



JUN -4 2015

MEMORANDUM FOR: Eileen Sobeck
Assistant Administrator for Fisheries

FROM: Keith Rizzardi *KWRizzardi*
Chair, Marine Fisheries Advisory Committee

SUBJECT: Marine Fisheries Advisory Committee Findings and
Recommendations from the April 2015 Spring Meeting

This memo transmits NOAA's Marine Fisheries Advisory Committee's findings and recommendations related to tasks assigned by NOAA Leadership and deliberated through task forces, working groups, and subcommittee work underway since the Fall 2014 meeting.

MAFAC appreciates the opportunity to provide these findings and recommendations which represent the culmination of this work on the following topics:

- **Review of the draft priorities for the new 2016-2020 Office of Aquaculture Strategic Plan (Attachment A)**
The Aquaculture Task Force and Commerce Subcommittee recommend revising the Vision statement, Mission statement, and Goals and Measures to more clearly articulate and support a robust and environmentally responsible marine aquaculture sector.
- **Review of the recommendations contained in the draft Cooperative Research and Cooperative Management White Paper (Attachment B)**
Additions to the text of the recommendations were developed and approved to help clarify and distinguish between cooperative research, cooperative management, and co-management.
- **Review of the Draft NOAA Fisheries Climate Science Strategy (Attachment C)**
The Draft is a thoughtful and concise blueprint for capturing the necessary key components of assessing climate change on living marine resources in the marine and riverine environments. Additions and clarifications are recommended by MAFAC to improve the document to serve the needs of the agency better.

MAFAC and its task force members and will be investing a significant amount of time and work through the remainder of 2015 on their ongoing projects including:

- Retrospective analysis of protected species recovery actions of seven representative species to help improve the identification of successful recovery actions in the future.
- Continued support of the NOAA Fisheries Climate Science Strategy and the development of regional implementation action plans.
- Support of the finalization of the Gulf of Mexico Rule for Aquaculture through input and feedback on the coordinated permit framework for aquaculture in federal waters and

development of “mock,” representative, commercial aquaculture projects of the type NOAA may be asked to permit under the Gulf of Mexico Fishery Management Plan for Aquaculture to test the framework.

- Review NOAA's progress on implementing the agency's 10-Year Plan for Marine Aquaculture (2007) and input into NOAA's future 5-year strategic planning effort.
- Support of the development of region-specific implementation plans under the recreational fisheries policy.

Cc: Dr. Kathryn Sullivan, Under Secretary for Oceans and Atmosphere
Dr. Holly Bamford, Acting Assistant Secretary for Conservation and Management

Attachments

Review of DRAFT Priorities for 2016-2020 Office of Aquaculture Strategic Plan

Submitted by the Aquaculture Task Force and Commerce Subcommittee
 Approved by MAFAC, April 30, 2015, where noted
 Consolidated Comments Included

Vision and Mission:

Vision Statement: “A vibrant U.S. marine aquaculture sector that creates jobs, provides sustainable seafood, and supports healthy oceans.”

Task Force:

- See definition of vibrant – do you want to use this term?
- Insert “an expanding” before vibrant
- Insert “healthful” before sustainable
- Change “supports healthy oceans” to “restores ocean ecosystems”

Aquaculture Subcommittee:

- Robust instead of vibrant?
- Insert Economically viable/sustainable and environmentally responsible

Revised Vision Statement: A robust, economically viable, environmentally responsible US marine aquaculture sector that creates jobs, provides sustainable seafood, and supports healthy oceans. **ADOPTED**

Mission Statement: “To provide science, services, and policies to support significant growth of sustainable U.S. marine aquaculture, including commercial production and restoration.”

Task Force:

- To provide: 1) science, services, and policies to support significant growth of sustainable U.S. marine aquaculture, including commercial production and restoration and 2) interagency coordination in the development and implementation of a national marine aquaculture development program.
- What does significant mean? Needs to be measurable.

Aquaculture subcommittee:

- Change provide to enhance or advance
- Change significant to ongoing or increasing
- Insert habitat and stock before restoration to clarify

Revised Mission Statement: To enhance science, services, policies, and interagency coordination to support rapid growth of sustainable US marine aquaculture, including commercial production and habitat and stock restoration. **ADOPTED**

Goals and Measures:

Goal 1: Develop a clear and effective regulatory system for the marine aquaculture sector.

Task Force:

- Insert efficient before “regulatory”

- Insert commercial before “marine aquaculture sector” to clarify
- Insert “support expansion”
- Insert “that will allow, encourage and support the expansion of” after system.

