Introduction

The 2020 benchmark stock assessment for American lobster provides the most recent information on the status of U.S. American lobster stocks. The assessment expanded focus on environmental influences on lobster population dynamics and was peer-reviewed by an independent panel of scientific experts through the Atlantic States Marine Fisheries Commission's external review process.

Management Overview

The management unit for American lobster (*Homarus americanus*) extends from Maine through Virginia. The population was historically divided into three biological stock areas which include the Gulf of Maine (GOM), Georges Bank (GBK), and Southern New England (SNE), but GOM and GBK were collapsed into one stock (GOM/GBK) based on evidence of stock connectivity discovered during the 2015 stock assessment. The GOM/GBK and SNE stock structure was maintained in this assessment.

American lobster is managed under Amendment 3 to the Interstate Fishery Management Plan (FMP) and its subsequent Addenda I-XXVI. The Amendment seeks to limit effort and increase egg production in the fishery by instituting traps limits, setting minimum/maximum sizes, and prohibiting the possession of egg-bearing lobsters and v-notched females.

Subsequent addenda to Amendment 3 have modified management measures to reduce exploitation and established reporting and data collection programs to improve understanding of the fisheries and stocks. Several addenda specifically aimed to rebuild the SNE stock after the 2006 and 2009 stock assessments found it to be depleted. In 2012, Addendum XVII required a 10% reduction in exploitation for SNE, and Addendum XVIII reduced traps allocated to the inshore SNE by 50% and to SNE offshore waters by 25% over 5 years.

Addendum XXV was initiated in response to the 2015 stock assessment showing continuing declines in the SNE stock, which considered management tools such as gauge size changes, trap reductions, and season closures to achieve a 5% increase in egg production. However only one out of the five Lobster Conservation Management Team proposals evaluated was sufficient to achieve this target, and the Board ultimately decided not to move forward with the Addendum.

What Data Were Used?

The assessment used both fishery-dependent and fishery-independent catch and size composition data as well as information about lobster biology, life history, and environmental interactions. Fishery-dependent data came primarily from the commercial fishery. Fishery-independent data were collected through scientific research and surveys.

Life History

American lobster is a bottom-dwelling crustacean that prefers rocky habitat, but can also be found on sand or mud bottoms. The species' range extends from Newfoundland south to the Mid-Atlantic region. In the U.S., American lobster is most abundant from the inshore waters of Maine to Cape Cod, Massachusetts.

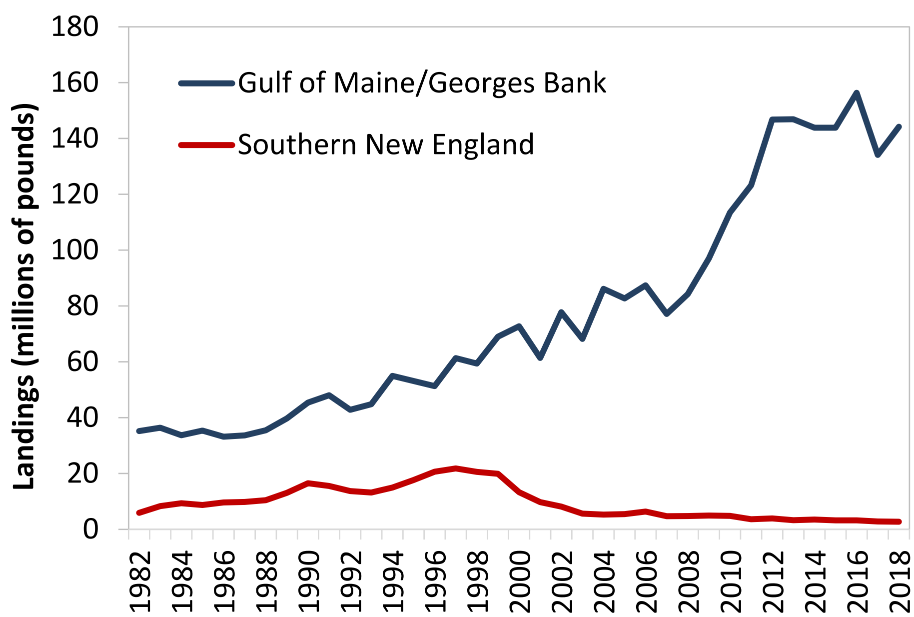
Lobsters grow by molting, which results in incremental growth patterns. This makes age determination, which is typically conducted using a species' anatomical hard parts, difficult as all hard parts are shed with each molt. Recent research reviewed in the assessment provides some promising signs of age determination using the gastric mill, a structure found in the stomach of lobsters. However, further research is necessary to understand the process responsible for marks on this structure that are counted as annual age marks before these data become useful for stock assessment. Lobsters have long life spans and continue to grow throughout their lives, potentially reaching more than 40 pounds in weight. Females carry fertilized eggs externally for 9-11 months, which then hatch into pelagic larvae that are dispersed passively (water currents) and actively (swimming behaviors). Larvae settle on the sea floor and begin the benthic phase of their life history that continues through the remainder of their life.

