Research Priorities and Recommendations to Support Interjurisdictional Fisheries Management

AMERICAN LOBSTER

Outstanding 2009 Lobster Stock Assessment Peer Review Research Recommendations Updated with Responses (in italics) from 2015 Benchmark Stock Assessment

HIGH PRIORITY: While improvements such as mandatory dealer reporting have been made, the 2009 Panel feels commercial landings and fishing efforts continue to be recorded piecemeal over the stock range. We recommend that they be standardized. The Panel recommends a statistically-designed survey (rather than current ad hoc approach) be implemented for collection of biological characteristics of the catch. The Panel commends the improvement in the spatial coverage of sea and port biological sampling from commercial landings since the last stock assessment, but stresses the need to continue this sampling so as to achieve representative coverage of all segments of the fishing fleet. These data were especially helpful in evaluating Georges Bank stock status in the 2009 stock assessment. In particular, the Panel recommends annual reporting by state agencies of the data needed for the assessment model be implemented so that data are readily available for annual updates of stock indicators to be presented to the Lobster Management Board and for assessment model updates every five years.

- *Additional funds are needed to address the staffing needed to complete annual data reporting due to the scale and complexity of the fishery.*
- *A first cut of sampling power was attempted in this assessment, and has identified statistical areas in need of sampling and others that are adequately sampled.*

MEDIUM PRIORITY: While growth and mortality are key factors influencing population dynamics, recruitment often is the driver behind population resilience. The lobster stock assessment models define recruitment as entry into the fishery and thus bypass the early life stages. Nevertheless, we think research into larval mortality and distributions should be carried out. In particular, the biophysical coupled modeling approach (Xue et al. 2008) that simulates the patterns of egg production, temperature-dependent larval growth, stage-explicit vertical distributions of larvae, and mortality in a realistically simulated physical environment should be extended to other areas to understand recruitment sources for the U.S. lobster stocks. It will likely provide insight for the assessment team with regard to stock connectivity and shed some light on the conundrum of unusual stock resilience. In particular, the Panel recommends use of the model to understand whether larval sources are the same for below average and strong year classes. Identifying sources of recruits may provide managers with options to help ensure the continued resilience of this stock.

- *A long-term stock-wide larval study would be necessary to complete this, which requires funding and research.*

HIGH PRIORITY: Include an option to estimate a stock-recruitment relationship within the length-based model.
- *This research recommendation was not completed in the 2015 assessment because attention was focused on implementing recruit covariates to deal with environmental effects on recruitment, which appear more important in all stock areas during recent years. Interested users can use preliminary spawning biomass estimates as recruit covariates until these modifications are made to achieve nearly the same effect.*

HIGH PRIORITY: Examine the implications of varying the weightings on components of the overall likelihood on model fits. Such exploration is considered good practice in assessment modeling. With respect to model output presentation, the Panel also would have liked to have seen the actual likelihood values from the base case and alternative model runs, rather than just relative differences.
- *The 2015 assessment team used relative differences which are presented in the report and neglected to provide absolute values as requested.*

LOW PRIORITY: Allow more surveys as input.
- *The structure of the current code prevents reprogramming to allow an arbitrary number of surveys. It would be easier to reprogram the model than to make this type of change to the existing code. For the 2015 assessment, the model was modified to accommodate up to sixteen surveys which can be broken down by sex and season for efficient use of the available slots. The updated model sufficed for this assessment but the model should be reprogrammed for the next assessment.*

HIGH PRIORITY: The success of MSE relies heavily on the assumed stock-recruitment relationship. The Panel recommends completing a meta-analysis of stock-recruitment relationships for long-lived crustaceans so that some reasonable parameter estimates for the stock-recruitment relationship may be identified for the lobster stock, and then be implemented in the MSE.
- *Funding and research is needed to complete a MSE.*

Outstanding 2010 CIE Review Recommendations of the TC Report on SNE Recruitment Failure Updated with Responses (in italics) from 2015 Benchmark Stock Assessment

- Lobster recruitment surveys should be continued into the future, and if possible their sampling intensity should be increased to enhance their power to detect changes in larval or young-of-year abundance. New surveys are also recommended to give a spatially comprehensive picture of spawning patterns across SNE. Deployment of passive postlarval collectors is a promising methodology for such surveys. These surveys

should be used (a) to improve understanding of recruitment processes, (b) to provide early feedback on the success of management measures aimed at protecting spawning potential, and (c) to allow forecasts of recruitment and landings for both inshore and offshore area.

