrospective analysis. **The SSC also supports the analyst's plan to continue exploring dredge selectivity and suggests that sediment-specific survey dredge analyses in the New England region may be informative. Finally, the SSC appreciates ongoing efforts to recover 1992 - 2008 fishery data to better inform the CPUE index and size compositions supplied to the model.**

Dr. Miller provided a socioeconomic update for the 2023 SAFE. Dr. Miller detailed Limited License Program (LLP) transfer information and reported that there were no known changes in cooperative membership or affiliated LLP ownership shares in 2022. Only two cooperative vessels fished during both the 2021/22 and 2022/23 seasons. Compared to 2021, scallop landings increased by 10%, price per pound increased by 23%, value increased by 35%, and potential crew shares increased 26%. During the 2022/23 season, 15 landings were completed in the ports of Dutch Harbor, Kodiak, Yakutat. **The SSC appreciates Dr. Miller's analyses and his overview of planned revisions in response to multi-year SSC comments that are scheduled to be completed in time for inclusion in the next full SAFE iteration (2024).**

D1 SSC Discussion of SSC February Workshop Report

The SSC received a verbal summary on the February SSC workshop report (Appendix A) from Dr. Franz Mueter (UAF; SSC Co-Chair). The SSC thanks Dr. Mueter and Dr. Bob Foy (NOAA-AFSC) for producing a comprehensive report in a short period of time. The overall takeaway from the document is that rapid changes in the northern Bering and southern Chukchi seas are having significant impacts on marine ecosystems, commercial fish stocks, and local communities that depend on marine resources for food and livelihoods. The report highlights the challenges faced by the Council as it balances potential trade-offs among interested parties that have had limited or no interactions in the past.

The report emphasizes the need for increased scientific understanding and monitoring to support future Council decision-making under increased uncertainty. The report also highlights the importance of proactive approaches for achieving management goals in a changing environment and assessing how existing frameworks may or may not be able to address ecosystem variability. **Developing specific proactive approaches or tools that might lead to better outcomes in the face of climate change remains a key gap.**

Overall, the document does a good job of capturing the discussion points and content of the workshop but would benefit from better organization as the gaps/findings/recommendations and next steps are scattered in multiple sections, then partly repeated in three different ways in the overall summary. For example, the section of bullets in Session 2 precede the topics and discussions in Session 2 and are a mixture from both sections. While the SSC appreciates the conciseness of bullets, many of these lack context to understand the role or importance in the discussion and recommends expanded description for clarity.

Rather than doing any substantial revisions to this document, **the SSC accepts the report and recommendations with any suggested revisions that can reasonably be incorporated in the version appended to the final April SSC report** and supports the development of a shorter "plain language" summary that was requested during the open mic at the workshop, as a way to share the results of the workshop to a wider audience. The SSC envisions that the summary would distill the key findings and recommendations from the complete list of gaps, findings and recommendations included in the various

sections of this report. **The SSC appreciates and accepts the offer from Council staff to assist the authors with producing this "plain language" summary of the workshop.** Several new requests could be added to this new document for clarity:

- The SSC noted that there was a substantial effort to define non-stationarity at the workshop, but a clear definition is not provided in the report and the main non-stationary process identified is spatial population changes. If non-stationarity is going to continue to be a commonly used term associated with climate change, the SSC recommends that the authors better define non-stationarity for a broad audience and provide examples of which processes are less stationary than the previously observed baseline. It also should be noted that statistical non-stationarity can mean either a change in the mean of the process, the variance of the process, or both, or it could refer to a change in the covariance among related processes.
- The SSC also suggests that a clearer definition of “dynamic reference point” should be established as most of the current reference points are dynamic to some extent, which is noted in the report but not clear in the recommendations. The goal may be to explore “more dynamic” reference points if the objective is to link to current environmental conditions and the question is how dynamic they should be.
- In the condensed plain language report, maps of where current sampling and fishing has occurred would be helpful. Additionally, maps of regional and overlapping jurisdictions could be helpful.

One of the key recommendations is to “identify which stocks are likely to do better or worse in a changing environment to help fishers build the best fishing portfolio.” The SSC cautions that any such predictions should be well caveated by characterizing the associated uncertainty around such predictions if the intent is to provide industry and communities with information on which to base business decisions or other decisions.

The SSC discussed the recommendation for a February 2024 SSC workshop based on outcomes from this report. The authors responded that it would likely be more focused on specific issues relevant to all Council-managed areas rather than general issues or spatially limited to the NBS and southern Chukchi Sea. The SSC agreed that including the GOA and the AI LMEs along with considerations of movement out of the EEZ will be essential moving forward. The SSC highlighted the urgency of addressing issues identified in the February 2023 SSC workshop, such as the questions for the subgroup to consider under “Recommendations for next steps” in the workshop report, and stressed the importance of making progress as soon as possible. In addition to, or alongside, the potential 2024 SSC workshop, the SSC discussed prioritizing work on these topics over other SSC agenda items in the near future. While specific agenda items were not discussed, the SSC discussion highlighted a sense of urgency while recognizing the difficulty of finding time for all agenda items. The SSC also notes that some of this work can be accomplished through other ongoing efforts such as the workshop proposed by the CCTF (see D3 BS FEP Climate Change Taskforce Workplan).

The SSC supported the idea of forming a subgroup of Council and SSC members to develop a roadmap that builds a bridge from assessment and climate science to adaptive management under climate change (see also bullet 4 under D6 Joint Groundfish Plan Team Workgroup Discussion). The SSC discussed the composition of the subgroup and suggests that the subgroup could include Plan Team members as similar issues have been raised in previous Plan Team reports. **The SSC recommended that the SSC chairs work with the Council to determine the best way forward in forming a subgroup to address the recommendations and plan for any 2024 workshop.** It was noted that this would be a novel type of group because the SSC was not aware of any similar groups in the past composed of Council, SSC and possibly Plan Team members. In addition, the SSC noted that the open forum style used at the February 2023 workshop was valuable and well-received and recommended the style be considered when developing future SSC workshops that have similar goals. The SSC found that this less restricted open dialogue was very informative (e.g., dedicated open mic sessions, no individual time limit on speaking).

Specific SSC comments on the report included:

- Elaborate on whether the recommendation of further risk considerations should extend beyond the risk table.
- Ensure that the report notes that there are more data and ongoing data sampling programs than were highlighted at the workshop. For example, there are sampling programs for juvenile fish abundance and condition that have long time series, but were not identified in the report. Identifying existing data sources such as these can help fill data gaps noted in the “Key take-home messages, recommendations, and next steps” and will be necessary to achieve the “improved coordination of relevant science across agencies, universities, tribes, and local communities to meet Council objectives and local needs” noted in the report under “Session 3. What tools do we have or need to apply these data to management of Bering Sea fisheries?”
- The report should note that identifying new metrics characterizing the cold pool and sea ice quality, which could be an avenue for including LT/TK, was identified as a key research need during the workshop.
- The SSC recommends adding “securing additional funding for” into the key recommendation on expanded monitoring of the NBS/SCS areas.
- The subgroup should be aware of a proposed North Pacific Research Board NBS Integrated Ecosystem Research Program, which will be a source of new research in the area and is expected to release a request for proposed research in fall of 2023.
- The SSC suggests that the statement regarding flexibility on p. 12 be changed to “The Council may want to consider prioritizing increased flexibility in the management process but this may require updates to current management objectives and regulations.”

D2 BS FEP Local Knowledge, Traditional Knowledge and Subsistence Taskforce Report and Protocol

The SSC received presentations on the “Protocol for Identifying, Analyzing, and Incorporating Local Knowledge, Traditional Knowledge, and Subsistence (LKTKS) Information in the NPFMC’s Decision-making Process” and the onramps for LKTKS information in the NPFMC’s process from Kate Haapala (NPFMC) and Sarah Wise (NOAA-AFSC). Public testimony was received from Christopher Tran (Aleut Community of St. Paul Island), Mateo Paz-Soldan (City of St. Paul), and Rebecca Skinner (self).

The SSC commends the LKTKS Taskforce on the thoughtful and inclusive process that was used to develop these products and appreciates the amount of work that has gone into creating the protocol and the onramp recommendations. Together, they represent important steps toward furthering the incorporation of LKTKS into the management decision-making process in a comprehensive, consistent, and culturally appropriate manner.

The SSC last reviewed the draft protocol in April 2022 and finds this version of the protocol responsive to previous SSC input. The development of sections with “Ideas for Moving Forward” under each of the guidelines in the protocol is particularly helpful, as is the additional development of specific onramps for Council consideration.

The SSC notes that, should the Council accept the protocol and specific guidelines for implementation, there will be a need to ensure sufficient capacity to support continuing efforts. In this regard, the SSC discussed existing capacity issues at the Council and specifically the need to expand non-economic social science capacity, including LKTKS expertise.