Aquaculture Subcommittee:

- Replace “clear and effective” with “streamlined, coordinated and predictable”,
- Change system for process or environment

Revised Goal 1: Develop a streamlined, coordinated, and predictable regulatory process for commercial marine aquaculture. **ADOPTED**

Goal 2: Promote environmental stewardship and sustainability in the marine aquaculture sector

Task Force:

- Insert “for long-term growth” after sustainability
- Insert “and economic”

Aquaculture Subcommittee:

- Insert “using best available technologies” at the end of the statement.
- Change “stewardship” to “responsibility”

MAFAC:

- Keep original statement
- Add “using best available technologies” as suggested by the subcommittee

Revised Goal 2: Promote environmental stewardship and sustainability in the marine aquaculture sector using best available science and technologies. **ADOPTED**

Goal 3: Provide science-based tools, technologies, and services for the marine aquaculture sector

Aquaculture Subcommittee:

- Insert “extension” before “services”
- Change “Provide” to “Develop”

Revised Goal 3: Develop science-based tools, technologies and extension services for the marine aquaculture industry. **ADOPTED**

Goal 4: Increase public understanding of marine aquaculture

Task Force:

- Insert “to foster long-term growth”
- Insert “and appreciation for” after understanding
- Insert “and its benefits” after aquaculture

Aquaculture Subcommittee:

- Insert “education”
- Insert “outreach capacity”
- Change “increase” to “improve”

Revised Goal 4: Increase education and outreach capacity to improve public understanding of marine aquaculture. **ADOPTED**

Goal 5: Build internal support for marine aquaculture

Task Force:

- Remove this as a goal

Aquaculture Subcommittee:

- Remove this as a goal **ADOPTED**

General Task Force Comments:

- We need a plan from NOAA that provides less in the way of aspiration and more in the way of quantitative goals and projected timelines. That will allow MAFAC and others to comment on the plan’s reality and measure performance as things move forward.
- We strongly suggest that the goals 1) be related and in support of the on-going 10 year plan and 2) be of a specific, quantifiable nature. The general language is problematic in its lack of specificity. As examples, we created a new Goal 1 that mirrors the 10 year plan and is quantifiable. Problematic in its generality is Goal 2. It states that NOAA will create a clear and effective regulatory system for coastal aquaculture. Coastal aquaculture occurs in state waters and it is very unlikely NOAA is going to be successful in negotiating with states and for certain, very significant regions, local governments.
- The lack of a research-oriented goal needs to be addressed. Funding is always an issue; however, the federal aquaculture research plan was a product of joint agency effort and it would seem an obvious goal to implement that plan across the research oriented NOAA programs.
- With regard to the vision statement – a vibrant US marine aquaculture sector is what we all want to see. But there is a need for specifics. Will ‘vibrant’ be defined in terms of projected production volumes in the plan that follows? For example, the US consumes about 5 million metric tons live weight of seafood per year of which 90% is imported. Would ‘vibrant’ be a reduction of 10 or 20% of imports?

With regard to Goal 1 – is there a clean distinction between coastal and offshore aquaculture, i.e. state vs federal waters? And what can NOAA do to change, improve or unify the different systems that have evolved in the states? For

example, coastal finfish aquaculture is banned in Alaska. Will NOAA change that?

Suggested New Goal Statements (not adopted by MAFAC):

Suggested Goal: In cooperation with the private sector, develop and implement a National Marine Aquaculture Development Program designed to double domestic marine aquaculture in 10 year.

Suggested Goal: develop and implement an International Aquaculture Technology Transfer Program designed to send private entrepreneurs and farm managers to visit and work in other countries with more advanced aquaculture sectors.

Suggested Goal: Ensure that with the increasing regulation of wild stock fisheries and a concomitant growth in the aquaculture industry that there is no resulting net loss of seafood industry jobs but rather an increase in employment in the sector.

Suggested Goal: Increase the value of marine aquaculture production in US waters by 100% within 10 years.

**Comments on the White Paper on
Cooperative Research and Cooperative Management**

**Submitted by the Strategic Planning, Budget, & Program Management Subcommittee
Approved by MAFAC, April 30, 2015**

Suggested text changes are shown in underline, where appropriate and page references are provided.

Recommendation #1 (page 3):

The Introduction discusses a letter from a broad set of stakeholders that was sent to Dr. Sullivan requesting that NOAA strengthen the use of co-management in fisheries management along with a suite of other issues. A copy of the letter should be included as an attachment to the white paper and a discussion of the broader efforts and working groups that are working on some of the other issues that are flagged in the letter from these constituents should be delineated.

