Sea Grant American Lobster Initiative
American Lobster Research Program
Project Summaries

2022 Projects

Integrating and evaluating non-traditional gear technologies to reduce the risk to whales from fixed-gear fisheries

Kevin Staples, Maine Department of Marine Resources

The purpose of this award is the testing and evaluation of various gear modification technologies aboard commercial vessels, including spring-tag and timed release systems and subsea gear location integrations with chart plotting systems, and the project will collect information on the performance of these systems and how time spent fishing and trap retrieval success are affected. This project will outfit select and voluntary lobster industry participants across multiple fishing areas with either the tagline spring release or timed release system designed by Nova Robotics. These systems both utilize relatively low-cost and accessible technologies to allow fishermen to access a stowed rope of traditional strength and safety, while providing a reduction in the risk of entanglement to right whales by either reducing the strength of the line or the amount of time it occurs in the water column. Electronic logbooks will be given to fishermen to detail their operation, experiences and gear use data for fished systems. These evaluations will inform the viability of the gear systems and provide feedback that may be used to improve system design. The testing of alternative gear systems will produce the information necessary on risk reduction and reliability to make informed decisions on whether they may be compliant with current federal regulations or able to be incorporated in future amendments to the Atlantic Large Whale Take Reduction Plan. Beyond their regulatory incorporation, the cooperative nature of this project will allow fishermen to directly assess the feasibility of these systems and produce an analysis that will identify optimal areas for deploying these technologies.

Providing the lobster industry new gear technology in response to regulatory and environmental changes

Erin Pelletier, Gulf of Maine Lobster Foundation

The purpose of this award is to provide lobstermen the necessary data imaging tools to navigate a changing environmental and regulatory landscape. The researchers propose new sensor deployments, model development and data products that will effectively deliver critical information to the fleet. The researchers will outfit dozens of commercial vessels with micro-computers, sensors and various ship-to-shore communication modes. Giving vessel operators access to real-time information both on their wheelhouse and home-based internet-connected screens will provide an additional source of information they can use to adjust their fishing activity. With direct feedback from stakeholders, the researchers will continue to improve the hardware and software. Improving environmental data collection and sharing within the Gulf of Maine should help lobstermen work in ways that are more strategic, surgical, cost-effective and ultimately profitable, all of which are more important than ever as the fishery faces a growing number of operational challenges. Project coordination with the Northeast Coastal Ocean Forecast System is also a key step towards the implementation of cooperative research methods for oceanographers around the world.

2021 Projects

An ecosystem-based approach to American lobster habitat and trophic dynamics: Integrated modeling to evaluate climate-related impacts

Damian Brady, University of Maine

This study will expand the decades-long work of modeling larval American lobster transport to include dynamics associated with prey availability. The project will use an existing Larval Transport Model to project the spatio-temporal distribution of lobster larvae and link the output to trends in the boreal calanoid copepod's (Calanus finmarchicus) distribution and abundance and availability of recruitable habitats. Climate-induced changes in water masses that control the rate of warming in the Gulf of Maine, circulation patterns, spatial and temporal dynamics in spawning lobster distributions, and development time of larvae synergistically impact the timing of these species in the water column and may act to intensify the disconnect between larvae and their optimal food source. Through the team's work with the Maine Department of Marine Resources, Maine Lobsterman's Association, and the Lobster Institute, the study will build a flexible ecosystem-based early life history model capable of answering fundamental questions from industry members and stakeholders regarding changes in ocean conditions, larval distribution, and their relationships to their food supply.

Answering an industry question, "Who's eating juvenile lobsters?": An evaluation of lobster predation in the Gulf of Maine using stomach content analysis

Rebecca Peters, Maine Department of Marine Resources

The Maine Department of Marine Resources and the Maine Center for Coastal Fisheries are partnering to understand what current and new predators of American lobsters exist in the Gulf of Maine, especially as it pertains to juvenile lobsters. To answer this question, they will use current surveys to collect stomachs from five species that have recently shown to be preying on lobster: Atlantic cod, white hake, red hake, Atlantic halibut, and Atlantic mackerel, and from two emerging species: black sea bass and striped bass. This team of researchers, state agency scientists, and industry members will share results with federal research partners, members of the lobster industry, and students across Maine. The research will provide data on potential lobster predators and allow managers to use these data to update current single species American lobster assessments and work on ecosystem models for the Gulf of Maine.