The SSC notes that the protocol is a Council document; however, capacity considerations are not limited to Council staff. For example, in addition to increasing Council capacity as recommended, the Council could also consider strategically using expertise from non-Council entities and other agencies to help build overall capacity. This may also involve non-Council agencies (e.g., NMFS) considering the protocol when providing analytical products used for Council decision making (e.g., Annual Community Engagement and Participation Overview (ACEPO)).

The SSC had the following additional recommendations:

- Should the Council support the protocol and/or specific onramps, the SSC notes having a communication strategy to roll out the protocol and allow Tribes and stakeholders to choose how best to engage with the overall Council processes would be useful.
- The SSC highlights and supports the protocol's recommendation for periodic review, including review of the analytical template.
- The SSC appreciates seeing information from the Tribal consultations related to the Cook Inlet Salmon FMP agenda item at this meeting and notes that receiving consultation information on relevant agenda items could be an important onramp for the SSC.
- The SSC considers the LKTKS search engine a useful tool that will help staff in their efforts to incorporate valuable information. However, updating and maintaining the database will require an ongoing commitment of time and effort for which dedicated staff time is needed.
- The SSC discussed the idea that the Council is not alone in striving to incorporate LKTKS into management decision making processes and that a formal or informal interagency group of individuals involved in these efforts could be formed to facilitate an ongoing dialogue on these issues. This could involve Council, AFSC, Regional Office, other federal agencies, and State personnel, among others.
- Consistent with other recommendations regarding socioeconomic information, the SSC suggests that, in addition to the onramps discussed in the protocol, a useful approach would include consideration of potential onramps within the recurring cycles of updating and improving existing decision-informing analytic products such as Ecosystem Status Reports (ESRs), SAFE documents, including Ecosystem and Socioeconomic Profiles (ESPs) where relevant, and ACEPO, among others.
- The SSC discussed the specific onramp to host a dedicated workshop for public engagement in the upcoming NPFMC research priorities triennial process in 2024. If the Council adopts this onramp, the SSC suggests that to provide the most effective input the workshop occur earlier in the process than the suggested timeline in the document to allow time to ensure effective inclusion of diverse perspectives on research priorities. NPFMC staff could also coordinate with the current SSC subgroup tasked with development of research priorities.
- The SSC encourages the taskforce to make sure that the documents distinguish between aspirational processes and what can be expected from realistic next steps. It is important to emphasize that knowledge must have a clear federal fisheries nexus to integrate into the Council process, and that while this establishes the Council's desire for including LKTKS information in management, steps must be taken by partner agencies to establish processes for this to happen regularly and according to best practices.

D3 BS FEP Climate Change Taskforce Workplan

The SSC received a summary of the March meeting of the Climate Change Task Force (CCTF), and accompanying meeting report, from Diana Stram (NPFMC). For the meeting and meeting report, the CCTF reviewed SSC comments on the Climate Readiness Synthesis (CRS) from the February SSC meeting and discussed plans for an upcoming Climate Change Scenarios and Advice workshop tentatively scheduled for early 2024. There was no public testimony.

The meeting report provided detailed responses to the SSC's comments on the CRS, and the SSC thanks the CCTF for their thoughtful responses. In particular, the SSC appreciates the CCTF's suggestions on how some of the SSC recommendations could be incorporated into the CRS, the upcoming workshop, and the EBS Climate Change and Adaptation Report (CCAR). The SSC also thanks the CCTF for the clarification of the differences between CRS and the CCAR. The CRS will be a periodically updated assessment of the status of climate readiness and the CCAR is a deliverable that will be informed by the upcoming Climate Change Scenarios and Advice workshop and will provide recommendations for increasing climate readiness. The meeting report provided an outline of possible sections to the CCAR including sections on adaptation and management effectiveness. The CCTF noted that an evaluation of the full scope of adaptation and management effectiveness is beyond the scope of the CCTF but suggested that they could provide a review and recommendations for conducting such analyses, which the SSC supports. With respect to the CRS, the SSC recommends continued consultation with stock assessment authors to develop a formal process to gather species-specific feedback on climate readiness and adaptation needs.

Dr. Stram provided an overview of the planning and organization of the Climate Change Scenarios and Advice workshop, which was detailed in the meeting report. The goal of the workshop is to “synthesize and summarize the critical needs, resources, and process to develop and maintain a robust and inclusive decision-making process to respond to climate change effects in the North Pacific.” The CCTF plans to achieve this goal by having participants consider potential solutions and tools within the existing process (incremental) and bigger picture changes (transformational). **The SSC supports the goals, objectives, scope, general organization, and timeline of the proposed workshop as described, as well as the outcomes and deliverables.** The SSC appreciates the CCTF's consideration and planned incorporation of some of the SSC recommendations from the February meeting, such as reviewing the ability to anticipate or respond to infrequent shocks or tipping points. The SSC supports the upcoming workshop's use of tools such as case studies, including retrospective consideration of information that would have been necessary to better respond to past climate shocks, and scenario-planning exercises to help focus and facilitate discussion. Other aspects of the workshop that the SSC appreciates is the proposed approach of assessing different time horizons (i.e., one year, ten years, 20 years) as well as exploring both “inside the box” approaches (i.e., what tools and processes are currently available) and “outside the box” approaches (i.e., what fundamentally different approaches or tools could be used even if not consistent with current FMPs).

The SSC had the following recommendations and suggestions for the workshop:

- With respect to case studies, the SSC discussed that there are many good examples of what has occurred (e.g., linear trends and periodic shocks or tipping points) that could be considered, both within Alaska and elsewhere (e.g., international). The SSC suggests that these would be a good starting point in that learning from the past will help inform future scenarios, with an emphasis on examples of what was done correctly vs. what would have been necessary for more effective management responses. Specifically, the SSC suggests that the CCTF should consider whether it is possible to draw upon examples of effective climate readiness in fisheries from both Alaska and other regions globally.
- It was noted during discussion that there was a Science for Nature and People Partnership (SNAPP) project on Climate Resilient Fisheries (<https://snapppartnership.net/teams/climate-resilient->

[fisheries/](#)) developed by a global fisheries management committee lead by Kathy Mills (Gulf of Maine Research Institute), Kristin Kleisner (Environmental Defense Fund) and Patrick Sullivan (Cornell University; SSC member) to address this problem. A product of this project was a tool/process that can be used to work through this issue with a group of managers or stakeholders to identify the attributes that may support or inhibit climate resilient fisheries (<https://climateresilientfisheries.net/>). The SSC suggests that this (as well as the associated case studies) might be a useful resource for the CCTF to explore as they continue to develop the workshop.

D4 Groundfish and Crab Economic SAFE Reports

The SSC received presentations on the Groundfish Economic SAFE and Crab Economic SAFE from Brian Garber-Yonts (NOAA-AFSC). There was no public testimony.

The SSC was unable to conduct a full review of both SAFE documents because the Crab Economic SAFE was not available until a few days before the presentation. Therefore, the discussion summary is based primarily on the presentations.

The SSC appreciates the high quality of the ongoing work that is being done to provide clear and consistent data summaries and analyses needed to address economic condition-focused aspects of SAFE reports, as described under National Standard 2 guidelines and illustrated in both presentations. These documents summarize the collection and use of economic data and indicators to address specific analytic needs and to broadly address needs related to National Standard 2 (among others).

As the breadth of social and economic information has increased, the SSC reiterates the need for a coherent strategy for where and when to report data used to monitor the fisheries and inform management actions; a significant update was expected at this meeting in response to previous years' SSC comments and the SSC was surprised to hear that planning and thought towards a coherent strategy has not begun. In addition to the Economic SAFE documents, additional economic and, in some cases, social/community information is reported in the ACEPO, ESRs, ESPs, new products developed under the Climate and Fisheries Initiative, and reports that can be accessed via the Human Dimensions Data Explorer Tool. The SSC found this year's presentation of the Economic SAFE and ACEPO at the same meeting to be helpful in providing a broader picture of the social and economic conditions within the fisheries. The SSC cautions that decoupling these documents and releasing them at different points in the year and having them reviewed during different Council meetings may result in a less comprehensive SAFE process than would be the case if reviews were concurrent. **The SSC supports the NOAA-AFSC plan to convene a workshop or other process to develop guidance about the social and economic information that will be contained in each of these products to eliminate duplication, maximize utility of different information to management decisions, and direct users to the information they need. The SSC recommends doing this as soon as possible and notes that the process could include Council members and members of Council committees and taskforces.** This group should also consider how to archive information should the form or content of these data products change in the future. The SSC reiterates the suggestion from the October 2021 SSC Report to look to the national Socioeconomic Aspects in Stock Assessment Workshop (SEASAW) as a model.¹

Groundfish Economic SAFE

The Groundfish Economic SAFE provides a broad overview of the economic performance of the groundfish fisheries in the 2021 data year, with particular attention to changes coinciding with COVID and some new

¹ A. N. Chan, 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. 2022. The SocioEconomic Aspects in Stock Assessments Workshop (SEASAW) Report: Recommendations for Increasing Assessment Accuracy and Improving Management Advice. U.S. Department of Commerce, NOAA. NOAA Tech.Memo. NMFS-F/SPO-232, 96 p

additions to the report. The SSC appreciates the organized and accessible format used to depict the current economic status of the fisheries, show changes in the economic status of fisheries over time, and provide a detailed economic history of the fisheries. The SSC finds value in the updated market profile in the Groundfish Economic SAFE and presentation. This provides important context for the fishery-specific price trends presented earlier in the document.

