N.H. Sea Grant Research Project Completion Report

**Today's date:** 01-07-2013

**Project number:** R/CFR-13

**Project title:** Establishing historic baselines and time series for rebuilding anadromous fish populations and coastal marine ecosystems in the Gulf of Maine

**Project initiation date:** 2/1/2010

**Principal investigator:** W. Jeffrey Bolster

**Affiliation:** UNH

**Associate investigator(s) and affiliation(s):**
William B. Leavenworth, Karen Alexander OPAL, UNH

**Technicians and affiliations:**
2010, John Greene, undergraduate student, UNH
2011, Althea Marks, undergraduate student, UNH

**Partner(s) and affiliation(s):**
Irit Altman, collaborator, MA SeaPlan
Bruce Bourque, collaborator, Maine State Museum
Jamie Cournane, collaborator, UNH and EDF
John Crawford, Pew and BU
Mike Frist, collaborator, SUNY Stony Brook
Carolyn Hall, Adrian Jordaan, collaborators University of Massachusetts, Amherst
Meghan Howey, collaborator, UNH
Beverly Johnson, collaborator, Bates
Steve Jones, collaborator, UNH
Les Kaufman, collaborator, BU
Emily Klein, collaborator UNH
Adrienne Kovach, collaborator, UNH
Theo Willis, collaborator, USM
Karen Wilson, collaborator, USM
Matt McKenzie, collaborator UConn Avery Point
Natalie Springuel, collaborator College of the Atlantic and Maine Sea Grant
Art Spiess, collaborator, Maine State Archaeologist
Bob Steneck, collaborator, Darling Center
Joan Trial, collaborator, Maine DMR
DSRRN, research network collaboration
MOP (and it’s successor organization, SeaPlan), research collaboration
Gloucester Maritime Heritage Center, education and outreach collaboration
Penobscot Marine Museum, education and outreach collaboration
Brief project overview/Abstract:
Restoring alewives (Alosa pseudoharengus) and shad (Alosa sapidissima) to rivers in the Gulf of Maine is a high priority for public and private organizations, at local, state, regional and federal levels. Small diadromous fish distribute energy among riparian, estuarine and marine ecosystems through foodweb interactions, and act as a bellwether for ecosystem health. Historical information may improve restoration goals for a single species by establishing biological baselines in the past. Such data may also inform researchers about past ecosystem configurations in terms of primary productivity based on the passage of massive numbers of fish into watersheds to spawn, and in terms of predator and prey species within a coastal foodweb. Correlating trends over time with changing human demographics and land-use practices, how anthropogenic change along coastal and freshwater river systems has affected these processes may be revealed.

Objectives:
Using methods developed during our previous research on Gulf of Maine cod (Gadus morhua), and in collaboration with scientists at the University of Southern Maine, the University of Massachusetts, Amherst, and Boston University, we will identify historical sources, extract landings data for anadromous and other fish species, and correlate demographic and land use information from customs records. Then we will link with modern datasets to calculate changes in catch per unit effort and catch per unit area over time.

Research findings:
We have located and digitized most of the Maine State Fish Inspectors Reports (1804-ca. 1900), and the Massachusetts State Fish Inspectors Reports (1804-ca. 1900). The Maine and Massachusetts Fish Commission Reports have been mostly located, digitized and data extracted. The New Hampshire Fish Commission Reports contained minimal data and have not been done. Connecticut and Vermont Fish Commissioners Reports were found in Hartford. Digitizing and transcription will be done as needed. Data from the Atkins Weir Records at Craig Brook National Fish Hatchery in Orland, Maine, were extracted and put into a spreadsheet. Digitizing in now underway. In total, this provides catch data by weir, by town or county and by state for parts of the Gulf of Maine going back to 1804.

To date (1-2013):
Maine Fish Inspectors reports have been digitized for 71 Maine towns running from 1804-1893. Data has been extracted for a significant part of them.
Maine Fish Commission Reports from 1867-1972 have been digitized, and data extracted from 1830-1965.
Mass. Fish Inspectors Reports for pickled fish from 1804-1883 have been digitized and data extracted.
Mass. Fish Commission Reports from 1865-1910 have been digitized and data extracted for 1867-1908.
N.H. Fish Commission Reports were investigated and found to be of little use, since they focused on stocking fresh water sport fish.
R.I. has been digitized and is online. Conn. and Vt. will be digitized, and data extracted under a new Pew Grant through UMass, Amherst.
Accomplishments:

Publications:

2011-02. Alexander, Leavenworth and Courane spoke about spatial and temporal scale and the analysis of historical data, and contributed data and insights on modeling historical data to Bob Sadzinski and the River Herring SASC.