All aspects of lobster life history are strongly influenced by water temperature. Due to increasing water temperatures in the Northwest Atlantic, lobsters in the GOM/GBK stock appear to be experiencing longer time periods within an optimal temperature range of 12° – 18° C. This is likely contributing to increased recruitment in this stock. In contrast, water temperatures in SNE have increased to an extent that is producing stressful conditions for lobsters (≥20° C), with many portions of the inshore environment experiencing prolonged time periods at these temperatures. These stressful temperatures cause a number of health issues in lobsters and are likely contributing to the lack of recruitment in the SNE stock.

Commercial and Recreational Data

Fishery-dependent data sources used in the stock assessment include commercial landings, effort, and biological sampling during at-sea and port sampling. Commercial at-sea and port sampling programs provide data that characterize the commercial catch, in terms of size composition and sex ratio. The commercial at-sea sampling programs also provide information on discards of egg-bearing females and v-notched females, which are released alive to protect the spawning stock.

Figure 1. American Lobster Landings by Stock Area



There are notable differences between the fisheries that operate in each of the two areas of the GOM/GBK stock. The GOM fishery accounts for the vast majority of U.S. lobster landings, averaging 81% of the landings since 1982 and is predominately carried out by small vessels (22 to 50 feet) making day trips in nearshore waters (< 12 miles). The GBK fishery is considerably smaller, averaging 5% of the landings since 1982, and is predominantly carried out by larger vessels (55 to 75 feet) making multi-day trips to offshore waters (> 12 miles). Total GOM/GBK landings increased from the late 1980s from approximately 35 million pounds through the 2000s, exceeding 100 million pounds for the first time in 2010. Landings since 2012 have been relatively stable at the highest levels on record, averaging 145 million pounds.

Historically, the SNE fishery was predominately an inshore fishery with landings that peaked in 1997 at 21.8 million pounds and accounted for 26% of the U.S. lobster landings. Following the peak, landings declined to the lowest on record in 2018 (2.7 million pounds), accounting for only 2% of the U.S. landings. The fishery has also shifted to a predominantly offshore fishery as inshore abundance has declined.

Recreational data are limited, but available data indicate recreational harvest is a negligible source of fishery removals.

Fishery-independent Surveys

There are multiple bottom trawl surveys (otter trawls) available for use in the assessment. Maine/New Hampshire (ME/NH), Massachusetts, Rhode Island, Connecticut and New Jersey conduct surveys within their respective state waters. Additional surveys available are a nearshore survey conducted by the Northeast Area Monitoring and Assessment Program (NEAMAP) that encompasses the Mid-Atlantic to Block Island Sound as well as the NOAA Fisheries Northeast Fisheries Science Center (NEFSC) survey covering U.S. offshore waters from Maine to New Jersey. These surveys all employ a stratified random sampling design and occur at least twice a year, in the spring and fall. These surveys provided indices of relative lobster abundance for assessing changes in abundance through time. GOM/GBK survey indices indicate increasing relative abundance since the early 2000s. Survey indices in SNE generally indicate peak abundance in the mid- to late 1990s, followed by declines to very low levels in recent years.

Beginning in 2006, the states of Maine through New York have collaborated with commercial lobster harvesters to conduct standardized ventless trap surveys (VTS). These surveys provide stock-specific indices of abundance from an alternative gear that can better access preferred lobster habitat than trawl surveys. Sampling in Long Island Sound by New York and Connecticut was discontinued in 2010, but sampling north of Long Island Sound is ongoing. The GOM/GBK VTS index indicates increasing abundance followed by relatively stable abundance since 2014, while the SNE index shows declines in abundance.

Young-of-the-year (YOY) larval and settlement surveys are also used to provide information regarding incoming recruitment to the stocks. There were two larval surveys available from Long Island Sound, one being an entrainment survey and the other being a plankton net survey. Several settlement surveys were also available from Maine (GOM/GBK), Massachusetts (GOM/GBK and SNE), and Rhode Island (SNE). These surveys are SCUBA-based air-lift suction sampling that provide density estimates of newly settled YOY lobsters. GOM/GBK settlement surveys have been trending downwards since the mid-2000s, particularly in Area 513 (east and west) and Area 514. In SNE, settlement and larval indices have declined and remain at very low levels.