Finally, **the SSC again expressed concerns over dropping the Amendment 91 EDR data from the report.** Although the data collected have limitations, it is important for process transparency to summarize for the public what has been collected, but also highlight deficiencies with, or limitations of, the data and what it does (or does not) show.

As the SSC has now reviewed several annual iterations of the Groundfish Economic SAFE with only minor comments, **the SSC recommends future reviews focus on the content of the updated data, rather than the format of the document.** Keeping the major structure of this mature document consistent will make it possible to automate updating figures and tables. The SSC suggests retaining the short narrative description of the current fishing year at the beginning of the document and including a short description of any additions or changes in structure.

Crab Economic SAFE

The Crab Economic SAFE presentation provided an overview of the economic performance of the fishery in 2021. This year's edition is responsive to a number of key structural suggestions provided by the SSC in recent years, largely with the goal of increasing the consistency with the Groundfish Economic SAFE. **The SSC appreciated the new report card section that parallels the report card in the Groundfish Economic SAFE.** The separate post-rationalization graphs work well, and separating the periods of time seems important for understanding trends. The SSC also appreciates the significant progress on understanding quota share ownership, and how it has changed over time. The SSC expects to provide a fuller review of the additions to the document next year.

D5 Annual Community Engagement and Participation Overview Report/ Norton Sound Red King Crab Research

Annual Community Engagement and Participation Overview

The SSC received a presentation from Sarah Wise (NOAA-AFSC) with updates to the Annual Community Engagement and Participation Overview (ACEPO) for 2023. The SSC recognizes the considerable effort and work that has followed from previous reviews of the document and the SSC thanks Dr. Wise and others who contributed to the update and addressed many of the SSC's previous comments. Public testimony was given by Stephanie Madsen (At-sea Processors Association), Rebecca Skinner, Mateo Paz-Soldan and Heather McCarty (City of St. Paul and CBSFA, respectively), and Marissa Wilson (Alaska Marine Conservation Council).

Dr. Wise highlighted three of the NPFMC top ten research priorities related to social science and followed with responses to SSC comments from the 2020 review of the ACEPO. The SSC notes that several of the SSC comments have been addressed with some that still need to be addressed or are ongoing.

This ACEPO document provides information and analyses on the social and economic benefits of the groundfish and crab fisheries at a community level and is conducted to meet Council management objectives and the Magnuson-Stevens Fishery Conservation and Management Act National Standard 8 (NS8). The SSC appreciates the ongoing efforts to develop the ACEPO report into a useful, decision-informing document.

The ACEPO analysis considers four performance metrics of community fisheries: commercial processing engagement, commercial harvesting engagement, the processing regional quotient, and the harvesting regional quotient. These measures are provided for both the groundfish fishery and the crab fishery. By providing the engagement tables and regional quotients the report provides an overall view of communities involved in these fisheries. The report also provides figures relating to the tax revenues in communities where data were available, which help in understanding the contribution of fisheries to overall community welfare through taxes levied. A recent addition to the ACEPO is a measure of school enrollment, which has been identified as a new indicator of community welfare. As pointed out in the document, a decline in school enrollment can be an early indicator of a loss of important services and possible out-migration of individuals who need community schools for their children. A declining population can lead to a declining tax base. The community sketches provide a more in-depth look at a select group of communities by providing demographic data along with other well-being measures that help consider the community social, economic, and cultural context within which fishing activity takes place. In addition, these community sketches do include selected climate change and social indicators.

The SSC acknowledges the responsiveness to previous SSC comments, the many improvements to the document and the capture of communities involved in these fisheries. The addition of new measures of community well-being provides a more comprehensive view of how fishing activity is embedded within a community. The SSC noted the following areas for further improvements:

- There is a need for continued efforts to characterize smaller communities and capture their involvement in the fisheries, along with a need to identify communities that have not been able to maintain sustained participation in the relevant fisheries. The SSC suggests that disaggregating information that already appears in the Economic SAFE to the community level might be one way to bring more information on those communities into the document. The document could also provide species-level information and analysis at the community level to support individual groundfish and crab stock assessments and possibly inform TAC setting. Such information might be used to identify potential unquantified uncertainty and risk not already accounted for in the assessment or tier system (i.e., risk table considerations for setting ABC, NS2) and information that addresses sustained participation and the minimization of adverse economic impacts for fishing communities to inform setting TAC (NS 8).
- The SSC notes that the document would benefit from additional explanatory text for social indicators similar to what is provided for vulnerability ratings.
- The SSC discussed the role of the Human Dimensions Dashboard and the goal of providing the report and the data behind the ACEPO to those interested in using the data for reporting and other uses. The SSC noted that the ACEPO seems removed from the other suite of SAFE reports such as the Economic SAFE and species-specific ESPs that typically appear as SAFE appendices. On the one hand, being able to download the data from the Data Explorer increases access that would be beneficial to managers, researchers and the public. On the other hand, it could result in fishery managers not having all the social and economic data they need to consider in combination with biological and other stock data when making decisions under NS1, NS2, NS4, NS8 and multiple Executive Orders.
- The SSC suggests that there are other sources of tax revenue data for State-shared Fisheries Business Tax and Fishery Resource Landing taxes that can be utilized, and are more consistent across communities. The SSC also noted an issue with conflating community tax revenues with fees associated with harbor infrastructure and other fishery associated enterprise funds.
- The SSC suggests further consideration of how to associate processing activity aboard stationary floating processors operating within municipal boundaries with their community of operation.

- The SSC encourages consideration of how to include the influence and benefits of CDQ programs on communities, possibly including quantitative metrics or other information provided by CDQ groups as part of their annual reporting process. A consistent listing of tribal entities by community would also improve the utility of the document for multiple reasons.
- The SSC suggests consideration of adding a table that combines the Social Indicators for Fishing Communities ratings and Climate Change Vulnerability Ratings across communities. It was extremely helpful to have these ratings in individual sketches, but it would also be valuable to be able to make comparisons across communities. Additional information that might be helpful to see across communities could include a table or stacked bar chart that summarizes the reliance on specific fish species by community and year (e.g., share of landing revenue by species, harvest by weight or processing by weight).
- The SSC recommends further improvement to capturing community engagement in the groundfish and crab fisheries through participation in the at-sea processing sector.
- The SSC suggests that school enrollment data might include a possible social indicator threshold to help the reader understand when social well-being might be vulnerable due to potential school closure.

The SSC had several suggestions regarding the report structure and highlighted some inconsistencies within:

- The SSC notes that it can be confusing to the reader when long term trends are presented with data and text that discuss annual changes. Recognizing that long-term trends are important for context, perhaps consistently noting both the long term trend and the most recent annual change (already accomplished in many cases) may help.
- Recognizing that data from the most recent year is not available for summary, the SSC suggests consideration of including a short section at the beginning of the document to note red flags or big changes (e.g., fishery disasters) that might greatly affect upcoming ACEPO results.
- The SSC recommends a change in the current format of the document posted on the Human Dimensions website from a PowerPoint to a format that is more accessible to the public and, as a public facing document, being particularly aware of using plain and clear language is always a worthy goal.

Norton Sound Red King Crab Research

The SSC received an update from Dr. Wise on the study “Adapting to change in the Norton Sound Red King Crab Fisheries: Including local knowledge to inform decision-making.” Over the past several years the SSC has indicated support for a socioeconomic-focused case study in this fishery and such a study was included in the Council’s Top Ten Research Priorities for 2022-2024. There was no public testimony.

This study was originally designed to be a multi-method effort, including ethnographic interviews in the communities substantially engaged in or dependent on the fishery. It included, among other goals, a specific focus on understanding the potential for local knowledge, traditional knowledge, and subsistence (LKTKS) information, systematically applied in culturally appropriate ways, to contribute to the management of the fishery. Initiation of the study, however, coincided with the outbreak of the COVID-19 pandemic, necessitating a fundamental shift in methodology, including a shift to phone interviews, and a modification of research goals to include a narrower focus on LK. Dr. Wise presented preliminary results through policy mapping, a summary of sustained participation in the fishery, overarching themes that emerged in interviews, and observed changes in the fishery coincident with changes in climatic and sea ice conditions, as well as species distribution changes. The presentation also covered findings with respect to effects on communities as well as continuing fishery challenges and ongoing informational needs.