2011-05. Leavenworth and Alexander presented talks on catch density and Maine river herring at the DSRRN meeting, and discussed future collaborations with Adrian Jordaan and Theo Willis.

2011-06. Leavenworth and Alexander presented a poster and a paper, respectively, at Northeast Consortium’s Spatial Scales conference.


2011-10. Leavenworth and Alexander attended the RARGM meeting in Portsmouth in October, 2011, and discussed forage fish, historical ecology and recovering the economic potential of healthy ecosystems with a number of participants, including the plenary speakers.

2012-02. Leavenworth gave a public lecture entitled “Mount Desert Fisheries and How they Died” at College of the Atlantic, February 2012.

2012-03. Leavenworth gave a public lecture at the Gloucester Maritime Heritage Center commemorating the 20th anniversary of Stellwagen Bank, entitled “Between the Arms of Cape Ann and Cape Cod: a History of Fishing on Stellwagen Bank.”

2012-03. Alexander gave a public lecture at the University of Magdalena in Santa Marta, Colombia, entitled, “Historical Marine Ecology in the Gulf of Maine.”

2012-06. Alexander presented a paper at the GMRI Cod Stock Structure Workshop. Ted Ames and her presentations were the first historical evidence presented at a NMFS-sponsored stock assessment meeting.

2012-06. Alexander, Leavenworth and Emily Klein were part of a team led by Adrian Jordaan at UMass Amherst that received a large, 3 year Pew grant to model food web relationships between forage fish (alewives and menhaden) and predators (cod, swordfish and tuna) based on historical data.

2012-09. Alexander gave a lecture at the Massachusetts Marine Educators annual meeting, entitled “Oceans Ago: The Historical Ecology of Stellwagen Bank.”

2012-10. Alexander gave a lecture to a BU marine ecology class at the Gloucester Maritime Heritage Center, entitled “A Brief History of Codfishing.”

2013-01. Poster presentation at DSRRN meeting, Adrian Jordaan, Mike Frist, Carolyn Hall, Emily Klein, Alexander and Leavenworth, entitled *Evaluating the historic role of forage fish in lost fisheries production: Implications for future sustainability.*

2013-01. Poster presentation at DSRRN meeting, Joan Trial, Leavenworth and Alexander, entitled *Timing of Alewife Immigration: Past and Present.*

The following papers are forthcoming, have been submitted, or are in revision:


Trial, Joan, Leavenworth, W.B., Alexander, K.E., Hall, C. and Jordaan, A. “Potential to use historic weir harvests to estimate alewife presence in Penobscot Bay.” Forthcoming as an appendix to an upcoming DMR NOAA cooperative agreement report.


Leavenworth, W.B., Alexander, K.E. Cournane, J. Willis, T.V. Hall, C. Bolster, J.B. “Volcanoes, River herring and ecosystem integrity, a case study from the early 19th century.” Withdrawn for revision and resubmission.

Funded projects that evolved in part from this work:

Gulf of Maine cod collapsed from overfishing in the 1990s, along with populations of cod and other groundfish across the Northwest Atlantic. Almost 20 years later, management strategies have brought back haddock to acceptable levels, but cod are still considered overfished, overfishing still occurs, and the current spawning stock biomass (SSB) is still only half of the goal set for full recovery (this goal was lowered 30% in 2007). Researchers are exploring two theories that might explain cod’s current precarious state. First, a substantial decline in genetic diversity from historical levels has diminished the resilience of the species, making it more vulnerable to environmental perturbations as well as to overfishing. One such perturbation, food supply, is the focus of the second theory. Heavy fishing on forage species such as alewives, menhaden, sea herring and shellfish have left cod with little to eat, and even less containing the fatty acids and other lipids found in menhaden and alewives that cod need to reproduce successfully. Two projects that are outgrowths of funding have begun that address different aspects of this problem:

**Trophic Relationships Project**

Discussions with Adrian Jordaan, Mike Frist, Carolyn Hall, Theo Willis, and Karen Wilson have resulted in a successful, 3-year Pew Grant to model historical data pertaining to alewives, menhaden and top predators using Ecopath to reveal long-term trophic relationships. The goal is to model number
of scenarios where forage fish are restored to different levels of initial abundance and explore the effect on predator populations. Les Kaufman and his BU lab are continuing to explore using historical data in MIMES/MIDAS models, develop proxies for abundance, standardize or rank fishing effort over multiple gear types using gear range, develop population baselines using time series over space, and particularly calculate the economic advantage enjoyed in the past of healthy inshore ecosystems anchored by healthy river herring populations. Both groups have discussed comparisons between results from Ecopath and the MIMES model. This has the potential to be quite interesting.