Connecting the dots: environmental drivers of egg production and stability in ovigerous American lobsters in the Gulf of Maine

Jason Goldstein, Wells National Estuarine Research Reserve

A key goal of this work is to evaluate the overall health and quality of ovigerous American lobsters with respect to their egg production and examine how environmental drivers of climate change in the Gulf of Maine may be impacting this key life history phase. This work will address: 1) why ovigerous lobster egg clutch sizes have declined and to what extent this limits egg production; 2) what factors have contributed the most to declines in egg production; and 3) what impact temperature, maternal history, and size have on egg production and viability. The data obtained from this project will be used to inform future stock assessments and lay the groundwork for a long-term monitoring program that includes the linkages between ovigerous lobster health and climate change. Stakeholder engagement and outreach will serve to connect the findings with the commercial lobster fishery, fisheries managers, students, and the public through data sharing, presentations, artistic visualization, and opportunities for student learning and experience.

Evaluating impacts of changing life history parameters on the American lobster stock dynamics under different management regulations in a warming Northeastern US

Yong Chen, Stony Brook University

The overarching objective of this project is to develop and conduct a simulation study to evaluate the impacts of possible climate-induced changes in American lobster life history parameters and alternative management regulations on the lobster population dynamics. The simulation framework will consist of the Individual-based Lobster Simulator, conditioned based on information derived in the latest stock assessments. The project will (1) develop a research collaborative team to help identify "what if" scenarios for simulating realistic ranges of changes in key life history parameters for Gulf of Maine and southern New England stocks; (2) develop a simulation framework for predicting the response of lobster stocks to changing life history parameters; (3) evaluate impacts of increasing temperatures on lobster stocks given status quo management; and (4) compare the performance of different management regulations in a changing climate.

Investigating the ecological impacts of range-expanding species to the American lobster fishery using collaborative surveys, fisher observations, and predator-prey experiments

Jonathan Grabowski, Northeastern University

As a consequence of climate change, range-expanding species such as black sea bass and blue crabs are entering southern New England and the Gulf of Maine. Yet many questions about these species' distributions in their newly expanded ranges and their effects on the American lobster fishery remain unanswered. This study will answer questions about range-expanding species, such as, how prevalent they are in the Gulf of Maine, which coastal New England habitats and depths they prefer, and if they overlap with and consume critical life-history stages of the American lobster, such as early post-settlement and larger juveniles. Answering these critical questions will help evaluate the degree to which novel species range expansions are a potential threat to the American lobster fishery. The collaborative team that will collectively answer these questions includes university researchers, nonprofits, industry organizations, state resource agencies, and lobster fishers.

The influence of season and temperature on the distribution and abundance of juvenile lobsters assessed via traditional ventless and novel early benthic phase traps

Joshua Carloni, New Hampshire Fish and Game

One of the major goals of this project will be to design and test a trap that effectively samples early benthic phase lobsters, an understudied segment of the American lobster population whose changes in abundance could give an early warning to potential changes in landings. Once this novel trap has been tested and calibrated it will be used in conjunction with SCUBA surveys and traditional ventless traps to explore the relationship between lobster density, temperature and catch. Further, the project seeks to better understand the degree to which ventless traps accurately reflect the size structure of the sublegal lobster population, and whether smaller lobsters may be excluded due to intraspecific competition. The data obtained from this project will be used to inform future stock assessments and lay the groundwork for a long-term monitoring program that includes early benthic phase lobsters and the linkages between each life history phase of the American lobster.

2020 Projects

Assessing the broad-scale distribution and abundance of lobster larvae and their potential food sources throughout the Gulf of Maine and Georges Bank

Heidi Henninger, Atlantic Offshore Lobstermen's Association

The authors propose a broad-scale survey that investigates the spatial and temporal distribution and abundance of early and late stage lobster larvae and their likely zooplankton prey to investigate factors affecting recruitment in the Gulf of Maine and Georges Bank (GOM/GBK) stock area. This effort will provide a comprehensive snapshot of lobster larvae across the GOM/GBK stock which will help inform biophysical models, provide context to better understand and model the SSB-recruit relationship under the current climate regime, and provide regional data to investigate the role of trophic interactions at the larval stage. Further, the authors propose to test different platforms for field work to inform best practices for future larval surveys. This work will complement ongoing lobster monitoring efforts and make it possible to consider the distribution of all lobster life stages in future management strategies.