The SSC expressed its appreciation for the quality of the work and the promising range of findings that were developed, especially given the challenging research conditions, and looks forward to seeing the completed research products. The SSC also indicated its support of using the current study as a pilot effort for a more comprehensive, multi-method analysis of the type originally intended and described in previous SSC reports. **The current work provides a strong foundation for targeted follow-on efforts as pandemic-related research challenges continue to ease.**

D6 Joint Groundfish Plan Team Workgroup Discussion

The SSC received a summary of previous discussions on workgroups from Sara Cleaver and Diana Evans (NPFMC). There was no public testimony. These discussions included:

- 1) October 2022 recommendations for crab working groups
 - Development of simpler models for snow crab, Tanner crab and Bristol Bay red king crab (completed March 2023).
 - Developing a framework for how to estimate the magnitude of unobserved mortality for use in stock assessments.
- 2) December 2022 discussion of potential groundfish working groups recommended by the JGPT
 - A working group focused on data-limited/Tier 6 methods
 - A working group that addresses current policies affecting harvest control rules and develops new approaches for accounting for changes in ecosystems related to climate change, including the exploration of environmental data to help inform recruitment.
- 3) Additional topics considered by the SSC in December 2022
 - Use of Tier 1 vs Tier 3 calculations and appropriate ABC buffers
 - Interaction between recruitment variability and harvest control rules
 - The effects of truncated age structure on the performance of harvest control rules
 - The treatment of recruitment in projections and its effects on reference points, including considerations of the appropriate time periods over which reference points should be calculated and how to account for ecosystem effects on recruitment
 - Concepts that may be relevant for harvest control rules and also TAC considerations, including maximum economic yield, catch stability, future value, and other considerations
- 4) Finally, the draft recommendations from the February SSC workshop on rapid environmental change
 - Form a subgroup of Council and SSC members (2-3 members each) to develop a roadmap that builds a bridge from assessment and climate science to adaptive management under climate change. The roadmap should consider the products and recommendations from the D1 SSC Workshop Report (April 2023, see Appendix), Climate Change Task Force, LKTKS Taskforce, and national Council Coordination Committee - Scientific Coordination Subcommittee (SCS) discussions. The roadmap would recommend a direction and timeline for moving forward, recognizing the urgency for action as the North Pacific expects continued change in the near future. Questions for the subgroup to consider include:
 - Are more dynamic reference points as an alternative to current management practices reasonable, given the current Council processes under the Magnuson Stevens Act?

- Could/should social or economic objectives (e.g., MEY, biomass thresholds) be incorporated into adaptive management approaches for some stocks?
- As stock footprints expand and shift in distribution, are regional allocations of catches in the EBS and NBS appropriate and could they be dynamic enough to address temporal variability?
- Can risk considerations be improved upon in the context of both stock assessments (ABC considerations) and management (TAC considerations)?

Council staff also provided an overview of types of working groups/workshops that could be considered within the Council process. The first of these is a technical meeting, or meetings, among analysts, PT members and SSC members (**‘working group’**) intended to provide a forum to generate new ideas and/or begin work on a topic, but with all products still going through the usual PT and SSC review and process. In order to convene quickly and to improve efficiency during meetings, these working groups may not be open to the public. A second type is an open public meeting (**‘workshop’**), intended to include broad participation and input from the public. Workshops, such as the annual February SSC workshop, may result in specific recommendations to the Council process.

The SSC recalled from previous discussions the importance of prioritizing working group/workshop needs across both crab and groundfish, given finite resources and the potentially large number of topics that could be addressed.

The SSC members noted that the recent working group on simpler models for snow crab, Tanner crab and Bristol Bay red king crab strongly benefitted from participation by analysts, PT and SSC members, and the SSC recommends this integrated approach across groups be taken where practicable.

Based on discussion of the working group/workshop topics already identified, and recognizing that the SSC has already supported the work on data-limited/Tier 6 methods and that a working group has already convened on the development of simpler models for crab, the SSC recommended the following priorities:

1) Following the successful February 2023 SSC workshop on rapid environmental change, the SSC recommends that the Council consider forming a subgroup of Council and SSC members (and possibly PT members) to develop a plan that builds a bridge from assessment and climate science to adaptive management under climate change, with additional specific topics as noted in the workshop report. The SSC further recommends that this effort may also consider the time periods over which reference points should be calculated for both crab and groundfish. The SSC noted that the choice of time periods has been an SSC decision in the past, but that these considerations are closely related to a broader evaluation of productivity and/or changes in productivity that may require Council perspectives for management. The SSC considers this a high priority for Council consideration, ideally forming this group during summer 2023.

2) The SSC continues to support a working group to develop a framework for how to estimate the magnitude of unobserved mortality for use in crab stock assessments and recommends it be formed as soon as possible (high priority).

3) The SSC recommends that a workshop may be the right format to address Tier-system related topics, including the use of Tier 1 vs Tier 3 calculations and appropriate ABC buffers, and the interaction between recruitment variability and harvest control rules. Given current resources, the SSC considers this to be a lower priority with no specific timeline.

4) The SSC discussed the need for a working group/workshop on concepts that may be relevant for harvest control rules and TAC considerations, including maximum economic yield, catch stability,

future value, and other considerations. **Given that this work has already been endorsed for sablefish (per the December 2022 Council motion), the SSC recommends that no working group/workshop be formed at this time, pending the results for sablefish. The SSC also recommends that evaluation of the effects of truncated age structure on the performance of harvest control rules also proceed first via a sablefish-specific analysis and that a workshop or broader working group be reconsidered following those results.**

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 that 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 immediate line of supervision by an SSC member, then that 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 associations 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 April 2023 meeting, a number of SSC members acknowledged associations with specific agenda items under SSC review. Jason Gasper provided analysis for C1 Cook Inlet Salmon FMP and is a member of the Climate Change Taskforce that developed the Climate Change Taskforce Workplan and response to SSC comments (D3). Brad Harris supervises Dr. Robert Murphy Jr., a member of the LKTKS Taskforce (D2 LKTKS Protocol and Onramp Recommendations). Mike Downs contributed analyses to the C1 Cook Inlet Salmon EA/RIR. Andrew Munro contributed to the original development of the status determination criteria, reviewed previous versions of the EA, but his only contribution to the current version of the document was providing data. Chris Siddon is the second level supervisor for Tyler Jackson, co-chair of the Scallop Plan Team and lead scallop assessment author. Curry Cunningham provided early analyses to the previous C1 Cook Inlet Salmon EA/RIR and discussed elements of the updated version with the authors of the current draft.

Appendix A: Final SSC February 2023 Workshop Report

Rapid change in the northern Bering and southern Chukchi Seas - Identifying ecosystem responses and effects on the management of Federal fisheries

North Pacific Fishery Management Council - Science and Statistical Committee Workshop

February 7-8, 2023

FINAL REPORT

Overview

On February 7-8, 2023 the North Pacific Fisheries Management Council – Science and Statistical Committee (SSC) held a workshop titled “*Rapid change in the northern Bering and southern Chukchi seas – Identifying ecosystem responses and effects on the management of Federal fisheries*” (Appendix 1). The workshop was motivated by recent rapid changes in the Pacific Arctic and, in particular, in the northern Bering Sea (NBS) and Bering Strait region. A number of Bering Sea commercial fish stocks moved into and possibly beyond the northern Bering Sea and their abundances in these areas increased dramatically during a recent marine heatwave. These changes have resulted in increased uncertainty about the status of Bering Sea stocks, as exemplified by the sudden and unexpected decline of snow crab and large scale movements of Pacific cod following an unprecedented warm period. There is a need to better understand the role of the NBS and southern Chukchi Sea ecosystems in supporting Bering Sea commercial fish and shellfish stocks, and – in turn – to understand the impacts of a northward expansion of Bering Sea fish stocks on the NBS ecosystem.

As Bill Tweit (NPFMC) noted in his opening remarks, the Council faces unprecedented challenges about how to balance protecting livelihoods and ways of life with sustainable harvests during a time of rapid change, as well as increased scrutiny and social conflict. He focused on four critical issues: understanding the limitations of current tools for decision making, concerns about litigation against new tools and approaches that could inhibit the adoption of new strategies, the need for clear demonstrations of how EBFM will help the Council adapt, and the lack of proficiency and familiarity with applications of risk-based management approaches. In approaching these challenges, he emphasized the importance of communication throughout, such as integrating different perspectives including indigenous knowledge, recognizing the social as well as scientific issues in selecting ecosystem indicators to use in management, and acknowledging that adaptive management requires trust among participants. Effective strategies will include the choice of accessible vocabulary, broadening our listening skills, encouraging creativity, and eliminating communication hierarchies. As we develop new management frameworks, as much thought must be given to inclusion, communication, implementation and defensibility as to the development itself.