Recommendation #2 (page 40 – 41):

Cooperative Management Policy #1-- Under Cooperative Management Policy (1) All three terms should be clearly defined and their individual application delineated. These are: (1) Co-Management, (2) Cooperative Management, (3) Cooperative Research to provide guidance to employees, partners and stakeholders. This is important as the terms are not interchangeable.

In addition, the following edit should be made for clarity:

Given the various definitions and understandings of “co-management,” this White Paper recommends use of the term “co-management” be reserved for the shared management with States and Tribes that have similar authorities. The working group recommends that a common definition of the term “cooperative management” be disseminated to differentiate the differences between “Cooperative management” and “Co-management” as well as “Cooperative research.”

Some ideas:

“Cooperative management” could refer generally to increased stakeholder engagement in the fishery management process – from data collection to development of management plans to addressing buy-in and accountability – to foster a shared understanding of the condition of and responsibility and task sharing for managing and protecting resources, consistent with conservation and management standards and legal requirements. This understanding would span NOAA’s responsibilities under the MSA, ESA, and MMPA.

Recommendation #3 (page 41):

Cooperative Management Policy #3-- NOAA Office of Communications and the Office of Policy should facilitate in-reach by training all appropriate NOAA Fisheries staff on the common understanding of co-management, cooperative management, and cooperative research and the suite of tools available to NOAA Fisheries under the MMPA, ESA and MSA. Facilitation and/or customer service training may be appropriate for specific staff to

improve interactions between NOAA Fisheries staff and constituents. Training could take place through webinars, training videos, field training and publicized information NOAA Fisheries Policy Office on the NOAA Fisheries intranet. This recommendation may initially require additional funding resources but may be offset by gains in management efficiency.

Recommendation #4 (page 42):

Cooperative Management Policy #5-- NOAA Fisheries Leadership and NOAA Fisheries Management and Budget should continue to push for statutory language needed to accept private donations and determine the proper guidelines regarding the use of private funds.

Recommendation #5 (page 42):

Cooperative Research #3-- The Cooperative Research Program and other cooperative research activities (i.e. SK Grants and BREP) should ensure that both stakeholders and NOAA Fisheries are involved from start to finish to set goals and objectives to ensure results have the best chance to be used for management purposes. Because cooperative research may be important in providing data necessary for stock assessments, stock assessment scientists should be included in the design, implementation, and analysis of projects.

Recommendation #6 (page 43):

Metrics -- NOAA Fisheries Office of Science and Technology should review 2014 cooperative research program projects and determine how many, and which of them better informed, facilitated or led to improved management decisions or enriched scientific products.

Recommendation #7 (page 43):

Conclusion -- The November 25, 2013 letter recommended that NOAA support cooperative management and cooperative research as a means to bring new resources to fisheries management, enhance NOAA's capabilities, and improve stakeholder relationships.

Recommendation #8:

Finally, the document needs a synthesis conclusion, explaining when cooperative management and cooperative research are best used. For example:

“Cooperative management” allows aspects of NOAA’s responsibility to be delegated to stakeholders, but may require those stakeholders to incur the burden of investing additional resources or incurring additional costs. As a general rule, cooperative management should be pursued when NOAA and the stakeholders gain mutual benefits and when legal authority permits.

“Cooperative research” allows stakeholders to contribute to the overall base of knowledge enabling NOAA to make informed decisions. In general, NOAA should support stakeholder research and advise the stakeholder on how to best structure their research efforts. Also, NOAA may choose to confer with stakeholders where multiple overlapping research initiatives exist, in an effort to determine whether one or more of the research projects could be modified to increase the overall knowledge. NOAA should consider how best to be a partner and facilitator to create a positive environment for cooperative research projects.

**Findings and Recommendations on the
NOAA Fisheries Draft Climate Science Strategy**

**Developed and Submitted by the Climate & Marine Resources Task Force
and Ecosystems Approach Subcommittee
Approved by MAFAC, April 30, 2015**

Thank you to the writers of the *Draft NOAA Fisheries Climate Science Strategy*. It is a thoughtful and concise blueprint for capturing key components of assessing climate change on Living Marine Resource (LMR) marine and riverine environments.

The mandates on NOAA are significant to the entire world in terms of identifying and adapting to climate change. Beyond even the mandates is the responsibility we (as both commentators and world citizens) all have in helping NOAA do its work to effectively *gather and communicate* those findings to the sectors – whether federal, tribal, state or local – that will be most impacted by marine and riverine changes. The enormity of that responsibility is certainly overwhelming to anyone who really cares about how the world will adopt positive adaptive strategies to mitigating and living with climate change.