- o *MA has added 4 new YOY sampling stations; RI has done additional sampling at 2 existing YOY stations. Additional sampling requires more funding, current state fiscal resources are limiting.*

- It is recommended that the UMM model and the model used in the report be investigated to determine which estimates of female abundance are most likely.
  - o *This recommendation was not directly addressed in the 2015 assessment but female abundance estimates and trends for SNE were similar in the basecase and a range of sensitivity analyses.*

- It is recommended that the MA survey be relocated to a region where it is a better prediction of abundance and CPUE in the MA region.

- It is recommended that more reliable effort data is routinely collected from the fishery and that CPUE replace landings in assessing the fishery.
  - o *Since the previous assessment most states have moved to 100% harvester reporting but the largest landing state still only collects 10% harvester reporting with 100% dealer reporting. This is an issue for the management to address.*

- It is recommended that effort be reduced in the fishery to a level equivalent to the 1980s and that a socio-economic study be implemented to determine the economic viability of effort reductions.
  - o *This is an issue for the management board.*

- It is recommended that a study be undertaken to investigate the longer term future of the fishery. This could be achieved by using the downscaled IPCC climate models.
  - o *Additional funds are necessary to apply IPCC modeling to the lobster fishery.*

- It is recommended that a decision rule process be considered that involves both government and industry and that incorporates both fishery independent (e.g. YOY) and fishery dependent (e.g. regional CPUEs) indices.
  - o *This is an issue for the management board.*

- It is recommended that several low recruitment scenarios be determined and included in the projections. Each scenario needs to define what the recruitment value is compared to a base case (e.g. the BH-R).

- Further studies are undertaken to attempt to separate F from M.
  - o *Additional funds are necessary to meet this objective.*

- It is recommended that the ASFMC adopts a definition of recruitment failure that is consistent with the criteria used to determine the threshold reference point that is used to assess whether the lobster stock is overfished.
    - *This is an issue for the management board.*

- It is recommended that, if and when exploitation of the SNE lobster stock is permitted, male lobster are preferentially exploited and female lobster are protected to the extent that is possible, *e.g.*, through use of a V-notch program or male-only fishery. It is also recommended that, if male lobster are preferentially exploited, monitoring programs are established to detect whether such exploitation produces a significant reduction in the number of females that are mated, or a significant reduction in the fecundity of females of different lengths.
    - *This is an issue for the management board.*

- It is recommended that managers impose a five-year moratorium on exploitation of the SNE lobster stock.
    - *This is an issue for the management board.*

2015 Lobster Stock Assessment Research Recommendations

Model Recommendations
Examine the use of a hierarchical modeling technique (Conn, 2010) to aggregate survey information for the different stock areas as an alternative to internally weighting indices in the model or using area-swept information.

Program Research
New research and expansion of existing monitoring programs in the following areas would provide information needed to improve future stock assessments.

FISHERY-DEPENDENT INFORMATION

- Accurate and comparable landings are the principal data needed to assess the impact of fishing on lobster populations. The quality of landings data has not been consistent spatially or temporally. Limited funding, and in some cases, elimination of sea sampling and port sampling programs will negatively affect our ability to characterize catch and conservation discards, limiting the ability of the model to accurately describe landings and stock conditions. It is imperative that funding for critical monitoring programs continues, and increased monitoring efforts for offshore areas, particularly those from which a large portion of landings originate, are necessary. These types of programs are essential for accurate lobster assessments and must have dedicated funding.

