



Atlantic States Marine Fisheries Commission

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MEMORANDUM

TO: American Lobster Management Board
FROM: American Lobster Technical Committee
DATE: April 25, 2016
SUBJECT: TC Follow-Up to February Lobster Board Meeting

The American Lobster Technical Committee (TC) met on March 14th to complete tasks assigned by the American Lobster Management Board (Board) in November 2015 and to address follow-up questions from the February 2016 Board meeting. These included impacts to the stock from gauge size changes, comparative sources of mortality, stock-recruit relationships, the costs and benefits of standardizing regulations in Southern New England (SNE), the attainability of recalculated reference points, and the need for a new comprehensive tagging study. The following report investigates these questions and is organized by issue.

1. Impacts to Stock from Gauge Size Changes

The Lobster Technical Committee was asked to analyze the potential effects of alternative minimum legal sizes on the SNE lobster fishery. Such analyses are highly sensitive to the growth and natural mortality rates of unfished lobsters because the outcomes are based on the net difference between the rate of increase in biomass-at-size due to growth and the rate of loss of biomass-at-size due to natural mortality. Unfortunately, available data on the natural mortality and growth rate of larger lobsters are too sparse to estimate these parameters with confidence. This is particularly true for females whose growth slows after sexual maturity. To address this uncertainty, we ran simulations under varying growth and natural mortality rates and estimated the equilibrium spawning stock biomass and landings under different minimum sizes. The goals of these simulations were to examine the potential effects of changing minimum legal sizes on lobster spawning biomass and landings, and to see if these results were robust to different assumptions about growth and natural mortality.

Simulation configuration

For the population simulations, we used the new stock assessment projection model to examine all combinations of three different growth rates, 11 levels of natural mortality, and different minimum legal sizes between 78 and 108 mm. The three different growth scenarios were selected to encompass reasonable upper and lower growth scenarios and included:

- 1) The basecase growth model used in the last assessment which is based on tagging data but grows small lobsters faster than is probable, particularly for females, with growth slowing to a 20% annual molt probability at 108 mm (Figures 1 and 2).

2) An intermediate growth model with the same male molt probability curve except the annual molt probability never drops below 33% (Figures 1 and 3). For the female molt probability curve, we examined the proportion of sublegal females that are egg-bearing, as calculated from the biosamples data for the last assessment. Assuming that these females would alternate years between molting and carrying a clutch, we directly calculated molt probabilities for these sublegal females to set the upper end of the curve. The lower end of the curve was set with the assumption that female molt probabilities were stable at 33% starting at 108 mm (ie: after 108 mm, a female should molt roughly once every three years).

3) A slow-growth model based on an assumption that 100% of females had reached sexual maturity (thus molt probability=50%) at 75 mm CL and minimum molt probabilities stabilized at 25% upon reaching 90 mm CL (Figures 1 and 4). Again, the basecase male growth model was used except that annual molt probabilities never dropped below 25%.

A total of 11 natural mortality rates were examined, ranging from $M=0.15$ to 0.4. Recall that M is assumed to be 0.15 for lobsters under normal circumstances but was increased to 0.285 in the latter years for the SNE stock in the last assessment. Updated likelihood profiles on the assessment model support natural mortality rates in these recent years between 0.24 and 0.27.

Across all simulations, we assumed random variation around a fixed recruitment rate based on the terminal years of the assessment. We used a constant fishery exploitation rate, also calculated from the terminal years of the assessment, but distributed across all legal lobsters. As a result, in situations where sex ratios skew to a higher abundance of males, the fishery compensates by increasing exploitation on males.

For each simulation scenario (combination of growth rate, natural mortality, and minimum legal size), the simulation was allowed to run forward for 20 years under the new growth, natural mortality, and minimum legal size, which allowed the population to reach a new equilibrium. Then the simulation recorded the spawning biomass and landings rate for each sex and converted biomass and landings to a relative measure based on the biomass and landings from simulations with the current minimum legal size for inshore LMAs of 86 mm. Each scenario was repeated 100 times and the results averaged within scenarios.

Results of the simulations are shown relative to current status; a value less than one represents a decrease while a value higher than one indicates an increase. The advantage of plotting results on relative scales is that the resulting patterns are not confounded by differences in magnitude resulting from different growth models and mortality rates and are robust to assumptions of future recruitment rates.

Finally, as an exploratory exercise, we used simulations to examine how changing the minimum legal size temporarily affects landings and spawning stock biomass (SSB). For this, we assume the basecase growth model, fishing mortalities, a range of natural mortality

rates and a shift in legal size from 86 to 95 mm (3 3/8" to 3 3/4") with three different implementation schedules: changing the legal size by 3/8" in the first year, changing by 1/8" each year for three successive years, and changing by 1/16" per year for six successive years. We allowed the model to run for 10 years under the current legal size, then implemented the new legal size and tracked the landings and population SSB over the next 15 years. Each simulation was repeated 100 times with representative random recruitment levels and averaged together.

Simulation results

Under all scenarios, increasing the minimum legal size resulted in increases in the biomass of mature lobsters (Figures 5 and 6). This is expected since, barring density dependent effects, allowing a lobster to stay in the water and grow to a larger size will always result in an increase in the population's biomass. The analyses also illustrated that slowing the growth rates or increasing natural mortality results in smaller increases in biomass with increasing legal size as natural mortality removes more individuals before they reach legal size. Changes in biomass are roughly linear with increasing legal size, approximately doubling at 93 mm, 96 mm, and 108 mm for the basecase, biosamples-based, and slow growth models, respectively (Figures 6, 9).

The general effect of increasing the legal size on catch varied across the scenarios, sometimes increasing or decreasing the net catch (Figures 7 and 8). At the lowest natural mortality rates ($M < 0.2$), the basecase and biosample-based growth scenarios suggest that moderate (<10%) increases in landings are possible at larger minimum legal sizes. Landings are fairly stable for moderate increases in legal size around assumed current mortality rates ($M \sim 0.275$), dropping by 20% only at legal sizes >98 mm for all growth scenarios (Figures 8 and 9).

Figure 10 illustrates the potential short term and long term impacts on biomass and catch that may result from different implementation schedules for increasing minimum legal size from 86 mm to 95 mm at varying levels of natural mortality. For example, an immediate implementation of the increase, at roughly the current level of natural mortality ($M = 0.275$), would cause landings to immediately decrease by approximately 50%, then require around 6 years for landings to stabilize at a new equilibrium of approximately 80% of current landings. At this same level of M , biomass would increase by slightly less than 50% of current values after 3-4 years. Under the slow implementation schedule, landings decrease slowly over six years, eventually having dropped by 25% in the sixth year, then rebound to the new equilibrium within three years. While the timing and magnitude of short term changes may vary with the different implementation schedules, increasing the minimum legal size would eventually result in new biomass and landings settling into a common trajectory in the long term.

Conclusions

The simulation results suggest that, relative to the continuation of the current gauge size, an increase in minimum size on the order of 5 – 10 mm may result in increased biomass

over time. It is important to note that the projected biomass and landings presented in these figures reflect a long-term equilibrium reached after a 20 year period and the short-term effects resulting from a change in the gauge size may be more dramatic. Specifically, a sudden change in regulations will likely result in sudden changes in both biomass and landings, followed by an eventual stabilization (see Figure 10). Furthermore, it is important to highlight that the relative magnitude of biomass increase depends on both the growth scenario and natural mortality.

We note that the simulation does not account for any shifts in the spatial availability of the resource to the fleet or the effects this may have on the fleet as these larger lobsters tend to migrate further offshore at larger sizes.

The TC also highlights that while these simulations predict increases in biomass as a result of changes in the minimum gauge size, these increases are relative to biomass that would result from no change to the current minimum size. Large reductions in fishing mortality are still required to stabilize the population and any increase in the adult population is dependent on favorable environmental conditions that allow for improved recruitment. Changes in the gauge size must be combined with other management measures to realize substantial improvements to the stock.

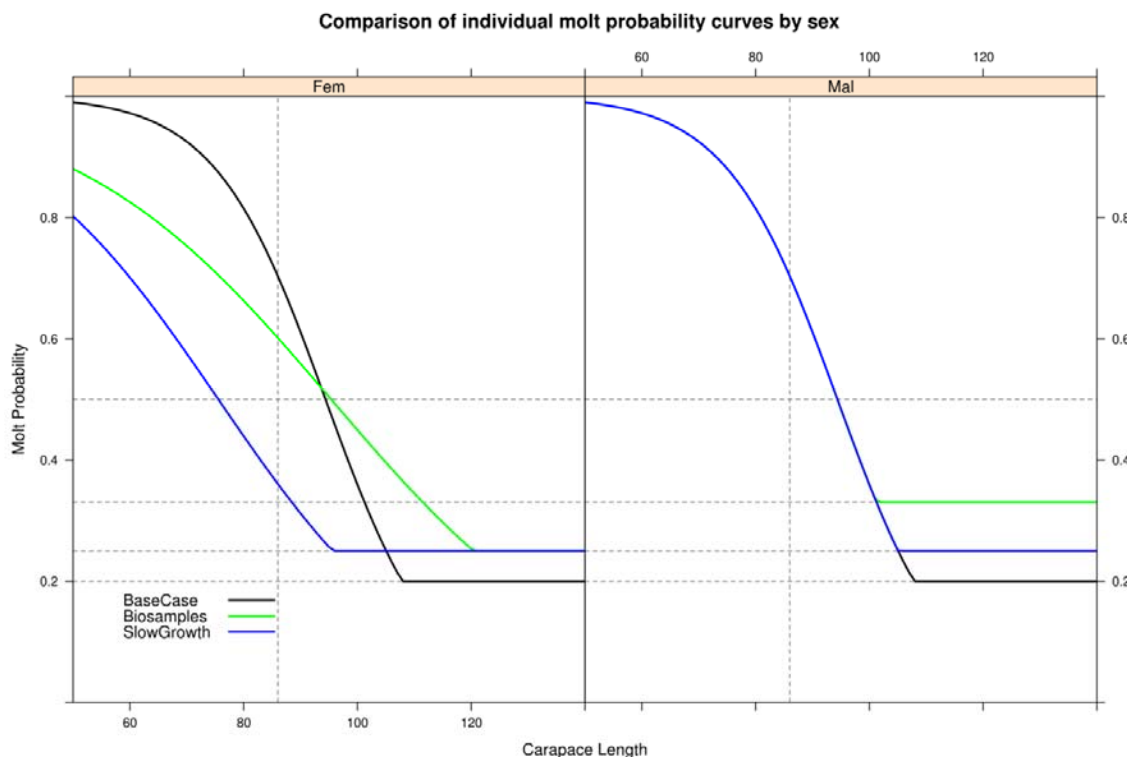


Figure 1. Annual molt probability at-size used in the three different growth scenarios. Dotted vertical line at 86 mm indicates the current minimum legal size for inshore LMA's.