The Climate & Marine Resources Task Force of MAFAC met on March 11, 2014 to discuss the *Draft NOAA Fisheries Climate Science Strategy*. The following detailed comments were derived from that meeting, as well as subsequent work by Task Force members. We appreciate the opportunity to provide these comments to the Ecosystems Approach Subcommittee of MAFAC for review. We hope these will be adopted and approved by the entire MAFAC Committee at its April 2015 meeting.

The Climate & Marine Resources Task Force commends the NOAA Fisheries Service for undertaking the development of a climate science strategy. The need to focus scientific resources in the face of climate change and variability is urgent. Having a clear strategy to address scientific questions is paramount.

The Task Force had extensive discussions and questions for NOAA Fisheries staff on the development and content of the Strategy. They suggested that additions and clarifications be made in the NOAA Fisheries Climate Change Science Strategy to improve it to serve the needs of agency better.

The Task Force's comments are organized into three sections: (A) comments on the entire scope of the proposed strategy; (B) comments organized, as is the strategy in Chapter 2, by the objectives established by NOAA; and (C) specific comments on recommended socioeconomic research to meet strategic objectives.

A. Comments on the entire scope of the proposed Strategy

1. Urgency and risk

The document could be strengthened by emphasizing urgency upfront. Related to the urgency of the issue is the risk of inaction in moving climate science forward. There is a great degree of risk associated with not acting and in not preparing now for changes that are coming as a result of

climate change. The reader needs a clear statement of this purpose and need, therefore a preface is recommended which highlights the urgency of the issue and the risk of inaction, such as opportunity costs. However, there is also risk in premature action that impacts present seafood harvest before new approaches are understood and vetted.

2. Communicate climate science results

A high priority should be placed on developing new approaches to communicating the results of climate change-related research undertaken by NOAA Fisheries to the diverse community of expert and non-expert stakeholders with whom NOAA fisheries interacts, particularly sector and community leaders and managers. The best research will be inadequate if it does not lead to wider and deeper understanding of the challenges confronting fisheries and marine ecosystems. Related to communications, the text of the Strategy should also be written in clearer, plain(er) language. This will ensure that the public, if an intended audience, can easily understand it and its need.

3. Socioeconomic dimensions

Three of the seven objectives make reference to “LMR-dependent human communities.” As the old saying has it, one does not manage fish, one manages people who fish. There are, in other words, socioeconomic dimensions to be understood in meeting all seven objectives. The draft strategy offers somewhat less information about how socioeconomic objectives will be reached, so Section C of these comments provides suggestions to conduct some of the social science research that will be needed. Additionally, there are many communities of stakeholders that are not in the commercial sector. The *Strategy* should encompass these other sectors (recreational, sport, charter, subsistence and sustenance fishing) as these fisheries and their dependent communities will also be hugely impacted by climate change.

4. Link objectives to management questions and decisions

In the Executive Summary, the document should briefly describe how the seven objectives were identified and developed and their connection to mission priorities, management questions, and decision processes. The internal discussion and deliberation was explained by staff to the Task Force, however the reader does not have the same benefit and the link to management challenges is not clearly written. The document discusses new approaches and management strategy evaluation techniques, but these are difficult to understand. It's not clear how they will be integrated into existing decision-making processes. More discussion of strategies to provide a transition from current management processes to processes informed by climate science would strengthen the document.

Additionally, NOAA should not abandon current stock assessment and management processes and the data collection required to support these activities. Fisheries management depends on accurate and timely stock assessments. While climate modeling is important, it operates on larger time scales (e.g., decades to centuries) and it should not interfere with empirical data collection (e.g., fish surveys) needed for shorter time scales (e.g., 1-5 years).

5. Ensure the *Climate Science Strategy* provides a focus on spatial and temporal habitat issues

The document would benefit from clearer focus and greater relevance to habitat programs and assessments (e.g., EFH and ESA section 7 consultations). This should not diminish the importance on temporal climate-driven patterns that are the main focus.

6. Resilience and Risk

Understanding resilience and actions to reduce risks could use more focus in the document. For example, there are some actions that should provide climate mitigation benefits, but more scientific information is needed to fully understand the benefits. Additionally, how does NOAA Fisheries propose to better account for the interactions of climate and non-climate stressors in all its program areas? Non-climate stressors may exist which combine or exacerbate climate change stressors. These points are mentioned in the document, however they are largely underrepresented.