- There are some indications that lobster harvest may be under-reported and this under-reporting may be significant during some periods in the time series examined for this

assessment. It is recommended that future research examine this potential under-reporting, and this examination should include simulation testing of these potential periods of under-reporting. One particular area that can be examined is the period prior to the implementation of the 100/500 possession rule for non-pot gear, as landings by non-pot gear may have been a significant source of under-reporting.

- A thorough investigation of methods for determining optimal biological sampling intensity based on variability in catch and spatial/temporal landings information should be undertaken. This investigation should explore other metrics that may be more variable than length composition (i.e. conservation discards, sex ratio, legal proportions), as well as an examination of the importance of the different Statistical Areas to the assessment and how this may interplay with the needed level of sampling from those areas.

FISHERY-INDEPENDENT INFORMATION

- ***Ventless Trap Survey-*** (***High priority***) Calibration work to determine how catch in the ventless trap surveys relates to catch in the bottom trawl surveys would be a useful topic of research. It is likely that at low densities, when trawl survey indices have dropped to near zero, ventless trap surveys will still catch lobsters due to the attractive nature of the gear and the ability to fish the gear over all habitat types. Conversely, it is possible that trawl surveys may be able to detect very high levels of lobster abundance, if trap saturation limits the capacity of the ventless traps. Ventless traps may be limited in their ability to differentiate between moderately high and extremely high abundance, and calibration with bottom trawl surveys may help to clarify how q might change with changes in lobster density.

- Now that funding for long-term ventless trap surveys appears to be more secure, there are some outstanding questions regarding this survey method that would benefit from further research. Namely, understanding trap saturation, in terms of high lobster densities and the capacity of the traps, along with the ensuing behavioral interactions that affect trapping of particular individuals, is a prime topic of interest to understand how density might impact the segment of the population represented in the survey catch. Also, the efficiency of the standardize survey gear could be explored in relation to effective fishing circles.

MATURITY AND GROWTH

- (***High priority***) Increases in water temperatures over the past several decades (see Section 2.2) have likely resulted in changes to size at maturity and growth patterns, since temperature has such a strong influence on these vital processes (see Section 2.1). Maturity data used in this assessment are more than 20 years old, making it likely that changes have since occurred. Evidence to suggest that decreases in the size at which

females reach maturity exists in both the GOM stock (see Pugh et al. 2013) and the SNE stock (see DNC 2013, Landers et al. 2001). Changes in sizes at maturity will subsequently affect growth, since female molting frequency decrease after reaching sexual maturity. Additionally, growth is directly influenced by water temperatures, and evidence exists in SNE for increased molt frequency and decreased molt increments (DNC 2013). It is critical to collect updated information on maturity and growth in order to appropriately assign molt probabilities to lobsters in the U. Maine length-based model.

AGE

- If a definitive age-length relationship can be developed, a research recommendation will be to confirm the transition matrices used in the University of Maine model and improve the current assessment.

- In 2013 the Maine Department of Marine Resources contracted with the University of Maine for a five year $250,000 project designed to apply Kilada et al.'s (2012) approach to ageing for lobster. This work will focus on lobsters ranging in size from newly settled lobsters to fully recruited sizes. Regional temperature regimes will be tested as well as differences between laboratory and field scenarios. Anticipated deliverables should be directly applicable to future assessment and will include size-at-age estimates, molt increments and molt frequency.

ENVIRONMENTAL INFLUENCE ON LOBSTER LIFE HISTORY PROCESSES

- Examine methods for determining age- or length-varying natural mortality, as well as looking at more rigorous ways of determining time-varying natural mortality for lobster, which may be driven by climactic shifts and changing predator fields. Additionally, interplay between natural mortality and the potential for underreported harvest should be examined to determine how these factors may impact assessment outcomes.

- Continue exploring relationships between environmental drivers (temperature) and recruitment. Develop techniques to enhance predictive capabilities of YOY indices used together with temperature time series. Improve methods to incorporate environmental data into population modeling.

