Oyster Stock Assessment Peer Review

Report of the Independent Panel

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To

Maryland Oyster Advisory Commission

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Who are the Reviewers?

- **Paul Rago** is a member of the Science and Statistical Committee of the Mid-Atlantic Fishery Management Council. Chief of the Population Dynamics Branch of the Northeast Fisheries Science Center of the National Marine Fisheries Service in Woods Hole (1993-2015). At US Fish and Wildlife Service (1978-1992) Rago served as research coordinator of the Emergency Striped Bass Study. PhD from University of Michigan.

- **Dan Hennen** is a Research Operations Analyst for the Population Dynamics Branch of the Northeast Fishery Science Center in Woods Hole (2009-present). Leads stock assessments for Atlantic surfclam, ocean quahog and Atlantic halibut. Research Biometrician for the Alaska Sea Life Center in Seward Alaska (2004-2009). Research interests include population simulation, parameter estimation, survey analysis and design. Ph.D. from Montana State in 2004.

- **Daphne Munroe** is an Associate Professor at Rutgers University in the Department of Marine and Coastal Science, Haskin Shellfish Research Laboratory. Over 15 years research experience in shellfish ecology, focusing on shellfish fisheries and aquaculture. Participated in federal and state assessments for clams and oysters. PhD from the University of British Columbia where she studied ecological interactions of intertidal clam farming.

Purpose of Scientific Review

- Ensure that existing data have been fully considered and that appropriate decisions on their use have been made.
- Ensure that the analytical methods are state-of-the-art, tested, and appropriate for the data.
- Ensure that the conclusions are suitable for management decisions.
- Focus on the integrity of the science without regard to management or regulatory consequences. These considerations come later.

Unique Aspects: Maryland Oyster Assessment

- Oysters both require and define habitat.
- Historic record of catches provides context for magnitude of the resource.
- However, large-scale and ongoing environmental changes since the 1890's compromise the efficacy of management actions.
- Growth rates vary with location, primarily along salinity gradients.
- Mortality rates are strongly influenced by diseases, which vary both spatially and temporally.
- Biological processes occur at a finer scale than spatial resolution of removals.

Balancing the Desirable vs Feasible

- Every data collection program imposes constraints on future uses of data.
- Spatial resolution matters for sessile animals.
- Ability to resolve historical data at finer spatial or temporal scales is limited.
- Methodologies evolve and as better approaches are implemented the ability to compare historical to recent data becomes more difficult.
- Ecosystem Changes:
  - Impacts of disease
  - Habitat loss
  - Trends in water quality.

The Peer Review Process

- Terms of Reference
- Pre-review conference calls
- Draft Report delivered in advance of the on-site meeting
- Written questions from panel to assessment team before meeting
- Three-day onsite meeting: assessment team + review panel
  - Full documentation of proceedings
  - Open discussions of issues
  - Closed sessions for writing
  - Feedback to Assessment Team
- Draft report of Panel to DNR
- Review by DNR for factual errors, not conclusions

Terms of Reference: Maryland Oyster Advisory Commission

1) Review strengths and weaknesses of all available data, and justify decisions.
2) Develop stock assessment model and biological reference points and quantify uncertainty.
3) Compare estimates of stock status generated by index and model-based approaches.
4) Include sanctuaries and restoration efforts in the development of stock assessment approaches.
5) Examine how hatchery plantings (aquaculture and public fishery) impact spawning potential in the fishery.

Evaluation of Existing Data Sources

- Assessment team conducted a thorough review of all primary sources of fishery-dependent and fishery-independent data as far back as 1889.
- Utility of these time series for stock assessment and modeling purposes varied over time.
- Stock assessments were based on 36 spatially discrete units based on removals recorded at the level of NOAA Codes.
- Official landings could not be resolved to a finer scale.
- Conversely, fishery-independent relative abundance indices could be combined in a scientifically credible way for consistent measures of trend.

Fishery-Dependent Data

- The Yates study from nearly a century ago provides a rigorous quantitative description of historical benthic habitats and a basis for defining the desired level of resolution for removals.
- Unfortunately, data on removals by oyster bar do not exist. Assessment team appropriately used the existing data at the resolution of NOAA code area.
- Historical information on landings were evaluated with respect to changes in reporting practices over time and spatial resolution.
- Concerns about the use of commercial CPUE* data are well founded since it is difficult to derive a meaningful measure of effort that can be used across all assessment areas and over all time periods.

Fishery-Independent Data

- The assessment benefits from a long time series of fishery-independent data monitoring studies that allow tracking of relative abundance.
- As these methods have changed and improved over time, the team made appropriate decisions to restrict the data to a period where consistent inferences are possible.
- Based on these considerations, the assessment period is restricted to 1999 onward.
- Data sources were integrated into overall assessment where possible. When such integration was not possible, index methods were compared with model results.

How far back can you go?

- Restriction of the assessment period to 1999 onward precludes the ability to estimate historical abundance levels, say in the late 1890's. Any such exercise is unlikely to yield precise estimates.
- It can be argued that the environmental and ecological conditions that were obtained nearly 150 years ago are unlikely in 2018 onward, and are therefore not useful as biomass targets.
- Despite these limitations and differences in size limits over time, it is relevant to note that the estimates of market oyster abundance of about 300 million market oysters in 2018 is less than 10% of the quantity ***harvested*** annually before 1900

Natural Mortality

- Natural mortality rates of oysters are both variable and high relative to fishing mortality. Diseases (MSX and Dermo) vary in intensity over time and along salinity gradients within the bay.
- Consistent long-term monitoring of oyster boxes (i.e., dead oysters whose shells remain hinged) allowed the assessment team to independently estimate annual natural mortality rates apart from the stage-based model.
- Three separate methods were used, allowing for valuable insights into model performance.

