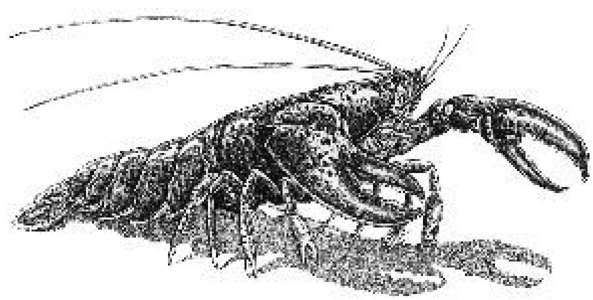
Stock Assessment Peer Review Report No. 00-01
of the

Atlantic States Marine Fisheries Commission

Terms of Reference & Advisory Report
for the American Lobster Stock Assessment Peer Review



July 2000

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Preface

Summary of the Commission Peer Review Process

The Stock Assessment Peer Review Process, adopted in October 1998 by the Atlantic States Marine Fisheries Commission, was developed to standardize the process of stock assessment reviews and validate the Commission's stock assessments. The purpose of the peer review process is to: (1) ensure that stock assessments for all species managed by the Commission periodically undergo a formal peer review; (2) improve the quality of Commission stock assessments; (3) improve the credibility of the scientific basis for management; and (4) improve public understanding of fisheries stock assessments. The Commission stock assessment review process includes evaluation of input data, model development, model assumptions, scientific advice, and review of broad scientific issues, where appropriate.

The Stock Assessment Peer Review Process report outlines four options for conducting a peer review of Commission managed species. These options are, in order of priority:

1. The Stock Assessment Workshop/Stock Assessment Review Committee (SAW/SARC) conducted by the National Marine Fisheries Service (NMFS), Northeast Fisheries Science Center (NEFSC).

2. A Commission stock assessment review panel composed of 3-4 stock assessment biologists (state, federal, university) will be formed for each review. The Commission review panel will include scientists from outside the range of the species to improve objectivity.

3. A formal review using the structure of existing organizations (i.e. American Fisheries Society, International Council for Exploration of the Sea, or the National Academy of Sciences).

4. An internal review of the stock assessment conducted through the Commission's existing structure (i.e. Technical Committee, Stock Assessment Committee).

Twice annually, the Commission's Interstate Fisheries Management Program (ISFMP) Policy Board prioritizes all Commission managed species based on species Management Board advice and other prioritization criteria. The species with highest priority are assigned to a review process to be conducted in a timely manner.

In June 1998, the American lobster stock assessment was prioritized for an external peer review. An external review panel was formed of six stock assessment biologists with expertise in American lobster life history and stock assessment methods. The external peer review for the American lobster stock assessment was conducted May 8-9, 2000 in Providence, Rhode Island.

Purpose of the Terms of Reference and Advisory Report

The Terms of Reference and Advisory Report provides summary information concerning the American lobster stock assessment and results of the external peer review to evaluate the accuracy of the data and assessment methods for this species. Specific details of the assessment are documented in a supplemental report entitled American Lobster Stock Assessment Report for Peer Review. To obtain a copy of the supplemental report please contact the Commission at (202) 289-6400.

Acknowledgments

Thanks are due to the many individuals who contributed to the Commission's American Lobster Stock Assessment Peer Review. Special thanks are extended to the American Lobster Peer Review Panel (Dr. Gerry Ennis, Canada Department of Fisheries and Oceans, Dr. John Hoenig, Virginia Institute of Marine Science, Dr. Peter Lawton, Canada Department of Fisheries and Oceans, Dr. Robert Muller, Florida Fish and Wildlife Conservation Commission, Dr. Saul Saila, University of Rhode Island, and Dr. David Sampson, Oregon State University) for their hard work in reviewing the meeting materials and providing advice on improvements to the Commission's American lobster stock assessment and fishery management. The Commission would like to extend its appreciation to the members of the American Lobster Technical Committee and Stock Assessment Subcommittee for development of the American Lobster Stock Assessment Report for Peer Review (Stock Assessment Peer Review Report 00-001 Supplement) and specifically to the following members for presenting this report at the Peer Review meeting: Josef Idoine (National Marine Fisheries Service, Northeast Fisheries Science Center), Dr. Larry Jacobson (National Marine Fisheries Service, Northeast Fisheries Science Center), Carl LoBue (New York State Department of Environmental Conservation), and Dr. David Stevenson (Maine Division of Marine Resources). Presentations of minority opinions were also provided by Dr. Victor Crecco (Connecticut Bureau of Marine Fisheries), Mark Gibson (Rhode Island Fish and Wildlife), and Josef Idoine.

The Commission would also like to thank the many people who attended the peer review and presented their individual viewpoints on the status of the American lobster assessment and fishery, including: Jim King (Mattituck, NY), Janice Plante (Commercial Fisheries News), Scott Olszewski (Rhode Island Fish and Wildlife), Matthew Mitro (ASMFC), Ernie Beckwith (Connecticut Bureau of Marine Fisheries, ASMFC Commissioner), Kurt Gottschall (Connecticut Bureau of Marine Fisheries), Harry Mears (National Marine Fisheries Service, Northeast Region), Pat White (ASMFC Commissioner), Patrice Farrey (York Beach, ME), John P. Davi, Jr. (Port Jeff, NY), Ed Rodman (Miller Place, NY), John German (Brookhaven, NY), David Borden (Rhode Island Fish and Wildlife, ASMFC Commissioner), David Spencer (Jamestown, RI), Paul Bennett (Middleton, RI), Bill Adler (Massachusetts), George Doll (Northpoint, NY), Linda Mercer (Maine Division of Marine Resources)Kevin Kelly (Maine Division of Marine Resources), Carl Wilson (Maine Division of Marine Resources), Clare McBane (New Hampshire Fish and Game), Kathy Castro (University of Rhode Island), Bruce Estrella (Massachusetts Division of Marine Fisheries), Don Landers (Northeast Utilities Environmental Laboratory), Thomas Angell (Rhode Island Fish and Wildlife), Jim Fair (Massachusetts Division of Marine Fisheries), Bill Andrews (New Jersey Fish and Wildlife), Richard Allen (Wakefield, RI), and George Lapointe (Maine Division of Marine Resources, ASMFC Commissioner).

Special appreciation is given to the staff dedicated to the performance of the Peer Review and finalization of peer review reports, specifically – Dr. Lisa Kline, Geoffrey White, Amy Schick, Tina Berger, and Vanessa Jones.

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Terms of Reference for the
American Lobster Peer Review

1. **Review and evaluate assessment methods used to assess American lobster stocks, including, but not limited to the following:**

   < **Quantity and quality of input data for models (in particular, trawl survey abundance indices and catch in numbers for DeLury models).**

   The methods used to assess American lobster stocks were appropriate given the data available. There were, however, problems with the quality of the data and major gaps in sampling that may have influenced assessment results. Current landings data collection programs for American lobster do not collect detailed data on area fished. Therefore, it was necessary to aggregate landings into large statistical areas (National Marine Fisheries Service statistical areas). For those statistical areas adjacent to the coast, it was impossible to separate landings into inshore (i.e., state waters) and nearshore federal areas (i.e., 3-20 miles from shore). Resolution of the current landings and effort data precludes certain types of analyses that could be done at a finer spatial scale, such as looking for movements of fishermen as indicators of changes in local abundance. Inclusion of tables with more detailed information on landings by area and finer spatial resolution in data collection programs are necessary to more fully evaluate the quality of landings data. Although information was provided by several states on attempts to track expansion of fishing effort outside traditional inshore waters, there is a need for a more standardized approach to mapping effort distribution across the three stock assessment areas.

   The design of sea sampling and port agent sampling programs is not documented in the stock assessment report. Information on sampling design presented in a standardized format is necessary for comparisons among surveys. Trawl survey data should be evaluated for possible differences in relative night and day sampling which may bias the catch rates due to the nocturnal behavior of lobsters. This should be performed for nearshore and offshore stations separately to determine if proximity to good sheltering bottom might also contribute to variability between daytime and nighttime sampling. Detailed haul-specific data should be spatially presented. Maps of zero catch hauls, or time series plots of their incidence, might give an indication of shifts in the range of lobsters. Development of spatial maps would also assist in evaluating the relationship between survey sampling stratification and landings data. The survey data should be analyzed to ensure that the assumptions of the delta distribution are met so as to prevent generating unbiased estimates of abundance (Meyers and Pepin,1990; and Stefansson, 1996). Sample sizes and variances are not presented for fishery independent survey data, sea sampling, or port agent sampling making it impossible to evaluate the overall quality and precision of all the different input data.