In particular, the *Strategy* should address the scientific needs related to actions that would increase resilience of living marine resources (LMR) and LMR ecosystems to climate change risks and increasingly dynamic/chaotic system responses. Examples are provided in section B, Objective 2 of this document. A couple of additional examples include:

- Testing of alternative limits to harvest regimes within marine protected areas including no harvest, reduced harvest, periodic cessation of harvest (10-12 year cycles), and selective reduction in take of species (or guilds) determined to regulate marine biological communities, for example forage fish species, and top predator species (i.e., applied research into management of marine reserves to mitigate climate and non-climate stressors to whole ecosystem). With respect to this, the Marine Protected Area Federal Advisory Committee (MPA FAC) developed a thoughtful [white paper](#) that addresses the topic of resiliency and climate change and it should be consulted.
- Identification and understanding the mitigation of non-climate stressors that impact habitats, populations of species, and LMR ecosystems, and how reductions to non-climate stressors can be achieved in order to improve LMR resilience.

7. Tools to prioritize science needs

The lay reader may not understand the purpose of the examples included within this section without understanding that, depending on the types of climate impacts or issues being examined, these are all appropriate decision analysis tools to reduce or eliminate climate-related scientific or management uncertainties. The document needs to emphasize that the extra capabilities we are in need of are continual – because the process should be iterative over time. It is helpful to avoid “linear” models of science delivery if one wants to argue the case for consistent effort, stable programs, and continued funding.

The scientific needs are two types: 1) data needs, and 2) synthesis, incorporation, and modeling needs. Although only modeling is addressed here, it is important to advance and prioritize the empirical data collection that is necessary to support immediate and short term management needs, such as stock assessments (as noted in 4. above), and not have that completely overshadowed by robust climate change modeling.

NOAA Fisheries will need to acquire additional science and technical capacity for:

- modeling
- climate-based assessments
- vulnerability assessments
- decision analysis tools to reduce uncertainty

Each of these activities should be a relatively high priority for NOAA, NOAA Fisheries, and partners. Two areas that help in this regard (and could use additional highlighting and be expounded upon in the document) are 1) examples of tools to prioritize science information needs (i.e., identify critical research needs and data gaps); and 2) more explicit examples of tools to integrate analyses into and influence decision-making.

NOAA should consider a phased approach: what aspects of its science capacity must improve immediately, and what aspects can be improved over time (e.g. prioritization may link to a fish stock's ecological or economic importance)? NOAA must accept limitations. Information will always be imperfect, and sometimes, imperfect information is acceptable. NOAA needs to think about the costs and benefits of obtaining information and the utility of the data it gathers. Not every aspect of every ecosystem must be fully understood. Not every stock assessment has economic value. Moreover, the more data NOAA tries to assemble, the more likely there will be a time lag in the analysis of these data. Simply put, NOAA does not have the resources to analyze unlimited data. To the extent that partners can undertake work, NOAA should be willing to share the burden (see 8. below).

Three types of tools which help illustrate these points are:

- a. Decision tree or matrix (e.g. a simple four quadrant matrix to focus initially on NOAA Fisheries climate science management needs within areas of strong jurisdiction or authority; as well as to cultivate outside partnerships or to assist partners with their information needs).
- b. Models and process studies, with projections displayed as animations or “movies” (people easily understand these).
- c. Experimental approaches (shellfish/aragonite example – research in this area needs to be more robust; factors other than ocean acidification, such as changes in upwelling, rainfall, anthropogenic nutrient inputs, also contribute to changes in aragonite saturation.).

Other examples which could be added in the document:

- a. Adaptive Management (A/M) examples (show the process as circular rather than linear).
- b. Bayesian Belief Networks (BBN) or other structured decision-making/learning tools.
- c. Expert Elicitation/Delphi approaches. This could involve an A/M process with follow up research, monitoring, and adjustment. A key aspect of this approach is to document the process, expected outcomes, actual results, and lessons learned.

8. Partnerships

The *Climate Science Strategy* should acknowledge Federal partners (e.g. USGS, USFWS), as well as others (e.g. First Nations, academic researchers) to ensure these partners realize they are being asked to be on board with this strategy. Fortunately, NOAA does not need to do all the work by itself. NOAA funds or provides grants to cooperative institutes, academic institutions, and other non-governmental organizations. These entities should be consulted for their ongoing scientific climate enterprise and in the development of scientific priorities. New climate challenges will require a new way of working with partners. All of these entities should pursue new ways of information exchange, such as by developing shared databases. An inclusive approach to climate change information management will lead to more cost effective and more transparent results that may also be perceived as less biased. (See also Objective 7, Part B below.)