Assessment Model

- Novel stage-based population model that also includes the dynamics of habitat. Habitat can increase from shell supplementation programs, but otherwise habitat is assumed to decline based on contemporary trends in bay-wide habitat degradation.
- The model explicitly accounts for the role of spatial and temporal variation in natural mortality, growth, and exploitation.
- Assessment model results are compared with index models.
- Spatial units are assessed under a consistent but flexible modeling framework:
  - Allows for rapid analyses of overall stock condition.
  - Avoids potential problems of overfitting model parameters and inconsistencies among spatial units.

Reference Points: Exploitation

- The biological reference points (BRPs) for exploitation are a useful starting point for characterizing relative magnitude of contemporary fishing mortality. Substantial improvements are not possible in the short term.
- Parameters that are assumed constant in the current model should be tested regularly and updated as appropriate. In particular, parameters that imply habitat declines consistently over time (in both the assessment and BRP models) should be updated as new information becomes available.

Reference Points: Biomass

- The assessment team used the minimum abundance estimated between 1999 and 2017 as the abundance threshold for each NOAA code. Key assumption—if abundances as low as those observed previously have not yet caused a population crash, they should be sufficient to prevent a crash in the future.
- Approach is often used in European finfish assessments where the lowest observed abundance provides an estimate of the threshold for recruitment failure.
- Recruitment failure per se is unlikely in oysters but the review panel agreed that this threshold criterion appropriately balanced the information content of the assessment with a longer term perspective on abundance.
- Determination of the carrying capacity of Chesapeake Bay under prevailing environmental conditions (particularly disease prevalence) is beyond the scope of existing data sources and scientific understanding.

Effects of Sanctuaries, Habitat Augmentation, and Hatchery Plantings

- Terms of Reference 4 and 5 were particularly challenging.
- The assessment team did an exceptional job of assessing the efficacy of various management policies implemented by the State.
- Where data allow, the quantitative impacts of these measures are explicitly incorporated into the model's interpretation of habitat changes, exploitation estimation, and reference point determination.
- Ongoing MD DNR long term studies may ultimately quantify the utility of these measures and improvements in approaches. Rigorous monitoring of well-designed management experiments within NOAA code areas may prove useful for improving management interventions.

"Sanctuary and habitat plantings, and aquaculture operations should not be considered a part of the standing stock of the fishery, nor part of the reproductive capacity of the fishery. Doing so will overestimate the spawning potential, and the contributions of sanctuaries, habitat plantings and aquaculture are as yet unclear and likely vary greatly by source."

- Difficult to assess in any stock assessment.
- Need fine-scale information and experimental design.
- Stock assessment resolution is limited by the collection of removal data. Generally too coarse.
- Spillover effects are very difficult to quantify. Low signal to noise ratio. E.g.,scallops on Georges Bank.

Panel Recommendations: Field

- An annual dockside monitoring program to estimate size composition of landings.
- Experiments to estimate of dredge efficiency for the survey.
- Conduct a detailed examination of trends from survey-based disease incidence and rates of natural mortality. Any evidence of disease resistance or changes in virulence should be thoroughly examined.
- In some NOAA codes, relative oyster abundance is estimated independently for more than one gear type. Investigate frequency and magnitude of disagreements between gear types.

Panel Recommendations: Modeling(1)

- Examine potential retrospective patterns in terminal year estimates of biomass and fishing mortality to address uncertainty concerns for management.
- Review the performance of the assessment and reference point models by examining likelihood profiles for key parameters and the influence of penalty functions on parameter estimates. Further simulation testing would be valuable.
- Develop an assessment model with the capability of estimating the reference point parameters internally.

Panel Recommendations: Modeling(2)

- Further simulation testing of model performance and application of likelihood profile analyses to examine model performance in the vicinity of the optimal values is desirable.
- Investigate and resolve different conceptual bases for treatment of habitat in the stock assessment and biological reference point models.
- Improve the habitat dynamics model, possibly allowing for regeneration of habitat through population growth and replenishment of shells through natural mortality of live oysters.
- Beware of shifting baseline bias, especially in biomass reference points.

Primary Conclusions of Review Panel

- All Terms of Reference were met.
- Assessment team fully utilized the available data at an appropriate temporal and spatial resolution.
- Innovative stage-based modeling and incorporation of habitat.
- All stock assessments are a compromise between the ideal and the realized. This assessment deals with these compromises in a rigorous and scientifically credible way.
- Assessment results can serve as a basis for management decisions.

Big challenges are yet to come

- How to implement science results while balancing many competing interests?
- Peak abundances likely occurred more than 150 years ago when Chesapeake Bay was a very different ecosystem and diseases were not a dominant factor in the oyster life history.
- A study from nearly a century ago provides a rigorous quantitative description of historical habitats and a basis for potential rebuilding.
- Rebuilding will require habitat enhancement and control of fishing mortality, and would benefit from reduction of natural disease mortality rates, increased recruitment and continued improvements in water quality.

End

Structure of the Peer Review Report

- Executive Summary
- Background on the Review
- Documentation of the Proceedings
- Terms of Reference
- Primary conclusions
- Research recommendations
- Appendices