Sex and size information from trawls surveys, sea sampling, and port sampling data were used to partition total landings in pounds into number of lobsters by sex and size for the various stock areas. The stock assessment report provides no documentation of how this catch matrix was developed, but instead refers to an earlier stock assessment report. As the expanded length frequencies are crucial to the development of core fishery status indices, future stock assessment reports need to provide more detailed information on all aspects of development of this portion of the stock assessment process.

Documentation is also necessary in order to evaluate how gaps in sampling were filled with data from adjacent areas or time periods. For instance, the Massachusetts sea sampling program samples a large portion of the stock area, but only a small number of samples are taken within each stratum. Without more detailed information on the development of the catch matrix it is not possible to evaluate the reliability of data used to fill these gaps in sampling. Of particular concern is the fact that the expanded length frequencies, once generated, were assumed to have been measured without error.

The mismatch between trawl survey indices and landings data is amplified in the modified DeLury model (note that although the Panel uses the term modified DeLury model in this report, a more accurate name for this model is the Collie-Sissenwine model) because catches were taken in areas that are not sampled by fishery independent surveys. This is particularly noticeable in the Gulf of Maine (GOM) where the majority (more than 70 percent) of landings data are from inshore areas, while fishery independent surveys are predominantly conducted in offshore areas. These mismatches cause potential errors both in the raw landings numbers and in the estimates of abundance. It is critical to have representative sampling in both fishery dependent and fishery independent sampling programs in order to allocate landings by sex and length.

- **Validity and utility of length cohort analysis and modified DeLury model, including model assumptions and parameter estimation techniques.**

A basic assumption of the length cohort analysis (LCA) is that the population is under equilibrium conditions. Given that recruitment has been increasing over the past 15 years, it is obvious that this assumption is not realistic. Therefore, the Panel does not recommend the continuation of the length cohort analysis. The Panel suggests that other options be explored, such as a modified virtual population analysis (VPA) type approach, further development of the Mark model, and application of biomass dynamic approaches.

A comparative study was not conducted between past assessments and current assessment methods, including blending of population sizes estimated with different surveys and changes in growth models. Without a side-by-side set of parallel calculations it is not possible to determine if changes in model results are due to changes in assumptions and input data or are truly representative of changes in stock status.

The modified DeLury model should be modified to include data by sex and multiple tuning indices (i.e., both the spring and fall surveys). Errors specified in the evaluation of data quality (Term of Reference #1 - first bullet) should be evaluated for potential effects on the catch matrix and propagation through modified DeLury model runs.

Although the Technical Committee provided a review of earlier approaches to estimate Q ratios (catchability coefficient), and provided a rationale for their selection of different Q ratios for state and National Marine Fisheries Service (NMFS) trawl surveys, the critical significance of these assumptions warrants further attention. Studies should be designed to empirically estimate Q ratios for the modified DeLury model using tag-recapture approaches. The Panel stresses that this is a critical need. A comparison of fall and spring trawl survey data should also be undertaken to determine if single Q ratios are appropriate for particular survey gear used in different seasons. Sensitivity analyses should be conducted and presented to evaluate trends in fishing mortality rates or F values with changes in Q ratios. Sensitivity analyses also should be conducted to evaluate the effect of estimating pre-recruits from molt increments and to evaluate the influence of growth differences in different areas.

- **Methods used to blend multiple modified DeLury model results into unit stock estimates of fishing mortality.**

  Blending of multiple modified DeLury model results was appropriate. To get global population estimates there are two issues to consider: 1) movement between areas, and 2) differences in catchability and intensity of various surveys. If movement is minimal and surveys vary greatly in efficiency and intensity, the blending approach is appropriate. If movements are extensive and the surveys are all equivalent, then treating the data as constituting one large survey is appropriate. The Panel believes the blended approach is most appropriate. The integrity of the landings data and assumptions in development of the catch matrix, as presented in the evaluation of data quality (Term of Reference #1), may have some influence on DeLury output.

  The modified DeLury method accounts for abundance changes exclusively in terms of mortality and recruitment. Problems could arise if the rates of movement into or out of sub-areas are not roughly equal. This could especially be a problem with some of the very small sub-areas, such as off Rhode Island or Connecticut. This issue could be examined by modeling the population characteristics of the larger area with the small-scale surveys only seeing fixed proportions of the larger populations. The Mark model may be able to be configured in this manner.

  A more general conceptual development of the assumptions underlying the blending process should be developed, and the potential sensitivity or bias should be evaluated, particularly with respect to movement of lobsters. In addition, an evaluation of the growth transitions within each sub-unit should be conducted to ensure consistency. The current blending process expands from the available surveys to the stock area. It may be that the extent of survey coverage and definition of survey strata for the NMFS, or possibly state, surveys should be partitioned out further.

- **Characterization of uncertainty associated with model results, reference point estimation, and sensitivity to model parameters.**

As noted above, a high degree of uncertainty existed in the landings by weight and size frequency data. The expansion of landings (pounds) to length and sex classes using the sea and port sampling data includes several assumptions. The report does not provide an evaluation of the uncertainty in the development of the catch matrix, which is problematic as the models assume no errors in the catch matrix. Sensitivity analyses should be performed to determine how potential changes in the catch matrix affect model results.

The amount of uncertainty presented in the results is underestimated due to the assumption that catches are known without error. Bootstrapped fits to survey data were conducted, however, natural mortality (M) remained constant in that analysis. Additional bootstrapping should be conducted to assess the effect of an uncertain M. Uncertainty was not characterized for either the egg per recruit (EPR) analyses or $F_{10\%}$ biological reference point analyses. It would be useful to vary natural mortality and link the bootstrapping of the modified DeLury model with the EPR model so as to estimate the benchmarks such as $F_{10\%}$, $F_{0.1}$, or the ratio of fishing mortality to $F_{10\%}$ with each iteration. Simple plots of the frequencies of outcomes can be quite informative to managers to illustrate the uncertainty in the measures. The practice of presenting point estimates of a given parameter or for a particular assessment method without dwelling on its uncertainty, provides a false sense of the precision of the assessment process, and understates the risk of stock decline as a consequence. Therefore, uncertainty estimates are extremely important as information relevant to rational decision-making.

< **Potential validity and utility of new assessment model (Mark model) developed for this assessment.**

The Panel recommends further development of new assessment models, including the Mark model, biomass dynamic model, and yield per recruit analyses. On the one hand, the Mark model has utility in that it integrates all available data into one model and potentially provides more reliable results of stock status. On the other hand, the inclusion of misleading or otherwise problematic data in a comprehensive model could be counterproductive. The Mark model could be used to evaluate several surveys simultaneously (e.g., Rhode Island and Connecticut) so that it would not be necessary to assume independent sub-areas, as was done in the current assessment with separate modified DeLury models that were then blended. Further development of the Mark model should be pursued and inclusion of variance estimates around model parameters should be evaluated.

The biomass dynamic model presented to the Panel was of a localized area that may not have been a closed system; however, the Panel recommends that the application of biomass dynamic models to larger stock areas be evaluated. The Panel notes that trends in residuals show changing carrying capacity over time. A more global biomass dynamics model would need to evaluate this potential problem.

To more fully evaluate growth overfishing, a yield per recruit analysis for male lobsters should be included in future assessments. A yield per recruit analysis for males and females combined should also be developed independent of the EPR model. This will provide a more complete view of the total yield associated with the American lobster fishery.

The Panel recommends that a predictive capability be developed from trawl survey data based on capture of small lobsters (i.e., lobsters that will molt into the legal size range in two or more years). Due to the two to three year lag in data availability, a predictive capability could bring estimates of stock status closer to real-time.

2. Evaluate the current status of American lobster stocks, and trends in abundance and fishing mortality, by examining model based indices and alternative indices derived from fishery dependent and independent data.

Abundance has shown increasing trends in all stock areas in recent years (Figures 1A-C). Recruitment has also been high and increasing or stable for the three areas since approximately 1994 (Figures 2A-C). The Panel believes that the increases in abundance are due largely to coincident increases in recruitment. Why recruitment has been so favorable is unknown, and it cannot be predicted how long this condition will continue and when recruitment will return to levels associated with long-term average conditions. Various explanations for increased recruitment have been speculated including environmental influences, feeding of lobsters in traps, and reduced predation by smaller groundfish populations.

