Atlantic States Marine Fisheries Commission

Management, Policy and Science Strategies for Adapting Fisheries Management to Changes in Species Abundance and Distribution Resulting from Climate Change

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Climate change is already having impacts on the fishery resources the Commission manages. As average temperatures rise, mobile marine species are moving toward the poles and/or deeper water to stay cool. Shifts in the distributions and productivity of stocks can cause ecological and economic disruptions, such as predators becoming separated from their prey impacting food webs, or fishermen no longer catching a species their livelihood relies on. In the face of climatic shifts, change is likely to be the only constant. Accordingly, managers will need to learn how to respond to and manage these changes. Managers will likely need to focus on sustaining ecological functions, rather than historical abundances. As conditions change, current conservation goals and management objectives may no longer be feasible. Successful climate adaptation will depend not only on adjusting management strategies, but also in reevaluating and revising, as necessary, the underlying conservation goals and objectives of fishery management plans.

The Climate Change Work Group was tasked with developing science, policy, and management strategies to assist the Commission with adapting its management to changes in species abundance and distribution resulting from climate change impacts. This is document is intended to be a guidance document that will evolve as additional information becomes available. Work Group discussions resulted in five main outputs: A) a proposed approach for working through climate related fishery management issues; B) a list of management options for stocks at persistent low biomass; C) a list of management options for stocks with changing spatial distributions; D) a recommendation to consider inclusion of a climate change terms of reference for stock assessments; and E) a recommendation to create a list of climate change data available for inclusion in analyses. For outputs B and C, the Work Group listed options that could be considered when evidence suggests a changing environment could be impacting species' biomass levels or distributions. However, none of the options have been analyzed to clarify their pros and cons, and there are options included that may not be consistent with current federal law or the fisheries management goals identified in the Interstate Fisheries Management Program Charter. **The lists are thus intended to provide a starting point for managers as they discuss the management options.**

A. A Stepwise Approach

Carrying out effective management strategies in the face of climate change can seem complex. By clarifying a process and demonstrating how the various parts of this process fit together, implementing adaptive management can be less daunting. A generalized framework can break the process down into discrete steps designed to help managers understand how the pieces of the process fit together, and how to recognize when various methods and approaches may be appropriate. The following stepwise approach is detailed in a resource document from the *National Wildlife Federation: Climate Smart Conservation* was modified slightly for marine resource management.

Step 1. Define planning purpose and scope. This includes: articulating a purpose; clarifying existing management goals; identifying management targets; specifying a scope and time frame; engaging key stakeholders; and determining resource needs and availability.

Step 2. Assess climate impacts and vulnerabilities. Understanding climate vulnerabilities is crucial for designing effective adaptive management strategies, and the specific components of vulnerability—exposure, sensitivity, and adaptive capacity—can provide a useful framework for linking actions to impacts.

Step 3. Review/revise management goals and objectives. Because goals serve as the basis for subsequent strategies and actions, they should be climate-informed and forward looking. Reevaluation of goals and objectives may either validate their continued relevance, or indicate a need for refinement or modification.

Step 4. Identify possible adaptive management options. What are possible approaches for reducing key climate-related vulnerabilities or taking advantage of newly emerging opportunities? At this stage, a broad array of alternative strategies and actions should be identified, with particular attention to creative thinking in crafting possible management actions.

Step 5. Evaluate and select adaptive management options. The array of possible adaptation options can now be evaluated to determine which are likely to be most effective from a biological/ecological perspective, and most feasible from implementation, social and economic perspectives.

Step 6. Implement adaptive management options. Successfully implementing adaptation requires individual leadership as well as institutional commitment and resources, and often depends on engaging diverse partners early on, and emphasizing benefits to multiple sectors of society.

Step 7. Track action effectiveness and ecological responses. Monitoring helps provide context for understanding climate-related impacts and vulnerabilities and for informing adaptive management. Monitoring approaches should be carefully designed to ensure they are capable of guiding needed adjustments in management strategies.

B. Managements Options for Stocks at Persistent Low Biomass

There are two main questions that should be addressed for stocks with persistent low biomass: 1) what, if any, is an appropriate harvest level, and 2) how many resources should be committed to continue monitoring and managing the species.

Approaches

1. Status Quo: Following the current status quo addresses the first question (appropriate harvest level) but does not address questions related to continuation of monitoring and management. The current harvest strategies include allowing landings that target a rebuilding fishing mortality (F) with a biomass target based on historic assessment information with the assumption that the stock will eventually respond to a low F. If biomass continues to decline, there are two harvest options:

a. Continue the above scenario with further reductions in F
b. Put a harvest moratorium in place for a period of time based on the life history of the species

2. Evidence of a Change in Productivity: As with the status quo option, the monitoring and management would be retained at historical levels. The harvest level would be adjusted as reference points are redefined based on evidence the stock will likely not recover to previous biomass targets because of a change in productivity from environmental causes. The reference points will target a sustainable yield from a biomass that is much lower than previously targeted. The actual yield will be much reduced from historic levels, leading to a very small fishery with presumably much fewer participants. This approach may also entail a rebuilding period. The rebuilding period would be reflective of the new reference points based on an expected lowered productivity level of the stock.

