NOAA FISHERIES
Alaska Fisheries Science Center

Ecosystem Science Program Review

Alaska Fisheries Science Center Summary and Response – May 2016

Introduction

On May 2-6, 2016, the Alaska Fisheries Science Center (AFSC) hosted a panel of experts to conduct a programmatic review of its ecosystem-related science program.

This review was the fourth in a series of annual reviews of AFSC science, directed at different topics each year over a five-year cycle and designed to maximize the transparency and effectiveness of major science programs located at NOAA Fisheries' six science centers as well as those located in or coordinated through NOAA Fisheries' Office of Science and Technology.

For the 2016 review, an independent panel evaluated the current scientific program of the AFSC that is directed to provide information relative to the management, protection and restoration of resilient and productive ecosystems. Here we define ecosystem-related science programs as those elucidating ecological, oceanographic, climate and habitat-related processes as they are linked to living marine resource (LMR) species. In addition, this review assessed the extent to which current science programs are focused on the priority information needs required to complete the NOAA Fisheries' mission. The following themes were covered as required by the Terms of Reference agreed upon by the NOAA Fisheries Science Board: 1) management context and strategic planning; 2) ecosystem data; 3) ecosystem modeling and analysis; 4) incorporation into management; 5) communication and peer review; 6) other.

The independent panelists were selected as experts in the relevant topic areas; they were not associated with the AFSC. The panel was provided with presentations from AFSC staff covering the state of AFSC's ecosystem-related science programs. Panelists were also provided with background material for more in-depth information and had time to discuss the AFSC's ecosystem-related science programs – and their utility – with AFSC management and staff and North Pacific Fisheries Management Council and Alaska Regional Office management during the review. Comments and responses to questions from the public participants who attended the review were also considered by the panelists.

More information regarding the review of AFSC's ecosystem-related science programs may be found at: http://www.afsc.noaa.gov/program_reviews/2016/default.htm

The results from this year's review, along with those being conducted at each of the other five fishery science centers, will be used to prepare a national summary to highlight best practices and to inform decisions on opportunities for improving science programs across NOAA Fisheries. The full suite of these reports will be found at: http://www.st.nmfs.noaa.gov/science-program-review/

The AFSC leadership would like to thank the review panelists who devoted a significant amount of time to participate in this review. Their observations and recommendations provide valuable feedback on how AFSC's ecosystem-related science program is performing relative to its stated goals and objectives. The AFSC also greatly appreciates the time and thought that participating stakeholders put into this review; their questions and comments sparked many conversations and their perspectives were invaluable particularly when addressing the issues of priority setting and overall objectives of this research.

The panelists for this review were:

- Beth Turner, Chair (NOAA Ocean Service, National Centers for Coastal Ocean Science)
- Manuel Barange, Panel Member (Plymouth Marine Lab, U.K.)
- Michael Dagg, Panel Member (Retired, Louisiana Universities Marine Consortium)
- Beth Fulton, Panel Member (Commonwealth Scientific and Industrial Research Organisation, Australia)
- Sarah Gaichas, Panel Member (NOAA Fisheries, Northeast Fisheries Science Center)
- Michael Seki, Panel Member (NOAA Fisheries, Pacific Islands Fisheries Science Center)

AFSC Responses to Review Panel Recommendations

The reviewers provided positive and constructive comments on the AFSC's ecosystem-related science program. The panel's summary and individual reports provide reinforcement of the AFSC's commitment to maintaining ecosystem-related research as a high scientific priority. However the reviewer's overall assessment was that AFSC's commitment to ecosystem research would be enhanced with a clearly articulated vision, whether through the AFSC's annual guidance memorandum (AGM), identification as "core research" within the AFSC's Strategic Science plan, or by developing an overarching set of goals and objectives supplemental to these two documents.