In spite of the increased recruitment and landings, the Panel has concerns for the condition of the lobster stock. Calculated fishing mortality rates (F) are high (the lower 90% confidence bounds of F exceeded the $F_{10\%}$ reference point) in all three areas based on the modified DeLury (Figures 3A-C). All three areas show evidence of truncated length-frequency distributions and a greater reliance on the first molt group above the legal size (Figure 4A-C). A shift in fishing effort from inshore to offshore areas has occurred in several of the stock areas. Further increases in offshore fishing effort may influence inshore abundance levels due to the possible dependence of inshore areas on offshore egg production. It was clear from the current stock assessment that there needs to be a more precise definition and description of the extent of traditional and emerging fishing grounds. Of particular concern is the expansion of effort into nearshore federal waters (3-20 miles from shore) which can not be adequately captured in current catch reporting systems.

Specific indications of localized problems have also occurred. For instance, localized depletion has occurred in Massachusetts Bay and the Long Island Sound stock is being reduced by recent die-offs caused by disease and other factors. In the Georges Bank and Southern New England Shelf (GBS) stock area a shift in the fishery to targeting of softshell lobsters as soon as they molt into legal size has occurred. The proportion of lobsters in the first molt has also increased from 40% to 70% in GBS (Figure 4C).

The Panel cautions that it is unrealistic to expect strong recruitment to continue indefinitely. Since most egg production is from recruits and the first molt group above minimum legal size, a decline in recruitment will lead to a decline in egg production. It is also clear that the pool of large lobsters cannot indefinitely maintain adequate egg production unless young lobsters are allowed to grow to sizes above the first molt group. In addition to limiting egg production, high fishing mortality rates have resulted in the cropping of newly recruited lobsters within the first year leading to growth overfishing. A significant reduction in egg production may or may not have a major impact on recruitment. However, it is not prudent to assume that reduced egg production will have no consequences. The Panel believes that it is important to increase egg production. If this were done (by increasing the minimum size, increasing the size of the escape vent, or decreasing the rate of fishing mortality) this would also increase yield per recruit, which is important because the stock is clearly growth overfished. The Panel further recommends a precautionary approach be maintained to ensure the American lobster stocks are not overfished (see Term of Reference #4 for more information on overfishing).

3. Comment on explanations for stable and increasing abundance despite the low estimates of recent egg production per recruit.

For approximately the past two decades, even though egg per recruit probably has been low for most of the period, abundance has been high; consequently, total egg production has been high. The Panel believes that favorable environmental/ecological conditions have resulted in high survival rates for early life history stages and possibly higher growth rates for all stages. Factors such as increased temperature, improved environmental/ecological conditions generally, broadscale shifts in climatic conditions as indicated by the north Atlantic anomaly, and low abundance in groundfish stocks may all have contributed. There is no basis for predicting how long these extremely favorable conditions will persist. There are various viewpoints and no consensus on what controls recruitment and production dynamics in lobsters.

4. Evaluate methods used to estimate the overfishing definition ($F_{10\%}$) for American lobster and if appropriate, suggest additional reference points or analyses which could be used to define overfishing.

A deterministic model incorporating calculations for eggs per recruit and yield per recruit for female lobsters was used to calculate F 10%, which is the fishing mortality rate that results in egg production per recruit equal to 10% of that value in an unfished stock. Estimation of $F_{10\%}$ is not precise due largely to the uncertainty in calculating egg production at zero fishing mortality. The Panel is concerned that model fits between the observed and predicted length frequencies seem quite inconsistent (Figure 5) and further investigation is recommended.

The Panel notes that the $F_{10\%}$ overfishing definition implies that we are currently recruitment overfishing the stock. This does not imply that the stock is overfished. Overfishing is a rate of removal and if too high the removals are not sustainable. Overfished status results from continued overfishing and implies a greatly reduced stock (Figure 6). Although recruitment overfishing appears to have been occurring in American lobster stocks for some time, fortuitous strong recruitment has maintained the stock biomass well above an overfished level. While strong recruitment could continue in the short term (possibly 20 years), it is unrealistic to expect it will do so indefinitely and the Panel cautions that under current conditions in some segments of the fishery the risk of significant recruitment declines is unacceptably high. Therefore, a precautionary approach is recommended to guard against significant stock declines and reduce the risk of future recruitment failure.

The Panel also believes that it is essential to have biological reference targets that are distinct from thresholds. The recruitment overfishing threshold should be identified as the 'danger' level which, when approached or reached, should give rise to management action in order to move the fishery away from the danger area. While it is uncertain how closely $F_{10\%}$ matches a real danger point, the Panel regards $F_{10\%}$ as a rule of thumb threshold. Despite this problem, the Panel believes that it is appropriate to maintain $F_{10\%}$ as a threshold, at least until it can be replaced or supplemented by a more useful reference point, such as a biomass based reference point.

Alternative methods of estimating the overfishing definition should be pursued. Threshold or target reference points based on percentage of female recruits that spawn or percentage that spawn more than once before dying should be investigated. Surplus production models and stock recruitment models can be used to develop overfishing or biomass-based reference points that have a more solid theoretical basis. These should be cast in a precautionary context with fishery control rules associated with each (Figure 6) (Restrepo et al. 1998; 1999 Report of the Mackerel Stock Assessment Panel). The Panel recommends the application of a similar control rule for the American lobster fishery.

5. Review management and research recommendations and identify any additional research necessary to improve future stock assessments for American lobster.

<u>High Priority Research Recommendations</u>

The following research recommendations, not listed in any specific order of priority, are suggested as high priority by the Panel. An indication of the amount of time required to implement these recommendations is provided through a notation for each recommendation that it should be completed for the next assessment or that it is a longer-term research need (indicating that it may not be fully completed by the next assessment).

<u>Improving Data Collection</u>

A standardized mandatory reporting system for American lobster fishermen, including the location of catches and effort, should be implemented in conjunction with the Atlantic Coastal Cooperative Statistics Program if possible. [Longer term research need]

Landings for nearshore and offshore areas should be identified. [Longer term research need]

Existing statistical reporting units should be decreased in size in order to assess spatial patterns and trends in landings. [Longer term research need]

Sea sampling and/or port sampling for biological characteristics of catches and landings should be enhanced with a sound statistical design. [Longer term research need]

A nearshore fishery independent index should be developed for the waters off Maine. [Longer-term research need]

Methods for monitoring recruitment variability at various pre-recruit life history stages and for forecasting catch should be developed (i.e., scuba, ventless traps). [Longer term research need]

Field and lab studies of male and female growth (molt transition probabilities and molt increments) should be conducted in each stock area. [Longer term research need]

Stock Assessment Modeling

General Modeling Issues

Variance estimates should be presented for landings and survey data, where possible. All zero-catch survey hauls should also be included. [Should be complete for next assessment]

Spatial mapping of survey abundance indices by size and sex should be conducted. [Should be completed for next assessment]

Information from the spatial mapping of survey abundance indices for broodstock should be linked with current understanding of larval drift patterns, and known patterns of lobster settlement to model major larval production sources and sinks. Such information may provide a clearer context for determining the potential impacts of offshore expansion of fishing effort on stock resiliency [Longer-term research need]

Diurnal variation in survey catch rates should be evaluated. [Should be complete for next assessment]

Early indicators of trends in smaller molt groups should be developed using existing trawl survey data. For maximum utility, analysis and review of pre-recruit indices should be conducted on an annual basis, not on an intermittent basis in the principal stock assessment cycle. [Should be complete for next assessment]

Improvements to Current Models and Implementation of New Models

The modified DeLury model should be modified to include data by sex and multiple tuning indices (i.e., both the spring and fall surveys). [Should be complete for next assessment]

Studies should be designed to estimate Q ratios for the modified DeLury model. These studies may involve tag-recapture and comparison of fall and spring trawl survey data. [Longer-term research need]

Predictions of EPR models with respect to data from fishery dependent and fishery independent sources should be validated. This includes projected growth trajectory, size frequency, size specific sex ratios, fraction egg-bearing, fraction soft shell and fraction v-notched. [Should be complete for next assessment]

Changes in egg production and yield associated with various changes in minimum legal size and fishing effort should be explored. [Should be complete for next assessment]

Biomass dynamic models should be applied to larger stock areas. [Should be complete for next assessment]

Further development of the Mark model should be pursued and model error propagation should be evaluated. [Should be complete for next assessment]

Yield per recruit analyses for male lobsters should be included in future assessments for evaluation of growth overfishing. [Should be complete for next assessment]

A yield per recruit analysis for males and females should be developed that is independent of the EPR model. [Longer term research need]

Broad Research Issues

The effects of bait on lobster production should be evaluated to determine whether high levels of bait in the water contribute to growth and survival of lobsters. [Longer term research need]

Molting frequency, mean and maximum intermolt periods, and molt increments should be evaluated, especially for larger lobsters. [Longer term research need]

Biochemical methods of aging should be evaluated and pursued. [Longer term research need]