Funding for the effort project to standardize effort across gear types has not been forthcoming, and preliminary time series analysis of spatially explicit catch has been disappointing. However, a less ambitions spatial range of gear paper is in prep, funded through the Pew grant.

**Genetic diversity and food web relationships of ancient cod stocks in the Gulf of Maine**

Historical data and descriptions reveal that, when Gulf of Maine cod were healthy, what is considered a single stock today was actually comprised of distinct sub-populations distinguishable by appearance, age, size and behavior. Moreover, sub-populations of cod may have returned to spawning grounds with the same fidelity of salmon. Current DNA analysis and tagging studies have confirmed this complex structure, but likely reflect only a small part of historical complexity since cod populations today are so severely depleted.

Archaeological digs on the Gulf of Maine coast routinely recover cod bones, often large vertebrae, that can be 200 to 5000 years old or more. Using these bones, this project aims to explore the genetic diversity and food web relationships of ancient cod at distinct locations and time periods. Bones will be selected from two sites, one in Massachusetts and one in Maine, and from at least three different time periods for each site. DNA and isotopes of carbon (C) and nitrogen (N) will be extracted from each bone for analysis. Results describing the genetic variation and the local availability of food will be correlated to a timeline of prehistoric and historical human activity, and mapped in GIS. Since cod were lightly harvested prior to the arrival of European fishermen and settlers, bones more than 400 years old will not only reveal conditions close to pristine, but also the amount of variability exhibited by this relatively unexploited population and ecosystem. After successfully proving concept, we hope to expand this study across the Atlantic to include Canada, Greenland, Iceland and northern Europe.

Participants include Art Speiss, Maine State Archaeologist, who will liaise with archaeologists and perform archaeological analysis, geneticist Adrienne Kovach, who will perform DNA analysis, Meghan Howey, archaeologist at UNH, who will perform archaeological analysis and who is curator of the Seabrook site collection, key to this project. Leavenworth will create the historical timeline, and Karen Alexander, all at UNH, will coordinate the project, oversee publications and public outreach.

An internal UNH grant has allowed us to set up an Ancient DNA lab in Morse Hall 106. A separate lab is necessary so that archaeological DNA is not contaminated with modern DNA. Funding from the Davis Foundation in Maine will pay for chemicals used in analysis and some processing. An ADVANCE grant awarded to Kovach and Howey will also go towards chemicals, processing and some salary funding. While we are applying for more funding, these three small grants allow us to begin work.

The best collection to start with is the Turner Farm site on Penobscot Bay in the Maine State Museum. We found that another team of Maine scientists was already performing stable isotope analysis on Turner Farm cod bones, Beverly Johnson at Bates, Bruce Bourque at the Maine State Museum, and Bob Steneck at the Darling Center and UMaine Orono. Thus, the BU team abandoned its stable isotope plans. Johnson, Bourque and Steneck have made available samples from the same bones they analyzed so that once our work it complete we will know genetic structure and food web interactions for the same fish. These samples are being processed for analysis, which should begin this spring. We are approaching the Sewall Foundation for funding analysis of bones at the Seabrook site.
collection, housed at UNH, and the Frazer site collection at Acadia National Park. Seabrook rivals the Turner Farm site in terms of age and richness, and the Frazer site adds bones from the historical period, which are actually the most difficult to find. Now we are on a position to begin work. We hope to build on these results by seeking funding for a North Atlantic study of changing cod stock structure and trophic interactions through time using extant archaeological collections.

Projects planned but as yet unfunded:

Other projects that as yet have no funding include a study of very long term primary productivity using phytoplankton in core samples as a proxy for primary productivity, and the gear study. The results of the trophic relationships study and the cod bone study will disclose information about forage fish abundance, including river herring abundance, predator abundance inshore, and the genetic fitness of predator species, particularly cod.

Impacts:

Historical information obtained with NH Sea Grant funding has been incorporated into 2 official stock status reports. This is the first time, to our knowledge, that historical information has been officially cited in such reports.