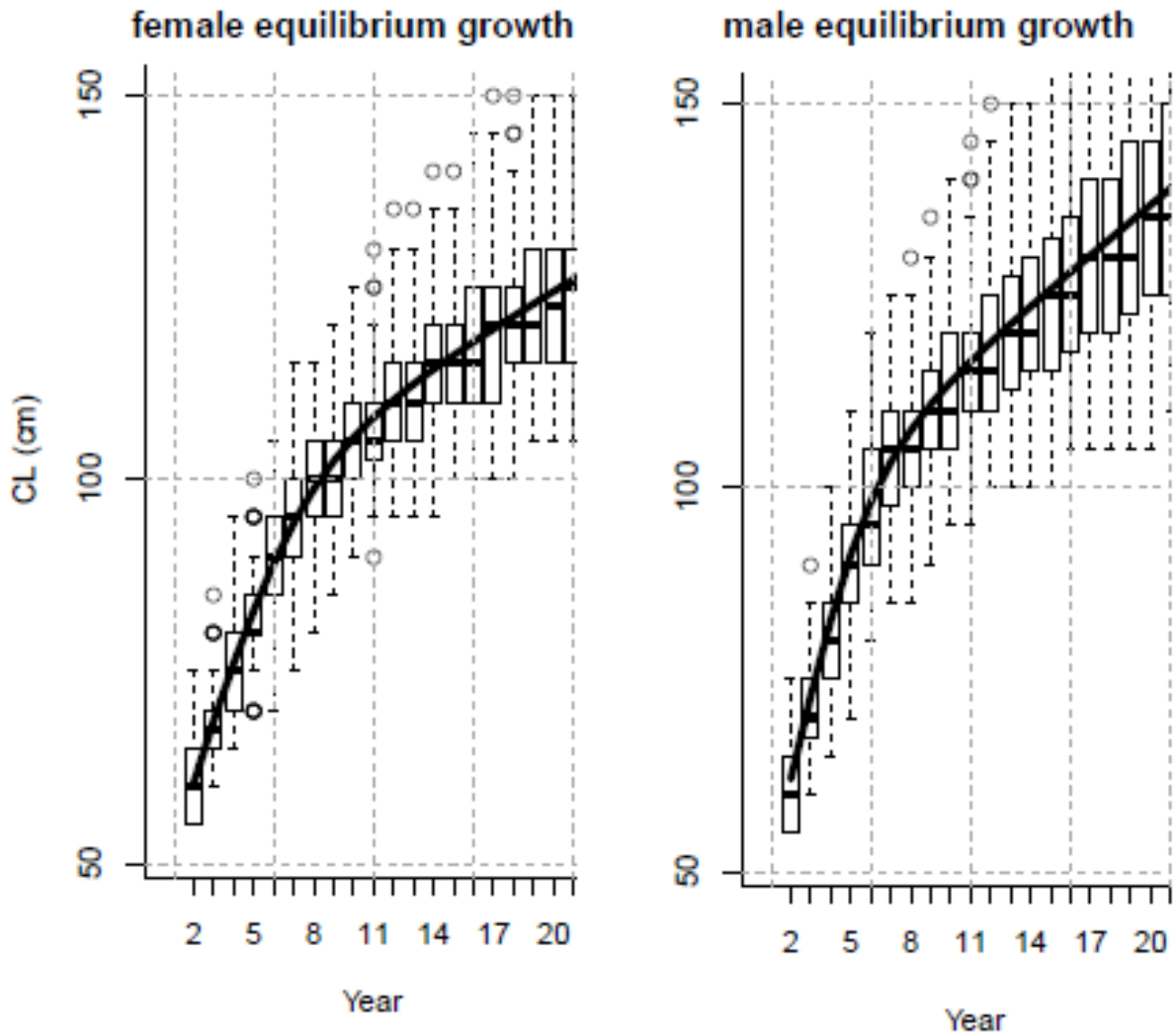


Figure 2. Equilibrium growth curves (length at age in the assessment model) assuming no fishing for the **basecase growth model**. Females reach 100 mm CL after ~ seven to eight years in the model (true age ~ 10-11 years).

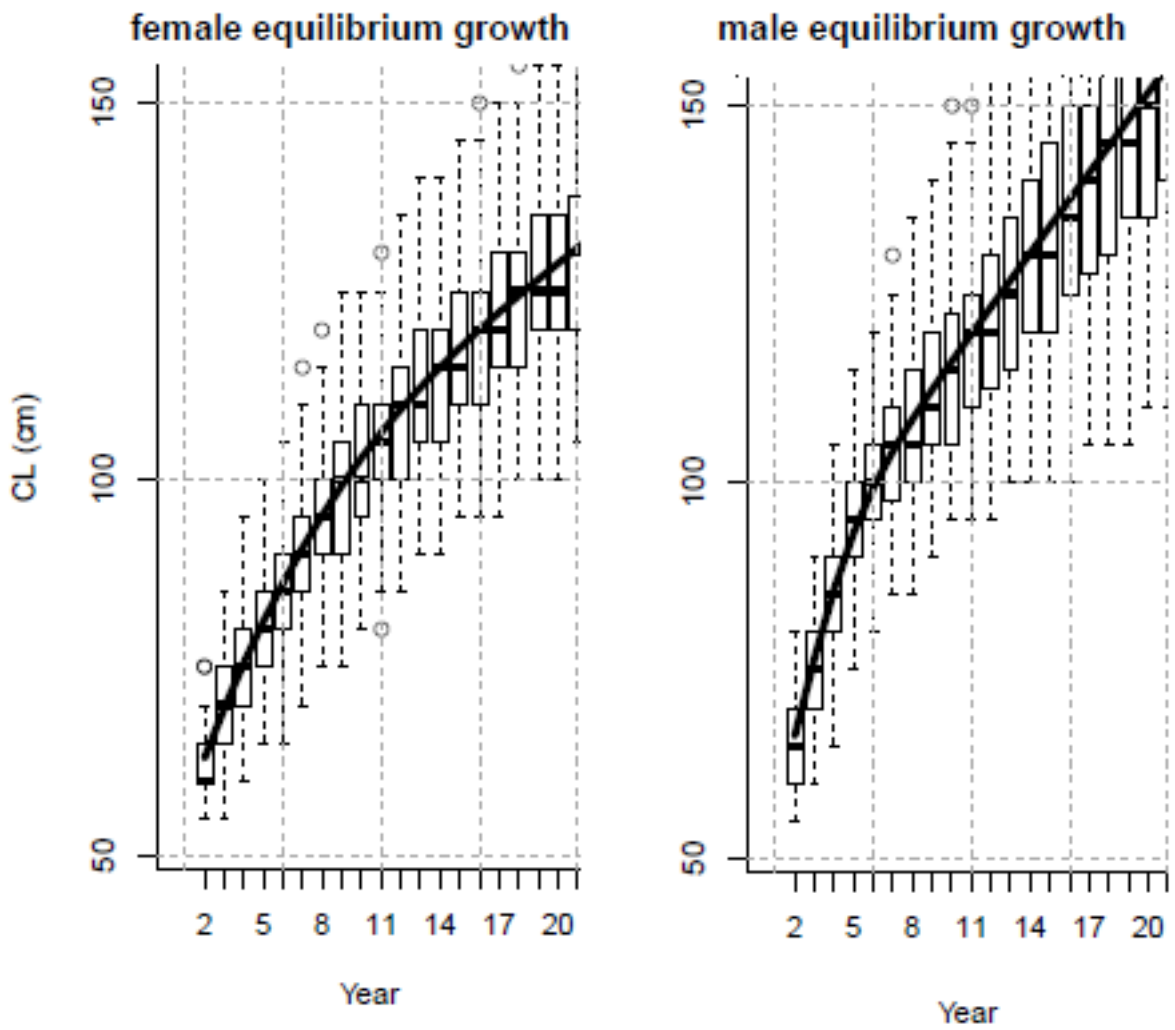


Figure 3. Equilibrium growth curves (length at age in the assessment model) assuming no fishing for the **biosamples growth model**. Females reach 100 mm CL after ~ eight to nine years in the model (true age ~ 11-12 years).

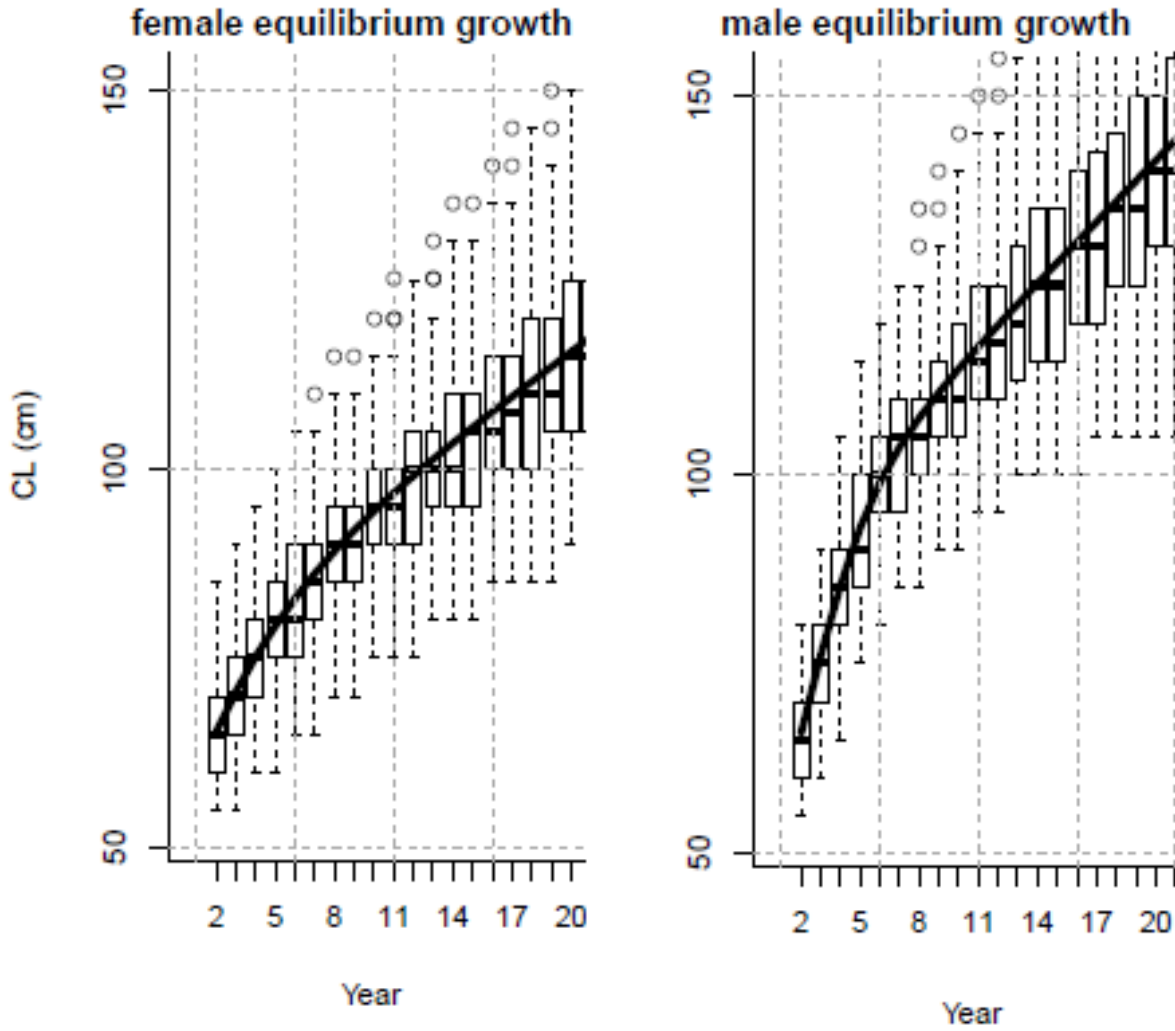


Figure 4. Equilibrium growth curves (length at age in the assessment model) assuming no fishing for the **slow growth model**. Females reach 100 mm CL after ~ 11 to 13 years in the model (true age ~ 14-16 years).