Greater viability/quality associated with eggs produced by second time spawners should be evaluated. [Longer term research need]

Coordination Issues

Environmental and ecosystem factors, and evaluation of these factors, should be included in the assessment process. [Should be complete for next assessment]

A centralized database containing all American lobster assessment data should be maintained, and data should be updated and reviewed annually as a basis for detecting signals of change in stock status at an early stage. [Should be complete for next assessment]

Collaboration with Canadian stock assessment biologists should be expanded from the existing structure of largely informal links between specific individuals and assessment groups to a more formalized and ongoing program of exchange of technical information on assessment approaches and stock status. [Should be complete for next assessment]

Management Recommendations:

The Panel recommends that egg production be increased in all three stock areas. The Panel is more concerned with GOM and GBS since the size at maturity in these areas is above the minimum size limit. Increases in egg production can be accomplished by a range of approaches, among which the following have particular utility:

- Increase minimum size
- Establish spatial closed areas (sanctuaries)
- Reduce fishing mortality
- Increase vent size

An increase in the minimum size limit will provide for increased egg production by increasing the number of females reaching sizes near 50% maturity at which the chance of spawning is much greater. Assuming fishing mortality on the remaining legal population does not increase, this would represent a decrease in fishing mortality on the population overall. Establishment of sanctuaries will contribute to a pool of large lobsters and will provide potential recruits to other areas if situated appropriately. These sanctuaries need to be large enough to be effective and migration patterns out of these areas need to be mapped. Fishing mortality reductions can be accomplished through effort reductions or quotas and will provide for increased numbers of females getting the opportunity to spawn once and some possibly for the second time before being taken in the fishery. Increases in vent size will reduce discarding of sublegal lobsters, but will not contribute to a pool of very large lobsters. It works similarly to increasing the minimum legal size. Depending on the specific management objectives, a combination of these measures will improve egg production in these stocks. Such measures will also result in increased yield per recruit in all stock areas.

The Panel recommends evaluating the utility of current management measures, such as V-notching, female maximum size, compliance with minimum size limits, as well as evaluating the benefits of other alternatives through the existing EPR model. The American Lobster Management Board should request evaluations of alternative management measures in the terms of reference for future stock assessments. In addition, the economic risks/benefits of implementation of new management measures should be evaluated.

U.S. fishery managers should review similar situations experienced by their counterparts in Canada. Abundance trends in Canadian lobster stocks have been quite similar to those in the U.S. over the past two to three decades. The Panel urges managers to consider declines that have occurred in some areas of the Canadian fishery in recent years as an indication of the extent of changes that can occur over the short term.

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State of Stock - Overfishing Advice (Term of Reference #2)

Abundance has shown increasing trends in all stock areas in recent years (Figures 1A-C). Recruitment has also been high and increasing or stable for the three areas since approximately 1994 (Figures 2A-C). The Panel believes that the increases in abundance are due largely to coincident increases in recruitment. Why recruitment has been so favorable is unknown, and it cannot be predicted how long this condition will continue and when recruitment will return to levels associated with long-term average conditions. In spite of the increased recruitment and landings, the Panel has concerns for the condition of the lobster stock. Calculated F values are high (the lower 90% confidence bounds of F exceeded the $F_{10\%}$ reference point) in all three areas based on the modified DeLury (Figures 3A-C). All three areas show evidence of truncated length-frequency distributions and a greater reliance on the first molt group above the legal size (Figure 4A-C). A shift in fishing effort from inshore to offshore areas has occurred in several of the stock areas. Further increases in offshore fishing effort may influence inshore abundance levels due to the possible dependence of inshore areas on offshore egg production.

The Panel cautions that it is unrealistic to expect strong recruitment to continue indefinitely. Since most egg production is from recruits and the first molt group above minimum legal size, a decline in recruitment will lead to a decline in egg production. It is also clear that the pool of large lobsters cannot indefinitely maintain adequate egg production unless young lobsters are allowed to grow to sizes above the first molt group. In addition to limiting egg production, high fishing mortality rates have resulted in the cropping of newly recruited lobsters within the first year leading to growth overfishing. A significant reduction in egg production may or may not have a major impact on recruitment. However, it is not prudent to assume that reduced egg production will have no consequences. The Panel believes that it is important to increase egg production. If this were done (by increasing the minimum size, increasing the size of the escape vent, or decreasing the rate of fishing mortality) this would also increase yield per recruit, which is important because the stock is clearly growth overfished. The Panel further recommends a precautionary approach be maintained to ensure the American lobster stocks are not overfished (see Term of Reference #4 for more information on overfishing).

State of Stock - Management Advice (Term of Reference #5)

The Panel recommends that egg production be increased in all three stock areas. The Panel is more concerned with GOM and GBS since the size at maturity in these areas is above the minimum size limit. Increases in egg production can be accomplished by a range of approaches, among which the following have particular utility:

- Increase minimum size
- Establish spatial closed areas (sanctuaries)
- Reduce fishing mortality
- Increase vent size

An increase in the minimum size limit will provide for increased egg production by increasing the number of females reaching sizes near 50% maturity at which the chance of spawning is much greater. Assuming fishing mortality on the remaining legal population does not increase, this would represent a decrease in fishing mortality on the population overall. Establishment of sanctuaries will contribute to a pool of large lobsters and will provide potential recruits to other areas if situated appropriately. These sanctuaries need to be large enough to be effective and migration patterns out of these areas need to be mapped. Fishing mortality reductions can be accomplished through effort reductions or quotas and will provide for increased numbers of females getting the opportunity to spawn once and some possibly for the second time before being taken in the fishery. Increases in vent size will reduce discarding of sublegal lobsters, but will not contribute to a pool of very large lobsters. It works similarly to increasing the minimum legal size. Depending on the specific management objectives, a combination of these measures will improve egg production in these stocks. Such measures will also result in increased yield per recruit in all stock areas.

The Panel recommends evaluating the utility of current management measures, such as V-notching, female maximum size, compliance with minimum size limits, as well as evaluating the benefits of other alternatives through the existing EPR model. The American Lobster Management Board should request evaluations of alternative management measures in the terms of reference for future stock assessments. In addition, the economic risks/benefits of implementation of new management measures should be evaluated.

U.S. fishery managers should review similar situations experienced by their counterparts in Canada. Abundance trends in Canadian lobster stocks have been quite similar to those in the U.S. over the past two to three decades. The Panel urges managers to consider declines that have occurred in some areas of the Canadian fishery in recent years as an indication of the extent of changes that can occur over the short term.

Stock Identification and Distribution

The U.S. American lobster resource occurs in continental shelf waters from Maine to North Carolina. Landings have increased steadily since the early 1970s and fishing effort is intense and increasing throughout the range of the species. About 80% of the landings are caught in state waters (within 3 miles of the coast). As fishing effort has increased, the traditional inshore trap fishery has expanded to nearshore federal waters (3-20 miles from shore). There is also a deepwater fishery for lobster that occurs farther from shore. American lobsters are primarily harvested by traps, and only 2% of landings are taken by bottom trawls.

The U.S. lobster resource is broken into three stock units as defined in previous assessments: the Gulf of Maine (GOM), Georges Bank and Southern New England Outer Shelf (GBS), and South of Cape Cod to Long Island Sound (SCCLIS) stock areas.

Management Unit

The management unit for American lobster is the entire Northwest Atlantic Ocean and its adjacent inshore waters where lobsters are found, from Maine through North Carolina.

For management purposes, the management unit is subdivided into seven areas (Figure 7): Area 1 - Inshore GOM; Area 2 - Inshore Southern New England; Area 3 - Offshore waters; Area 4 - Inshore Northern Mid-Atlantic; Area 5 - Inshore Southern Mid-Atlantic; Area 6 - New York and Connecticut State Waters (primarily Long Island Sound); and Outer Cape Lobster Management Area.

Fishery Description (Fishing Effort)

The operational characteristics of the U.S. American lobster fishery have changed significantly in recent decades. Substantial increases in trap numbers and the areal extent of the fishery have occurred. In conjunction with higher numbers of traps, a change from wood to wire gear and an increase in trap size have made for more efficient traps. An associated increase in soak time per trap has also occurred. Fishing power has been improved through changes in vessel and gear technology. Each of these factors affect catch rates and overall yield from the fishery.

Total traps in U.S. waters have increased over three fold since the late 1960s and currently number over four million. During this 30-year period, landings increased at a similar rate.