- Examine post-larval settlement dynamics in relation to movement/re-distribution of spawning stock. Develop habitat suitability models for spawning stock and settling post-larvae. Integrate climate projections into habitat suitability models for lobster.

- The Maine Department of Marine Resources conducted a three year study (2010-2013) where settlement was measured in randomly selected sites, based on depth and substrate, and compared to standardized sentinel locations in Mid-Coast Maine. Mid-

Coast Maine is the region with the longest time series for settlement, dating back to 1989. For this reason, it was important to investigate the patterns of settlement from fixed and randomly selected sites. Initial results indicate fixed and random stations have similar magnitude and trend with respect to settlement density for this region.

In other regions in Maine, there may be evidence that thermal conditions may have changed, providing additional habitat for settlement. Annis et al. (2013) suggest that small differences in water temperature may shape settlement patterns through either behavioral avoidance of colder settlement sites or elevated post-settlement mortality of postlarvae settling at colder sites. Wahle et al. (2013) observed young-of-year lobsters as deep as 80 m. If available substrate has increased in eastern/northern Maine, simply as a result of increasing water temperatures, then fixed sentinel sites in shallow water may miss a broader pattern of settlement in the region. As such, deep water settlement should be investigated, using an appropriate number of passive settlement collectors (see Wahle et al. 2009) to detect anticipated settlement in conditions where the lack of thermal stratification would tend to distribute postlarvae evenly with depth.

- With the high prevalence of shell disease in the SNE stock, particularly in ovigerous females, some exploration of the potential sub-lethal effects of disease should be examined. These effects could include negative impacts to larval quality, fecundity issues in females who need to re-direct physiological resources to dealing with the disease, and male sperm quality (see Comeau and Benhalima 2009). Any sub-lethal effects of shell disease could further impede the potential for the SNE stock to rebuild.

POPULATION DYNAMICS AND MATING SUCCESS

- With the SNE stock in such poor condition, questions arise regarding how the population functions at some basic levels. In particular, because of the nature of the American lobster mating system (wherein males establish mating shelters and females seek out and choose to mate with dominant males; see Atema 1986, Atema and Vogt 1995 for reviews), low population abundance may be causing a mate-finding Allee effect (Stephens et al. 1999, Gascoigne et al.2009). There is some evidence indicating that larger, presumably reproductively mature females have not mated in some inshore regions (Pugh et al. 2103, Pugh 2014). In order to understand the potential the SNE stock has to rebuild, it is important to know whether current stock conditions have disrupted the mating system. Additional work to examine female mating activity and success should be initiated.

Due to the continuation of female-skewed sex ratios observed in the GBK stock (on-going since the previous assessment), questions regarding the reproductive capacity of these large females should be considered. Recent laboratory work showed that females who mated with smaller males, or who mated under female-skewed sex ratios, did not have completely filled seminal receptacles, and may have been sperm-limited (Pugh 2014). As such, information regarding the location and timing of the female molt (thus

mating) would be required to determine whether the skewed sex ratios and larger female size structure might impact female reproductive output. Additionally, sampling of the large females to determine whether they have mated would also be informative with regards to reproductive activity, as preliminary data indicated some large females had not mated (Goldstein et al. 2014).

STOCK CONNECTIVITY

- (*High priority*) There is need for a comprehensive large scale tagging study to examine stock connectivity between the Gulf of Maine and Georges Bank. Historical tagging studies demonstrate movement from the inshore Gulf of Maine to locations east of Cape Cod in the inshore portions of Georges Bank, from the Scotian Shelf to Georges Bank, and from inshore areas east of Cape Cod to inshore Gulf of Maine (see Section 2.9). What is lacking is a tagging study of lobsters in the fall/winter on Georges Bank proper, prior to seasonal migrations which occur in the spring. This information would be extremely valuable to help complement other data used to justify the combination of the Gulf of Maine and Georges Bank stock and to confirm the connectivity of the Gulf of Maine and Georges Bank.