These challenges and strategies echo themes identified during the SCS7 workshop, *Adapting Fisheries Management to A Changing Ecosystem*, and its key findings. Findings were summarized by Diana Stram at the beginning of this workshop and included the need for Councils to prepare now for complex management decisions due to climate change, the need for investing in the development of new data collection and analysis tools that are responsive to changing conditions, the need for SSCs and Councils to transition towards more sophisticated tools and approaches, and the critical role of stakeholder engagement for adaptive management to be successful.

The workshop included opportunities for open discussions among SSC members, among the SSC and subject matter experts, and among the SSC and Council members. Ample opportunities were also provided for the public and a wide variety of stakeholders to comment on the challenges the Council faces and to participate in these discussions. The SSC workshop was part of an emerging dialogue among the SSC, scientists working in the NBS, other knowledge holders from the NBS and other interested stakeholders. Many issues were raised during the workshop to inform and support the work that is needed to develop the scientific basis for managing Bering Sea fish stocks in a time of unprecedented changes. This is especially

critical given the expanding footprint of Bering Sea fish populations into habitats that previously were dominated by an Arctic fish assemblage and that provide the food and livelihoods for people in the region.

The goal of the workshop was to identify the science and monitoring requirements for supporting future Council decision-making under increased uncertainty. This included exploration of proactive approaches for achieving management goals in a changing environment, and an assessment of how existing frameworks may or may not be able to address ecosystem variability. To achieve this goal, session objectives included an assessment of our current understanding of the major changes occurring in the NBS that affect all components of the ecosystem (Session 1), identification of critical gaps in understanding, as well as research and monitoring needs to address these gaps and to adequately assess ecosystem status and trends (Session 2), and assessment of the tools and approaches currently used or needed in the future to manage Bering Sea fish and crab stocks (Session 3).

SESSION 1. WHAT DO WE KNOW ABOUT THE CURRENT STATE AND NEAR-TERM FUTURE ENVIRONMENTAL AND ECOLOGICAL STATES OF THE NORTHERN BERING SEA AND SOUTHERN CHUKCHI SEA?

Summary of key indicators of change

Physical environment: This session started with a description of and recent changes to the physical environment and climate trends in the region (Seth Danielson, UAF). Key processes associated with dynamic water flow, typically driven by winds, have changed with environmental conditions. The overall net flux of heat to the north has increased, with excess heat gain measured in the Chukchi Sea relative to the North Pacific. The result of this flux was observed in the sea ice conveyor belt and cold pool characteristics. These changes have potential consequences for species distributions, species' metabolism, food quality, competition for resources, and pelagic export to the benthos. The presentation concluded by highlighting some characteristics of the Northern Bering Sea that will likely persist in a warming climate, including extreme seasonality, large nutrient fluxes that drive primary productivity, and diatoms that sink to the seafloor to sustain high benthic production. Questions were raised about the quality of sea ice habitat, the impact of increased shipping on sea ice habitat, and the changing contribution of sea ice algae to the annual production and to the benthos, which are poorly understood at present.

Plankton and epibenthic invertebrates: Lower trophic level responses to environmental changes were considered for phytoplankton and zooplankton (Dave Kimmel and Lisa Eisner, AFSC), epibenthic invertebrate community diversity (Lauren Sutton, Kachemak Bay NERR), and epibenthic infaunal biomass (Libby Logerwell, AFSC). Recent work supports the hypothesis that warming and earlier sea ice retreat have favored a shift to longer food chains (and lower carbon flux to the benthos), starting with smaller phytoplankton and microzooplankton species. The role of larger, fatty zooplankton such as *Calanus* will change as it may no longer accumulate in large numbers on the shelf in the absence of the cold pool. This reduces food availability for small fish, and may reduce the potential for the ecosystem to support key fish species. It is possible that euphausiids may replace *Calanus* as important food in warmer years, but the abundance of euphausiids is poorly known as they are difficult to sample. In addition to changing abundances, changes in bloom timing may affect all trophic levels. For example, in 2018 in the northern Bering Sea earlier ice retreat led to a delayed phytoplankton bloom that was decoupled from the ice retreat. The number of open water blooms is expected to increase as the ice edge retreats northward and sea ice melts earlier, with unknown effects on overall phytoplankton biomass and productivity.

A retrospective analysis of epibenthic invertebrates in the northern Bering Sea and Chukchi Sea suggests that functional groups have changed from more sessile invertebrates to more crawlers and swimmers during the recent warm years from 2015-2019 and these trends are expected to continue through the end of the century. At the same time, infaunal biomass from 1998-2018 decreased in southern regions of the northern Bering Sea while increasing north of the Bering Strait. As temperatures continue to change, the habitat for some species shifts to the north and shrinks, in particular cold water habitat for some snails and mussels that provide important food for seabirds, mammals and flatfish. Similarly, the preferred habitat for snow

crab will shrink, while warm water habitat will expand, along with warm-water invertebrates that have a broad temperature tolerance such as basket stars.

Seabirds, marine mammals, and groundfish: Upper trophic level responses to the observed environmental changes were considered for seabirds (Adrian Gall, ABR Inc., and Robb Kaler, USFWS), marine mammals (Michael Cameron, AFSC), and commercial groundfish species (Franz Mueter, UAF, SSC member, Kerim Aydin, AFSC, and Lauren Rogers, AFSC). Seabirds were identified as useful ecosystem indicators because their distribution, abundance and reproductive success reflect the location, abundance, composition and quality of suitable prey. Seabirds have been concentrated offshore during previous marine heatwaves and the abundance and distribution of seabirds changed substantially during the recent marine heatwave beginning in 2014/15. Fish eating seabird species moved to the north while plankton eaters stayed in the northern Bering Sea in 2017-2019 compared to earlier years. The diet of plankton eating auklets that stayed in the northern Bering Sea during this period consisted almost entirely of euphausiids, rather than the more mixed diet of copepods, euphausiids and other zooplankton that characterized diets in earlier years. Murre, kittiwake and auklet colonies throughout the region experienced reproductive failures during the heatwave (2016-19) and widespread die-offs of both plankton eaters and fish eaters were observed during the same period and have been linked to nutritional stress. The abundance of seabirds at many breeding colonies in the Bering Sea has declined, while the abundance of kittiwakes and murrelets at Cape Lisburne in the Chukchi Sea increased despite reproductive failures, suggesting immigration towards this northern colony from the south. Participants highlighted concerns over seabird die-offs due to poor food availability and commented that local residents in the Bering Strait region have a wealth of information on seabird trends and condition.

Similar to seabirds, marine mammals can serve as indicators of a changing northern Bering Sea ecosystem, in particular species closely associated with sea ice. Sea-ice dependent ice seals experienced a decline in body condition during the marine heatwave, due to loss of habitat and nutritional stress. Poor body condition led to low pup survival as well as mortalities of some subadults and adults. Due to their dependence on sea ice, and despite high abundances, bearded and ringed seals have been listed as “threatened” and critical habitat has been designated for both species. While interactions with fisheries are rare, these could increase if more fisheries expand into the northern Bering Sea. The abundance and distribution of whales in the Bering and Chukchi seas is also changing as sea ice cover and temperature change. For example, the overwintering distribution of endangered bowhead whales has shifted from the Southeast Bering Sea into the northern Bering Sea and southern Chukchi Sea, with the potential to change their interactions with fisheries that can entangle or strike whales. An unusual mortality event for grey whales occurred primarily along the US West Coast, but has been attributed to poor foraging conditions in the northern Bering Sea and Chukchi Sea. There is also concern for endangered North Pacific Right Whales, which have been observed in the Bering Strait region. Workshop participants highlighted that the four species of ice-associated seals are essential to the nutritional, economic and cultural needs of communities throughout the Bering Strait region.

Changes in temperatures and ice cover during the marine heatwave were associated with changes at the base of the food chain that not only impacted seabirds and mammals, but had a profound impact on the distribution of several commercial groundfish species. In particular, during warm years, wholesale distributional shifts to the north were noted in Pacific cod, walleye pollock and other subarctic species, whereas a cold water assemblage of more Arctic species shrank back to a much more limited northerly distribution. The expansion of large migratory fish species into the NBS increased the overall consumption of prey resources in this region by groundfish predators, likely competing with seabird and marine mammal predators for available prey. The estimated consumption peaked in 2017 in the Chirikov Basin north of St. Lawrence Island, but not until 2019 in other areas of the NBS. While pollock primarily consumed pelagic prey, Pacific cod primarily consumed benthic invertebrates including a large proportion of snow crab, which likely contributed to a pronounced decrease in benthic biomass on the NBS shelf after 2019. Tagging studies suggest that Pacific cod use the NBS seasonally for feeding and disperse to spawning locations

along the outer shelf and slope, including Russian waters, in winter. Spawning habitat for Pacific cod is projected to expand onto the shelf but the NBS is not predicted to become thermally suitable for Pacific cod spawning based on lab-derived estimates of hatching success and projected temperatures on the shelf through the end of the century. However, recent warming on the Bering Sea shelf has already exceeded levels that were not expected for several decades.