Landings

Total landings were relatively constant at 14,000 mt through the late 1970s. Since then, landings have doubled, reaching 36-37,000 mt in 1997-98. During the last ten years, landings in Maine constituted about half of the total with 23% occurring in Massachusetts, 9% in Rhode Island and New York, 4% in Connecticut, and 2% in New Hampshire and New Jersey. Over the last decade, the relative proportions of landings among states have been relatively constant. On a relative basis, landings in the SCCLIS assessment area have increased faster than in the other two areas.

GOM

The GOM accounts for 71% of the total U.S. landings. Landings remained stable and averaged 10,000 mt/year between 1962 and 1976, reached 20,000 mt in 1991 and exceeded 25,000 mt in 1997/8 (Figure 8). The catch was evenly divided between males and females.

GBS

Total landings increased steadily from 2,444 mt in 1982 to a peak of 4,279 mt in 1990 and remained constant around 3,600 mt from 1992 to 1997 (Figure 8). Landings of male lobsters caught in this stock area increased by 50% between 1982 and 1992, then declined by almost the same amount in more recent years. During the last three years, males accounted for 47% of the landings and 50% of the recruit size group, but only 32% of the fully recruited population. Landings of females generally increased from 1982 to 1984, then remained relatively constant except for a large harvest in 1990

SCCLIS

Total landings (both sexes) from the SCCLIS stock area increased from less than 6 million lobsters in the mid-1980's to 14 million in 1997. Landings from the SCCLIS stock area in 1997 were 18% of total U.S. lobster landings and have increased steadily from 2,352 mt in 1982 to a record high of 6,894 mt in 1997 (Figure 8). The majority of the increase was from Long Island Sound (area 611). On average, females accounted for 61% of all the lobsters landed from the SCCLIS stock area between 1984 and 1997 (range 55-70%), while males made up 39% of the 1995-97 catch.

Data and Assessment

Fishery dependent and fishery independent data collected by the NMFS and the states from Maine to New Jersey were used in the American lobster stock assessment. Fishery dependent data included commercial landings collected by NMFS, Maine, New Hampshire, Massachusetts, Connecticut, and New York; and port and sea sampling data collected by NMFS, Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, and New York. Fishery independent data included trawl surveys conducted by NMFS, Maine, Massachusetts, Rhode Island, Connecticut and New Jersey.

Trends in abundance and fishing mortality for male and female lobsters in individual stock areas were derived from the Collie-Sissenwine model (misnamed DeLury model). LCA was used to estimate fishing mortality rates in recent years for the GBS stock. The egg per recruit/yield per recruit (EPR) model was used to estimate egg production and yield per recruit as a function of fishing mortality for female lobsters in the three stock areas. In addition to the results derived from assessment models, "common sense' indicators of stock and fishery status were evaluated by examining trends in 12 different fishery dependent and fishery independent indices. Finally, a preliminary version of a new sex and size structured assessment model that can incorporate multiple stock status indices was developed (Mark model) and reviewed by the Peer Review Panel.

Biological Reference Points

The status of the lobster stocks was compared to three overfishing definitions/standards: the Commission's overfishing definition, and growth overfishing, and recruitment overfishing. The Commission's overfishing definition is the basis for management actions as established by Amendment 3 in order to protect lobster stocks and provide for sustained harvest over the long-term. The overfishing definition is a fishing mortality rate that results in egg production per recruit equal to 10% of that value in an unfished stock. The Commission's overfishing definition applies to the resource throughout its range, but is applied on a stock by stock basis to lobsters in three stock units as defined above. The $F_{10\%}$ values determined in this assessment were 0.34 in the GOM, 0.29 in GBS, and 0.84 in SCCLIS.

On the other hand, growth and recruitment overfishing are inferred from biological characteristics of the stocks. Growth overfishing means that the maximum yield is not produced because of high fishing mortality on smaller lobsters. Recruitment overfishing means that the number of new lobsters available to the fishery each year is reduced by high fishing mortality rates. Scientists often evaluate the status of the stock by determining the level of growth and recruitment overfishing.

The stock assessment reports that all three stock areas are not recruitment overfished. However, all three stock areas are growth overfished and overfished according to the Commission overfishing definition.

Fishing Mortality

GOM

The 1995-97 fishing mortality rates are 0.74 (49% annual exploitation rate) for females and 0.59 (42%) for males. Even though females are protected from fishing to a greater degree, estimated female fishing mortality rates in the GOM were noticeably higher than male fishing mortality rates every year since 1987. Fishing mortality rates have remained relatively stable since 1993 for both males and females.

The EPR is 3.2%. There is a 90% probability that female fishing mortality rates have exceeded the $F_{10\%}$ EPR reference point (0.34) for this stock every year since 1982. According to the Commission's overfishing definition, this stock is overfished. However, recruitment into the fishery, total potential egg production, and stock abundance have increased in recent years, thus, the majority of the Stock Assessment Subcommittee concluded that the stock is not currently recruitment overfished. Based on yield per recruit analysis for females, this stock is growth overfished (yield per recruit could be increased under lower fishing mortality rates).

GBS

The 1995-97 fishing mortality rate was 0.41 (31% annual exploitation rate) for females and 0.63 (44%) for males. Fishing mortality rates were higher for males, which only made up 30% of the average fully-recruited population but 53% of the landings during 1995-97. Fishing mortality estimates for 1995-1997 calculated by LCA were 54% higher for females and 48% higher for males than DeLury estimates.

EPR for this region is 6.2%. There is a 90% probability that female fishing mortality rates have exceeded the $F_{10\%}$ EPR reference point (0.29) for this stock in 8 out of the last 16 years. According to the Commission's overfishing definition, this stock is overfished. However, recruitment into the fishery, total potential egg production, and stock abundance have remained stable in recent years, thus, the majority of the Stock Assessment Subcommittee concluded that the stock is not currently recruitment overfished. Based on yield per recruit analysis for females, this stock is growth overfished.

SCCLIS

The1995-97 fishing mortality rates are 1.25 for females (67% annual exploitation rate) and 1.41 for males (71%). These fishing mortality rates were much higher than the average 1995-97 fishing mortality rates in the other two assessment areas.

EPR for this region is 8.3%. There is a 90% probability that female fishing mortality rates exceeded the $F_{10\%}$ EPR reference point (0.84) for this stock in 11 out of the last

16 years and every year since 1991. According to the Commission's overfishing definition, this stock is overfished. However, recruitment into the fishery, total potential egg production, and stock abundance have increased in recent years, thus the majority of the Stock Assessment Subcommittee concluded that the stock is not currently recruitment overfished. Based on yield per recruit analysis for females, this stock is growth overfished.

Recruitment / Spawning Stock

GOM

Average recruit abundance during 1994-97 was 50% above the long-term mean. Fully-recruited (83+ mm) population abundance was 88% above the time series average during 1995-97. Total potential egg production increased during 1994-98, after varying without trend from 1976 to 1993.

Stock conditions in Area 514 (Massachusetts Bay), an area where fishing effort is concentrated, were different than the rest of the GOM: there was no change in recruitment over the past 16 years; fully-recruited abundance (only 30% female) declined slightly in recent years; total potential egg production was higher during the early 1980s than it is now; fishing mortality rates are high and have increased in recent years; and fishing effort is shifting from inshore waters to fishing grounds located further offshore.

The status of the lobster resource along at least a portion of the Maine and New Hampshire coast may be more like area 514 than is indicated by the present assessment. In the GOM stock area, with the absence of a survey along the Maine coast, it is likely that current fishing mortality rates for the entire stock area are underestimated.

GBS

The abundance of recruits varied without trend over the time series. Abundance of fully-recruited males dropped steadily from a high in 1988 to a low in 1995 while fishing mortality on males doubled between 1988 and 1994. Male abundance increased in the next two years as fishing mortality dropped. The abundance of fully-recruited females was above average during the last four years, after varying without trend since 1982.

GBS stock area total potential egg production changed very little since 1976 and is currently at average levels with 80-90% produced by lobsters at least one molt group above minimum legal size.

SCCLIS
Recruit abundance increased almost three-fold since the mid-1980s. The most notable gains in recruit abundance were in Long Island Sound. Despite increases in recruit abundance, abundance of legal-sized lobsters did not increase until 1996-97.

Total potential egg production increased in recent years. Most of the egg production in inshore waters of this stock area is derived from sub-legal lobsters and about 90% of the landed lobsters are in the first molt group above minimum legal size.