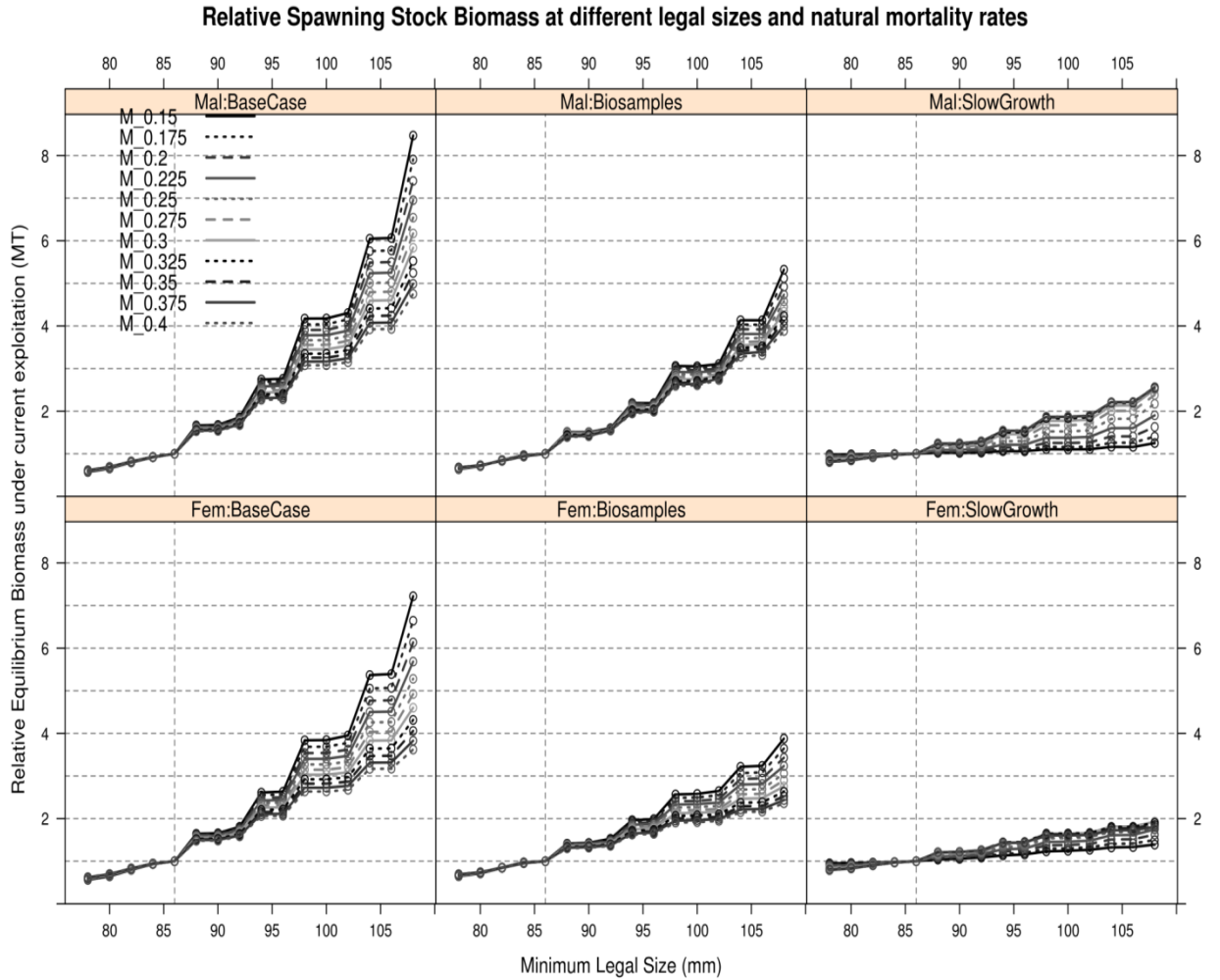


Figure 5. Changes in mature biomass by sex with increasing minimum legal size under different growth and natural mortality scenarios. Growth rates decrease in the panels from left to right with males on the top row and females on the bottom and each line within a panel indicating a given natural mortality rate. Values are relative to the current legal size of 86 mm. For interpretation, values less than one represent a decrease in biomass while values greater than one represent an increase in biomass.

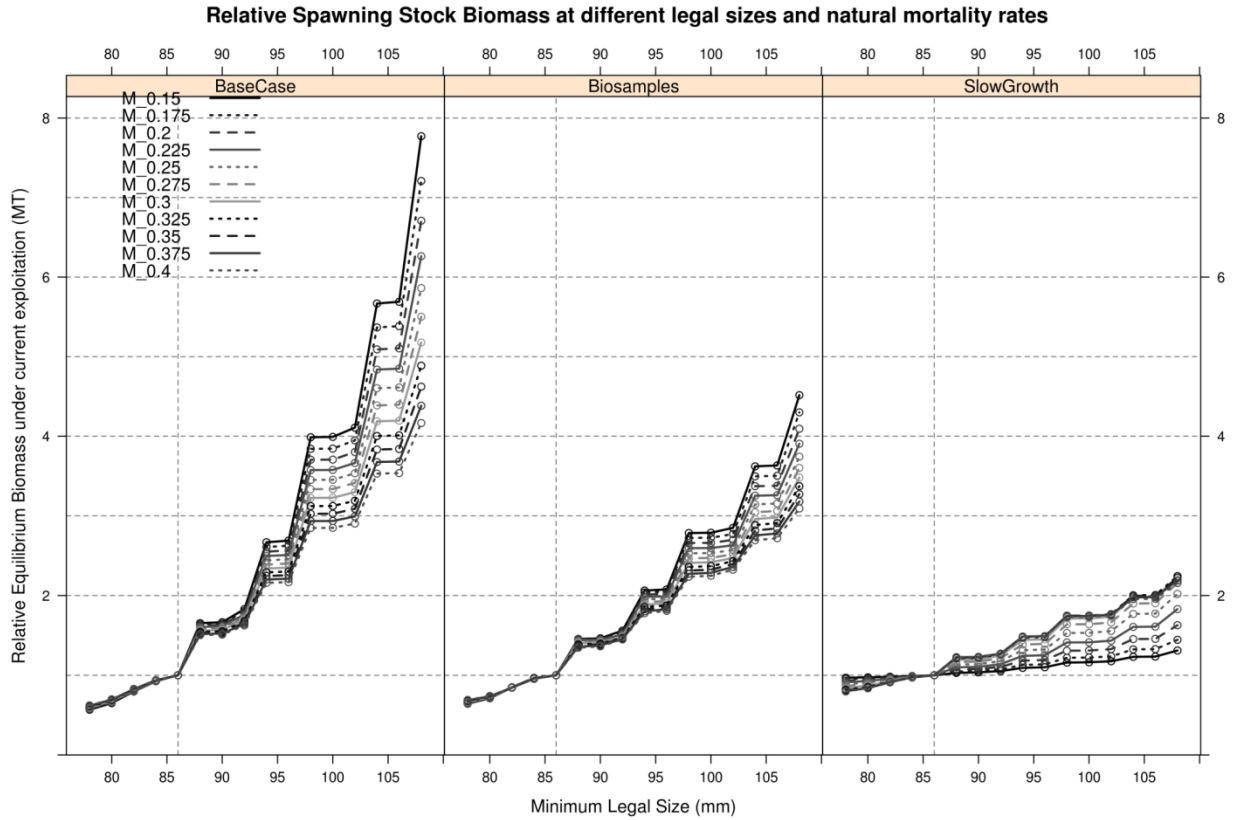


Figure 6. Changes in total biomass (sexes combined) with increasing minimum legal size under different growth and natural mortality scenarios. Growth rates decrease in the panels from left to right with each line within a panel indicating a given natural mortality rate. Values are relative to the current legal size of 86 mm. For interpretation, values less than one represent a decrease in biomass while values greater than one represent an increase in biomass.

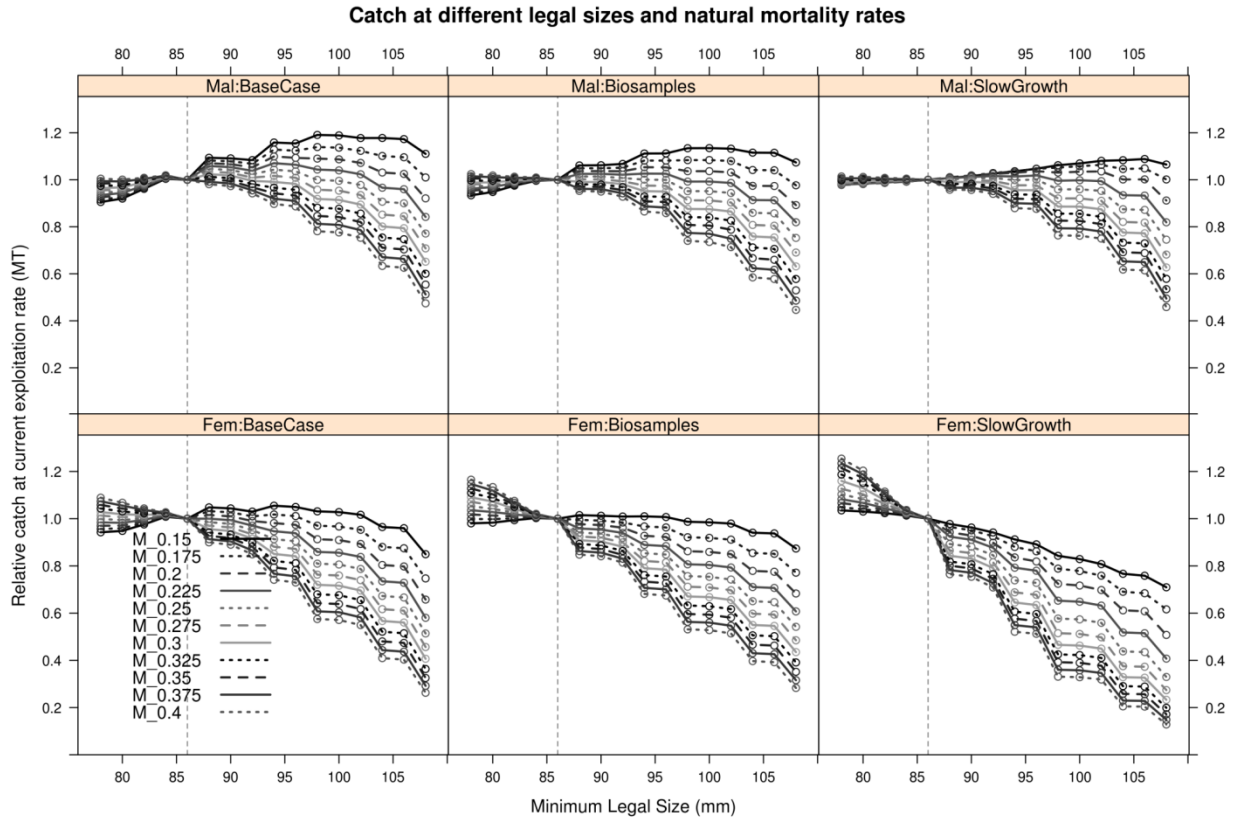


Figure 7. Effects of changing legal size on projected landings by sex for different growth and natural mortality rates. Growth rates decrease in the panels from left to right with males on the top row and females on the bottom and each line indicating a given natural mortality rate. Values are relative to projected landings for a legal size of 86 mm.