Bait alternative development and future visioning in the New England lobster fishery

Adrian Jordaan, University of Massachusetts Amherst

This work targets the research topic focused on socio-ecological investigations to inform future management decisions by completing research exploring bait alternatives to herring and the implications for the lobster fishery. The research will be focused on the Gulf of Maine (GOM) but with potential to impact any trap fishery in the U.S. Specifically, the authors aim to develop a bait alternative that conforms to state guidelines developed, or being developed, to limit negative impacts of the lobster industry on the Atlantic herring stock, create resilience within the lobster fishery by reducing cost uncertainty, and redirect seafood processing waste streams from local resources into a value added product.

Early life history of American lobsters in coastal southern New England waters

Jeremy Collie, University of Rhode Island

The Southern New England (SNE) lobster stock is currently experiencing recruitment failure, with a population bottleneck occurring somewhere between the egg and juvenile stages. The objective of this project is to measure the abundance and spatial distribution of lobster larvae and post-settlement juveniles in Rhode Island waters to identify where in the life history the recruitment bottleneck occurs. The project components include lobster larvae sampling and temperature profile measurements. Resulting data will be used to test whether lobster recruitment is limited more by pre- or post-settlement processes. The authors will test whether a thermal refuge exists for juvenile lobsters at depths deeper than those that have been historically occupied. Field data will be interpreted in the broader context of circulation patterns and thermal habitat on the SNE continental shelf. A better understanding of the connectivity between egg production, pelagic larvae and benthic young-of-year, and juvenile abundances will provide insight into survival during this critical period of lobster life history. Understanding the processes regulating recruitment and the survival bottleneck is imperative for rebuilding the SNE lobster stock.

Fishing in hot water: Defining sentinel indicators of resilience in the American lobster fishery

Joshua Stoll, University of Maine

The intent of this research is to develop sentinel indicators of resilience for the lobster industry that can be used to detect early signs of vulnerability among harvesters. In pursuit of this research, the authors will use peer-reviewed methods to develop and evaluate sentinel indicators and work closely with the lobster industry, managers and the Lobster Regional Extension Program to solicit input and distribute results. Although the status of the lobster stock is closely monitored in the Gulf of Maine, no indicators currently exist to detect vulnerability among participants in the industry. Understanding vulnerability is vital to informing future management decisions and coastal community resilience.

Incorporating changes in thermal habitat and growth to improve the assessment of American lobster stocks and spatial distribution in the Gulf of Maine, Georges Bank and southern New England

Walter Golet, University of Maine

The pinnacle purpose of this project is to develop a modeling framework to assess and forecast spatio-temporal dynamics of American lobster in a changing ecosystem. A forecasting model will be built into the American lobster stock assessment framework that utilizes stock assessment output and projected thermal habitat to predict stock size and catch seasonally. This will allow for simulating multiple future climate scenarios and fishing mortalities in the Gulf of Maine, Georges Bank and southern New England. Additionally, this work will also enable the testing of the UMaine Lobster Stock Assessment model under previously utilized spatial scales from the Atlantic States Marine Fisheries commission to determine if the stock unit assumptions hold true using this stock assessment model. Throughout the testing and application process this work supports the implementation of a grounded outreach plan that will allow for method fluidity due to feedback from American lobster management agencies and stakeholders including state agencies, the Atlantic States Marine Fisheries Commission, NOAA Fisheries and lobster industry.

Surface convergences: A critical pelagic microhabitat for American lobster postlarvae?

Jesús Pineda, Woods Hole Oceanographic Institution

The few studies that have noticed the occurrence of American lobster postlarvae in surface convergences suggest that these features could be critical for the ecology and population dynamics of this species. Here, the authors propose: (a) To elucidate the main pelagic habitat of American lobster postlarvae, including open unstructured waters and different types of surface convergences (e.g., hydrographic fronts, nonlinear internal waves and Langmuir cells), (b) to resolve whether postlarvae aggregate differentially in hydrographic or non-hydrographic convergences (e.g., tidal fronts or Langmuir cells), (c) to evaluate the type and variability of convergences that occur in the Gulf of Maine and to describe their environmental variability, including circulation and hydrographic structure, and (e) to test whether postlarvae in convergences (hydrographic or non-hydrographic) are in better condition than postlarvae in open, unstructured waters. This study will be one of the first to address the microhabitat of postlarvae and the microhabitat properties that may enhance their survivorship, a critical link in determining the population dynamics of the American lobster.