In June 2012, work on historical cod populations based in part on this grant and also on NH Sea Grant R/MED-3 was presented at the NMFS and GMRI-sponsored Cod Stock Assessment Workshop. Information on historical abundance, range and the importance of forage fish was presented by Ted Ames and Alexander, and incorporated into the workshop final report to NMFS. (Annala, J. 2012. Report of the Workshop on Stock Structure of Atlantic Cod in the Gulf of Maine Region, June 12-14, 2012, Portsmouth NH. Gulf of Maine Research Institute, Portland ME.)

In early 2012, work on a historical alewife run, obtained with recent NH Sea Grant Funding, was the basis for a paper exploring how the timing of alewife runs may interact with salmon and mask the migration of smolts. This will be published as an appendix to an upcoming DMR NOAA cooperative agreement report (Trial, Joan, Leavenworth, W.B., Alexander, K.E., Hall, C. and Jordaan, A. “Potential to use historic weir harvests to estimate alewife presence in Penobscot Bay.”)

Research and data are accessible by (1-2013), or already incorporated into, ongoing analytical projects that model the ecological and economic role of forage species in the parts of Gulf of Maine, or are stimulating the development of new methods to estimate species abundance and distribution from historical data:

Kaufman’s group, including MOP (and it’s successor organization), and the MIMES/MIDAS model, is still seeking funding to incorporate the very long time-series and spatial distribution patterns of alewives and other clupeids, generated by this project, into models of nearshore ecosystems and coastal economies in MA and the Gulf of Maine.

The DSRRN group is exploring novel analytical techniques such as variability analysis to estimate changes in abundance of ME alewives and other diadromous species over time. Our collaboration with Trial grew out of this working group, and it was also instrumental in putting together the Pew/UMass Amherst collaboration that now funds out research. This work has suggested that fish ladders between 1880 and 1930 were relatively successful at maintaining low to moderate populations of alewives that were harvested relatively sustainably by weirs until offshore landings began in the 1950s. Moreover, the contribution of small streams emptying into estuaries to ME’s diadromous fish population was substantial, as it is on Cape Cod, and has been overlooked in models that look only at the production of large rivers. Data from state Fish Commission reports in New England will be essential to modeling the ecosystem effects of changing anadromous and other forage fish populations.
**Tools, technologies or information services resulting from this project that are being used to improve ecosystem-based management** (e.g., that reduce contaminants that harm coastal ecosystems and seafood consumers; that track changes in ecosystem processes, biological responses and conditions):

While we hope that use of historical data in ECOPATH and the MIMES/MIDAS model will eventually show whether or not spatially explicit historical data can provide greater predictive accuracy, Emily Klein’s dissertation research, closely connected with this work, suggests that non-linear time series analysis is a good way to model historical data from the Bay of Fundy with promising results. Her work should be finished this summer.

**Related grants and contracts** (Other grants and contracts that funded this research or that were obtained as a result of this research):

Forage Fish Project:
- Internal UNH equipment grant to Adrienne Kovach, 2012. Funding for Ancient DNA lab equipment.
- ADVANCE grant to Adrienne Kovach and Meghan Howey for Ancient DNA analysis, 2012.

**Problems encountered:**
Not enough funding.

**Publications to date received by N.H. Sea Grant:**


Additional Publications

Peer reviewed publications:


Other communications products (non peer-reviewed pubs, manuals, tech reports, videos, etc.):
Documentary film for Carl Safina’s PBS program, Saving the Oceans, entitled “Cod Comeback?” Provisional air date 1-10-2013 (http://chedd-angier.com/savingtheocean/Season1/Episode8.html)

Presentations to date, with published abstract citation if applicable:
NASOH 05-2010: Anadromous fish in Maine Rivers after Tambora,1815-1820

The largest volcanic eruption in recorded history occurred in 1815 in Indonesia, at the Tambora Volcano. Effects were felt worldwide. 1816 became known as “The Year without a Summer” in the Northern Hemisphere and widespread famine resulted from crop failures. Researchers have yet to piece together the impact of that dramatic climate change event on anadromous fish stocks and landings. While Maine was still a province of Massachusetts, the Bay State Commissioners of Fisheries determined that all Maine fish exports should be inspected, and that the quantities and qualities of such fish should be reported, and the reports collected. Fortunately, these reports from 1805 to 1820 survive in original manuscript form in the Maine State Archives in Augusta. The records of river towns on the Kennebec and Penobscot show an interesting rise and fall of shad and alewife catches in the years 1805-1820, with a rise in the catch of both species until the year 1817, followed by a precipitous decline through 1820. Did the summer of 1800-and-froze-to-death have an impact on the anadromous fisheries of Maine’s largest rivers? Upon gaining statehood in 1820, Maine did not require fish inspectors to send their reports to Augusta until 1832, when the Secretary of State ordered such returns for the year 1828. These returns vary, but present questions about anadromous fish harvests in the settlement period. One question presented by the early data is, why were shad reported extensively from Kennebec towns, with occasional alewife catches, while alewives were caught extensively in Penobscot towns, with shad catch in a distant second place? The returns from 1828 hint at a possible explanation.