Theme 1: Management Context and Strategic Planning

Recommendation 1.1: Several panelists felt that the AFSC should develop clear goals for integrated ecosystem research in general, and not just respond to external requests for proposals (RFPs) in an *ad hoc* way. Similarly, panelists recommended that the AFSC establish a baseline level of integrated ecosystem science supported as a core activity within its science plan.

Response: The revision of the AFSC Science Plan, currently underway, intentionally prioritizes climate research, which includes both climate effects on fisheries and protected species, and also climate effects on ecosystems. The AFSC has participated in 3 Integrated Ecosystem Research Programs (Bering Sea 2007-2015, Gulf of Alaska 2010-present, and Arctic 2016-present); all 3 have been hypothesis driven and hence provided clear goals for integrated ecosystem research.

Since the review, the AFSC has developed a 3-year plan (2017-2019) that identifies priorities for integrated ecosystem research in general for the 5 LMEs. In particular, the AFSC plans to complete integrated ecosystem research with focal species and regions of Arctic cod in the eastern Chukchi Sea, walleye pollock in the southeastern Bering Sea, walleye pollock in the western Gulf of Alaska, and pilot work on sablefish in the eastern Gulf of Alaska. In addition, the Bering Sea Fisheries Ecosystem Plan, currently being developed, will help to drive integrated ecosystem research.

Recommendation 1.2: Panelists noted that future AGMs need to include ecosystem studies and activities, if ecosystem science is truly valued by AFSC leadership.

Response: Typically the AGM is more project-centric than focusing on integrated ecosystem research. This year research on process studies related to linking recruitment of commercially important species to environmental change, including climate change, was identified, which was an ecosystem research area highlighted at the AFSC review. In addition, the AGM usually identifies cooperative projects with other agencies as a priority. This grouping includes integrated ecosystem research projects (IERPs) like the Arctic IERP, which has been approved for funding by the North Pacific Research Board, as well as the Bering Sea IERP and Gulf of Alaska IERP highlighted during the AFSC review. In addition, the AGM, which is updated annually, operates within a Science Plan which is updated about every five years. The 2016 update of the Science Plan identifies, as one of three major themes, "Understand and forecast effects of climate change on marine ecosystems."

Recommendation 1.3: Taking inventory of the available skill sets and the operational *vs* research/development needs in each research area would highlight the relative staffing needs and whether this is in line with the intent of the various plans and strategies.

Response: The AFSC has been completing "deep dive" reviews with each of our research Divisions this year to identify research needs and consider whether current staffing will meet these needs for the next 3-5 years. This process was not described to the review panel so the panel did not hear about this AFSC effort. These "deep dives" include identification of capability gaps for staffing, ship time, and airplane time. This series of "deep dives" meets the panel call for inventory through the review of staffing capabilities. Typically the AFSC does R&D with the intent of making the new approach operational within a two year window. This occurs through constant improvement practices, evaluating utility of current operations and research and development (R&D) efforts, and separate R&D projects (e.g., Saildrone, upward looking acoustics). Usually these separate R&D projects are used to enhance sampling capability, but can also be used to repurpose existing platforms (e.g., Saildrone replacing oceanographic sampling currently accomplished by ship-based efforts, unmanned aerial vehicles replacing manned-aircraft marine mammal surveys).

Recommendation 1.4: Panelists recognized the enormous challenge as well as the importance of work in the Arctic, but the funding constraints will be limiting. A strategic plan that focuses less on potential target species and more on ecosystem change and multiple drivers was recommended by some panelists.