Sources of Information

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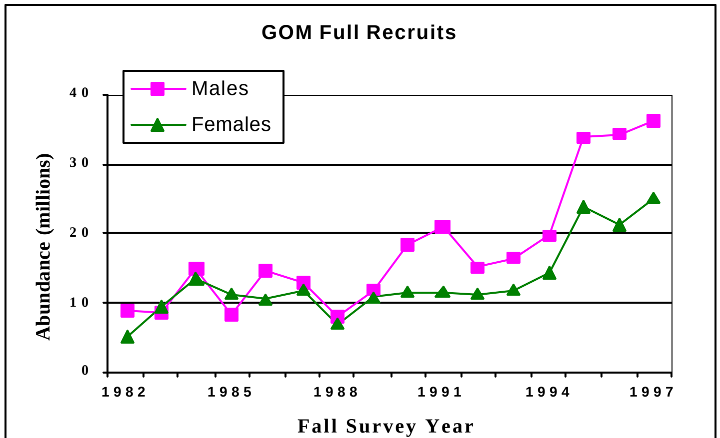
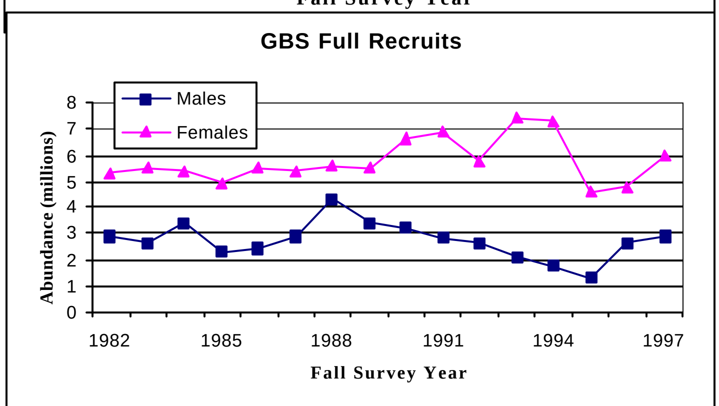
Figure 1 A-C. DeLury model point estimates of abundance of male and female lobster full recruits for GOM, GBS, and SCCLIS stock areas, fall survey years 1982-1997.

A.



B.



C.

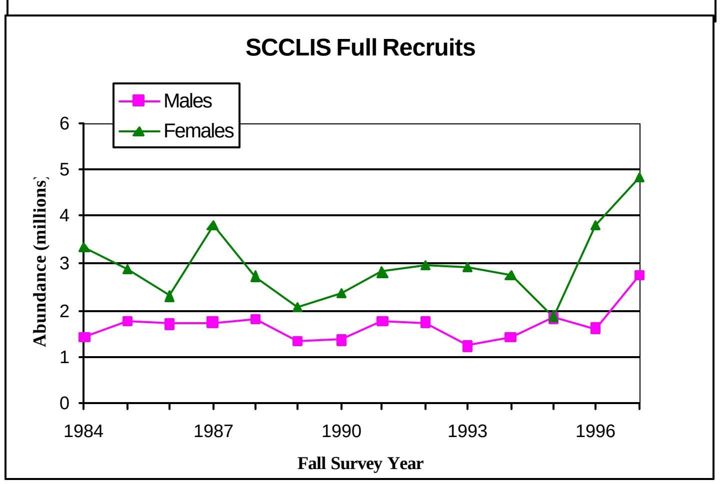


Figure 2 A-C. DeLury model point estimates of abundance of male and female lobster recruits for GOM, GBS, and SCCLIS stock areas, fall survey years 1982-1997.

A.

B.

C.

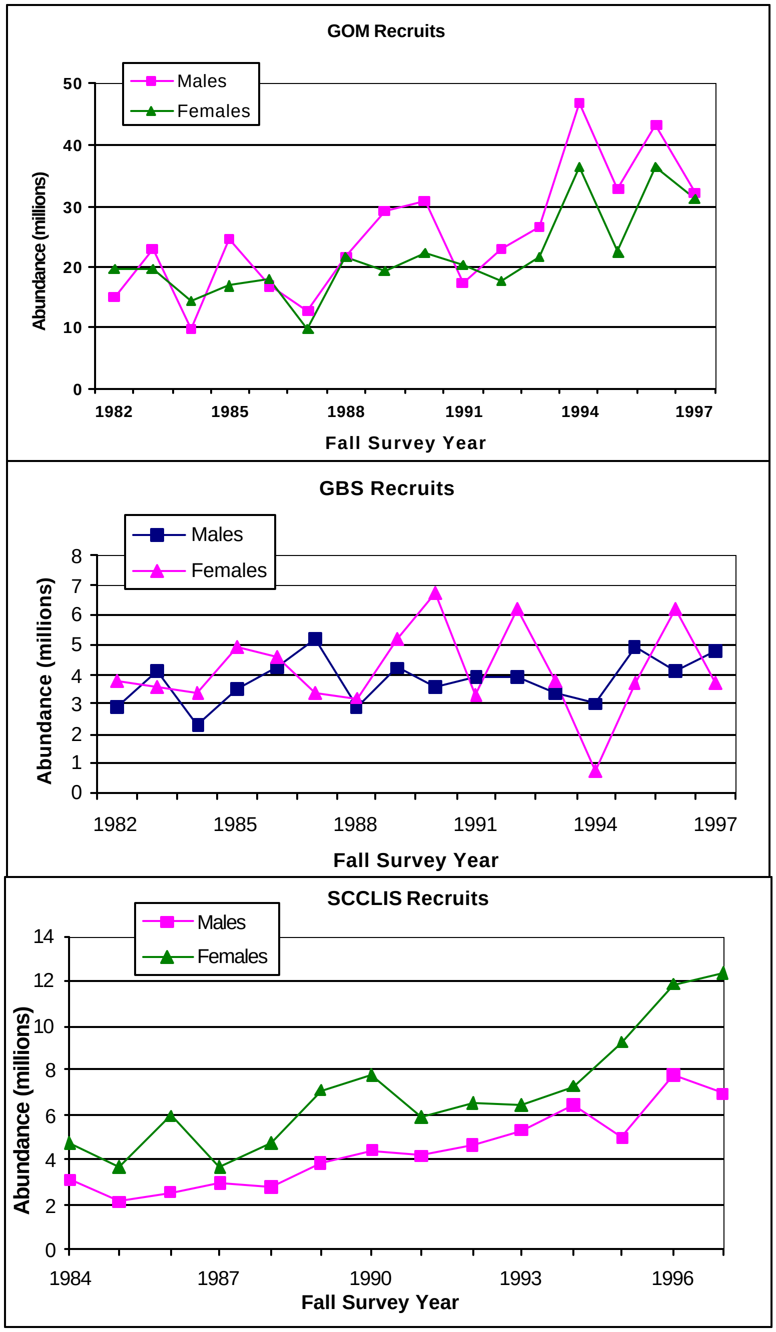


Figure 3A-C. Fishing mortality estimates for female lobsters in the GOM, GBS, and SCCLIS stock areas, fall survey years 1982-1997. Lines connect 10, 50, and 90 percentile estimates from bootstrapped model runs, triangles indicate point estimates, and straight line shows $F_{10\%}$ maximum EPR reference point).

A.

B.

C.