9. Link to the National Climate Adaptation Framework and its objectives

The *Strategy* could identify better linkages to the [National Fish, Wildlife & Plants Climate Adaptation Strategy](#) and its objectives¹. The objectives in this adaptation strategy are proactive and relate directly to management decisions. The document would be strengthened by mapping the seven NOAA Fisheries objectives onto the NCAS seven objectives in several areas that are discussed below. For instance, the NCAS seven objectives are consistent with NOAA Fisheries' EFH, ESA Section 7, and NEPA responsibilities and also address interactions of climate stressors, non-climate stressors, and habitat alterations, including loss of critical habitats and habitat connectivity.

10. Make the science strategy operational not just aspirational

The document would be improved by relating overall objectives to operational guidance, rather than being limited to aspirations. The operational guidance could discuss how the strategy will be operationalized by stepping down to the regional (and partner) level in order to deliver clear results. The results should be focused on reducing climate risk and uncertainty. If including such operational guidance is not appropriate for this draft, then these steps should be outlined in a future implementation guidance which also outlines a clear time line for incorporation of objectives 1 to 7.

11. Capacity and Limitations

NOAA must understand its *capacity* to process the scientific information related to climate change. This requires an understanding of existing capabilities and a projection of future needs. For example, new data observation systems, laboratories, or computer modelling capabilities may be needed, and budgetary changes may be necessary. It should be noted that gathering climate change information now, is an investment that helps to avoid future expenses.

To assist with exercise, NOAA should review the *Strategy's* Chapter 3 actions, identify which actions involve investments and their specific budgetary requirements, develop timeframes for implementing the action, and tie each action clearly to one of the seven objectives. Also, as currently written, the *Draft Climate Science Strategy* seems to reflect the desires of the science team; NOAA managers and leaders need to engage in a review of this Draft Strategy to ensure the whole agency's perspective is reflected.

Unfortunately, in a climate changed world, the usefulness of historic data can vary. While it may be the best available data, it may be inadequate. Data need to be collected in ways that take advantage of new technologies and efficiencies, and is appropriate for the spatial and temporal extent of the problem. Existing data collection should be carefully evaluated and less frequent collection or analysis of data for one program might create opportunities to invest in new scientific information elsewhere. Internal and external peer review might help to identify appropriate changes in data collection and analysis. In addition, any redundancies in the data collection need to be eliminated. Finally, NOAA needs to remain open to the use of data collected by other public and private entities, even for regulatory decisions, if that information is the best available.

¹ A concise Highlights document to the National Fish, Wildlife & Plants Climate Adaptation Strategy can be found here: <http://www.wildlifeadaptationstrategy.gov/pdf/Strategy-Highlights-Brochure.pdf>

B. Comments organized by the objectives established by NOAA in the Strategy

Objective 1: Identify appropriate, climate-informed reference points for managing LMRs.

- Describe how the process of determining “biological reference points” actually works. Biological reference points are actually not points but rough estimates of system capabilities or limits. It may be better to think of them as “climate informed reference conditions.” Some of the most useful reference points may not be immediately linked to short term management objectives.
- Add “habitat” to the first bullet of this objective (“Identify ecosystem-based reference points that include climate change and ecosystem information for all LMR management plans and strategies”... and their habitats.)
- Identify appropriate reference points needed for international treaty requirements.
- Ensure current and any future reference points take into account both the common and distinct needs of commercial, subsistence, and recreational fisheries and marine-dependent communities.

Objective 2: Identify robust strategies for managing LMRs under changing climate conditions.

- Climate stressors (ocean acidification, storm surges, alteration of upwelling, changes in ocean currents, etc.) are not happening at the same rate or with the same impact, and this has tremendous implications for LMRs and LMR ecosystems. This is alluded to at least twice in the document, but would be strengthened by incorporating follow-through on these matters, such as measuring of impacts, risk assessment prioritization and refinement, indicator development, and response strategies.
- Support the emphasis on the use of Management Strategy Evaluation as a way to identify robust management measures in the context of a changing climate.
- Identify strategies to include non-marine resource use and impacts in marine integrated ecosystem assessments (i.e., agriculture competition for fresh water; climate change is exacerbating old conflicts so a new paradigm must be created).
 - Encourage scientific strategies to identify and protect marine, coastal, estuarine, and riverine critical habitat, especially strategies which may also mitigate risks from climate change.
- Research aspects of population structure of fisheries to support strategies that distribute fishing effort across sub-stocks, age classes, and genetically distinct populations in an effort to preserve the potential for fish populations to adapt.
- Develop the capacity to critically examine the costs and benefits, including health and mitigation costs, incurred in substituting natural environments, i.e., wild stock vs. farmed stock and adaptations to climate fluctuations.
- Utilize modeling technology that can realistically illustrate cause and effect of shifting regimes.