Environmental Data

Extensive research has highlighted the influence of the environment on American lobster life history and population dynamics. Among the critical environmental variables, temperature stands out as the primary influence. Further, lobster's range is experiencing changing environmental conditions at some of the fastest rates in the world. Therefore, considering these environmental influences is vital when assessing lobster stocks and was a focal point of this stock assessment. Environmental data time series included water temperatures at several fixed monitoring stations throughout the lobster's range, average water temperatures over large areas such as those sampled by fishery-independent surveys, oceanographic processes affecting the environment, and other environmental indicators such as lobster prey abundance.

Environmental time series were analyzed for regime shifts, which indicate a significant difference in the lobster's environment and population dynamics from one time period to another. Regime shifts can change a stock's productivity, impacting the stock's level of recruitment and its ability to support different levels of catch. Temperature time series were also analyzed to quantify the effect of temperature on survey catchability of lobster and correct trends in abundance estimated from surveys by accounting for temperature-driven changes in catchability through time.

What Models Were Used?

The University of Maine Stock Assessment Model for American Lobster (UMM, Chen et al. 2005) was used to assess each stock and determine stock status. The UMM is a statistical catch-at-length model that tracks the population of lobster by sex, size, and season over time. The model starts tracking lobster once their carapace grows to at least 53 mm (about 2.1 inches) and they are approximately age-4 or age-5 in SNE or GOM/GBK stocks, respectively, so that all lobster are tracked at least one molt before reaching a harvestable size. Observed survey indices, time series measuring temperature effects on survey catchability, landings data, size compositions of catch, size selectivity by the commercial fishery, and assumed life history characteristics (growth, natural mortality, maturity) are inputs to the model. The model generates predictions of survey indices, landings, and size compositions as close to the observed inputs as possible and uses these predictions to estimate population parameters including recruitment, total abundance, spawning stock biomass, and exploitation rates. The trends in these model-estimated population parameters tend to be more certain than the overall magnitude of the estimates. As such, trends and their respective reference points are more useful in determining stock status because they are less influenced by the magnitude of population estimates.

GOM/GBK

Abundance estimates for the GOM/GBK stock show an increasing trend beginning in the late 1980s. After 2008, the rate of increase accelerated to a record high abundance level in 2018. Spawning stock biomass and recruitment are also at or near record highs. Analysis of these estimates indicates increasing stock productivity (number of recruits produced by spawning stock biomass) through the 1980s, followed by a relatively stable period of productivity before a slight shift to high productivity in 2007.

Exploitation of the GOM/GBK stock declined in the late 1980s and has remained relatively stable since.

SNE

In contrast to GOM/GBK, model results for SNE show a completely different picture of stock health. Abundance estimates in SNE have declined since the late 1990s to record low levels. Model estimates of recruitment and spawning stock biomass have also declined to record low levels. Analysis of these estimates indicates a declining trend in stock productivity, indicating reproductive success is insufficient to sustain a stable population at current exploitation rates.

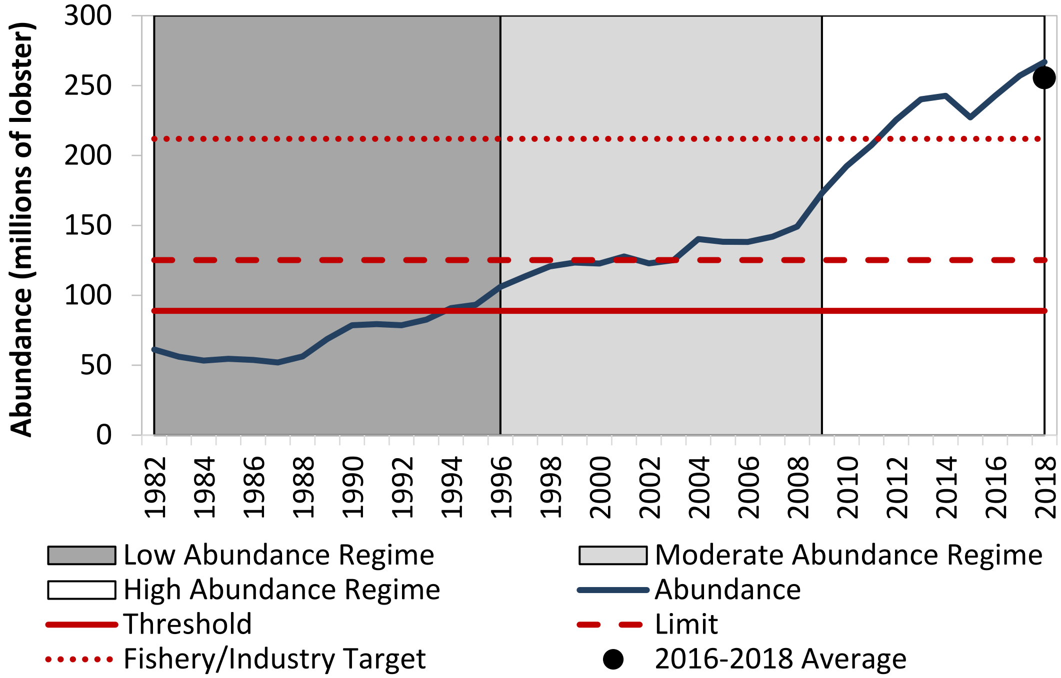
Exploitation of the SNE stock was high and stable through 2002, declined sharply in 2003, and has remained lower and stable since.