Response: In the [high] Arctic (i.e., north of the Bering Sea LME), we are intentionally focused on nodal species, like Arctic cod. By regulation, there are no commercial fisheries in the Arctic Exclusive Economic Zone. One broad question to be addressed in the upcoming Arctic Integrated Ecosystem Research Program: Is the balance between pelagic and benthic systems changing away from benthic dominance? This question is ecosystem-change related and thus addresses this recommendation of the Panel. To date, most of our research effort has focused on bottom-up effects; we admit that we should enlarge our effort to also include top-down effects. In addition, we are examining multiple physical and chemical bottom-up drivers including loss of sea ice and ocean acidification. Lastly, we intend to prepare a NOAA Fisheries Regional Action Plan (RAP) for Climate Science for the US Arctic once other regional plans for Alaska are complete. The development of a clearly articulated ecosystem science vision for the AFSC will help all of our future endeavors such as the Arctic RAP have a more holistic, robust ecosystem focus.

Theme 2: Ecosystem Data

Recommendation 2.1: Many panelists noted that AFSC should strive to balance its ecosystem data collection programs to ensure that a full range of species and life stages are sampled, and maintain an appropriate balance between core assessment work, process studies, and more integrative analysis.

Response: First, core assessment work and process studies are not separate; the core single species stock assessments provide a good portion of our understanding of ecosystem dynamics and hence are informative to the other ecosystem research, including process studies, modeling, and more integrative analyses. In addition, managing research output, labor costs, and operational costs has been extremely challenging given recent years of flat or declining funding. The balance of activities are reviewed each year through the annual activity plan process, which provides a vehicle to prioritize core assessment work, process studies, and integrative analysis. The prioritization process typically identifies core assessment work as first in line for funding and the majority of funds are required to support this work. The number of AFSC staff has fallen through attrition and lack of back-filling positions in order to maintain operational capacity. As a result, little room remains to reduce core assessment work and add to process studies or integrative analysis from existing AFSC funding. Instead the AFSC uses existing staff and competes through RFPs for additional funding for process studies and more integrative analysis. Specifically, the AFSC has reduced staffing levels by over 70 people in the past 4 years and still has roughly 90% fixed costs (e.g., labor and leases) projected for the FY17 budget, leaving only about 10% of the AFSC budget for operations. Hence, the AFSC has limited discretion in supporting process-oriented research, as funding is primarily supported by project-specific temporary funding from NOAA Fisheries' Headquarters or reimbursable funding from other agencies and organizations (e.g., Bureau of Ocean Energy Management, North Pacific Research Board).

Recommendation 2.2: Some panelists recommended a more ambitious vision to investigate the ecology of the 5 LMEs under consideration, focusing on issues such as energy flows, connectivity and exchanges, climate change impacts, etc., combining observation and modeling approaches.

Response: With the current situation of 90% fixed costs at the AFSC, we are unable to address ecological studies in 5 LMEs, a number which almost equals the total number of LMEs for all the remaining NOAA Fisheries' Science Centers. Instead we have a foundation for combining modeling and observation approaches, which is less expensive, and this is an area where we can develop in the future. Some work has been done on energy flows, connectivity, and exchanges comparing 2 of the 5 LMEs (e.g., Gaichas et al., 2009). Certainly this work could be resurrected, in particular comparisons among the 5 LMEs. Efforts have been limited in part because of the relative lack of ecosystem modelers at the AFSC. One approach would be to combine single-species, multi-species, and ecosystem modeling activities and blur the lines among these now distinct programs, which may result in some synergies that could be used to boost effort in the more complex ecosystem models. Further, some slowing of the tempo of single-species assessments may be decided, as was recommended in the stock assessment review, which again could be directed toward more complex ecosystem models. As for the next level of complexity, we also would consider expanding to understand emergent ecosystem properties if the resources were made available. However, we also are challenged by attempting to create models that would predict emergent properties given that such phenomena likely occur through nonlinear and thus difficult to predict effects.

Recommendation 2.3: Several panelists felt that the AFSC should invest in Center-wide data management systems and investigate where data recovery efforts might bring long term benefit to multiple projects/assessments.