Objective 3: Design adaptive decision processes that can incorporate and respond to changing climate conditions.

- Identify interim and long term strategies for sector/communities to get timely and adequate information for making adaptive changes.
- Accurately portray the adaptive management process. The current adaptive (management) framework in the document is portrayed as a linear process of altering biological reference points. This is not consistent with adaptive management process. AM is continual, circular, and evolving.
- Incorporate local and traditional knowledge (LTK) and traditional ecological knowledge (TEK) for adaptive and pre-emptive practices as well as identifying cumulative impacts:
 - Research existing oral and written histories.
 - Maintain continual dialogues with Native American tribes.
 - Increase LTK and TEK data collection.
 - Research adaptive measures from world history
- Research existing adaptive practices from around the world.
- Create greater dialogue on the significance of impacts of *marine* changes on *non-coastal* terrestrial ecosystems, i.e., how ecosystems integrate and what this means to in-land adaptive measures.
- Conversely, create greater dialogue on climate change impacts on marine systems to non-coastal terrestrial ecosystems.
- Enhance methods of data recording and transfer to real time information systems.
- Undertake “research on the research,” that is, actively investigate how the information generated by the research strategy is being used, including how perceptions of risks are affected by improved measures of risk.

Objective 4: Identify future states of marine, coastal, and freshwater ecosystems, LMRs, and LMR -dependent human communities in a changing climate.

- Since this is the most critically needed outcome of research and analysis, the steps listed on page 36 as “important strategies” is an important start.
- Build on these strategies by identifying better ways to integrate with many systems throughout the world and translating to fisheries, marine, and community managers everywhere.
- Develop measures of vulnerability to change in communities and industries and extend to creating models of what the socioeconomic responses to the ecological and management changes may be.

Objective 5: Identify the mechanisms of climate effects on ecosystems, LMRs, and LMR-dependent human communities.

- On p. 39 of the draft *Strategy* it is noted, “NOAA Fisheries’ current capacity to conduct process-based research will not meet the demand for understanding how aquatic species, ecosystems, and LMR-dependent human communities may respond, acclimate or adapt to climate change.” This says it all and is the critical message for garnering necessary support for NOAA to increase its capacity.
- Particularly needed are the data and analysis of changes in LMR-dependent communities, including both coastal communities and fisheries related industries that will lead to improved understanding and prediction of social and economic changes resulting from the ecological effects of climate change.

Objective 6: Track trends in ecosystems, LMRs, and LMR-dependent human communities and provide early warning of change.

- Increase, establish, and invest in community-based or citizen science monitoring systems, with uniform protocols (e.g. Alaska Community Based Monitoring Systems, or CoCoRaHS, the Community Collaborative Rain, Hail, and Snow network), and identify key geographic areas (marine and riverine) to target their establishment.
- Develop uniform protocols for community-based monitoring to feed into integrated data sets.
- Identify key indicators to track and monitor (e.g. changes in occurrence or prevalence of diseases in wild fish populations; this might include working with USFWS and USDA to expand the National Wild Fish Health Survey). Identify key environmental indicators of change in important habitats and their impacts on marine environments.
- Integrate a model for identifying major signs of long-term change in distinct geographic socio-ecological systems combined with larger systems.

Objective 7: Build and maintain the science infrastructure needed to fulfill NOAA Fisheries mandates under changing climate conditions.

- NOAA should review the actions in Chapter 3 of the draft *Strategy*, identify specific budgetary requirements, timeframes for implementation, and prioritize them.
- Increase partnerships (as noted) with other federal agencies, state governments and agencies, coastal and riverine communities, environmental NGOs, tribal governments, universities, international organizations, etc., to integrate existing science.
- Increase the budget of NMFS's Social Science Branch and expand its National Standard 8 responsibilities to include social indicators relevant to climate change.
- Identify *new* constructs for continual data collection, analysis and data sharing among sectors.
- Use socio-economic data already collected and distributed by public agencies to track socio-economic changes.
- Include research of resources use in subsistence communities. Subsistence resource use is essential to the discussion of *real economies* based on their extreme remoteness from straight cash economies.