What is the Status of the Stock?

Reference Points

Abundance and exploitation reference points are used in the stock assessment. In previous stock assessments, abundance and exploitation were compared to reference points calculated as percentiles of abundance and exploitation during a fixed reference period (1982-2003 for GOM/GBK and 1984-2003 for SNE) to determine stock status. These reference periods were based on the full time series of estimates during the 2005 assessment, but there has been a growing belief that these reference periods may not be appropriate given the changes in environmental conditions these stocks have experienced since the 2005 stock assessment.

Figure 2. Abundance for GOM/GBK Relative to Reference Points



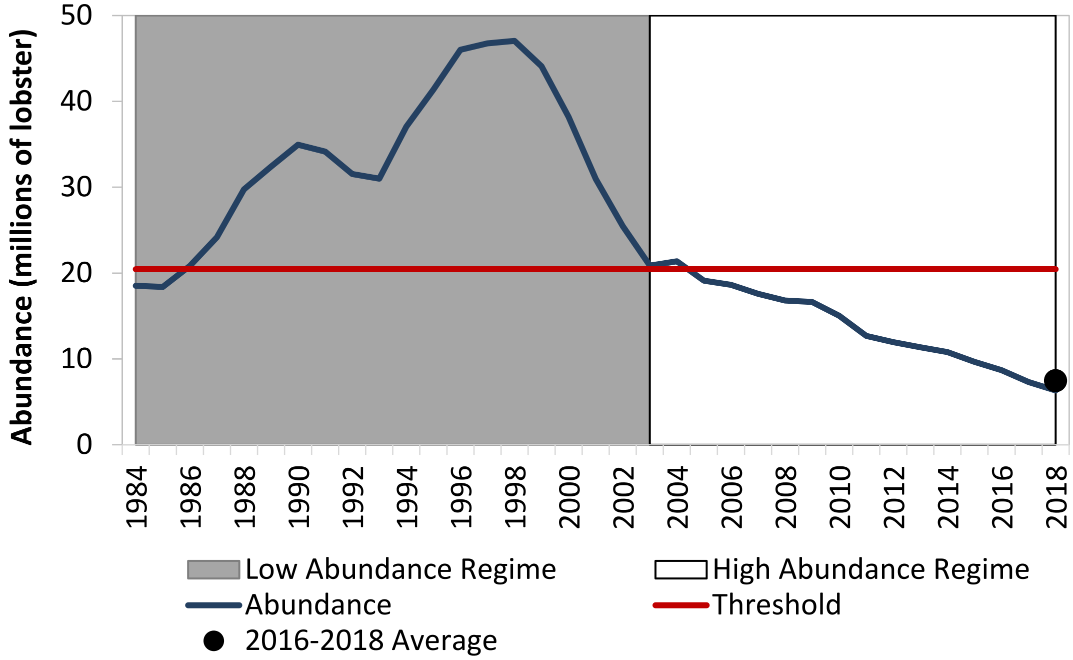
GOM/GBK stock abundance (solid blue line) compared to the fishery/industry target (dotted red line), abundance limit (dashed red line), and abundance threshold (solid red line) reference points based on detected low (dark grey period), moderate (light grey period), and high (white period) abundance regimes. The circle is the three-year (2016-2018) average reference abundance.

As a result, model-estimated abundance time series were analyzed for shifts that may be attributed to changing environmental conditions and new baselines for stock productivity. Regime shifts were detected for the GOM/GBK stock in 1996 and 2009 and one shift was detected for the SNE stock in 2003. The GOM/GBK stock shifted from a low abundance regime during the early 1980s through 1995 to a moderate abundance regime during 1996-2008, and shifted once again to a high abundance regime during 2009-2018 (Figure 2).