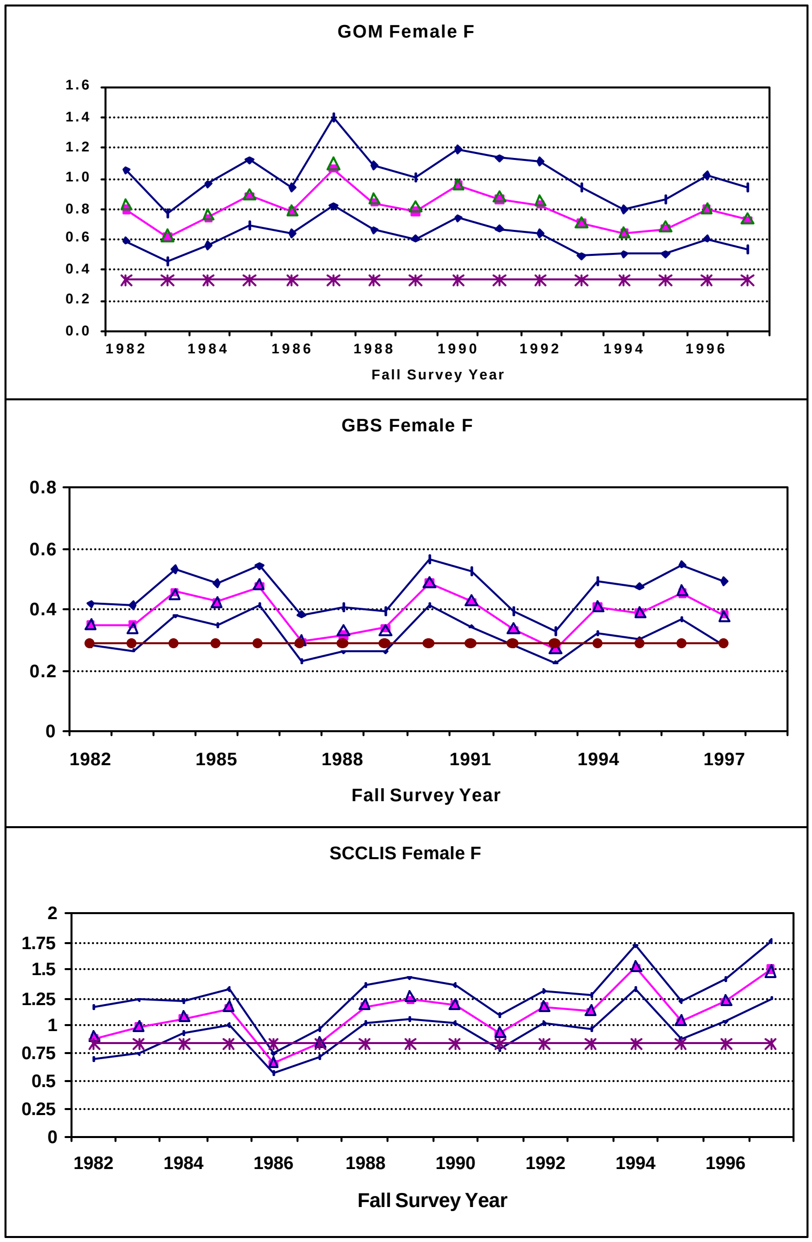
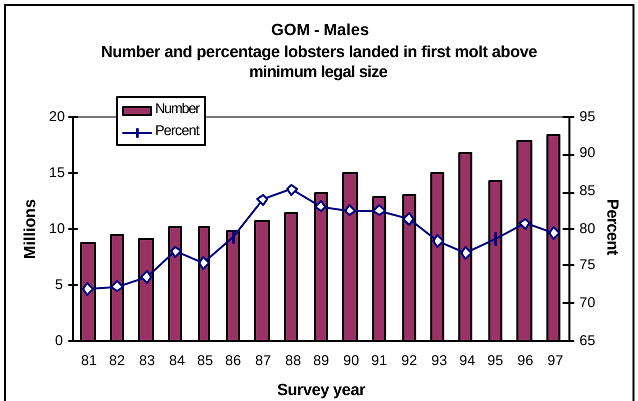
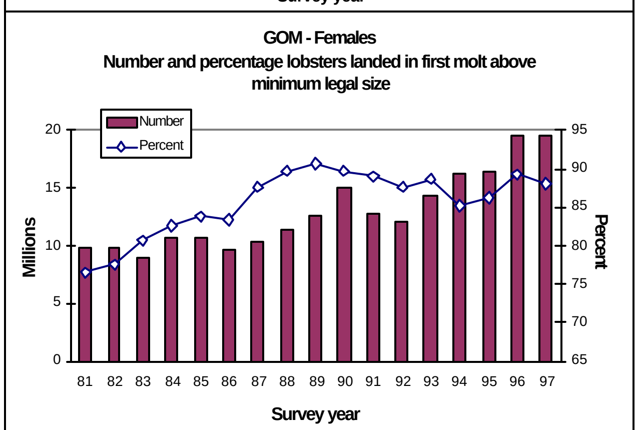


Figure 4 A-F. Number and percentage of lobsters landed in first molt above the minimum legal size for the GOM, GBS, and SSCLIS stock areas, 1981 - 1997.

A.



B.



C.

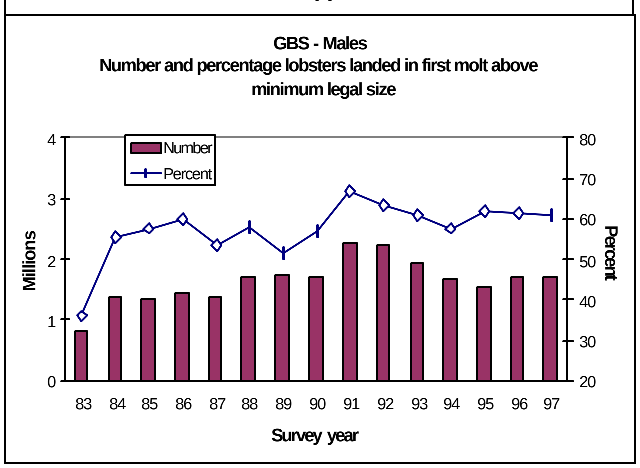
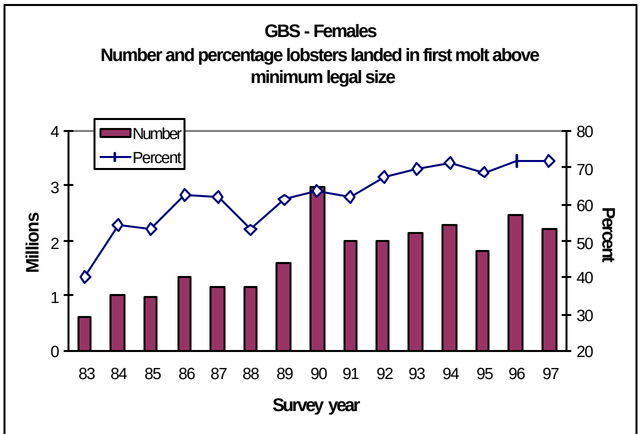
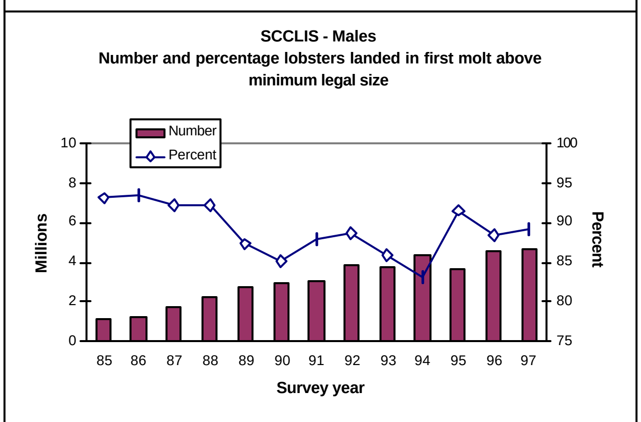


Figure 4 A-F. Continued

D.



E.



F.

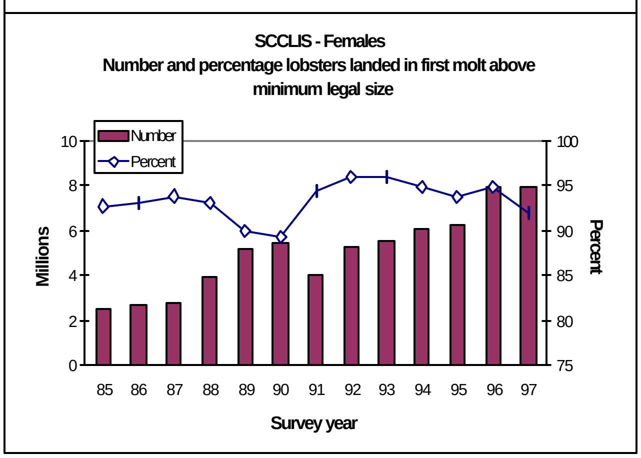


Figure 5A-C. Size distributions of expanded 1995-97 landings, or expected landings at female fishing morality rate (F) that achieves 10% of the maximum egg production per recruit, and of expected landings of females at prevailing average 1995-97 female fishing mortality rate in the GOM, GBS, and SSCLIS stock areas. Expected size distributions are based on output from EPR model runs.

A.

B.

C.