Response: The AFSC is actively pursuing Center-wide data management activities as a component of meeting the Public Access to Research Results policy. Not only will these efforts allow the public to more easily discover and utilize our data, but it will also better enable AFSC researchers to identify and leverage resources within our own organization. The AFSC has completed the first step in this process by cataloging and publishing metadata for all our digital data and is now working on publishing useable archives and establishing partnerships to increase the utility of our data. Further, several of our researchers have pursued new funding sources for data recovery projects, although there are few opportunities available.

Recommendation 2.4: To ensure that collaborative links do not dissolve with personnel turnover, panelists recommended that high level agreements should be put in place between agencies or line offices recognizing the value and intent of these connections. This was seen to be especially important with NOAA's Pacific Marine Environmental Laboratory (PMEL).

Response: The relationship between AFSC and PMEL has lasted longer than multiple leaders and staff at both AFSC and PMEL (i.e., over 30 years). The directors of each institution and their deputies regularly talk with one another. The functionality of the links are strong because the relationships have benefited both institutions scientifically. JISAO (University of Washington) also has very strong links with the AFSC and PMEL; this triad strengthens the AFSC-PMEL relationship. In our view, multiple working relationships are greater than a top-down, single agreement. However we will consider whether formalization will add to the durability of the relationships.

Theme 3: Ecosystem Modeling and Analysis

Recommendation 3.1: Some panelists recommended that the AFSC should embrace the Ecosystem Considerations Chapter as a Center-wide product, and reinforce its production accordingly through inclusion in employee performance plans.

Response: Currently, the production of the Ecosystem Considerations Chapter relies, in most cases, on voluntary provision of data and indicators to the editor of this chapter in the Stock Assessment and Fishery Evaluation reports. As a consequence, there are indicators that could be updated regularly, but aren't as people's schedules and willingness varies. Similarly, there are potentially new data sources and indicators that may not come to the attention of the editor, and therefore are not incorporated into the document. Supporting the Chapter as a Center-wide product may alleviate some of the current challenges related to inefficiencies with the annual process of tracking down information to incorporate, particularly with the compressed timelines. Based on this panel recommendation, the AFSC will develop a more top-down approach that lists contributions within employee performance plans. This would benefit the contributors by giving people credit for the effort required to provide the information in a timely manner. AFSC would also benefit by having more timely and complete time-series to provide ecosystem science for resource managers.

Recommendation 3.2: The synthesis groups must be reasonably resourced with some depth of support. Similarly, the maintenance of models must be supported or that capability will be lost.

Response: Currently, the ecosystem synthesis group devotes the majority of its single staff member's capacity to fulfill the basic need of providing annual ecosystem assessments and associated products to inform fisheries managers. As in Recommendation 4.4, we agree that there is opportunity to increase the breadth and depth of the ecosystem synthesis with additional support. Permanent funds currently support a single ecosystem modeler. National Integrated Ecosystem Assessment (IEA) funds (non-permanent) partially support the maintenance and updating of the physical models (through PMEL) and a portion of the biological models used in the Bering Sea to support the Alaska Climate Change Integrated Modeling (ACLIM) project and other analyses. Expansion of such modeling to other regions (e.g. the GOA) would require additional resources. It's important that these funds are "stable" as making models management-ready and keeping them up to date is not accomplishable through piecemeal proposal processes.

Recommendation 3.3: Panelists felt that provision must be made for IT hardware that meets modeling needs.

Response: As has been stated, competing needs for resources is an issue that touches on all aspects of the AFSC's mission. IT hardware is a major investment, and can be short-lived. The AFSC recently invested in new hardware to maintain our High Performance Computing (HPC) cluster. As modeling needs have grown, relying on only AFSC IT infrastructure has become unsustainable. To expand our available resources, the AFSC is partnering with the University of Washington to evaluate alternative HPC platforms, cloud solutions, and web tool development.

Recommendation 3.4: Some panelists suggested using qualitative (conceptual) models to facilitate syntheses, to compare LMEs and alternative energy pathways (e.g. pelagic vs demersal) and how the system may have functioned through time or under perturbation.