*Testing and developing effective non-invasive female maturity assessment methods and protocols for the American lobster (*Homarus americanus*)*

Jesica Waller, Maine Department of Marine Resources

The Maine Department of Marine Resources (MEDMR) began conducting female American lobster maturity studies via ovarian staging, widely recognized as the most accurate maturity assessment methodology, although time and resource-intensive, in 2018. The goal of the work proposed here is to leverage MEDMR's recent efforts in order to evaluate and develop two promising non-invasive maturity assessment methodologies and generate publicly accessible instructional materials that would allow for lobster maturity datasets to be easily updated in the future. The authors will build upon three years of female lobster maturity research by the MEDMR by analyzing samples collected through these recent works to test the effectiveness of these methodologies on females from across the Gulf of Maine. This research team represents a new collaboration of state agency researchers, members of the lobster industry, an industry trade association and Canadian researchers all invested in the continued success of the American lobster fishery and eager to contribute to the National Sea Grant American Lobster Initiative. The research proposed here will provide insight into the most appropriate maturity assessment approach and provide long-term benefits to researchers who can utilize these methods to update size at maturity datasets regularly as conditions in the Gulf of Maine continue to change.

Understanding and improving spatial distribution projections for lobster: Considering predation and building expert consensus

Kathy Mills, Gulf of Maine Research Institute

In this project, the authors aim to address the limitations of lobster distribution models and strengthen stakeholders' trust in our ability to accurately quantify, project, explain and apply lobster distribution and abundance models under future climate conditions. The authors will advance lobster distribution models by graduating from traditional single species, single life stage, "environment-only" models to a joint species distribution model, which accounts for juvenile and adult life stages, environmental conditions, trophic interactions and unmeasured spatial and spatio-temporal variability. Second, they will use the joint species distribution model to generate future projections of juvenile and adult lobster distribution and abundance, which incorporate both changing environmental conditions and the spatial distribution and abundance of lobster predators. Finally, they will lead a working group composed of other experts and stakeholders to discuss modeling differences, diagnose key sources of uncertainty, and guide future model development and output application efforts. In sum, this research will provide information necessary to support forward-looking conservation and management strategies for the lobster fishery, ultimately enhancing the resilience and adaptation capacity of coastal communities that rely on lobster to support their livelihoods and maintain their cultural identity.

Understanding the cause of low dissolved oxygen in Cape Cod Bay and initiating a hypoxia warning system for the lobster fishery

Tracy Pugh, Massachusetts Department of Fish and Game

The authors propose to develop a comprehensive understanding of the conditions that resulted in the 2019 hypoxic event in southern Cape Cod Bay (CCB) and to improve the ability to forecast such conditions. The goal is to be able to predict the onset of hypoxia in CCB, allowing researchers to alert the commercial lobster fleet and other stakeholders of changing conditions. This will enable fishers to make critical real-time decisions regarding their fishing operations. The authors will also establish a real-time telemetered buoy that continuously measures bottom oxygen concentration during the summer and early fall. The buoy will be complemented by weekly high-resolution sampling to characterize the spatial distribution of bottom oxygen and water quality parameters throughout Cape Cod Bay. Together, these data will serve as an early warning system for the lobster fleet to warn of conditions when bottom oxygen levels may become lethal.