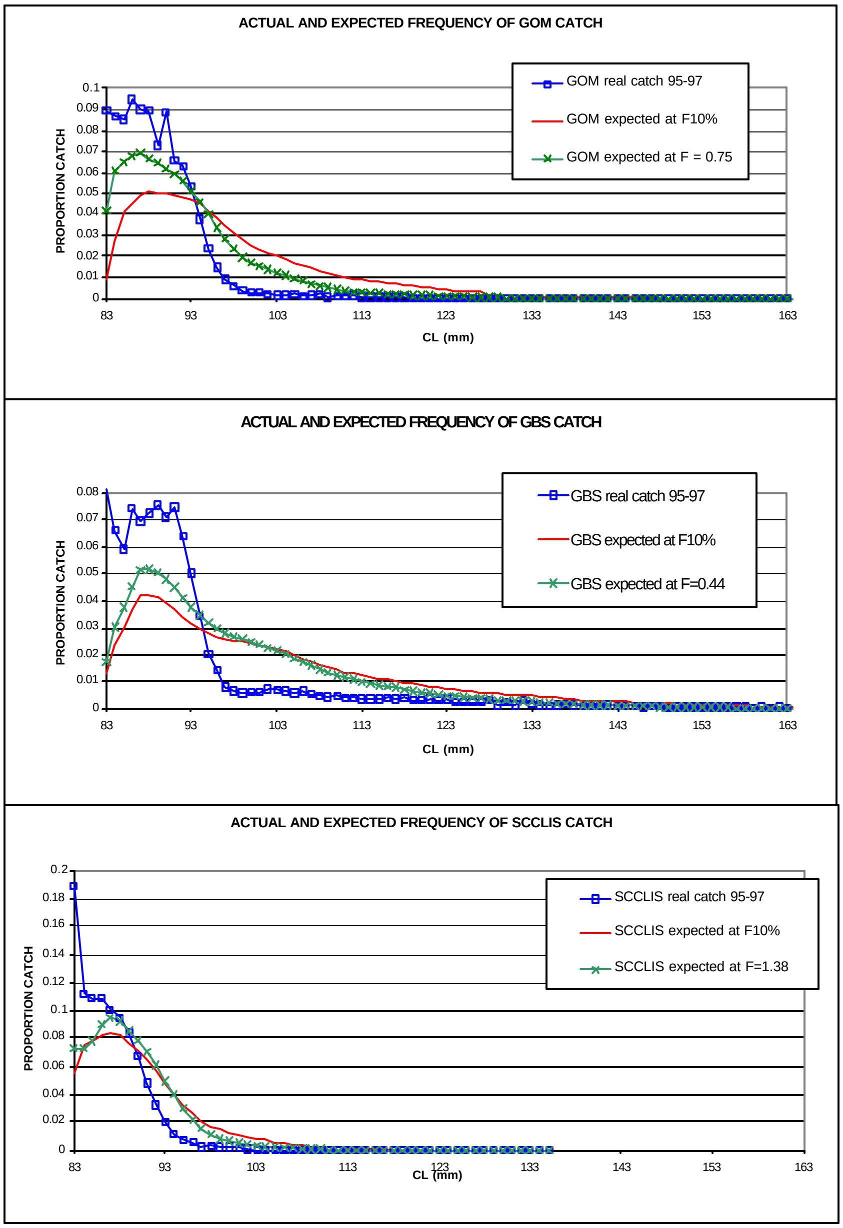


Figure 6. Default control rule and area descriptions. MSST = Minimum spawning stock threshold (1 - M), MFMT = Maximum fishing mortality threshold (F - current fishing mortality rate), Fmsy = fishing mortality rate associated with harvesting the maximum sustainable yield (MSY), B = current biomass or spawning stock biomass, and Bmsy = the biomass at MSY.

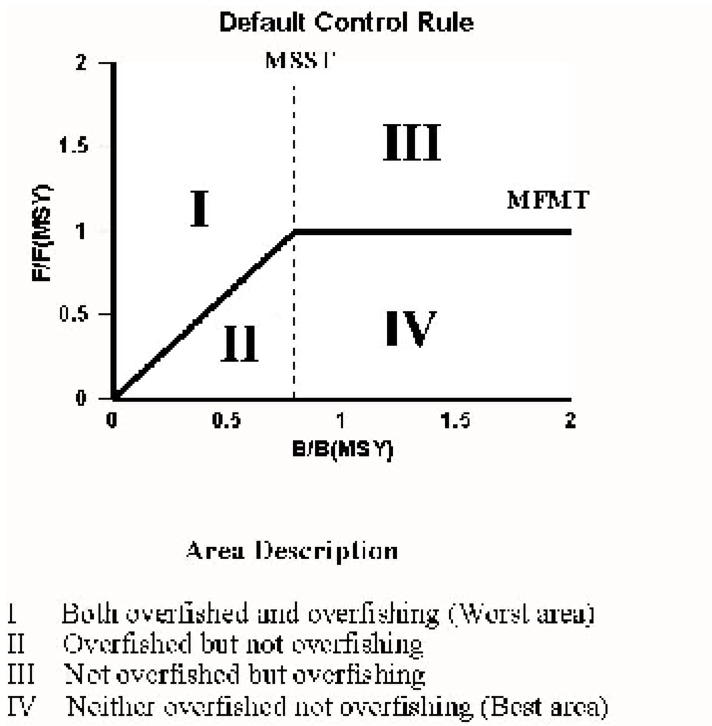


Figure 7. The seven management units for management of American lobster by the Atlantic States Marine Fisheries Commission. Area 1 - Inshore Gulf of Maine; Area 2 - Inshore Southern New England; Area 3 - Offshore waters; Area 4 - Inshore Northern Mid-Atlantic; Area 5 - Inshore Southern Mid-Atlantic; Area 6 - New York and Connecticut State Waters (primarily Long Island Sound); and Outer Cape Lobster Management Area.

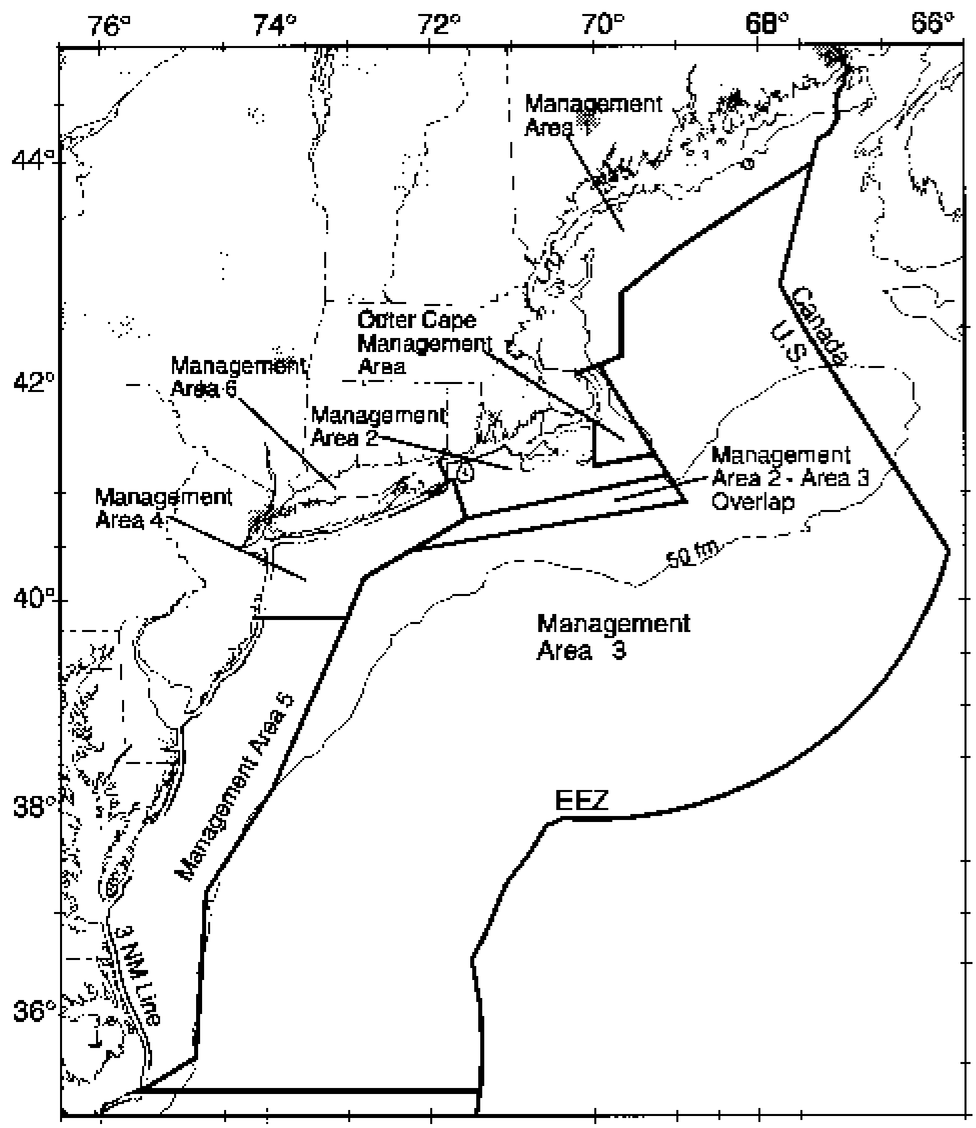


Figure 8A-C.   Landings in metric tons for the GOM, GBS, and SCCLIS stock areas from 1982 - 1997.

A.

B.

C.