Response: We agree that conceptual models for the 5 LMEs off Alaska would be useful for comparison and synthesis. Efforts are underway to develop a conceptual model for the southeastern Bering Sea as part of the Fishery Ecosystem Plan that is currently under development for the Council. There is ongoing research that includes developing a conceptual model for part of the Gulf of Alaska. Both of these efforts are being funded by the national IEA program. Comparisons between the Gulf of Alaska and southeastern Bering Sea have been done in the past (Gaichas et al., 2009; Link et al., 2009). The Aleutians and Arctic were not part of this comparison, but could be done, though at an incomplete level because fewer trophic levels usually are sampled in the Aleutians and time series are very short for the Arctic. Conceptual models comparing Arctic LMEs have been developed (Carmack et al., 2011), but none include comparisons of southeastern Bering Sea, Aleutian Islands, or Gulf of Alaska LMEs.

Theme 4: Incorporation into Management

Recommendation 4.1: Panelists felt that the AFSC should continue to support further development of the Bering Sea Fishery Ecosystem Plan (FEP) and its Action Modules, in collaboration with the North Pacific Fishery Management Council. AFSC should also fully support production and further development of the Ecosystem Considerations Chapter.

Response: AFSC staff is closely involved with the development of the Bering Sea FEP and plans to remain actively involved through the Action Modules. Increased support for the production and further development of the Ecosystem Considerations Chapter would result in a stronger, more impactful document could readily incorporate new techniques and research for supporting the rapidly-evolving ecosystem approach to fisheries management.

Recommendation 4.2: The AFSC should accelerate IEA efforts, in particular ecosystem level risk assessment to prioritize which ecosystem processes require evaluation by more quantitative methods.

Response: In FY16 and FY17, national IEA funds will be used to complete conceptual models for the eastern Bering Sea and Gulf of Alaska as per recommendation 3.4. It is anticipated that these conceptual models, through qualitative network modeling, will identify relative risks (at the level of a 'rapid assessment') and aid in prioritizing critical pathways and mechanisms for quantitative analysis. At the current IEA funding level (both local and national), more formal risk analyses could be contemplated beginning in FY18.

Recommendation 4.3: The AFSC could undertake an exercise to uncover key links and points of failure and assess whether these are suitably resourced and supported.

Response: The AFSC has completed some analysis of capabilities and needs. For example, the AFSC has completed a staffing plan for the Recruitment Processes Alliance. This plan has been useful for decision-making on filling vacant positions and new hires. Through the ecosystem science review process, we have uncovered two obvious points of failure, which are the small size of the modeling group and having only one person overseeing and organizing the Ecosystems Considerations chapter. This lack limits or slows the ability of the AFSC to complete some panel recommendations, such as the LME comparisons of energy flows, connectivity, and exchanges (recommendation 2.2) and development of ecosystem thresholds (recommendation 4.4). One possible solution is to coordinate single-species, multi-species, and ecosystem modeling activities through a Modeling and Adult Fish Alliance, similar to the Recruitment Processes Alliance, which may result in some synergies that could be used to boost effort in the more complex ecosystem models. This recommendation was presented by Kerim Aydin during the Ecosystem Review. Further, some slowing of the tempo of single-species assessments may be decided, as was recommended in the 2014 stock assessment review, which again could be directed toward more complex ecosystem models. Lastly, AFSC leadership will consider adding one full-time ecosystem modeler to AFSC staff beginning in 2017.

Recommendation 4.4: In the absence of specific metrics from the Council, the AFSC may wish to develop and propose its own objectives to assess the state of the ecosystems under consideration.