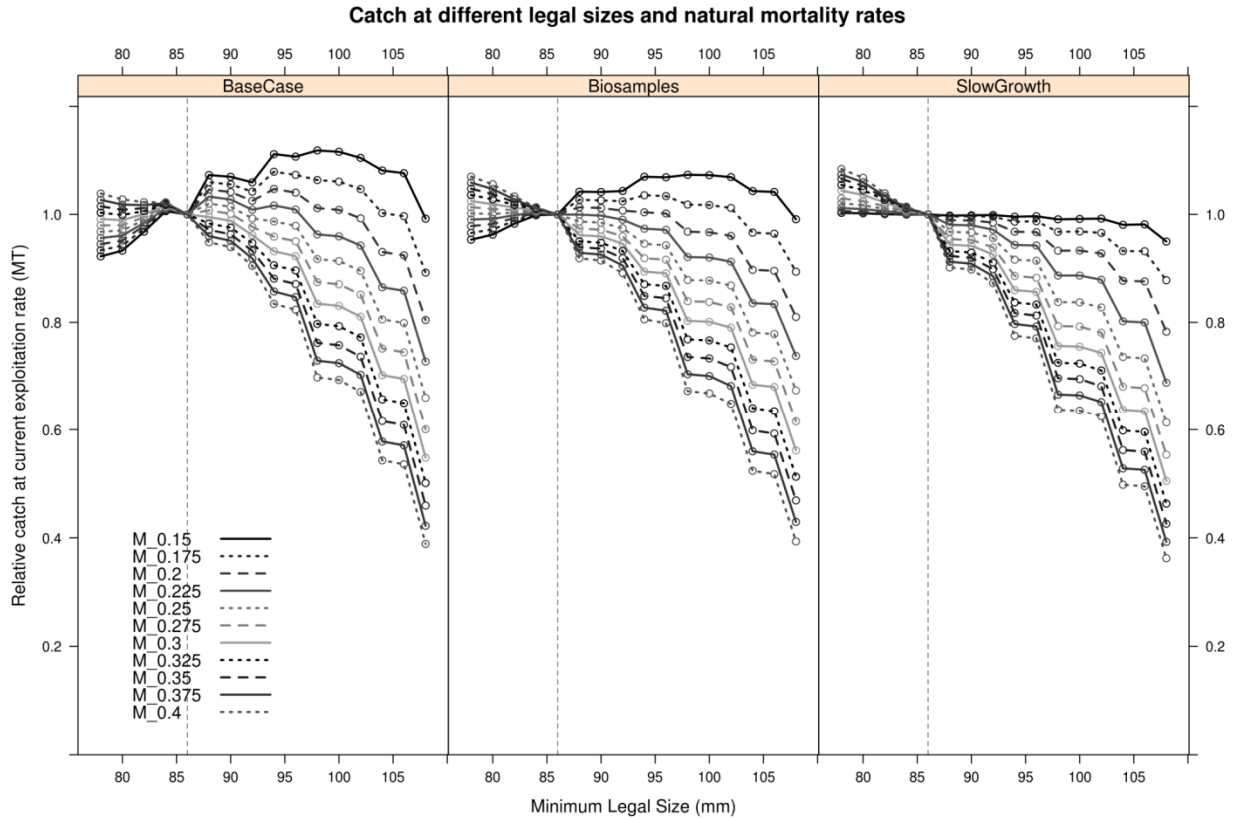
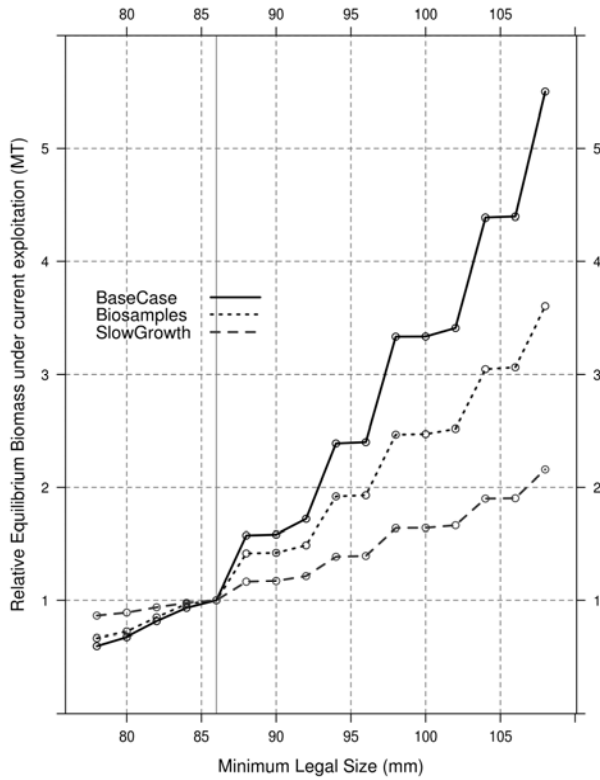


Figure 8. Effects of changing legal size on total projected landings (sexes combined). Growth rates decrease in the panels from left to right with each line indicating a given natural mortality rate. Values are relative to projected landings for a legal size of 86 mm.

Relative Spawning Stock Biomass at different legal sizes at M=0.275



Relative Catch at different legal sizes at M=0.275

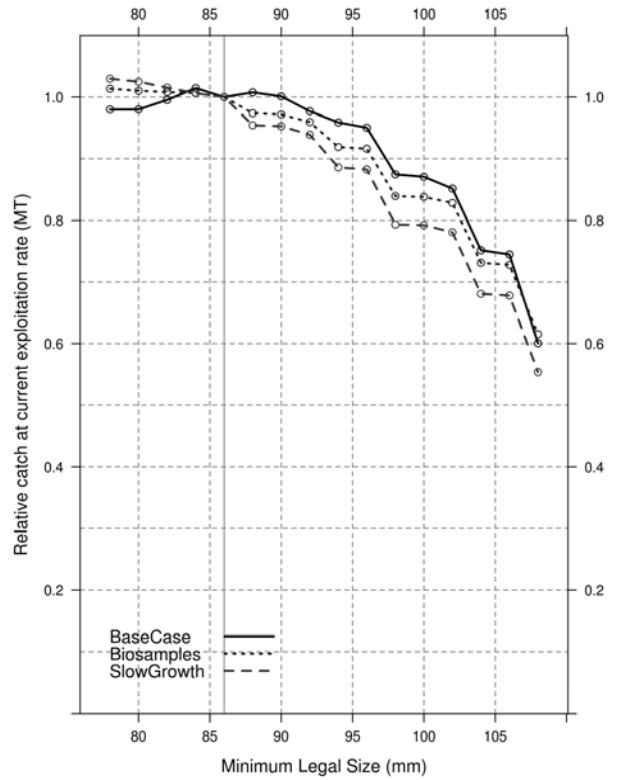


Figure 9. Comparison of changes in total biomass (left) and landings (right) across different growth models assuming a natural mortality of 0.275.

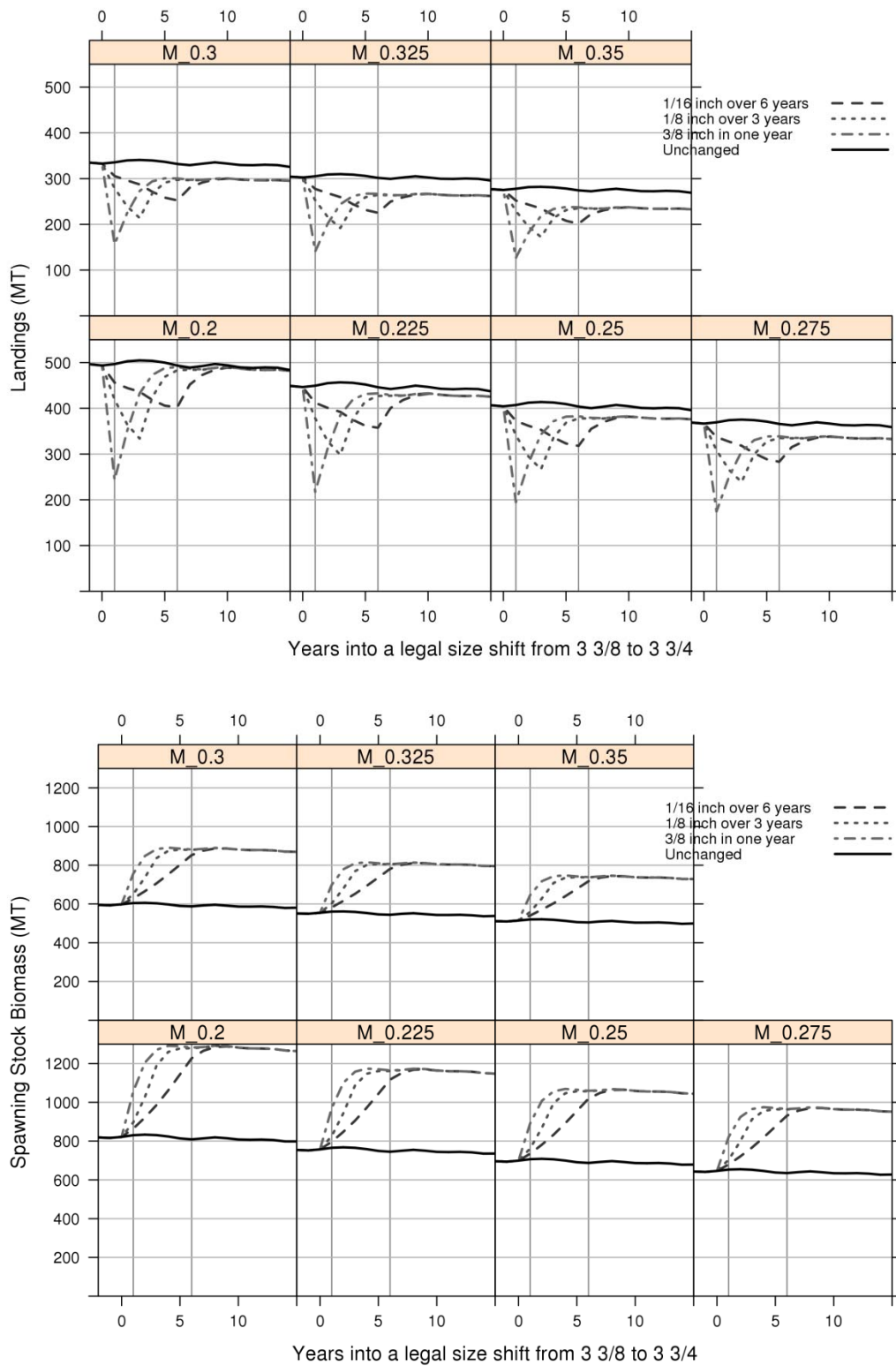


Figure 10. Simulation results illustrating effects of changing minimum legal size on landings and SSB at varying levels of M. Minimum legal size was shifted from 86 mm to 95 mm under three different implementation schedules. Vertical gray lines denote the first and sixth years after initial implementation.

2. SNE Sources of Mortality and Survival Rates

We first calculated the relative importance of natural mortality (M) and fishery extraction (F) on the population SSB (males and females included) using the assessment model output. Loss of SSB from natural mortality was calculated by applying the assumed M to the estimated quarterly length composition to get the numbers of removals by size. We then applied a length-based maturity schedule and length-weight relationship to the removals and summed across lengths and quarters to get annual removal of SSB by weight. For catch effect on SSB, we take the model-predicted quarterly catch-at-size, apply the same maturity schedule and length-weight relationship and sum across size and quarter to get annual removal of SSB. Finally, we calculate surviving SSB using the model-estimated population size and length composition at the end of each year, applying the same maturity schedule and length-weight composition.

Natural mortality has a very consistent impact on SSB within modeled regimes, removing 9% of SSB in the early part of the time series and 17% after the regime shift in the late '90's (Figure 11). Loss of SSB to the fishery varies interannually without trend within modeled regimes (with a slight time lag), accounting for 39% and 35% of SSB in the early and late regimes respectively. The difference in mortality between fishing and natural sources suggests the fishery is currently removing about twice as much SSB from the population annually than natural mortality. This is encouraging as it further suggests that, even at elevated natural mortality rates, management action can still have real effects on spawning stock and egg production.