3. Evidence the stock has a low to no productivity; recovery to sustainable levels is highly unlikely

a. Management: A permanent moratorium is put in place or harvest continues until it becomes economically unfeasible. Decision between these options could be based on confidence in prediction of no recovery and consideration of genetic diversity that is often high at the tail end of a species range (Nowack et al., 2013). It may be more beneficial to protect the remaining genetically diverse stock, or it may be more beneficial to allow economic harvest of the species.

b. Monitoring: Determine what level of monitoring would occur: increased, current, or reduced

4. Management and monitoring cease and harvest does not continue because it becomes economically unfeasible.

Science requirements
Each of the options places great demands on the science. Questions to be answered before choosing among the options would include:

1. What is the mechanism of decline/loss of productivity?
2. What evidence is there that the stock will likely not come back to its former productivity?
3. How is sustainable yield determined and at what level of biomass will a harvest be permitted?
4. Are there ecological/genetic considerations to be considered before taking any of these approaches to manage a stock or population?
5. What are the economic and ecological tradeoffs of continuing to harvest at lower levels vs. a moratorium?

C. Management Options for Stocks with Changing Spatial Distributions:

1. Maintain current state-by-state or regional allocations.
    - Quota sharing by fishery or within fishery: Under state-by-state management without quota reallocation it is necessary to allow for transfer of quota between states in order to have a mechanism to respond to changing distributions of stocks. But under regional or coastwide quota management, sharing of quota becomes less important when

responding to distributional changes in stocks; although sharing between two regions may still be needed.

- Add a minimum allocation for states with low quotas or states that are on the edge of stocks that are moving north or south
- Include an episodic events approach (quota set aside) for species that are moving northward
  - A certain percentage of the coastwide quota would be set aside for use by specified states/regions. The set aside is designed to allow for harvest of fish that episodically move in and out of a region

2. Maintain regional or state-by-state allocations and develop a Commission policy to revisit allocation based on identified triggers (see NMFS Allocation Policy).
   - Triggers could be based on time, an indicator of change, or a threshold of public comment.
     a) For time based triggers, triggers could be a set number of years or could be related to the life history of the species. Allocation reviews may not automatically result in a re-allocation, but they would require the Board to "revisit" the state or regional allocations periodically and decide whether to initiate management action to change allocation or vote to reaffirm current allocation. Alternatively, the board could include a provision in the FMP where the state or regional allocations would "sunset" on a prescribed date so the Board must initiate management action to either reinstitute current allocation or modify allocation.
   - Options for who makes the final decision regarding reallocation could be internal or external to the Commission:
     a) Species management boards know the fishery the best but could be open to strong political pressure from impacted states.
     b) Australia has used independent panels to determine allocations as they can take the pressure off managers and allow fairer compromises. For more information, see section 9.2 in Morrison and Scott 2014.
   - Potential options for adjusting allocations:
     a) Use distribution and abundance data from certain fisheries independent surveys that cover extended geographical areas to help determine the state or regional quota allocation percentages (e.g NEAMAP surveys; NEFSC bottom trawl survey, etc.)
     b) Use a combination of historical allocations and current distribution that adjusts through time: 75% historical allocations years 1-2, 65% historical allocations years 3-4, etc.
     c) Use Management Strategy Evaluation (MSE) to determine allocation using 4 evaluators:
        - Catch distribution
        - Recruitment
        - Productivity
        - Total yield across years

    d) Use it or lose it provisions: revisit a state's quota after X number of years of not utilizing quota.

3. Change management away from state-by-state allocations. Ideas include:
    - Change management from species focus to area focus. Allow for area allocations where industry can be permitted for multiple species at once where they can move from stock to stock as they rise and fall
        - For example, an area could be GOM; species could be lobster, herring, groundfish, menhaden, black sea bass, dogfish, others?
        - Allocations would be set based on the health of the ecosystem overall. Every 1-3 years do assessments on an area to determine what level of harvest is feasible for stocks. Look at more than just species assessment to determine allocations. Also look at ocean environment to help make predictions of the direction of stock levels.
        - This would be a significant change to how we manage stocks
    - Allocation by timeframe (e.g., calendar quarters)
        - Quotas could be allocated by seasons and open to all fishermen when the season opened (e.g., 4 seasons: spring, summer, fall, winter each with a specified percentage of the quota each season. All fishermen would have access to the quota each season).
        - Seasonal quota could be further broken out by area (e.g., the summer quota could be divided into a northern and southern allocation).

D. Including a Climate Change Terms of Reference

Work Group discussions resulted in a recommendation that stock assessment committees consider including a terms of reference (TOR) to evaluate whether climate change impacts on the species of interest are evident. Climate change recommendations were reviewed by the Commission's Assessment Science Committee (ASC). The ASC supported a process where assessment committees consider including new climate TORs when starting new stock assessments. If a TC/SAS thinks there may be climate impacts on a stock and related analyses are possible, a climate TOR is to be added. If a TC/SAS does not think there are climate impacts, a TOR does not need to be added. TCs will then have the option to include a brief assessment report section describing why climate impact analyses on a stock were not conducted.