Conversely, the SNE stock shifted from a high abundance regime during the early 1980s through 2002 to a low abundance regime during 2003-2018 (Figure 3). New reference points were developed to account for the changing regimes.

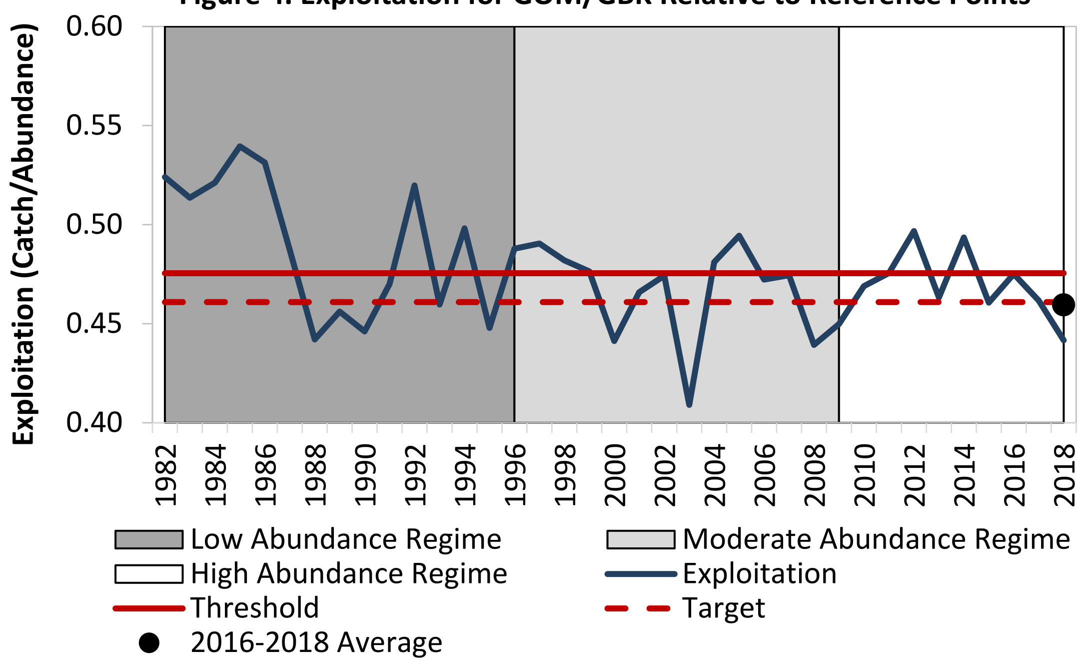
In this assessment, three reference points are used to characterize stock abundance. The **abundance threshold** is calculated as the average of the three highest abundance years during the low abundance regime. A stock abundance level below this threshold is considered significantly depleted and in danger of stock collapse. This was the only abundance reference point recommended for the SNE stock due to its record low abundance and low likelihood of reaching this threshold in the near future. The **abundance limit** is calculated as the median abundance during the moderate

Figure 3. Abundance for SNE Relative to Reference Points



SNE stock abundance (solid blue line) compared to the abundance threshold (solid red line) reference point based on detected low (dark grey period) and high (white period) abundance regimes. The circle is the three-year (2016-2018) average reference abundance.

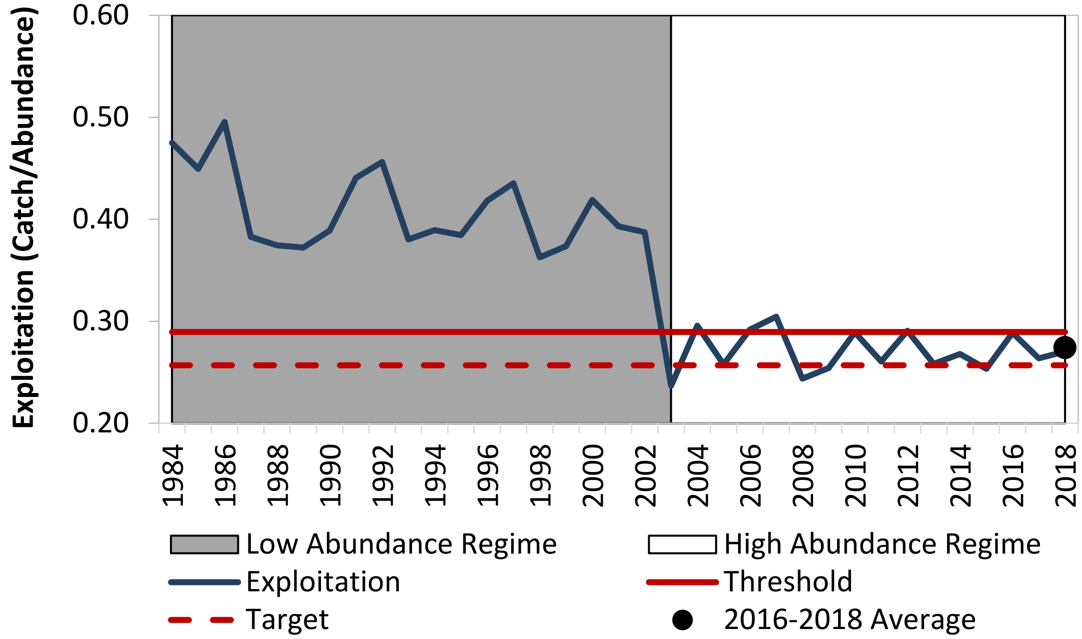
Figure 4. Exploitation for GOM/GBK Relative to Reference Points