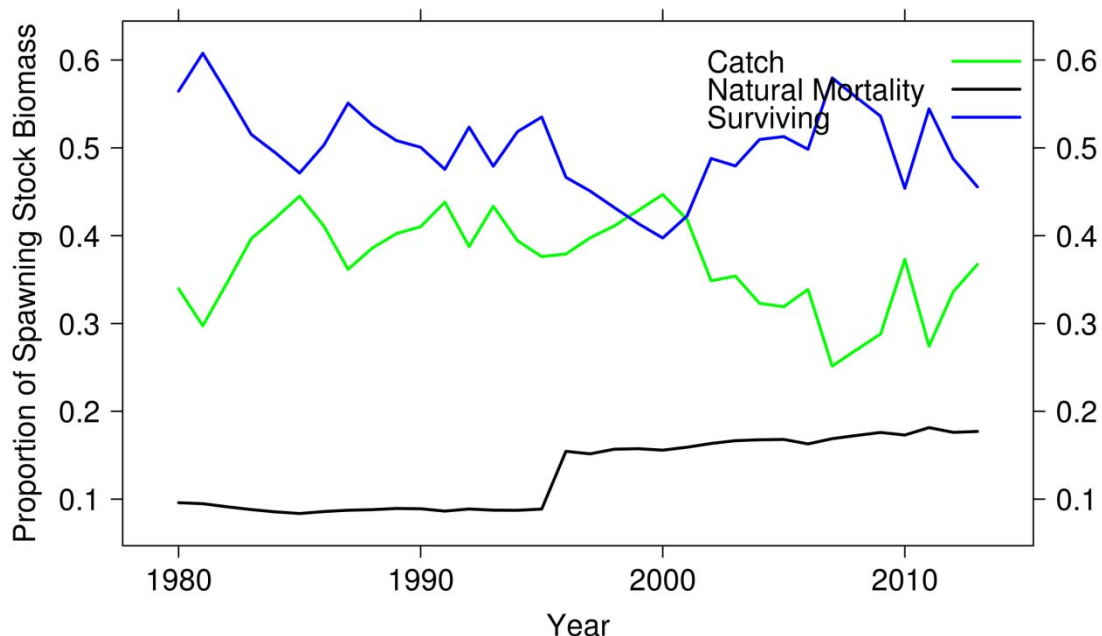


Figure 11. Proportion of SSB surviving or removed by fishing and natural mortality annually.

3. Stock-Recruit History

In the January 19th memo to the Board (re: *Report on TC Tasks from the Nov. 2015 Board Meeting*), the TC presented the model-estimated trajectories of spawning stock biomass and recruitment from 1995 to 2011. Figure 12 shows this same trajectory over an extended time period, from 1979-2011. Analysis of the relationship between SSB and recruits shows recruitment has plummeted over the past decade while SSB remained fairly constant. This suggests depensatory mechanisms may be at play in the SNE lobster stock, such that recruitment drops to very low levels well before SSB reaches zero. Moreover, the resulting rate of recruitment appears to be decoupled from SSB, potentially as a result of reduced mating success, environmentally-mediated changes in survivorship of early life history stages, and/or increased predation.

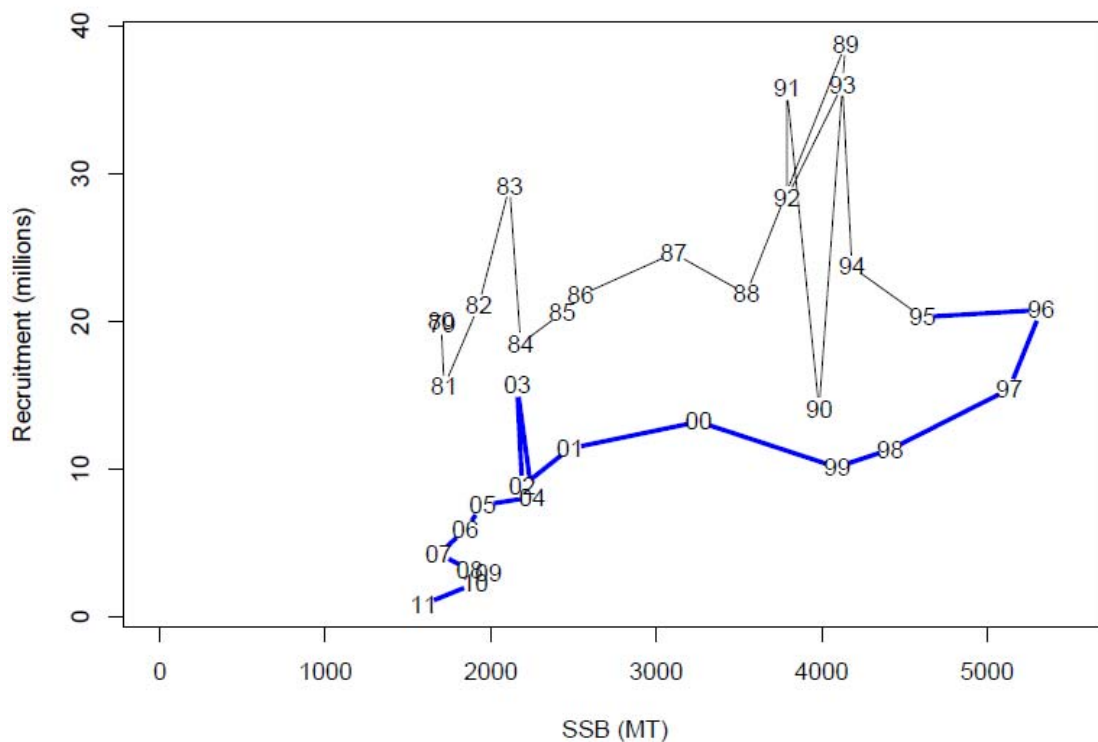


Figure 12: The relationship between model-based spawning stock biomass and recruits from 1979 to 2011. The blue line denotes the trajectory from 1995 – 2011 (recruiting to the model from 1998 to 2014).

4. Costs and Benefits of Standardizing Regulations in SNE

The TC was asked to review the costs and benefits of standardizing regulations across Lobster Conservation Management Areas (LCMAs) in SNE. Overall, the TC felt standardizing regulations would benefit the stock and improve the assessment process but would negatively impact the industry. Furthermore, the TC felt standardizing regulations would create clear winners and losers in the fishery, especially in regards to changes in the minimum and maximum gauge size.

The TC identified three primary benefits to standardizing regulations in SNE. These would largely result in benefits to the stock.

- A. Standardizing regulations would decrease the competitive effects of disparate management measures among LCMAs and would minimize the impacts of management related to size selectivity on the population. Moreover, standardizing regulations would ensure lobsters are equally susceptible to fishing pressure regardless of where they are located in SNE.
- B. Standardizing biological measures would simplify the current regulations, leading to enhanced enforcement and compliance.
- C. Standardizing regulations would improve future analysis on the stock condition as scientists would be better able to estimate the effects of the fishery on the lobster population. Currently, the Stock Assessment Subcommittee must estimate the impact of disparate regulations on the stock by pooling landings from statistical areas to estimate the effects in each LCMA. This introduces uncertainty since the boundaries of the LCMAs and statistical areas do not align. Standardized regulations would eliminate this source of uncertainty and the need to weight the effect of different management measures in future stock assessments.

The TC also identified three costs to standardizing regulations in SNE. These largely result in costs to the fishery.

- A. Standardizing biological measures ignores the existing population demographics, including spatial trends in size and sex. This would create inequities between LCMAs, some of which may be long term due to ontogenetic shifts in lobster habitat use (ie: the movement of lobsters offshore from coastal nursery areas as they get bigger).
- B. Standardizing regulations, namely gauge size, would result in portions of the fleet having to make gear modifications, especially to their escape vent size.
- C. As the LCMAs are currently defined, standardizing regulations in SNE would have impacts throughout Area 3, including Gulf of Maine and Georges Bank (GOM/GB). Should the Board consider standardizing regulations, it may be necessary to separate the SNE portion of Area 3 from that in GOM/GB.

There were also two consequences identified by the TC which could result in a mixture of costs and benefits for different sectors of the fishery.

- A. Increases in the minimum gauge size would disproportionately impact inshore fishermen who primarily rely on lobsters which have recently recruited into the fishery. In contrast, a decrease in the maximum gauge size would primarily impact Area 3 fishermen whose catch is comprised of larger lobsters.
- B. Standardizing biological measures would eliminate the need for permit holders with multi-LCMA trap allocations to declare which Area(s) will be fished. Assuming a fisherman is not limited by his or her trap allocation, uniform regulations (including uniform trap caps) would remove the necessity of the most restrictive rule. This would benefit dual permit holders since they would have greater flexibility in where to fish but

it could be a cost to single area permit holders who may experience increased effort moving into their fishing grounds.

5. Attainability of Recalculated Reference Points

As a follow-up to the analysis presented at the February Board meeting, the TC was asked whether the recalculated reference point of 22.5 million lobsters for the SNE stock is attainable given current environmental conditions (see: TC memo to Board dated January 19, 2016; re: *Report on TC Tasks from the Nov. 2015 Board Meeting*). Given none of the projections which use the current natural mortality of $M=0.285$ show the stock reaching an abundance of 22.5 million lobsters, the TC feels it is very unlikely this reference point will be achieved under present environmental conditions.

6. Inshore/Offshore Tagging Studies

The TC was asked whether a new tagging study would better illuminate connectivity between the inshore and offshore lobster stocks in SNE. Overall, the TC feels previous studies show strong evidence of a migration in which adult lobsters make directed seasonal migrations offshore in the fall and return inshore in the spring (see: TC memo to Board dated January 19, 2016; re: *Report on TC Tasks from the Nov. 2015 Board Meeting*). As a result, the benefit from an additional tagging study may be minimal in increasing our knowledge on stock connectivity. The TC does note a lack of information on growth and size-specific natural mortality in the lobster fishery and believes a tagging study would be useful to address these data gaps. As a result, it may be more fruitful to allocate resources towards a tagging study focused on growth, maturity, molt increments by area, and molt frequency by size. Hurdles to implementing a tagging study include cost and need for significant industry participation. A potential budget for a tagging study is included on page 18 of this report.

A proposal for a tagging study in GOM/GB can be found on page 20 of this report. Following the recommendation of the 2015 American Lobster Benchmark Stock Assessment, the Board combined the GOM and GB stock areas into one biological unit. This boundary revision was based on survey data which showed seasonal fluctuations in the abundance of large female lobster between the GOM and GB. While these data suggest the migration of ovigerous females between the two regions, the specific movement patterns of lobster are poorly understood. The proposal seeks to tag 10,000 lobsters between May 2016 and April 2017 in the nearshore and offshore regions of the GOM/GB stock and is an extension of a tagging study that was conducted in 2015. The goals of the project are to improve knowledge on the movement of lobsters in GOM/GB and to collect growth data using experimental and traditional methods. The project would include participation from New Hampshire Fish & Game, Maine Department of Marine Resources, the Atlantic Offshore Lobstermen's Association, MRAG federal lobster observers, and commercial lobstermen. The total budget for this tagging study is \$107,251.29.

Draft Budget for a Southern New England Tagging Study

Goal:

To document the inshore/offshore movement of lobsters in one comprehensive study under current climatic conditions.