2019 Projects

Projecting climate-related shifts in American lobster habitat and connectivity: Integrated modeling to inform sustainable management

Damian Brady, University of Maine

Ocean warming can drive poleward shifts of commercially important species with potentially significant economic impacts. Nowhere are those impacts greater than in the Gulf of Maine where North America's most valuable marine species, the American lobster (Homarus americanus), has thrived for decades. However, concerns are growing as monitored shallow water young-of-year lobsters decline and landings shift to the northeast that the regional maritime economies will suffer. The authors focus on the potential effects of warming on the early life history of the American lobster by asking: How will climate-induced shifts in larval development time and settlement habitat affect lobster population connectivity? A necessary corollary to this question is how potentially shortened development time and dispersal would affect local retention and recruitment. This proposal presents a 2-year participatory modeling collaboration of investigators at the University of Maine, Woods Hole Oceanographic Institution, The Lobster Research Collaborative (as organized by the Maine Department of Marine Resource), and the University of Massachusetts at Dartmouth. Researchers will use an existing Statistical Distribution Model (SDM) to project the spatio-temporal distribution of spawners and will link the output to a Larval Transport Model (LTM). They propose to update fundamental work by co-PIs Xue and Incze that simulated lobster larval transport for the years 2002-2004, some of the coldest years in the recent record. Since that time, the three warmest years on record (2012, 2016, and 2018) have occurred and have the potential to significantly affect larval development time as well as circulation in the region. Finally, the authors will emphasize a participatory approach to developing fundamental questions relevant to management (Squires and Renn 2011). Through the PIs' work with the Maine Department of Marine Resources Lobster Research Collaborative, they will build a flexible modeling system capable of addressing the fundamental questions being asked by lobstermen and the agency regarding larval transport and supply.

Fish less, earn more: assessing maximum economic yield effort levels in Gulf of Maine's lobster fishery, incorporating lessons learned from southern New England, Canada and Australia

Kanae Tokunaga, Gulf of Maine Research Institute

Severe declines in lobster fisheries have occurred in Southern New England (SNE) in 2010 and Australia (AUS) in 2009. What lessons can we learn from their experiences? What management adaptations were considered or acted upon? How can we better prepare the Gulf of Maine lobster fishery to prevent a significant economic contraction in the face of expected declines in landings and increases in operating costs? These questions must be informed through not only biological assessment of the population and health of the stock, but also through socio-economic analysis aimed at maximizing economic yield. The authors will look to their existing network of lobster industry members for updates, and consult with fisheries managers in other regions for lessons learned. These interviews will provide a basis for assigning a range of assumptions to be tested. The authors will derive and then assess the effects of moving to maximum economic yield effort levels in the Gulf of Maine lobster fishery given the predicted future state of the fishery, so as to inform management options in the fishery.

The potential influence of increased water temperatures in the Gulf of Maine on the distribution of female American lobsters and the impacts of these distribution shifts on larval recruitment

Jason Goldstein, Wells National Estuarine Research Reserve

Abundance estimates of American lobster (Homarus americanus) are currently at an all-time high in the Gulf of Maine (GoM), but at all-time lows in Southern New England (SNE; ASMFC 2015). As SNE water temperatures have warmed over the past 15 years, the lobsters have moved to deeper, cooler offshore waters and this, along with associated problems such as shell disease, is correlated with low levels of recruitment to inshore nursery grounds (Glenn et al. 2011, ASMFC 2015). This same trend now appears to be underway in the GoM. This water mass is warming at an alarming rate (Nye 2010, Mills et al. 2013, Pershing et al. 2015, LeBris et al. 2018), and lobster recruitment to inshore nursery grounds has been below median levels throughout much of the GoM since 2012 (ASMFC 2015, Carloni et al. 2018). American lobster comprise the most valuable single-species fishery in the U.S. (NMFS 2018), and persistent low levels of recruitment in the region have created concern over the future sustainability of this resource. The overall goal of this research is to better understand the impacts of warming GoM waters on the movements of sexually mature female lobsters, and the fate of their larvae that recruit into the fishery. This information will help predict the impacts of a changing climate on the future of this critically valuable marine resource.

Resilience, adaptation, and transformation in lobster fishing communities

Kathy Mills, Gulf of Maine Research Institute

The experiences of Southern New England fishing communities during the decline of American lobster populations in the late 1990s can offer important lessons for lobstermen and communities in the Gulf of Maine, where lobster is currently thriving but may be on the precipice of temperature-associated declines. The authors hypothesize that there are three major categories of outcomes for fishermen and communities responding to change: (1) resilience, demonstrated by communities in which fisheries persist in a similar state pre- and post-disruption; (2) adaptation, demonstrated by communities in which fishing persists but the types of fisheries change substantially; and (3) transformation, demonstrated by communities that transition out of fisheries. The authors also posit that actions and characteristics at individual (i.e., fisherman or vessel) and community scales both shape responses and outcomes. Through this study, the researchers will draw on quantitative fishery-dependent data and insights gained from qualitative case studies to understand the consequences of a major downturn in Southern New England lobster fisheries and to evaluate how lessons from this experience may be applicable to lobstermen and communities in the Gulf of Maine. These findings will be relevant for efforts to plan for resilience and adaptation in culturally, socially, and economically important fishing communities.