NASOH 05-2010: The Sea Serpent & the Mackerel Jig: New Englanders’ Re-Assessment of The Sea, 1815–1860

Sometime around 1815, in a fishing village on Cape Ann, Abraham Lurvey experimented casting molten lead and pewter around the shank of a mackerel hook. At least that’s how the lore has it. Someone did. Mackerel hooks were relatively small. Being iron, they rusted. Being thin, they broke easily. Lurvey figured that a bit of dried sharkskin or other ready-to-hand sandpaper could shine the lead or pewter, perhaps attracting the fish. Later, fishermen realized that the reinforced shank also allowed them to
“slat” the mackerel into a barrel on deck without touching hook or fish. Fish hit those jigs hard. And though Lurvey and the men with whom he fished tried to keep their jigs secret, word spread. Quintessential Yankee tinkering, simple as it seemed, had produced gear with more fishing power. And nineteenth-century America’s growing infatuation with mackerel, and later with menhaden and other species, would rely on increasingly relentless gear.

Cranberry Isles Historical Society 07-2010: Cranberry Isles fishermen in the 1860s.

Woods Hole 08-2010: Historical Marine Ecology in the Gulf of Maine.

The Gulf of Maine has one of the best archaeological and historical records of fishing that exist anywhere in the world. Documentary evidence is particularly strong for the 19th century and includes state Fish Inspector reports starting in 1804, codfishing logs from 1852-1866, state Fish Commission reports starting in the 1860s and US Fish Commission/Bureau of Fisheries reports starting in 1872. Collectively these documents describe the vibrant coastal ecosystem and fisheries that existed before World War II. Using cod fishing logs, we examine the fishery out Frenchman’s Bay and Blue Hill Bay, Maine, to reconstruct baseline indicators for cod and coastal marine ecosystems, and learn about the people who fished there in the 1860s. Fish Inspector and Fish Commission reports reveal a swordfishery centered around Martha’s Vineyard and the coast of Maine before 1900. Comparing pound net, trap and weir catch to beam and otter trawl catch from the 1880s to World War II shows significant changes over time and space in the biodiversity and abundance of catch. Summarized here, these case studies suggest that the life histories of marine species and ecosystem processes operate at different spatial and temporal scales, and that small spatial scales and long time periods are frequently ignored in science and management. Coastal ecosystems in particular have languished in this blind spot, yet they are necessary for healthy marine ecosystems.

NEOSEC 11-2010: Historical ATLAS of Marine Ecosystems and Image Gallery


College of the Atlantic: 04-2011: Historical Marine Ecology in the Gulf of Maine.

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DSRRN Workshop -Variability of North Atlantic Diadromous Fish Populations: Establishing Reference Points for Restoration Assessment: 05-2011: MA & ME Fish Inspectors Records 1804-1820, 1828, 1834,
1836, Adult Alewife Catch inspected, Four Maine watersheds, Five NE Massachusetts watersheds
Distinguishing anthropogenic from geophysical influences in anadromous catch records.

DSRRN Workshop -Variability of North Atlantic Diadromous Fish Populations: Establishing Reference
Points for Restoration Assessment: 05-2011: Maine Fish Commission, and US Fish Commission and
successor agencies, 1887-1965 (MEFC reports go back to 1867), Catch statistics only (diadromous
species), State (also by county; earliest MEFC records are by river.), By gear

Spatial Scales Conference 06-2011: Comparing spatial distribution of historical and modern fisheries in
the Gulf of Maine