Overview:

This tagging study would take place over the course of a year, with leadership and heavy participation by MADMF and AOLA. Inshore tagging would take place in the spring and summer while offshore tagging would occur in the late fall and winter. A total of 9,000 lobsters would be tagged in the following locations:

- Inshore LCMA2 MA: 1500 tags
- Inshore LCMA2 RI: 1500 tags
- Mid-Shelf/Dumping Grounds: 1500 tags
- Hudson Canyon: 1500 tags
- Block Canyon: 1500 tags
- Atlantis Canyon: 1500 tags

Industry Compensation:

Participating boats would get \$250/\$1000 (inshore/offshore) to take a biologist onboard. In addition, the fishermen would be paid for every legal lobster that was tagged and released at \$6.00/lb based on the length-weight relationship from the data.

Budget:

Salaries	Category	Annual Total
MADMF Fisheries Technician 1 (1 year)	<i>Salary</i>	\$31,200.00
	<i>Fringe</i>	
	<i>Indirect</i>	\$10,077.60
MADMF Fisheries Technician 2 (7 months)	<i>Salary</i>	\$16,800.00
	<i>Fringe</i>	
	<i>Indirect</i>	\$5,426.40
AOLA Staff (salaries for assistance with coordinating project)	<i>Placeholder</i>	\$50,000.00
	Total Salary	\$98,000.00
	Total Fringe	\$0.00
	Total Indirect	\$15,504.00
	Total Salaries	\$113,504.00

Equipment & Supplies		
Tags		\$15,000.00
Laptop, digital cameras		\$2,500.00
Supplies		\$1,500.00
	<i>Total</i>	\$19,000.00
Travel		
Symposia/Conferences		\$2,500.00
Mileage Reimbursements		\$750.00
	<i>Total</i>	\$3,250.00
Contracts		
Legal Lobsters (3500*2lbs*\$6.00)		\$60,000.00
Inshore Tagging Sea Days (30 days @ \$250.00)		\$7,500.00
Offshore Tagging Trips (20 trips @ \$1000 per trip)		\$20,000.00
Tagging Incentives		\$25,000.00
	<i>Total</i>	\$112,500.00
	Total Direct	\$232,750.00
	Total Indirect & Fringe	\$15,504.00
	Grand Total	\$248,254.00

Lobster Migration and Growth:
Continuation and Expansion of 2015 Tagging Effort on Georges Bank

New Hampshire Fish &
Game

Maine Department of Marine
Resources

&

Atlantic Offshore Lobstermen's
Association

SUMMARY OF PRIOR WORK

In 2015, New Hampshire Fish and Game (NHF&G) and the Atlantic Offshore Lobstermen's Association (AOLA) were awarded funds from the Atlantic Coastal Cooperative Statistics Program for a project titled: "Improving American Lobster Biological & Catch/Effort Data for Georges Bank, and Characterizing Seasonal Egger Aggregation in Closed Area II (Statistical Areas 561 & 562)" (NA15NMF4740253). The goal of that project was to document a persistent seasonal aggregation of ovigerous female lobsters in eastern portions of Georges Bank, while gathering fishery dependent biological data in the stock region.

Specific Objectives were to:

1. Deploy NOAA certified observers on randomly selected federal lobster vessels to collect biological, catch, effort and bycatch data in SA 561 and 562 on board multi-day trips.
2. Characterize the catch per unit effort and spatial distribution of ovigerous females in SA 561 and 562 via logbooks given to lobster harvesters.
3. Tag large female lobsters as a cost effective way to understand the distribution and movement of mature female lobsters on Georges Bank.

Project Outcomes:

Industry participation: Logbooks were completed by five vessels, who documented trip data from June through December 2015 during a total of 13,047 trap hauls (368 trawl hauls) in the offshore regions of the Georges Bank/Gulf of Maine stock area (henceforth called GBK/GOM). A total of 48,342 lobsters were counted, of which 19,051 were egg-bearing females. Logbooks were reported from statistical areas 464, 465, 512, 561, 562, 522, and 525 (Figure 1).

Observer trips: MRAG Americas (MRAG) was contracted to sea sample and NOAA Fisheries Northeast Fisheries Science Center (NEFSC) agreed to manage the collected data. Five trips were completed between July and October, for a total deployment of 45.6 seadays. MRAG technicians utilized NOAA Standardized Bycatch Reduction Methodology (SBRM) data

collection protocols (www.nefsc.noaa.gov/fsb/SBRM/). These data will permanently reside in the NOAA SBRM database, which is readily available to members of the Atlantic States Marine Fisheries Commission's (ASMFC) Lobster Technical Committee. NHF&G, AOLA, and staff from NEFSC are currently analyzing these data in preparation for a final report due in May of 2016.

Tagging: MRAG technicians tagged 2,674 female lobsters (ovigerous, vnotched, and/or larger than the maximum gauge) during five trips between August and October, 2015. Coonamesett Farm Foundation (CFF) researchers tagged 409 lobsters between August 2015 and March 2016, during Georges Bank scallop dredge bycatch surveys. CFF and AOLA have entered into an agreement to continue this effort during the 2016 fishing year using surplus tags.

Tag returns and outreach: To date, 67 tag recapture records have been reported by industry members, MRAG, and NEFSC NEFOP. We expect fishermen will report additional recaptures in 2016 as fishing pressure within the tagging area increases.

Data analysis: Project participants are currently working on data analysis and final reporting. Analyses and data will be available to the ASMFC's Lobster Technical Committee by June 2016.

NEED FOR ADDITIONAL FUNDING:

The ASMFC's 2015 peer-reviewed American Lobster Stock Assessment proposed revising stock boundaries to combine Georges Bank (GBK) and Gulf of Maine (GOM). This revision was approved by the Lobster Management Board at their fall 2015 meeting. This recommendation was made by the stock assessment committee based primarily on NOAA trawl data analyses that demonstrated seasonal fluctuations of large animal abundances between GOM and GBK, suggesting migration of animals throughout the region. Additionally, model results performed better when the two areas were run as a single broad stock. This newly defined stock area represents greater than 95% of annual lobster landings, valued at more than \$500 million per year.

While these findings were sufficient to warrant revision of the stock boundaries, the movement patterns between GBK and GOM are poorly understood. There has been only limited research on migration and connectivity between inshore and offshore areas in this region (see literature review in Appendix A). Gaining a better understanding of movement patterns of lobsters in the GBK/GOM stock is particularly germane given the apparent shift in distribution to areas farther away from the coast, and the fact that settlement has been below average in areas of the GOM for the past three to four years. With rapid warming in the region it is imperative that we better understand population dynamics and growth; both questions are at the foundation of the assessment and paramount to making informed management decisions on a fishery with landings in excess of 150 million pounds.

The 2015 Stock Assessment notes the following items as priority research needs:

1. "There is a need for a comprehensive large scale tagging study to examine stock connectivity between the Gulf of Maine and Georges Bank...What is lacking is a tagging study of lobster in the fall/winter on Georges Bank proper, prior to seasonal migration which occur in the spring."
2. "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"

We are seeking \$107,251.29 to tag up to 10,000 additional lobsters during the period of May 2016 to April 2017 in nearshore and offshore regions of the newly identified GBK/GOM stock. An additional year of tagging will not only allow for replication and comparison to 2015 findings, but will also bolster the total number of tags deployed and expand tagging efforts to nearshore Gulf of Maine. Tag returns across both 2015 and 2016 projects will allow for documentation of migration activity in both spring and fall as animals move from winter to summer grounds. Recapture rates with this type of tag are inherently low, especially in offshore areas where fishing pressure is low. Past studies in this area show recapture rates that range from seven to 14 percent (Campbell et al., 1984 and Cooper and Uzmann, 1971). The questions that we hope to answer from this study will require a robust tagging effort as recapture rates are known to be low in this area.

The 2015 tagging effort depended on commercial sampling trips with observers in a target area known for a seasonal aggregation of ovigerous females. Only the ovigerous, v-notched, or oversized female lobsters were tagged and the regions of tagging activity were limited to locations of the commercial fleet on Georges Bank. With the combined GBK/GOM stock, we want to address the questions of where the lobsters are migrating to and from throughout the region. In 2016-2017, we will expand tagging efforts on ovigerous, v-notched, and oversized females to include sublegals of both sexes and oversized males. This will be accomplished through dedicated tagging trips in offshore waters and opportunistic tagging by Maine DMR samplers on day trips in nearshore waters of GOM (outside of three miles). The majority of this effort will be fishery dependent, with the exemption of one study area managed by ME DMR that will be targeted using a fishery independent approach.

To conduct fishery independent tagging, ME DMR will charter an eastern Maine vessel to set gear in an area and at a time of year with low commercial fishing pressure. ME DMR staff will tend this gear via day trips from an eastern Maine port. All hauled lobsters, sublegal and legal, will be tagged and discarded. This effort will allow us to target an area outside of the lobster fishing grounds, providing the released tagged lobsters more time and space to migrate before being recaptured in commercial gear.

In addition to tagging, growth information will be gathered on recaptured lobsters. The American Lobster Stock Assessment utilizes a statistical catch at length model. At the heart of this model is a growth matrix, which is based on a set of probabilities that lobsters of a certain length molt into a larger size bin. Our current knowledge of lobster growth, particularly in the

larger size range (> 90 mm carapace length) is severely limited and could lead to inaccurate estimates. In order to accurately model these populations and to better understand the effects of changing regulations (e.g. minimum and maximum gauge size) it's imperative that we attempt to collect accurate growth data that represents the current environment.

This expanded tagging effort provides the opportunity to collect valuable growth information. In nearshore waters it is unrealistic to distribute calipers and logsheets to the entire fleet. Instead, we will request that fishermen take a picture of recaptured tagged lobsters and use image analysis software, such as ImagePro, to estimate carapace length (CL) (Harbiz, 2007 and Rycroft et. al, 2013). Offshore, where the fleet is smaller, fishermen will be given calipers and asked to both measure and photograph recaptured lobsters. Use of both modalities offshore will allow us to compare the image analysis method to direct measurements and estimate measurement error. It is possible that measurement error will be high, therefore a high sample size of recapture measurements is required in order to collect accurate growth information. This is further justification for the large number of tags requested in this proposal.

Finally, we plan to replicate the industry data collection effort conducted in 2015. We feel it is important to gather a second year of data on the spatial distribution and abundance of ovigerous females in and around statistical areas 561 and 562 to compare to 2015 findings and start to evaluate the spatial and temporal persistence of aggregating ovigerous lobsters.

SPECIFIC OBJECTIVES:

1. Tag 10,000 lobsters in the GBK/GOM broad stock during the period of May – November 2016. Tagging will be conducted by ME DMR and MRAG technicians deployed on federally permitted lobster vessels.
2. Involve the lobster industry in collecting growth data via imaging technology and direct measurements.
3. Replicate industry's 2015 ovigerous lobster data collection effort via logbooks given to lobster harvesters in offshore regions of eastern GOM and GBK.

METHODS:

MRAG Tasks: As was the case for the 2015 field work, MRAG will be sub-contracted to provide fully insured and previously trained technicians to tag lobsters on three multi-day offshore lobster trips into GBK and GOM (30 seadays). MRAG Americas is currently the only company certified by NOAA fisheries to conduct sea sampling on federal lobster vessels. They employ four experienced sea samplers who will participate in this project; these are the same individuals that collected biological data and conducted tagging during our previous project. NHF&G will provide MRAG staff with another round of tagging training before tagging trips.

Technicians will be tasked solely with tagging lobsters and collecting associated biological information, with the goal of applying 6,000 tags. The expectation is that technicians will tag 300-350 lobsters per active fishing day (~7 days during a 10 day fishing trip). In 2015, while collecting a full suite of operational and biological data according to the NOAA SBRM protocol,

technicians were able to tag an average of 100 lobsters per day (min = 21, max = 290). The previous tagging was limited to female broodstock, while 2016 tagging will cover all cohorts of discarded catch, including sublegals and oversized males and females.