Exploitation for GOM/GBK stock (solid blue line) compared to the exploitation target (dashed red line) and exploitation threshold (solid red line) reference points based on detected high (dark grey period), moderate (light grey period), and low (white period) exploitation regimes. The circle is the three-year (2016-2018) average reference exploitation.

abundance regime. Stock abundance that falls below this limit is considered depleted because the stock's ability to replenish itself is diminished. The **fishery/industry target** is calculated as the 25th percentile of the abundance during the high abundance regime. In this case, when abundance falls below this target, the stock's ability to replenish itself is not jeopardized, but it may indicate a degrading of economic conditions for the lobster fishery.

Figure 5. Exploitation for SNE Relative to Reference Points



Exploitation for SNE stock (solid blue line) compared to the exploitation target (dashed red line) and exploitation threshold (solid red line) reference points based on detected high (dark grey period) and low (white period) exploitation regimes. The circle is the three-year (2016-2018) average reference exploitation.

Two reference points are used to evaluate the fishing mortality condition of the stocks. The **exploitation threshold** is calculated as the 75th percentile of exploitation (annual catch in numbers divided by abundance) during the current abundance regime. The stock is considered to be experiencing overfishing if exploitation exceeds the exploitation threshold. The **exploitation target** is calculated as the 25th percentile of exploitation during the current abundance regime.

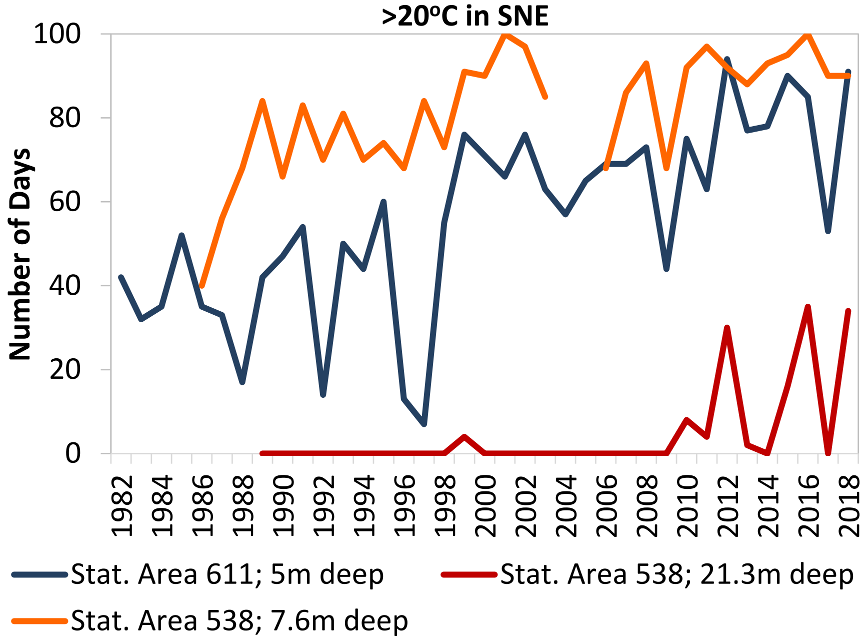
Based on these reference points, the GOM/GBK stock is not depleted and overfishing is not occurring (Figures 2 and 4, respectively). The average abundance from 2016-2018 was 256 million lobster, which is greater than the fishery/industry target of 212 million lobster. The average exploitation from 2016-2018 was 0.459, below the exploitation target of 0.461.