Discussion: During the open mic session and SSC discussions, participants identified a number of core themes and highlighted some of the challenges facing the region, including:

- The pervasive, ecosystem-wide changes that were observed following the recent marine heatwaves suggest a change in how the energy captured by primary producers is transferred to higher trophic level predators and a possible change in the number of seabirds and mammals the region can support (carrying capacity). **This has important consequences for food security in a region that is heavily dependent on the marine environment.**
- The NBS is relatively under-studied in terms of key processes and the length of available time series. Important knowledge gaps limit our understanding of ecosystem processes and food web dynamics. Specifically, it is unclear how changes in the timing, quantity and quality of sea ice, the changing dynamics of ice-associated algae, and the expansion of predatory groundfish into the NBS has already modified the NBS ecosystem and will continue to affect all ecosystem components in the future. **Addressing these knowledge gaps will require a coordinated approach to understanding the ongoing changes through improved monitoring and process studies.**
- A recurring theme was connectivity among different regions and the need to better understand and account for these connections. A number of eastern Bering Sea groundfish stocks have extended their distributions into the NBS, into Russian waters, and into the Chukchi Sea. Participants highlighted work that is underway to understand these connections, such as tagging studies, acoustic moorings to track movements across the dateline and genetic work to understand population connectivity. **There is a need for increased collaboration and coordination not just within the region but also with Russian scientists and managers** to address emerging transboundary issues. Despite challenges associated with the current geopolitical environment, there are ongoing collaborations with Russian scientists (e.g., through PICES, WWF) that can provide a foundation to build on.
- Participants also highlighted the **potential for NBS residents to contribute data and information on many aspects of the ecosystem such as ice conditions, seabird and mammal diets, body condition of harvested animals, presence of parasites or injuries, and many other aspects.** The challenges associated with incorporating local knowledge and traditional knowledge into the Council's decision-making process were noted, as were efforts to identify appropriate 'on-ramps' led by the LKTK taskforce.
- There are many opportunities for sharing information, co-producing knowledge, and co-management approaches, but **these will require improved coordination among agencies and between agencies and local / tribal governments due to multiple jurisdictions with overlapping authorities and responsibilities.** Participants also noted the general increase in human activity (e.g., shipping) in the region that requires consideration of other sectors in Council decision making.
- Finally, it was noted that in order to implement ecosystem-based fisheries management in the NBS, and to develop the science required to support it, the Council in collaboration with NBS residents should identify appropriate goals and objectives for fisheries management that may be specific to this region. **A review of ecosystem-level objectives, including the need for regional objectives, could be undertaken as part of a Programmatic EIS if and when it is initiated.**

Specific data gaps, research needs and recommendations that emerged during session 1 from either the presentations or public input are included in the list of recommendations below.

SESSION 2. WHAT DATA DO WE NEED TO COLLECT OR MONITOR IN THE NORTHERN BERING SEA AND THE SOUTHERN CHUKCHI SEA?

During Session 2, the SSC discussed the need for resources and ecosystem surveys, biological information, ecosystem considerations, and other sources of knowledge. We provide a brief overview of the discussions before listing key gaps and data needs that were identified during either session 1 or session 2. The list summarizes the main points that were brought forward during presentations, open mic sessions and SSC discussions, but will require further synthesis and prioritization.

Fish and ecosystem surveys

The core NOAA Fisheries surveys conducted in the NBS include recent increases in bottom trawl surveys starting in 2010, 2017-2019, and annually since 2021. Demersal survey index data are beginning to be incorporated in some stock assessments. Acoustic surveys are periodically conducted in the NBS to assess pelagic backscatter. The NOAA Fisheries/Alaska Department of Fish and Game ecosystem and salmon survey has been annually conducted since 2002. The data collections include oceanography, zooplankton, juvenile gadids and salmon, forage fish, and recently benthic data, including juvenile crab and flatfish abundance and condition. Data are used in salmon forecasts, Ecosystem Status Reports (ESRs), and Ecosystem and Socioeconomic Profiles (ESPs). Tagging studies on Pacific cod and Pacific halibut have been particularly informative on movement patterns relative to seasonal environmental conditions.

In the Chukchi Sea, periodic surveys of various trophic levels (physics, plankton, forage fish, benthic species) have been conducted between 2000 and 2018 under various programs. Ongoing surveys in the region include physical and biological oceanographic data collected under the multi-agency supported Distributed Biological Observatory (DBO) program.

Motivation for additional surveys in the Chukchi Sea region include monitoring the proportion of EBS groundfish and crab stocks moving out of the EBS Fishery Management Plan (FMP) region, establishing an ecosystem baseline, validation of predictive ecosystem models, and assessment of non-fisheries activities in the region such as oil and gas development and increased shipping.

Discussions were focused on what the periodicity of surveys should be in the NBS and the potential for surveying fish stocks in the Chukchi Sea. **The SSC commented on the critical importance of the regular and area-wide fish and ecosystem surveys and recommended that new resources support the necessary data collection in the Chukchi Sea.**

The potential for ecosystem surveys in the Chukchi Sea were also discussed. It was noted that resource limitations in other Alaska regions may prevent survey opportunities in the Chukchi Sea. **Partnerships and comprehensive/integrated surveys will be necessary to build capacity for data collection in the Chukchi Sea and should be focused on ecosystem understanding and fish surveys that could support stock assessments.** Improved sampling designs and innovative data collection tools should be considered. It was noted that identification of the certainty required in stock assessment surveys will be important to designing expanded surveys in this region.

Biological information needs

The SSC discussed basic biological information that should be considered to track changes in the NBS and Chukchi Sea. The importance of increasing focus on coordinated tracking of the movement of fish and marine mammals was noted. However, indexing movement from moorings versus tracking a few individuals should be evaluated. Collecting environmental data and vital rate data concurrently may be an innovative means of increasing data availability. Expanding sampling through community involvement can support frequent, systematic, and comprehensive sampling. **Considering key bottlenecks (e.g. recruitment) will help refine data collection on appropriate aspects of the ecosystem.** With changing

environmental conditions, there may also be a need for more periodic growth and maturity assessments that inform stock assessments.

List of knowledge gaps, monitoring needs, and tools

Specific data, information, and knowledge gaps; unmet monitoring goals; and tools needed to advance key data collections that emerged from discussion during sessions 1 and 2 are listed below, but have not been fully synthesized nor prioritized yet.

Data/information/knowledge gaps

In the development of key indicators of change noted in this region, gaps were noted in the data, information, and/or knowledge available to consider for observing or monitoring the changes.

- The predictability of temperature “stanzas” relative to extreme events that may be tested with existing regional climate models.
- Identification and importance of aggregating processes (frontal zones) and their variability.
- Role of ice-associated algae in changing sea ice ecosystems.
- Euphausiid requirements for fish and seabird species at a time when large, ice-associated Calanus zooplankton may be declining.
- Pelagic and benthic juvenile fish, crab, and prey condition, abundance, and distribution, including juvenile life stages of commercially important species.
- Taxonomic expertise for species identifications, particularly for lower trophic levels, to effectively monitor ecosystems for continued changes and support ecosystem research.
- Species and life history-specific physiological thresholds and tolerances to temperature and ocean acidification, considering the subsequent effects on ecosystem production.
- Physiological responses (growth and maturity) and temperature thresholds of commercial species to understand effects of extreme events and the potential for recovery in between events.
- Expected distributional shifts, changes in movement patterns and rates, and what the effects are on connectivity among the ecosystem in the region.
- Suitability of the NBS as spawning (e.g. cod, pollock) or nursery habitat and the potential role of the Chukchi Sea as juvenile or adult summer habitat.
- Effects of fishing gear on unobserved mortality and habitat in the NBS ecosystem.
- Carrying capacity for commercial fish in the NBS under increased predation pressure caused by distribution shifts, including summer feeding movement and potential lateral expansion to the western Bering Sea shelf.
- The resilience of the NBS ecosystem if cooler conditions return and distributions return to previous states.
- Specific causes of seabird and marine mammal mortality events related to changing prey availability.
- Productivity trade-offs between feeding success and haulout requirements for juvenile ice seals and how it relates to the capacity of the system to support ice seals.
- Comparative analyses with other polar regions that experience similar climate-change forcing (including sea ice loss), have a history of commercial exploitation, and are home to communities dependent on marine ecosystems.