ME DMR Tasks: ME DMR will deploy technicians to conduct tagging on federally permitted Maine lobster vessels fishing outside of three miles. This effort will be a combination of fishery dependent tagging during sampling trips and fishery independent tagging. The ME DMR staff will complete at least 10 sampling day trips tagging lobsters on federally permitted vessels outside the 3 mile line with a preference for trips furthest from shore. ME DMR will aim to apply 1,000-2,000 tags; only discards will be tagged, as described above.

The fishery independent tagging project will contract one Maine vessel to set up to 200-300 traps in an offshore region of eastern Maine in June 2016 for 4 weeks. The target area will be selected for low seasonal commercial fishing effort, proximity to the port (so day trips can be conducted), and likelihood of catching lobsters of all sizes. The area of interest is located in a nearshore area off of eastern Maine at depths ranging from 95 – 140 fm. The study area will not conflict with whale migration at this time of year (Erin Summers, ME DMR, Personal communications April 1, 2016). The gear will be configured in trawls of at least 20 traps and each trawl will have two end lines. All gear will comply with whale safe regulations. The traps will be hauled 4-6 times on day trips and all lobsters caught will be tagged and discarded. The goal will be to tag 2,000-3,000 lobsters.

Tagging Procedure: Conspicuously colored t-bar tags will be inserted at the dorsal intersection of the abdomen and tail. These tags are capable of remaining intact after a molt, providing growth information as well as movement data. Printed on each tag will be a unique sequential identification number, a phone number, and "AOLA". For each animal tagged the following data will be collected: date, location, lobster size (CL), sex, egg presence, egg maturity, and v-notch presence. Tagging data will be reported to AOLA for storage.

Growth: To collect growth data, we will use both experimental and traditional methods. We will test the utility of measuring tagged lobster size using image analysis by calibrating CL to a standardized lobster gauge included in photos of recaptured lobsters. We will depend on pictures to estimate CL for recaptures in the nearshore regions. In the offshore areas, volunteers will be outfitted with calipers and asked to both measure and photograph tagged lobsters. Use of both modalities offshore will allow us to estimate measurement error for the image analysis method.

Reward raffles will be used to incentivize industry to report recapture and growth measurements. Each time a fishermen reports a recapture their name will be included in one of two raffles with prizes given out at the end of the project. Recapture reports including growth information will be entered into a higher value raffle than recapture reports alone.

Approximately 16 vessels already have calipers as part of ongoing projects by other parties (primarily in SNE). Recently, MA DMF and AOLA were awarded funds for a 2016 Jonah crab

tagging project which also includes a growth component with industry participation. That project will distribute an additional 22 calipers, although they may be modified for measuring crabs. Given that AOLA is involved in both projects and overlap between the lobster and crab industries, we will leverage the crab project to the extent possible to increase lobster growth reports.

Outreach: To encourage tag returns, AOLA will conduct outreach to all area fishing associations, governmental bodies, and academic researchers via emails, social media sites, Association publications and regional fishing publications, such as Commercial Fisheries News. These efforts will be in conjunction with outreach efforts for the above mentioned Jonah crab tagging project planned for 2016- 2017. The lobster/crab industry has expressed support of these projects and is expected to be active in consistently reporting tag returns, which is vital to the success of a tagging program. Fishermen will be asked to discard animals with tags intact. AOLA will maintain a hotline for tag recapture reports.

COLLABORATIVE APPROACH: NHF&G will provide general Project Supervision and will be the lead on communications with the ASMFC. ME DMR will organize nearshore tagging efforts. AOLA will coordinate offshore tagging and will serve as Project Coordinator, in charge of maintaining the tagging database and recapture hotline.

PERIOD OF PERFORMANCE: Tentatively, May 1, 2016 – April 31, 2017 or one year from when the project funds become available.

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BUDGET: \$107,251.29

	Amount	Rate	Total	In Kind
PERSONNEL				
Supervisor, NHF&G	117	\$53.67	\$6,279.39	
Supervisor, AOLA	30	50		\$1,500.00
Coordinator, AOLA	450	\$30.00	\$12,750.00	
CONTRACTUAL – sea day rates				
MRAG Americas	30	\$725.00	\$21,750.00	
ME chartered Vessel	8	\$6,250.00	\$50,000.00	
SUPPLIES				
Anchor T-Bar Tags	10,000	\$0.64	\$6,400.00	
Tagging Guns and needles	3	\$100.00	\$300.00	
Carrera Digital Calipers – 8”	15	\$30.00	\$450.00	
Shipping Handling			\$100.00	
INDUSTRY				
Raffle rewards			\$8,000.00	
TRAVEL				
Hotel	6	\$70.00	\$420.00	
Per Diem	6	\$74.00	\$444.00	
Mileage	258	\$0.44	\$113.52	
ME Indirect			\$244.38	
TOTAL			\$107,251.29	\$1,500.00

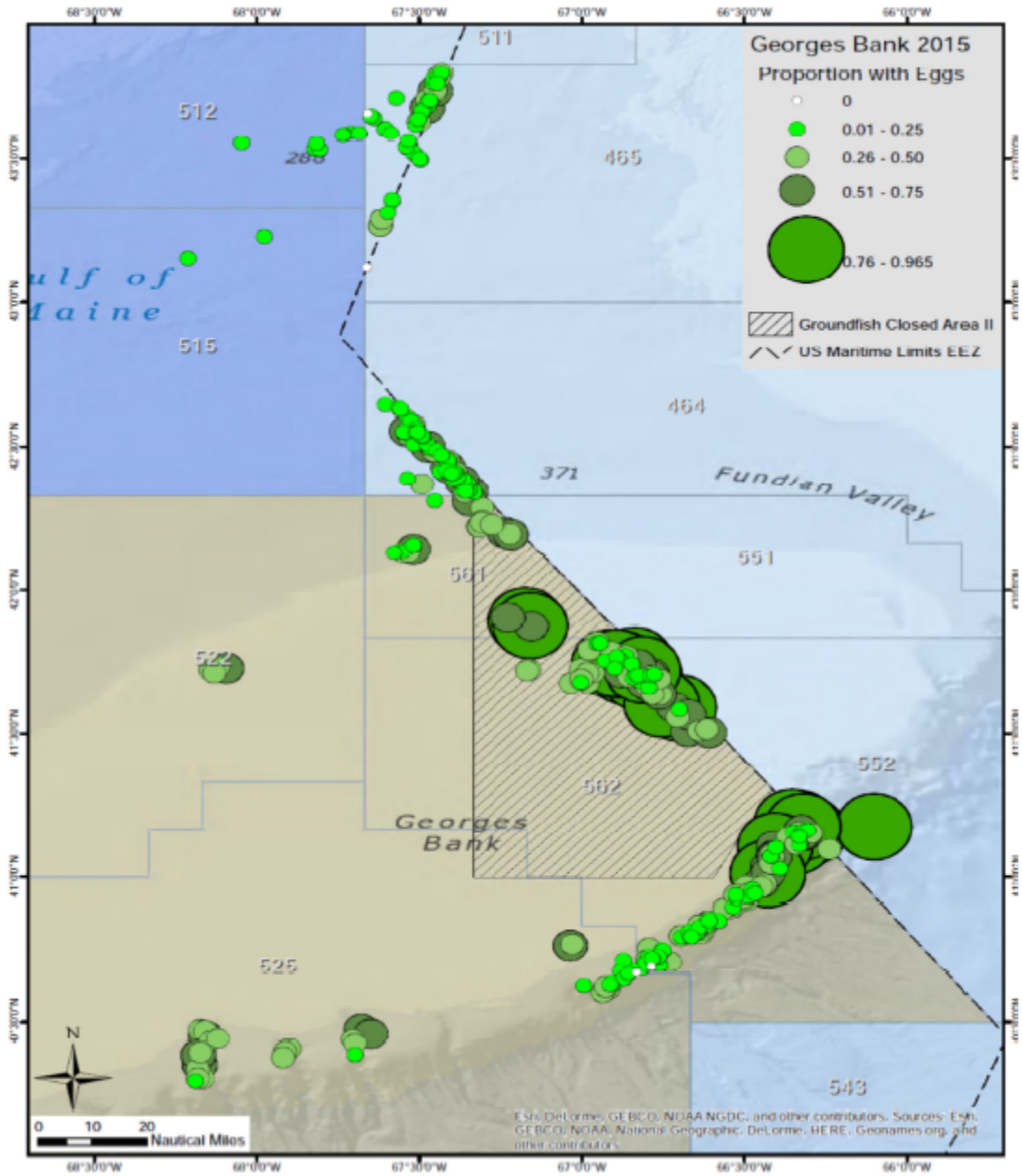


Figure 1. Proportion of total catch that were egg bearing lobsters reported from industry logbooks in Statistical Areas 464, 465, 512, 561, 562, 522, and 525 in 2015.

Appendix A – Literature Review - originally included in ASSCP grant proposal for 2015 funded research

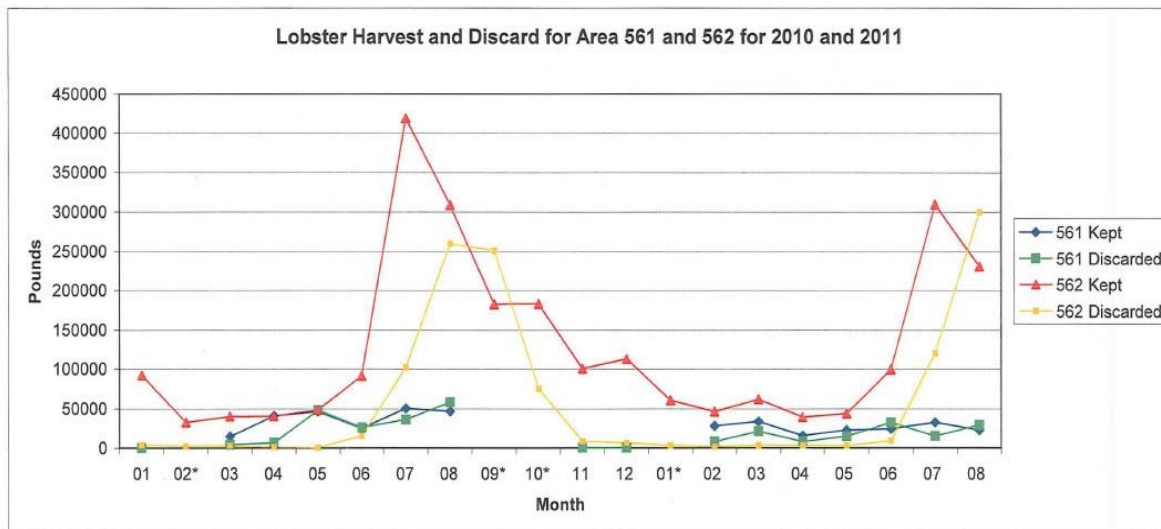
Closed Area II hosts a seasonal lobster fishing fleet of approximately 20-25 large fixed gear vessels (generally 70+ feet in length), fishing 20,000 to 30,000 traps annually and worth over \$4 million. The CA II fleet represents close to one third of the active Lobster Conservation Management Area 3 (LCMA 3) vessels, with approximately one half of the fleet home ported in New Hampshire, the balance split between Massachusetts and Rhode Island. This fleet has been active on Georges Bank for over 30 years. During the last 20 years, there has been very limited mobile gear fishing in large portions of CA II. Lobster harvesters have made substantial investments during this period in vessels, gear, and permits to access the area.