The SNE stock is significantly depleted and overfishing is not occurring (Figures 3 and 5, respectively). The average abundance from 2016-2018 was 7 million lobster, well below the abundance threshold of 20 million lobster. The average exploitation from 2016-2018 was 0.274, falling between the exploitation threshold of 0.290 and the exploitation target of 0.257.

Indicators

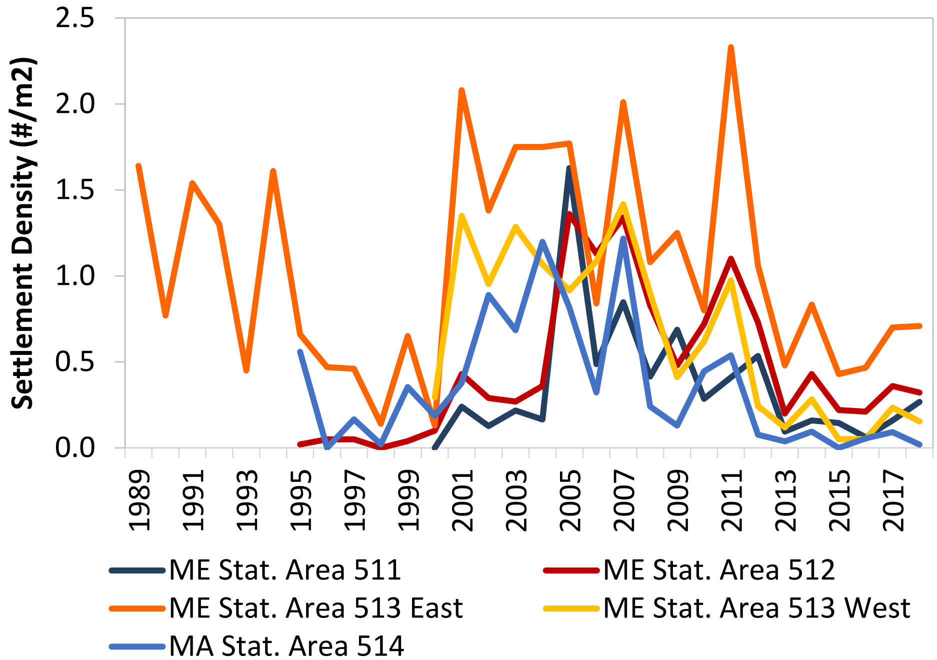
Stock indicators were also used as an independent, model-free assessment of the lobster stocks. These indicators are based strictly on observed data and are free from inherent assumptions in the population dynamics models. Indicators developed in previous stock assessments and updated during this stock assessment include exploitation rates as an indicator of mortality; YOY, fishery recruitment, and spawning stock biomass as indicators of abundance; encounter rates as an indicator of distribution; and total landings, effort, catch per unit effort, and monetary measures as fishery performance indicators. During this assessment, annual days with average water temperatures >20°C at several temperature monitoring stations and the prevalence of epizootic shell disease in the population were added as indicators of environmental stress. The 20°C threshold is a well-documented threshold for physiological stress in lobsters. Epizootic shell disease is considered a physical manifestation of stress that can lead to mortality and sub-lethal health effects.

Figure 6. Number of Days Bottom Temperature >20°C in SNE



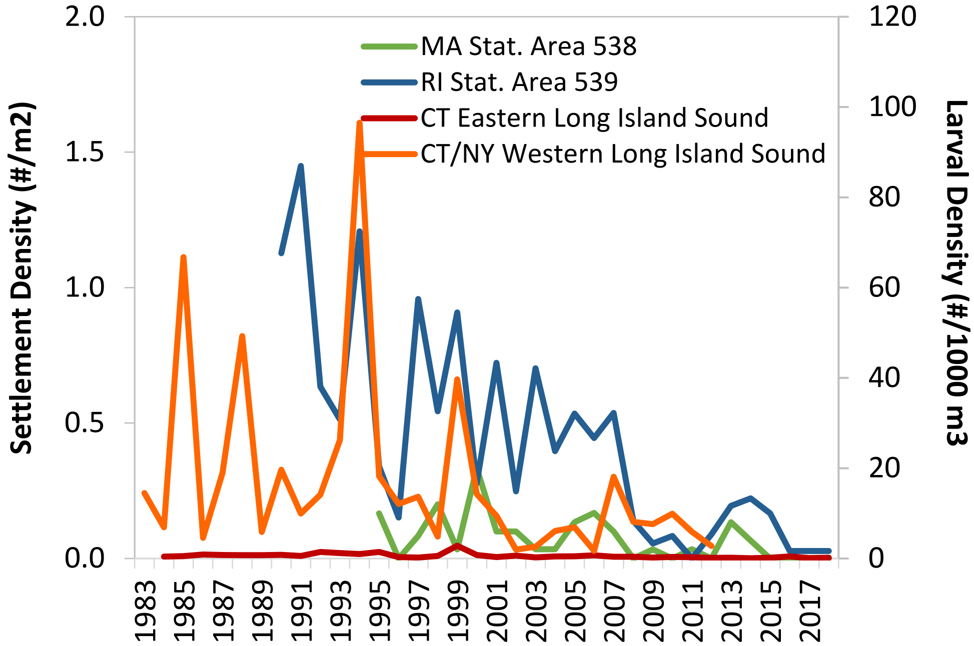
GOM/GBK abundance indicators showed similar results to the assessment model, with increasing abundance and distribution of recruits and larger-sized lobster over time. However, abundances of YOY lobster have been negative or neutral since the 2015 stock assessment and YOY abundance appears particularly poor in the southwestern areas of the stock. Recent research has indicated lobster larvae may be settling in habitat outside that covered by current surveys, but these unfavorable YOY indicators are concerning, warrant attention as they could foreshadow future declines in recruitment to the GOM/GBK fishery, and need to be further investigated. Mortality indicators generally declined through time to their lowest levels in recent years. Fishery performance indicators were generally positive in recent years with several shifting into positive conditions around 2010. Stress indicators show relatively low stress, but indicate some increasingly stressful conditions through time, particularly in the southwest portion of the stock.