Response: We agree that there is a wealth of opportunity to more fully develop and propose AFSC ideas for expanded ecosystem assessments. The main stumbling block is the current limited staffing level. Efforts are being made to leverage activities with other Center's activities, for example with research to develop ecosystem thresholds. AFSC scientists are contributing to a group effort funded by the California Current IEA Program to develop methodologies to define ecosystem-based thresholds for human activities and environmental driver (Samhouri et al, in prep) that could be applied in Alaska. Similarly, AFSC scientists are contributing data to inter-regional ecosystem comparisons that will inform Alaska's assessments. A concerted effort to develop AFSC-specific ecosystem assessment objectives would help guide future research efforts. The AFSC agrees with the recommendation of the Panel and will move to develop ecosystem thresholds.

Theme 5: Communication and Peer Review

Recommendation 5.1: The AFSC should continue to promote dialogue with stakeholders, etc., Dialogue may develop more through the ACLIM project management strategy evaluation, the Bering Sea FEP, and development of IEA conceptual models, as well as existing outreach efforts to Alaska communities.

Response: The AFSC plans to continue to reach out to members of the fishing industry, Alaska Native communities, environmental non-governmental organizations (ENGOs), state, federal and academic partners, members of Congress and the general public to seek their input, as appropriate, and provide regular updates on the various ecosystem related projects underway including the Alaska Climate Change Integrated Modeling (ACLIM) project and the Bering Sea Fisheries Ecosystem Plan (FEP). In fact, plans are to host constituent calls/via webinar, conduct radio interviews and regularly communicate through traditional and social media to provide information about progress, including an announcement of the completion of species vulnerability assessments and to describe the Bering Sea FEP in the fall of 2016.

Recommendation 5.2: The AFSC should continue to support peer-reviewed publication of results, while recognizing that supporting management processes requires significant staff time and is equally important as peer-reviewed publication in promoting the use of ecosystem science in management.

Response: The AFSC will continue to support the production and publication of peer-reviewed results of ecosystem research conducted by our scientists. This includes broader promotion of the availability of these publications, respecting journal restrictions, to the fishing industry, Alaska Native communities, the ENGO community, state, federal and academic partners, members of Congress and the general public. We recognize that the AFSC is a mission-driven institution and that supporting management processes requires significant staff time in the field and for other activities that directly support the NOAA Fisheries' mission, such as producing stock assessments, ecosystem assessments, regional action plans, etc.

Recommendation 5.3: The AFSC should maintain their good support of the communication team and foster further mechanisms of stakeholder involvement to facilitate the development of responsive tools.

Response: The AFSC believes timely and effective communication is of great importance and has made a considerable investment in establishing a communications program. In 2015, we hired a new Communications Program Manager who is committed and is already making inroads into using new technologies such as social media (e.g., Facebook which is used by Alaska Native Communities) and other innovative tools like "Tweet Chats" on Twitter, live broadcasts via YouTube, operator-assisted webinars and constituent calls, and dedicated community outreach (both in person and via expanding platforms like Google Hangout, now available to government agencies) to better inform, educate and engage constituents, Congress and the general public. Our goal is not only to raise awareness about ecosystem and our other research activities but build further understanding and support for our mission.

Recommendation 5.4: The communications team can examine the possibility of using parts of the annual Ecosystem Report for broader science communications beyond the Council.

Response: Last year, the Communications Program issued a press release and worked with a national ENGO to increase visibility of this important report. In addition, when a new Ecosystem Report website was established, a concerted effort was made to reach out to constituents and members of the press to let them know that the site was up and running and that a variety of ecosystem level information was available for public use from the site. Annual promotion of this important report will continue to be undertaken as new indicators are added and new information is made available on existing indicators.

Theme 6: Other

Recommendation 6.1: Panelists urged the AFSC to take a step back and consider the entire scientific philosophy behind the ecosystem science programs. A process-based single-species focus is valid (and productive) but is not the only philosophy and may come with risks if the system changes.