- Capacity building through coordinated data collection and processing across projects and programs (including industry partnerships, communities, and through academic programs) to build capacity.
- Social science capacity, including quantitative expertise, to address impacts on fishery- and subsistence-dependent communities from fisheries management decisions and climate change.
- Identification of human indicators of change and community-based prioritization of species (e.g. marine mammals) that require further study.
- Traditional ecological knowledge, local knowledge and Indigenous knowledge from northern communities and co-management entities to incorporate into the understanding of ecosystem processes and ongoing changes.
- Traditional and local knowledge from industry groups to inform biological understanding, research priorities, analytical products, and decisions.

Unmet monitoring needs

These are specific items that were identified as important but need additional monitoring to better understand changing processes.

- Sea ice characteristics and subsequent changes in the cold pool, thermal dynamics, and salinity dynamics.
- Seasonal changes in hypoxic conditions occurring in benthic ecosystems.
- More seasonal (Spring-Fall) phytoplankton and zooplankton composition data and timing relative to temperature and total production.
- Infaunal/epifaunal species composition, functional/taxonomic diversity, and abundance (e.g. through eDNA or meta-barcoding approaches) relative to pH and temperature trends if coupling to broader ecosystem processes and fish stocks can be shown.
- Benthic sedimentation to track interannual changes and trends in pelagic-benthic coupling.
- Expanded sampling (acoustic, nets) of forage fish species and nearshore juvenile fish.
- Upper trophic levels species composition and abundance (e.g. vessels of opportunity, eDNA) with focus on community-specific data collection (sea bird and marine mammal mortality events; seabird production, condition, and biological samples).
- Expanded food habits studies to inform our understanding of trophic changes.
- EBS slope survey to inform a fuller understanding of the EBS/NBS ecosystem.

Specific tools that need to be developed to advance key data collection

- Genomic approaches for rapid and efficient phytoplankton, zooplankton, infauna/epifauna identification (e.g., DNA meta-barcoding, eDNA).
- Research and development of tools (e.g. acoustics, nets) for euphausiid sampling.
- Gear innovation that improves interactions with habitat and other species.
- Imaging technology to improve plankton assessment (CytoBOT) and to track movement of pelagic species (e.g. pollock) from mooring data.
- Efficient and effective collection of local and traditional knowledge that fills information gaps on ecosystem processes, community sustainability, and subsistence interactions with commercial fisheries.

- Better use of remote sensing (ship-board or mooring-based acoustic data collection, satellite-based observations, tagging marine mammals) to gather ecosystem information.

SESSION 3. WHAT TOOLS DO WE HAVE OR NEED TO APPLY THESE DATA TO MANAGEMENT OF BERING SEA FISHERIES?

This session aimed to assess whether current tools and approaches used by the Council, including assessment models, the tier system, and current harvest control rules (HCR), are adequate to deal with the management challenges that arise under increased uncertainty, or whether we need to consider novel approaches to deal with a rapidly changing, and increasingly non-stationary environment. While many gaps remain in our understanding of the northern Bering Sea, much has been learned in recent years that can be integrated with our understanding of the Bering Sea ecosystem more broadly to better inform the management of Bering Sea stocks in light of the ongoing changes. **Any next steps need to be considered in the context of the many processes that are already underway**, such as the Alaska Climate Integrated Modeling Project (ACLIM), NOAA's Climate, Ecosystems, and Fisheries Initiative (CEFI), and the work of the Climate Change Task Force, and the LKTKS Task Force, **or processes that are in the planning stages**, such as the newly initiated process to consider a Programmatic EIS.

The workshop received a presentation by Kirstin Holsman (AFSC) on the potential for improving the predictive capacity of climate-informed ecosystem models to support the management of commercial fish species. Much of the work presented was based on ACLIM results. The presentation highlighted ongoing work to model the effects of downscaled climate predictions on the Bering Sea ecosystems, including initial applications to project future trends in the physics, chemistry, zooplankton and key fish stocks through the end of the century. Of particular interest to the Council, preliminary results from ongoing work to evaluate the performance of alternative HCRs and the 2 MT cap on groundfish removals were summarized. It was noted that, while there has been considerable progress on the physical and biological modeling components, the socio-economic models that will be necessary to better inform fisher's choices and Council decisions are less developed. Based on experiences from around the world, the presentation also noted that adaptation is well underway but remains largely reactive, uncoordinated, and uneven across regions, communities, and sectors. There is a general lack of proactive planning for a changed future. **The key to making progress is to focus on actionable advice and locally tailored solutions.**

Curry Cunningham (UAF, SSC member) and Ian Stewart (IPHC, SSC member) provided food for thought on the challenges associated with non-stationary processes and dynamic reference points, highlighting the potential benefits, risks, and necessary considerations for managing fisheries in a changing ecosystem. **Non-stationarity is pervasive in Alaska's marine ecosystems and in biological processes including mortality, recruitment, growth and maturity/fecundity.** For example, the average recruitment or productivity of many stocks, and its variability, may change over time, either directionally or periodically as 'regime shifts', with important consequences for biological reference points. It was noted that **most reference points used in our assessments are dynamic** in the sense that they typically rely on 'regime period averages' for population processes and parameters. A primary challenge for fisheries stock assessment is knowing when and how to adjust assumptions about the dynamics of a stock when such changes occur. It was suggested that any natural processes that affect stock dynamics should ideally be accounted for in stock assessment models for setting reference points based on unfisher conditions. However, it is unclear if and how transient environmental events (e.g. heat waves), catastrophic events (e.g. oil spills, disease outbreaks), or gradual directional changes should be incorporated as drivers in models. While the occurrence of some of these events may reflect a new reality and may become more frequent, **whether or not to manage to a 'new normal' is a policy call as much as a scientific decision.** A case in point are the recent marine heatwaves that led to a period of high mortality and the collapse of Pacific cod in the Gulf of Alaska and snow crab in the Bering Sea.

Workshop discussions focused on several considerations regarding stock assessments for groundfish and crab in the Bering Sea, as well as more generally.

- A discussion about the downside of biomass reference points that are too low noted that this could result in fishing a stock too hard and could ultimately result in foregone catches. For example, if natural mortality is set too high, we would typically fish harder and could trap the stock in a low-productivity state.
- It was suggested that F-based reference points (input controls), which are less sensitive to uncertain biomass estimates and could potentially follow variations in stock size more closely, may reduce the risk of overfishing and may be more robust under non-stationarity. This would be a major change from how Bering Sea fish stocks are currently managed, but may be worth exploring as an alternative in some situations. However, the data requirements for reliably estimating fishing mortality can be very high and the approach may be impractical for many stocks. Moreover, past problems with input controls prompted the shift to annual catch limits in the first place, and it is unclear if these problems can be overcome with modern approaches.
- The time frame for defining stock productivity (average recruitment) is a key consideration for most stocks in Alaska. For Tier 3 groundfish stocks that period has been selected to start in 1977, following the 1976/77 regime shift. This puts the focus on trying to maintain the long-term average productivity, but may not reflect current conditions as average recruitment has declined over time for some stocks. **When to change the reference period is a critical question in a changing climate.** Selecting a more recent productivity period when recruitment is declining carries risks of overfishing an already declining stock and can result in a ‘ratcheting’ effect. At the same time, it can result in more conservative management of stocks whose productivity is increasing.
- Another challenge is the current focus on single-species assessments and reference points that may not adequately account for species interactions or the interactions between multiple stocks and multiple fishing fleets with different selectivities. The system-level cap on groundfish removals in the Bering Sea is one tool that forces explicit trade-offs among species and has been shown to provide some buffer for potential negative effects of climate change on Bering Sea fish stocks (ACLIM results).
- The workshop did not discuss changes to HCRs at this time, but reviewed preliminary ACLIM results that explored the consequences of moderate adjustments to the HCRs. Changes considered in these analyses were (1) reducing fishing mortality to 0 below $B_{25\%}$ or (2) increasing the biomass target to $B_{50\%}$. **Preliminary results suggest declines in biomass and catches of major groundfish stocks and snow crab under most warming scenarios and HCRs.** In some cases, variability associated with different climate projections was larger than differences among HCRs and climate effects tended to reduce differences among HCRs. There was little benefit from the $B_{25\%}$ threshold to biomass, but the threshold resulted in considerable losses to the fishery in some cases due to frequent fishery closures when biomass would be reduced below $B_{25\%}$. Analysts also found that **the effect of adjustments to the HCRs was generally much smaller than the effects of the 2 MT cap.**

During the open mic period and additional SSC discussions, participants touched on a wide range of issues relevant to the northern Bering Sea in a fishery management context. Much of the discussion centered around **improved communications with and opportunities for input from local communities, as well as the fishing industry.** The importance of identifying shared priorities and being clear on mutual expectations was noted. Participants appreciated the opportunity for input provided by the workshop and highlighted the importance of better approaches for incorporating this input into the management process. Existing barriers to communication were also noted, including the high costs of attending meetings, language barriers due to technical jargon, and in some cases the need for translators between local languages and English. Smaller panels that can travel to and hold workshops at the community level, including in more remote villages, was offered as one approach for improving engagement. It was suggested that a brief,

plain language summary report from this workshop might be a useful outreach tool to invite further input and engagement, as well as to learn about local needs and concerns.