C. Additional Comments on Socioeconomic Research to Meet Strategic Objectives

There is a variety of socioeconomic research strategies that should be considered to address the objectives described in Section B:

1. Vulnerability Analysis

Analysis of the vulnerability of LMR-dependent communities depends first on defining them. Landings data, combined with data on the regional economies such as contained in the NOAA Economics-National Ocean Watch (ENOW)/ National Ocean Economics Program and the social indicators developed by NMFS's Social Science Branch can provide first-order measures of fisheries dependence for most commercial fisheries.

These data can also be used to approximate measurement of recreational fishing dependent communities, though survey data on marine recreational fishing will be needed to provide additional detail.

National studies can be done using these data down to the county level to identify relative levels of LMR dependence. As the data used for these studies are regularly produced, the construction of vulnerability indexes along these lines will provide both a picture of current vulnerability but allow tracking of changes over time.

Subsistence fisheries in native and indigenous communities need to be included in this analysis. Data sources for these investigations, such as Census data, will have to be supplemented with field research. Subsistence fishing is a primary issue in Alaska, but subsistence fishing as an important part of the diet among native and indigenous communities is in fact common in the entire US and in the Pacific islands.

Subsistence fisheries are also not confined to native and indigenous communities. Low income people in U.S. coastal communities, particularly in urban areas, frequently supplement their diet with fish. These consumers are relatively under studied outside the public health field.

For proper vulnerability analysis we need a better understanding of organism-level impacts, especially the impact of ocean acidification on calcifiers.

2. Industry Analysis

Investigations of climate change impacts on fisheries focus on changes in the ecosystems that will affect possible levels of catch, but there will also be changes in the commercial fishing industry in response to the ecological and biological changes. The ecological and biological changes will interact with changes in the industry to create new economic structures in harvesting, processing, and distribution. Little is known about how these changes will take place largely because the climate-induced changes are only recently beginning to show up in the economic systems. This raises two questions:

- a. What changes are occurring?

The strains on the commercial fishing industries resulting from overfishing and restrictions required for stock management have resulted in a variety of adaptations to changing conditions in timing of activity, gear and other technology, and markets. These changes point to possible directions of responses related to climate change and need to be more systematically understood. Given the variety of industrial organizations within U.S. fisheries, this research will need to be carried out over several years.

It should also be noted that many of these same questions about how adaptation will occur might apply to subsistence fisheries. Local and traditional knowledge is critical to understanding past changes and adaptation in subsistence societies that may help understand responses to climate change. Other more formal theoretical frameworks will have to replace industrial organization, such as community development, for this research.

b. What changes should occur?

Changing fisheries response to climate change will raise the policy question: what should government's role be in assisting LMR-dependent communities and the fishing industry itself? Previous efforts have mostly focused on compensating losses and shifting people out of the fishing industry to reduce effort. Future changes may require more active intervention in reshaping industries and communities. A first step in such efforts will be identifying social preferences and values within fishing communities.

The most applicable economic framework for potential policy in this area is the work on innovation and economic networks, often called "cluster theory." This field moves beyond traditional impact analysis of the type that has typically been done in relation to management plans by focusing on how networks of industry, government, educational, and other institutions work to encourage a sustained level of innovation in economic activity through new technologies, products, and markets. Working with other government agencies that regularly operate in this space, such as the Economic Development Administration in DOC and the Rural Development Administration in USDA, NOAA should investigate how and where government (Federal, state, and local) policies can foster innovative adaptations in industries and communities.

3. Understanding perceptions and preferences for risk of decision makers and stakeholders in fisheries management.

The *Science Strategy* implicitly defines the problem of fisheries adaptation to climate change as a problem in risk management with the intention of greatly increasing the measurement and understanding of the risks from climate change and to the fisheries. This is an essential element in fulfilling NOAA Fisheries' missions, but improved measures of risk have been shown to be inadequate to assure effective responses. The example of climate change as a larger issue in society demonstrates this problem clearly.

To the extent that NOAA wishes to fully understand the challenges of climate change, the concept of risk needs to be extended to the perceptions of risk and to preferences for risk among the decision makers and stakeholders involved in the policy process. Developments in the understanding of how people perceive risks and how risks are communicated such as prospect theory and status quo bias over the past two decades have altered understandings of the economics of risk and shown that even the best measurement of risk may not be sufficient.

Over time, NOAA should engage researchers with backgrounds in the social analysis of risk to monitor the development and communication of risk data within the fisheries management community (government, industry, and other stakeholders) to understand how different participants see the risks associated with different projections of climate change, impacts, and responses. The goals of this research will be to understand how people respond to changes in measured risks in order to improve communication of the risks and to identify gaps between the outputs of the research strategy as a whole and decisions incorporating the results of that research.