Figure 7. GOM/GBK Young-of-the-Year Indices



Abundance indicators for the SNE stock also showed similar results to the assessment model, with abundance and distribution of all life stages decreasing to low levels in recent years. All abundance indicators averaged below their time series medians since the 2015 assessment and many have averaged below the 25th percentile. Based on the majority negative YOY indicators, further declines in the SNE resource and landings are likely. Mortality indicators were variable across surveys, and fishery performance indicators have generally shown deteriorating performance in recent years. The stress indicators point toward similar negative conditions in the stock's environment, including unfavorably warm waters and the manifestation of a stressful environment through high shell disease prevalence. Combined, these indicators reflect the SNE stock's very poor condition and continuing recruitment failure.

Figure 8. SNE Young-of-the-Year Indices



Data and Research Needs

The Technical Committee compiled a list of prioritized research needs to improve understanding of lobster life history and population dynamics and aid in the development of future stock assessments. High priority needs include updating growth estimates and accounting for time-varying growth in the stock assessment model, monitoring settlement in deeper waters not currently covered by settlement surveys, and convening a stock boundaries workshop to further evaluate geographic-based stock definitions. The Technical Committee also recommended development of a management strategy evaluation and economic analyses to guide management in rebuilding the SNE stock and providing resiliency for the GOM/GBK lobster industry.

What are the Next Steps for Management?

The American Lobster Management Board accepted the Benchmark Stock Assessment and Peer Review Report for management use, adopted the new reference points as recommended by the assessment, and committed to considering management responses to the assessment findings at its next meeting in February 2021. In addition, the Board intends to continue development of Addendum XXVII, which was initiated in 2017 to proactively increase resilience of the GOM/GBK stock but stalled due to the prioritization of Atlantic right whale issues.

Whom Do I Contact For More Information?

Atlantic States Marine Fisheries Commission
1050 N. Highland Street
Arlington, VA 22201
703.842.0740 info@asmfc.org

Glossary

Benthic: Inhabiting or occurring at the bottom of a body of water.

Depleted: Reflects low levels of abundance though it is unclear whether fishing mortality is the primary cause for reduced stock size.

Entrainment: Transportation of organisms through power plant cooling water systems.

Exploitation: The percent of abundance removed by fishing over the course of a year.

Fishery-Dependent Data: Information collected from fishermen and seafood dealers on catch, landings, and effort.

Fishery-Independent Data: Information collected by scientists via a long-term research survey or other scientific survey.

Overfishing: Removing individuals from a population at a rate that exceeds the threshold established in the FMP, impacting the stock's reproductive capacity to replace individuals removed through harvest.

Recruit: An individual fish/organism that has entered a defined group through growth, migration, or maturation. Individuals recruit to the fishery when they reach the minimum legal size. Individuals recruit to the spawning stock when they become sexually mature.

Recruitment: The total weight or number of individuals that enter a defined group, such as the spawning stock or fishable stock.

Statistical catch-at-length model: A length-structured stock assessment model that works forward in time to estimate population size and fishing mortality in each year. The model assumes some of the catch-at-length data have a known level of error.

Spawning stock: The female portion of a stock that is mature.

Young-of-the-year (YOY): An individual fish/organism in its first year of life.

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