A second, related theme was improved coordination of the relevant science across agencies, universities, tribes and local communities to meet both Council objectives and local needs. Many important data gaps were identified in Sessions 1 and 2. While addressing these gaps may require new resources to not compromise data collection elsewhere, opportunities to build on existing or develop new partnerships across agencies, with local experts, and with the fishing industry were noted. While new funding sources for relevant monitoring and process studies are explored, pilot studies to identify what additional data are needed would be valuable. There is no single model for how best to conduct research in the region and different models for cooperation have been successful, whether initiated by researchers outside the region reaching out to local communities (e.g. cod tagging study) or the region identifying a need and reaching out to potential partners (e.g. halibut tagging study). Several participants highlighted the wealth of expertise that exists within the region about individual species as well as the broader ecosystem, although the pathways for bringing this information into the management process is not always clear and needs improvement. Other emerging opportunities include cooperative research with industry partners that have expanded their operations into the northern Bering Sea due to shifting fish distributions. The capacity to integrate and analyze existing and new data sources is often lacking at the local level, but increased engagement with universities could tap into underutilized capacity that may exist at some institutions, again highlighting the need for improved coordination.

The strong dependence of local communities on marine resources for food was another frequent theme throughout the workshop, highlighting the tension between local food security and commercial fishing interests as fisheries expand into the northern Bering Sea. This presents new challenges to the Council as it balances potential trade-offs among user groups that had limited or no interactions in the past.

A key focus of SSC discussions during Session 3 was on how to manage current fisheries in the face of directional changes in the ecosystem and increased uncertainty. As we consider the implications of climate change for stock dynamics and how best to incorporate observed changes into assessments, the objectives for managing fisheries in a rapidly changing environment are not always clear. Options may range from trying to preserve the existing ecosystem, with some participants arguing for maintaining the NBS ecosystem in an unfished state, to managing under the assumption that the overall productivity of the ecosystem, and the productivity and abundance of individual species, will be changing in a new environment. **Preserving the existing ecosystem may no longer be an option and the reality of changing productivity, changing distributions, and an increased likelihood of future ecological surprises need to be clearly communicated to all stakeholders and should be accounted for in management.** However, to what extent productivity or stock dynamics have already changed is unclear and work is still needed to quantitatively evaluate if and how dynamics in the recent past, and possibly in the future, may be different from current reference periods.

How to best address these uncertainties and whether to opt for more or less dynamic reference points requires a better understanding of the associated risks as well as the level of risk tolerance, which is ultimately a policy decision. However, appropriate ‘on-ramps’ for communicating risks to managers, or tools for managers to assess risks and respond appropriately are currently not well developed in our region. Lessons from other regions or management bodies, such as the risk framework used by the Mid-Atlantic Fishery Management Council, should be considered. **Expediting progress on these issues may require increased dialogue between the SSC and Council, as the solutions reside at the science-policy interface.**

Several participants raised the need for more flexibility in management. Some of the work on adapting to climate change, including under ACLIM, focuses on resource users adjusting or optimizing their portfolios in a changing environment. However, **under current management, the options for fishers are highly constrained and regulations may be too restrictive to allow for effective adaptation. Allowing for**

more flexibility should be prioritized but may require updates to current management objectives and regulations. This will require a careful balance as some management policies (e.g. sideboards) were specifically put in place to support communities. **Providing clear information on which stocks are likely to do better or worse in a changing environment may be one approach to help fishers, where possible, build the best fishing portfolio.**

KEY TAKE-HOME MESSAGES, RECOMMENDATIONS AND NEXT STEPS

Some key messages emerged from the workshop discussions. These reflect only a partial list to be further refined in future discussions among the SSC, the Council and stakeholders.

- The 2014-2022 heat wave event(s) and concomitant ecosystem changes are potentially on a similar level as the 1978 North Pacific regime shift as pivot points in the time series of oceanographic change in the North Pacific.
- There are major gaps in our understanding of the changes occurring in the NBS, capacity to support commercial species, and expectations for future ecosystem states.
- There are major gaps in our understanding of the relative importance of the southern Chukchi Sea as seasonal habitat for EBS fish stocks.
- Non-stationarity is pervasive in Alaska's marine ecosystems and in biological processes including mortality, recruitment, growth and maturity/fecundity.
- Regular and area-wide fish and ecosystem surveys are critically important to tracking changes and supporting sustainable management. New resources are needed to support the necessary data collection in the Chukchi Sea without degrading data collections in other regions in Alaska that are also changing.
- To ensure common understanding and inclusive engagement in issues associated with extreme events affecting ecosystems and subsequent management, improved communication and coordination among agencies, industry sectors, local communities, tribal governments, academic partners, and international parties in the North Pacific are needed.

Some high-level recommendations are provided below in table format to address both scientific and management needs at either local (northern Bering Sea) or global scales, with the latter being applicable to fishery management throughout Alaska:

Key science and management recommendations (for science community and the Council)

	Science	Management
Local (NBS & Chukchi)	<ul style="list-style-type: none"> ● Develop a monitoring program focused on understanding process changes in the NBS that inform current understanding of carrying capacity and expectations for future commercial fisheries. ● Develop recommendations and secure additional funding for a periodic assessment of the southern Chukchi Sea ecosystem. ● Improve overall science coordination in the region. 	<ul style="list-style-type: none"> ● Improve engagement with tribes and communities. ● Consider mechanisms for incorporating the full spatial distribution of transboundary stocks into management.
‘Global’	<ul style="list-style-type: none"> ● Re-assess the time periods that are currently used to define the productivity of crab and groundfish stocks. ● Consider alternatives to current HCRs based on available analyses. ● Increase dialogue between SSC and Council on issues that straddle the science-policy interface. ● Identify which stocks are likely to do better or worse in a changing environment to help fishers build the best fishing portfolio. 	<ul style="list-style-type: none"> ● Increase dialogue between SSC and Council on issues that straddle the science-policy interface. ● Renewed discussion on reference period determinations in light of increased periodicity of extreme events. ● Improve the use of approaches that explicitly consider risks

Recommendations for next steps

- Consider outcomes from this workshop as the Council identifies research priorities for 2023-24.
- Incorporate the recommendations from this workshop into the development of the planned Programmatic Environmental Impact Statement process to better address the impacts of climate change on the marine ecosystems and on the people dependent on those ecosystems.
- Produce a brief, plain language summary report from this workshop as a useful outreach tool to invite further input and engagement, and to learn more about local needs and concerns.
- Form a sub-group of Council and SSC members (2-3 members each) to develop a roadmap that builds a bridge from assessment and climate science to adaptive management under climate change.

The roadmap should include the products and recommendations from the Climate Change Task Force, the LKTK Task Force, and the national Council Coordination Committee - Scientific Coordination Subcommittee (SCS) meeting held in August 2022. The roadmap would recommend a direction and timeline for moving forward, recognizing the urgency for action as the North Pacific expects continued change in the near future. Questions for the subgroup to consider include:

- Is the use of more dynamic reference points a viable alternative to current management practices, given the current Council processes under the Magnuson Stevens Act? This includes consideration of when to change the time periods over which reference points are calculated for crab and groundfish stocks.
 - Could and should social or economic objectives (e.g. Maximum Economic Yield, biomass thresholds, catch stability) be incorporated into adaptive management approaches for some stocks?
 - As stock footprints expand and shift in distribution, are regional allocations of catches in the EBS and NBS appropriate and could they be dynamic enough to address temporal variability?
 - Can risk considerations be improved upon in the context of both stock assessments (ABC considerations) and management (TAC considerations).
- Plan for a February 2024 follow-up workshop that focuses on discrete aspects of the key recommendations for science and management raised at this workshop to advise the Council. In addition to the outcomes from the sub-group roadmap, the SSC may consider the following questions that emerged during this workshop:
 - What temporal and spatial scales of information are needed to track non-stationary production, shifting boundaries, and changing species interactions?
 - What baseline information is required ahead of future extreme events to be better positioned to manage fishery responses?
 - How can we better identify ecosystem bottlenecks influencing production of key commercial fish species so the limited resources are effectively focused.
 - Can overall as well as benthic vs. pelagic carrying capacity be reasonably assessed and tracked to inform optimum yields in an environment changing as quickly as the NBS?