The following are options related to climate for TCs to consider when devising the full set of TORs at the outset of a stock assessment.

- Describe the thermal habitat and its influence on the distribution and abundance of species X, and attempt to integrate the results into the stock assessment.
- Consider the consequences of environmental factors on the estimates of abundance or relative indices derived from surveys.
- Characterize oceanographic and habitat data as it pertains to species X distribution and availability. If possible, integrate the results into the stock assessment.

- Evaluate new information on life history such as growth rates, size at maturation, natural mortality rate, and migrations. Explore possible impacts of environmental change on life history characteristics.
- Present the survey data available for use in the assessment, evaluate the utility of the age-length key for use in stock assessment, and explore standardization of fishery-independent indices. Characterize the uncertainty and any bias in these sources of data, including exploring environmentally driven changes in availability and related changes in population size structure. Explore the spatial distribution of the stock over time, and whether there are consistent distributional shifts.
- Provide best estimate of population parameters (fishing mortality, biomass, and abundance) through assessment models. Evaluate model performance and stability through sensitivity analyses and retrospective analysis, including variation in life history parameters. Include consideration of environmental effects where possible. Discuss the effects of data strengths and weaknesses on model results and performance.
- Update or redefine biological reference points (BRPs; point estimates or proxies for B_{MSY}, SSB_{MSY}, F_{MSY}, MSY). Evaluate stock status based on BRPs. If possible, develop alternative MSY-based reference points or proxies that may account for changing productivity regimes.

E. Climate Change Data Availability and Gap Analysis

Climate change is affecting a number of aspects of the environment which may affect abundance, distribution, and productivity of various species. Besides warming waters, changes to other aspects of the marine environment (such as salinity, pH and currents – Table 1) may also be occurring. To assist the assessment committees in this work, the Work Group recommended the creation of a coastwide database summarizing the types of climate related data various state, federal, and university programs collect. The database would not store the actual data, but provide metadata on the programs (i.e., the database would contain a summary of the types of environmental data collected, temporal and spatial aspects of the data, sample design, and contact information). The database would be a central repository of information for the species assessment committees to identify and request available climate data appropriate for the species and area of interest. The decision to house the metadata and contact information and not the actual environmental data was to avoid:

- Needing to annually update the data
- duplication of datasets
- adapting the data inappropriately, and
- ensuring the most recent information is used

Development of the database will be a collaborative coastwide effort to ensure all known programs that collect environmental data are included. In addition to the numerous ocean observing buoys, data portals, and state and federal monitoring programs, the database should include power plant monitoring data and smaller-scale programs conducted by counties, towns, and universities for a variety of purposes. The ASC noted that some data sources may need to be converted to usable format.

Two levels of gap analysis will be conducted after development of the environmental metadata database:

1. Review to ensure all known programs that collect environmental data are included
    a. Verify that all appropriate information is included
        i. The review should be conducted by each state and federal agency to assure completeness coordinated by the ASC and reviewed by the Management and Science Committee.
2. Review the types of environmental data collected and temporal and spatial scale of the information
    a. Determine if there are temporal and/or spatial gaps in data necessary to investigate the effects of climate change on species
        i. Task species TC and SAS for review
    b. Determine relative importance of filling individual data gaps
    c. Prioritize data gap filling and identify strategies to address the important gaps

Table 1. Climate Data Types

- Temperature
    - Annual, seasonal, daily
    - days above threshold (need daily data)
    - timing of ice melt
- Salinity
    - Temporal/spatial changes
    - Temporal/spatial changes of estuarine salt wedge
- pH (ocean acidity)
- Precipitation
    - River currents
    - Temporal/spatial salinity changes
- Wind
    - Changes to local wind patterns
    - Frequency of storm events – spatial and temporal patterns
- Currents
    - Strength and location of local currents
    - Location of basin wide currents (i.e. – Gulf Stream, Labrador currents)
- Global climate measures
    - North Atlantic Oscillation (NAO)
    - Atlantic Multidecadal Oscillation (AMO)
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Resources to Assess How Species and Environments are Being Impacted by Climate
The following are potential resources managers could use to determine if a stock has reached a point that necessitates change in a fisheries management strategy to adapt to climate change impacts

- Northeast Fish and Shellfish Climate Vulnerability Assessment developed by NOAA

- Ecosystem status reports/Ecosystem indicators- large scale requires significant resources would need to partner with NOAA
- Ocean Adapt – analysis of changing distributions by NMFS and Rutgers
- NOAA National Center for Environmental Information – hosts and provides public access to archives of climate data
- Stock predictions
    - Climate predictions
    - Species distributions
    - Species abundance (climate velocity)
- Citizen Science—create venue for watermen to report changes they are seeing on the water as an advanced warning to managers.
- Triggers defined by fishermen: seek public input on triggers for when management would adapt due to changes in the resource from climate change

References:

Pauls, S., C. Nowak, M. Balint, and M. Pfenninger. 2013. The impact of global climate change on genetic diversity within populations and species. Molecular Ecology 22:925-946.