Landings statistics in the past often presented great geographic specificity. Data from fishing
logs can identify relatively precise fishing locations. Landings aggregated by state and federal agencies
after 1800 can be assigned a geographic range based on the size of the vessel and the fishing gear
employed, and weirs can be mapped from old tax and property records. Research has shown that most
historical fisheries operated over nearshore grounds until catch declined enough to force fishermen
elsewhere. This can be easily demonstrated for the Gulf of Maine. Before 1882, bluefin and other tunas
were landed primarily from weirs and poundnets, while Saco Bay and its neighboring coastline was a
center of the swordfishery. Between 1885 and 1905 swordfishing moved from within 20 miles of the
cost to over 30 miles offshore, eliminating the small boat fleet from the fishery.
Before 1930 weirs and pound nets landed more kinds of species than any other gear deployed. In 1919
Massachusetts weirs and pound nets took 38 different species of fish, including tuna, cod, flounders and
skate and squid. Otter trawls did not surpass the fixed gear fishery in species caught (29 to 27) until
1930. Many shore or coastal fisheries before 1900 are now pelagic fisheries, and coastal zones are
almost barren of commercial fisheries other than lobster. I compare coastal biodiversity before otter
trawling to conditions today to show that the spatial change is almost as great as the decline in species
abundance, and has enormous implications for ecosystem recovery.

Spatial Scales Conference 06-2011: Catch Density and the spatial distribution of fisheries
Today single fish stocks are identified and managed over their entire range, which is divided into
statistical management areas. The goal is to effectively regulate fishing activities anywhere in the range,
and in rebuilding haddock and yellowtail flounder stocks this strategy yielded good results. Historically,
however, the range of fisheries was only a fraction of the range of species, and fish catch in some cases
was much larger. In 2005 NEFSC reported a total nominal catch of 500mt for shad landed from Cape
Hatteras to the Bay of Fundy. In 1789, however, 830,000 shad were landed in the Merrimack River.
Estimating an average fish size of 4.5 lbs, this comes to 1,695 mt. Total catch has declined, yet the true
magnitude of decline is lost when landings over 13 statistical areas are compared with landings on one
river.

We have proposed a new metric, Catch Density (CD), defined as catch/(unit area). In this paper,
we calculate historical CD from catch statistics reported for fishing grounds and for statistical areas
(introduced in the 1930s) by precursors to NOAA. Then we compare them to modern CD for the same
species over the species range, and map trends in CD spatially and temporally. Changing distribution
and concentration affects fish populations, the ecosystem they live in, and the fisheries that they
support. Since CD directly relates the density of fish stocks to their distribution, it may play a useful role
in spatial management and the organization of sectors.

College of the Atlantic 02-2012: Mount Desert Fisheries and How they Died.

Gloucester Maritime Heritage Center 03-2012. Between the Arms of Cape Ann and Cape Cod: a History
of Fishing on Stellwagen Bank.
University of Magdalena, Santa Marta, Colombia 03-2012. Historical Marine Ecology in the Gulf of Maine.

GMRI Cod Stock Structure Workshop, Portsmouth NH 06-2012. What can historical sources tell us about cod stock structure and distribution in the past?

**Historical marine ecology uses data that extend far back in time to explore environmental conditions in the past, and learn how and why conditions have changed.** Historical data from the Gulf of Maine cod fishery reveal information about the cod fishery from Frenchman’s Bay, Maine, to Grand Manan in the Bay of Fundy, much of the eastern Gulf of Maine. This large, primarily coastal fishery landed more than 12,000 mt of cod in that region in 1861. Average fish size, time period and location of catch has allowed some reconstruction of population structure, suggesting far more complex and larger stock at this time, with an estimated population of more than 52,000 spawning cod more than 8 years old. A high mortality rate of 1.3 in the Eastern Gulf of Maine may have been supported by replenishment from the Bay of Fundy. Scaling up for total fishing effort, overall landings in the Gulf of Maine were estimated at about 70,000 mt in 1861. Further work using Bureau of Fisheries Statistics from 1928-1969 describes the fishery as data aggregation changed from named fishing grounds to statistical areas.

**Additional information:**
We also work with Emily Klein, PhD candidate in NRESS, on aspects of working with historical data. Since Emily is getting her last year of funding from our Pew Grant, her work is even more closely associated with ours.

**Students Supported** *(see next page)*
## Students Supported

<table>
<thead>
<tr>
<th>Student Name</th>
<th>Where is he/she now?</th>
<th>Institution/Department</th>
<th>Duration of support</th>
<th>Type of support (stipend, travel, supplies, etc.)</th>
<th>Type of degree: Undergrad Master’s PhD</th>
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<tr>
<td>John Greene</td>
<td></td>
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