Growth in large offshore lobsters: Addressing a critical data gap in the US Lobster Stock Assessment

Tracy Pugh, Massachusetts Division of Marine Fisheries

American lobster stocks in U.S. waters are assessed by the Atlantic States Marine Fisheries Commission (ASMFC) using a length-based assessment model. This model relies heavily upon a growth matrix that informs the model when to transition lobsters from one size bin to the next over the course of modeled time steps. Unfortunately, growth is a data-poor element of lobster life history and has been identified as a data research recommendation by the ASMFC lobster stock assessment committee in the past two stock assessments (ASMFC 2009, 2015), and likely will be again in the 2020 assessment (per ASMFC committee members Pugh and Shank). Gaps in relevant growth data, particularly for larger animals, persist and continue to introduce substantial uncertainty into the assessment. The Gulf of Maine / Georges Bank (GOMGB) lobster stock has experienced unprecedented abundance increases in recent years, including increases in the abundance of large lobsters (> 100 mm carapace length (CL)). The GOMGB stock accounted for 97% of all U.S. lobster landings in 2017 (ASMFC unpublished data), and the commercial industry dependent on this resource is a vital component of the economies for many New England coastal communities. The ability of the stock assessment to accurately assess the status and trajectory of this resource is critical to its sustainable management. Therefore, this study will address the lack of sufficient growth information, which is crucial to the future success of the stock assessment process.

Reproduction in an era of rapid environmental change: The effect of multiple stressors on reproductive success, embryogenesis, and emerging larvae of the American lobster

Emily Rivest, Virginia Institute of Marine Sciences

Against a backdrop of rapid environmental change, the authors want to understand how multiple stressors (rising temperature and ocean acidification) affect the reproductive success of the American lobster in the Gulf of Maine (GoM). They propose an ambitious project to examine how changes in temperature and ocean acidification (OA) affect the reproductive care, fecundity, and natality of the American lobster (Homarus americanus), and how these stressors interact to affect embryo development and the physiology of early life stages of the lobster. The American lobster supports the region's most economically important fishery and this research is highly relevant to NOAA's Next Generation Strategic Plan for sustaining healthy fisheries (NOAA, 2010). The project also supports a component of the National Marine Fisheries Service Strategic Plan by addressing goals related to rebuilding over-fished marine fisheries, maintaining currently productive fisheries, and integrating conservation of protected species and fisheries management. The findings of this research can be used to improve estimates of the effects of multiple stressors on natural systems in the GoM and provide baselines for representative physiological markers for future work.

Bridging the 'Great Disconnect': Linking the Gulf of Maine pelagic food web to lobster recruitment dynamics

Richard Wahle, University of Maine

The project represents an interdisciplinary collaboration to examine the paradoxical disconnect between historic highs in Gulf of Maine (GoM) lobster egg production and lows in young-of-year recruitment. The authors evaluate the hypothesis that changes in the abundance and distribution of zooplankton prey may profoundly impact recruitment success (Carloni et al. 2018). The project therefore addresses aspects of National Sea Grant's top three priorities for Lobster Research: life history; larval studies; and spatial distribution within the GoM and Georges Bank. The authors have identified a previously undocumented correlation between recent declines in components of the larger planktonic (copepod) assemblage and declining trends in the young-of-year (YoY) recruitment of the American lobster. The marked disconnect between record breaking lobster spawner abundance and low recruitment in the GoM suggests decreased survival of the planktonic larval stages. The proposed project aims to investigate the mechanism underlying diminished recruitment success by capitalizing on an existing long-term (>30 year) data set augmented by targeted high resolution field sampling, novel molecular diet analysis and laboratory experiments, enabling the researchers to move beyond correlative analyses to clarify the American lobster's link to the pelagic food web.