Response: As a science agency that supports fisheries management and protected resource conservation, our science must be driven by that mandate and the specific information needs identified by Regional resource managers administering this mandate. That said, we appreciate the panel pointing out that there are risks to a focal species approach. To mitigate this risk, the AFSC has taken three steps. First, a large swath of the ecosystem is studied as context for understanding focal species productivity. For example, typically two trophic levels below and one trophic level above the focal species are studied. In addition, a snapshot of the physical environment typically is taken. Second, integrative analyses are conducted to synthesize these results. By using an integrative approach, one gains insight not only for the focal species but also other species within the ecosystem, and the processes that link the different trophic levels. Third, an effort has begun to develop ecosystem thresholds; this effort will motivate and sharpen our integrative analyses. Such ecosystem thresholds likely will force people to think more deeply about ecological relationships. This process has begun by tracking ecosystem indices in the Ecosystem Considerations chapter and marking when indicators march outside the range of normal variation. Thus we are monitoring the ecosystem status and trends of current ecosystem properties.

Recommendation 6.2: AFSC could undertake a scenario assessment considering what will be the major science drivers under alternative climate, development, management pressures and policy environments. What would these drivers mean for the volume and kinds of science required and how does that map to what is currently performed or feasible? What indicators or markers should be formally/informally tracked to assure that AFSC/NOAA is aligned with changing trends?

Response: The recently-initiated ACLIM project intends to estimate climate effects on fisheries. As part of the project, ACLIM is conducting a scenario assessment to identify representative fishing pathways, which will provide for the investigation of changes in fishing patterns expected under climate change. This scenario assessment could serve as the basis for a mapping exercise to explore how well current AFSC research activities would fulfill the science needs identified under the scenario. Additional scenarios could be developed through ACLIM, other research programs, or in concert with regional action plan development activities that could serve as a jumping off point for additional mapping exercises. In addition, the AFSC has about 20 staff involved in management strategy evaluations, expending about $1,000,000 annually in scenario-based assessments and analyses.

References

Carmack, E. and McLaughlin, F., 2011. Towards recognition of physical and geochemical change in Subarctic and Arctic Seas. *Progress in Oceanography*, *90*(1), pp.90-104.

Gaichas, S., Skaret, G., Falk-Petersen, J., Link, J.S., Overholtz, W., Megrey, B.A., Gjøsæter, H., Stockhausen, W.T., Dommasnes, A., Friedland, K.D. and Aydin, K., 2009. A comparison of community and trophic structure in five marine ecosystems based on energy budgets and system metrics. *Progress in Oceanography*, *81*(1), pp.47-62.

Link, J.S., Stockhausen, W.T., Skaret, G., Overholtz, W., Megrey, B.A., Gjøsæter, H., Gaichas, S., Dommasnes, A., Falk-Petersen, J., Kane, J. and Mueter, F.J., 2009. A comparison of biological trends from four marine ecosystems: Synchronies, differences, and commonalities. *Progress in Oceanography*, 81(1), pl 29-46.

Samhouri, J.F., Andrews, K.S., Fay, F., Hazen, E.L., Harvey, C.J., Hennessey, S.M., Holsman, K. Hunsicker, M.E., Large, S.I., Marshall, K.N., Stier, A.C., Tam, J.C., Zador, S.G., Defining ecosystem-based thresholds for human activities and environmental drivers in the California Current. *In prep.*