The lobster fleet has historically fished in the study area from June through October, which coincides with the period when the lobster migrate to the shoal waters of Georges Bank. As noted in the NEFMC's Draft Habitat Omnibus Amendment II environmental impact statement (HOA2 DEIS), ovigerous females are present in this area in high numbers, as high as 80% of the haul, July-December of each year (HOA2 DEIS, Volume 3, page 622). These data are supported by the Vessel Trip Reports, with high discard rates reported by offshore lobster vessels in CA II July through September (Figure 1). Most of these females are large (3-8 lbs.), have large egg masses, and would be expected to release their eggs in late fall. These are some of the most fecund individuals in the lobster population, possessing large eggs, which should generally improve larval survival (Attard and Hudon, 1987). Work done by Smith and Howell (1987) showed that monthly incidence of major damage or immediate mortality on lobster from the trawl fishery varied seasonally with values as high as 14% were observed.

In addition to the lack of knowledge regarding the spatial distribution of egg bearing females in offshore waters, there's also a lack of biological sampling in this area for American lobster. The current level of biological sampling in offshore waters is inadequate and the lobster SAS is forced to characterize landings from a very large area on a limited number of samples. This is specifically worrying in the Georges Bank stock area, given its high proportion of offshore waters/offshore fishing compared to the other stock areas. Furthermore, the ACCSP Biological Review Panel ranked lobster in the upper 25 percentile based on sampling priority and sampling adequacy. Increased biological sampling for lobster received the highest priority ranking (5 out of 5) from ASFMC, and a high ranking (3 out of 5) from NOAA NMFS, with current sampling levels marked as inadequate. These data will be used in future stock assessments and all the biological data will be uploaded into the ACCSP data warehouse.

If a resource of this geographical size and magnitude is to be managed as a sustainable fishery, then it is imperative that regional populations are closely monitored and that we gain a better understanding of the distribution of egg bearing females. Protection of egg bearing females is at the foundation of the lobster management pyramid (ASMFC, 2006; ASMFC, 2009), and it's critical to provide protection to areas with known aggregations of these animals. Data collected under this proposal will provide important biological and catch per unit effort (CPUE) data for an offshore fishery that's currently under sampled. Furthermore, the proposed work will

provide a better picture of the spatial distribution of egg bearing females within SA 561 and 562. The proposed work will provide managers with baseline data to properly assess the impacts of opening CA II to mobile gear, as well as providing much needed data to the stock assessment in an area that is currently deficient.



*Removed to protect confidentiality.

Figure 1. Kept and discarded lobster from federal vessel trip reports for Statistical Areas 561 and 562, January 2010 - August 2011. Figure from NH FG’s letter to NEFMC dated January 26, 2012.

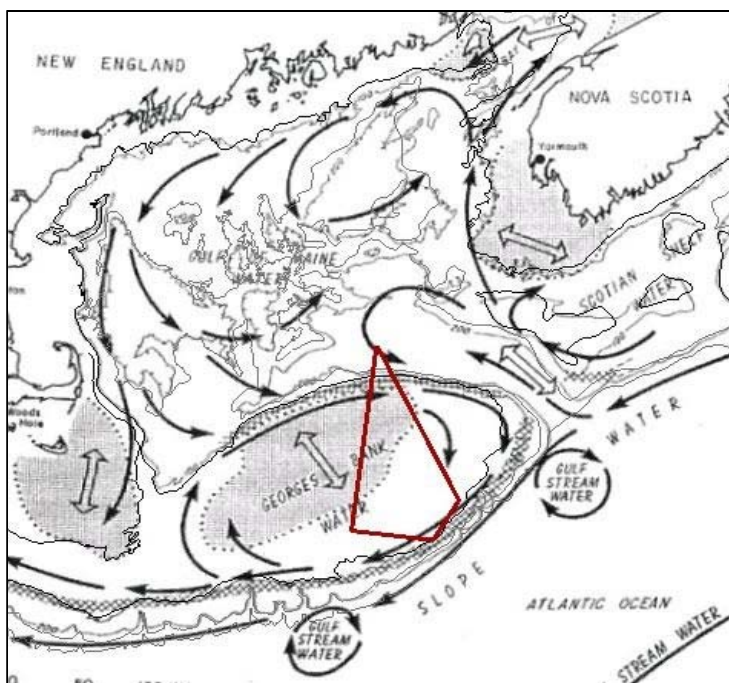


Figure 2. Map taken from NEFMC HOA2 draft environmental impact statement, with Closed Area II superimposed.

Connectivity: The density and persistence of ovigerous females in this area occurs annually, suggesting importance of this area to egg brooding and/or egg release. Given the location of this area and the circular currents that persist in the Gulf of Maine, lobster in this area could be supplying larvae to Georges Bank, as well as inshore fisheries in the Gulf of Maine and/or Southern New England (Figure 2). In view of the declining settlement rates in inshore areas (Wahle et. al, 2013; Figure 3), it is extremely important to characterize location, size composition, and catch rates of egg bearing lobster in the CA II, which will prompt a greater understanding of their potential recruitment contribution to inshore fisheries.

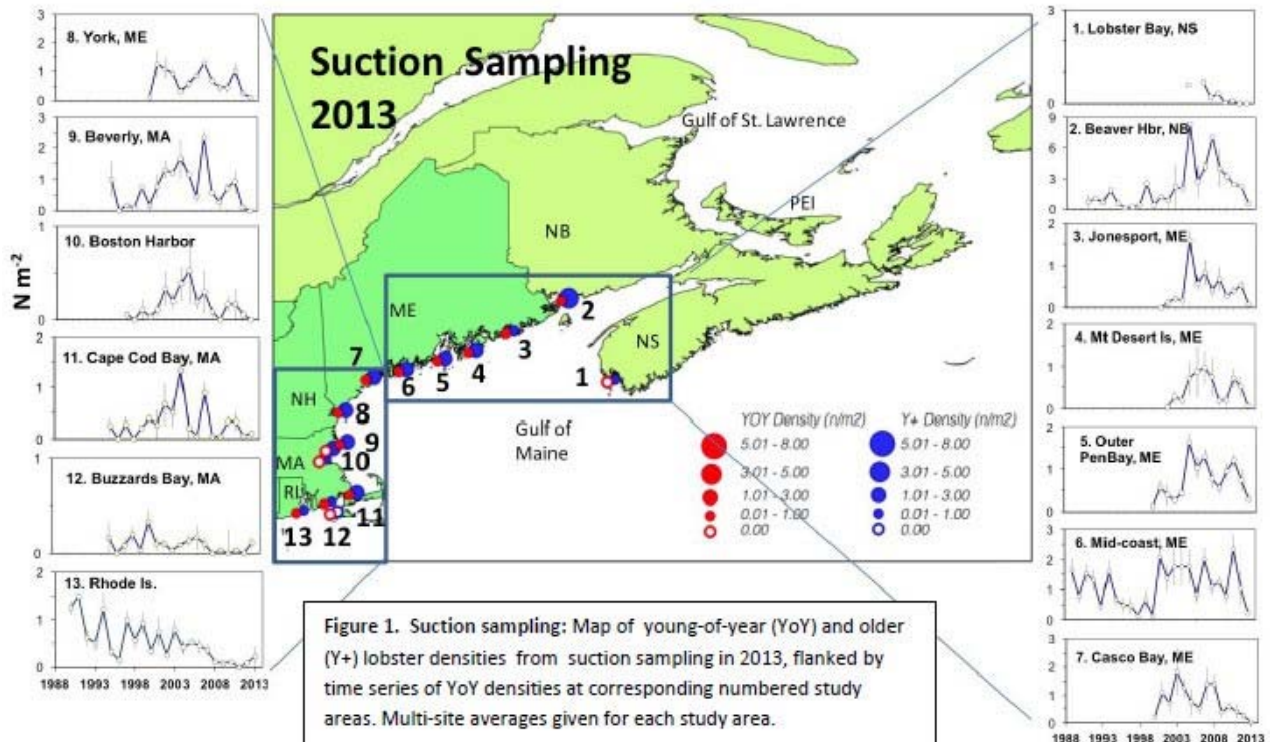


Figure 3. Atlantic Lobster Sustainability Index (ALSI) data, originally published in the 2013 ALSI Annual Report, courtesy of Rick Wahle.

While the scientific community has yet to definitively conclude the interconnectivity of inshore and offshore lobster populations, the body of literature does support the hypothesis that migration and larval transport connect regional lobster populations. We note the following papers and conclusions, as example. Cowan and Watson (2007) show that ovigerous lobster, particularly large females, move offshore to optimize temperature degree days and reduce temperature variability when brooding eggs. Tagging studies show that inshore ovigerous lobster migrate to deeper water in the winter (Campbell, 1986) and offshore lobster migrate inshore in the summer (Cooper and Uzmann 1971). Watson (unpublished, 2007) in collaboration with AOLA did related tagging work showing that ovigerous lobster reside in deep water in the winter and move to shallower water in the summer. He found that offshore eggers move more than inshore and that larger lobster (>90mm CL) moved much farther than

smaller ones. Data collected by AOLA members since 2001, show that most of the female egg bearing lobster within CA II are greater than 90 mm carapace length (CL). Watson (unpublished, 2009) also found evidence for brooding-site fidelity, although this work was not done on Georges Bank. He also tracked lobster movement from inshore New Hampshire to offshore Gulf of Maine.

In regard to larval transport, a number of studies potentially link the inshore and offshore lobster stocks. Work by Canadians in the 1980s and 1990s document larval lobster in the waters above Georges and Browns Bank in the summer and suggest that ovigerous females release larvae from shoal areas (Harding, et. Al, 2003 review). From drifter work they inferred that larvae released offshore would be transported inshore (as described by Hare, 2005). Harding and colleagues (1983) found that oceanographic data (wind, tidal forces, seasonal surface circulations and occasional plumes escaping the northern edge of Georges Bank) and the ability of later stage larvae to conduct directional swimming support a high level of offshore to inshore connectivity and suggest that the Gulf of Maine, inclusive of Georges Bank, could be considered a single lobster recruitment system with larvae expected to move counterclockwise. Lawrence and Trites (1983) modeling surface oil from Georges/Brown Bank region in the summer found frequent impacts on coastlines of southwestern Nova Scotia and Bay of Fundy.

Incze, Xie and colleagues have published a series of papers related to modeling larval dispersal and population connectivity in the Gulf of Maine (Incze and Naime, 2000; Incze, et al., 2006, Xue et al., 2008; Incze, et. al, 2010). Their work suggests that recruitment can be a very local event, but there is potential for long distance dispersal, especially when females hatch eggs farther from shore. Modeling work by Fogarty (1998) of the NOAA Fisheries Northeast Fisheries Science Center found that even relatively low levels of larval transport from offshore to inshore could explain resilience of the inshore population despite high levels of fishing mortality. Hare (2005) of the NOAA's National Ocean Service, advocates for the "precautionary approach", noting that offshore larval supply need be considered when managing inshore lobster fisheries.

South of Cape Cod, Katz et al. (1994) sampled larvae along an offshore-inshore transect (Hydrographers Canyon to Rhode Island waters) and found a gradient of stages with a greater proportion of earlier stage lobster larvae offshore and later stage lobster larvae inshore, suggesting hatching offshore and transport inshore. Further, Crivello et al. (2005) used genetic methods to link Long Island Sound larval lobster to female lobster from Hudson Canyon, suggesting that up to 45% of the larvae in Long Island Sound came from Hudson Canyon females. There is also morphometric evidence from throughout the region supporting mixing of inshore and offshore stocks (Harding et al., 1993; Cadrin, 1995). Documenting aggregations of egg bearing females is a critical step in understanding the eventual location of settlement.

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