Table: Summary of action items and deadlines

Recommendation number and action item	**Deadline**
1.1: Several panelists felt that the AFSC should develop clear goals for integrated ecosystem research in general, and not just respond to external requests for proposals (RFPs) in an *ad hoc* way. Similarly, panelists recommended that the AFSC establish a baseline level of integrated ecosystem science supported as a core activity within its science plan.	September 2016
1.2: Panelists noted that future AGMs need to include ecosystem studies and activities, if ecosystem science is truly valued by AFSC leadership.	September 2016
1.3: Taking inventory of the available skill sets and the operational *vs* research/development needs in each research area would highlight the relative staffing needs and whether this is in line with the intent of the various plans and strategies.	August 2016
1.4: Panelists recognized the enormous challenge as well as the importance of work in the Arctic, but the funding constraints will be limiting. A strategic plan that focuses less on potential target species and more on ecosystem change and multiple drivers was recommended by some panelists.	September 2018
2.1: Many panelists noted that AFSC should strive to balance its ecosystem data collection programs to ensure that a full range of species and life stages are sampled, and maintain an appropriate balance between core assessment work, process studies, and more integrative analysis.	Ongoing
2.2: Some panelists recommended a more ambitious vision to investigate the ecology of the 5 LMEs under consideration, focusing on issues such as energy flows, connectivity and exchanges, climate change impacts, etc., combining observation and modeling approaches.	September 2018

2.3: Several panelists felt that the AFSC should invest in Center-wide data management systems and investigate where data recovery efforts might bring long term benefit to multiple projects/assessments.	Ongoing
2.4: To ensure that collaborative links do not dissolve with personnel turnover, panelists recommended that high level agreements should be put in place between agencies or line offices recognizing the value and intent of these connections. This was seen to be especially important with NOAA's Pacific Marine Environmental Laboratory (PMEL).	Ongoing
3.1: Some panelists recommended that the AFSC should embrace the Ecosystem Considerations Chapter as a Center-wide product, and reinforce its production accordingly through inclusion in employee performance plans.	September 2016
3.2: The synthesis groups must be reasonably resourced with some depth of support. Similarly, the maintenance of models must be supported or that capability will be lost.	Ongoing
3.3: Panelists felt that provision must be made for IT hardware that meets modeling needs.	Ongoing
3.4: Some panelists suggested using qualitative (conceptual) models to facilitate syntheses, to compare LMEs and alternative energy pathways (e.g. pelagic vs demersal) and how the system may have functioned through time or under perturbation.	September 2017
4.1: Panelists felt that the AFSC should continue to support further development of the Bering Sea Fishery Ecosystem Plan (FEP) and its Action Modules, in collaboration with the North Pacific Fishery Management Council. AFSC should also fully support production and further development of the Ecosystem Considerations Chapter.	September 2017

4.2: The AFSC should accelerate IEA efforts, in particular ecosystem level risk assessment to prioritize which ecosystem processes require evaluation by more quantitative methods.	September 2017
4.3: The AFSC could undertake an exercise to uncover key links and points of failure and assess whether these are suitably resourced and supported.	April 2017
4.4: In the absence of specific metrics from the Council, the AFSC may wish to develop and propose its own objectives to assess the state of the ecosystems under consideration.	September 2018
5.1: The AFSC should continue to promote dialogue with stakeholders, etc., Dialogue may develop more through the ACLIM project management strategy evaluation, the Bering Sea FEP, and development of IEA conceptual models, as well as existing outreach efforts to Alaska communities.	December 2016
5.2: The AFSC should continue to support peer-reviewed publication of results, while recognizing that supporting management processes requires significant staff time and is equally important as peer-reviewed publication in promoting the use of ecosystem science in management.	Ongoing
5.3: The AFSC should maintain their good support of the communication team and foster further mechanisms of stakeholder involvement to facilitate the development of responsive tools.	Ongoing
5.4: The communications team can examine the possibility of using parts of the annual Ecosystem Report for broader science communications beyond the Council.	Ongoing
6.1: Panelists urged the AFSC to take a step back and consider the entire scientific philosophy behind the ecosystem science programs. A process-based single-species focus is valid (and productive) but is not the only philosophy and may come with risks if the system changes.	September 2016

6.2: AFSC could undertake a scenario assessment considering what will be the major science drivers under alternative climate, development, management pressures and policy environments. What would these drivers mean for the volume and kinds of science required and how does that map to what is currently performed or feasible? What indicators or markers should be formally/informally tracked to assure that AFSC/NOAA is aligned with changing trends?	September 2017