# “Piloting a Lobster Research Fleet Approach in New England: Working Towards a Sustainable Lobster Fishery”

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Final Project Report

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Authors:

Anna J. Malek Mercer, Program Administrator
Commercial Fisheries Research Foundation
Email: amalek@cfrfoundation.org
Phone: (401) 515-4892

Margaret E. Petruny-Parker, Executive Director
Commercial Fisheries Research Foundation
Email: pparker@cfrfoundation.org
Phone: (401) 515-4662

CFRF
COMMERCIAL FISHERIES
RESEARCH FOUNDATION
P.O. Box 278, Saunderstown, RI 02874
Phone: (401) 515-4892 | Fax: (401) 515-3537
www.cfrfoundation.org

**Executive Summary:**

The Lobster Research Fleet pilot project began in 2013 and focused on implementing a cost-effective method to collect critically needed biological data for lobster and Jonah crab and coincident bottom water temperatures in the southern New England region utilizing modern technology and lobstermen's time on the water. The project provided an opportunity to test methods aimed at integrating state of the art data collection and verification techniques into standard fishing vessel operations, while also developing a working partnership between scientists, managers, and members of the lobster and Jonah crab fishery in the southern New England region. At the start of the pilot project, members of the commercial fishing industry, scientists, and managers worked together to finalize data parameters and sampling protocols. As the project progressed, the CFRF staff worked closely with ASMFC and ACCSP to make sure data transfers would be seamless and timely. This was critically important in enabling the data to be used in the 2014 lobster stock assessment and early efforts to begin managing the Jonah crab fishery. Data management strategies also ensured that industry members felt confident that they could maintain a copy of the data they collected while at the same time knowing that data was being relayed to and used by stock assessment scientists. The quantity and spatial coverage of the data collected by a fleet of 12 fishing vessels during this relatively short pilot project was very impressive, with 61,851 lobsters and 15,542 Jonah crabs sampled from 14 Statistical Areas in LMAs 2 and 3, extending from the Gulf of Maine to Hudson Canyon off of New Jersey. Furthermore, more lobstermen wanted to participate in this pilot project than could be accommodated with available resources, highlighting the fact that the geographic area covered and the amount of data collected could have been even more expansive.

Overall, the Lobster Research Fleet pilot project was successful in: 1) piloting modern technology (tablets, electronic calipers, and Bluetooth temperature sensors) on lobster fishing vessels to collect biological and environmental data, 2) Developing efficient data sharing protocols that supported the direct use of project data by state, regional, and federal scientists/managers, while also ensuring that lobster industry members retained access to the data, and 3) Building an engaged and committed research fleet that wants to continue working together to collect critically needed biological lobster and Jonah crab data and bottom water temperatures to reduce uncertainties in stock assessments and begin to better understand the influence of environmental factors on the abundance and distribution of these species. The fishery dependent data collection approach successfully demonstrated in this pilot project has the potential to serve as a model for other fisheries and in other regions.

**Background:**

The American lobster (*Homarus americanus*) supports one of the most valuable fisheries in southern New England (SNE), producing nearly $70 million in revenue annually (ACCSP 2010). Massachusetts and Rhode Island are the primary contributors to the southern New England lobster fishery, supporting fleets of 1,500 and 250 vessels, respectively (MADMF 2010, Hasbrouck et al. 2011). In addition to nearly 2,000 commercial fishing jobs, the SNE lobster fishery sustains a variety of support businesses, such as trap-builders, gear suppliers, bait and ice dealers, shipyards, fuel companies, engine sales and repair businesses, and marine electronic retailers. The lobster fishery also benefits industries such as shore-side sales, tourism, and food systems, which are critically important to coastal communities in SNE.

Despite the economic and cultural importance of the lobster fishery in SNE, scientists, managers, and lobstermen agree that the data being used to assess the resource and manage the fishery are inadequate (ASMFC 2009, ASMFC 2010). For example, there is a marked mismatch between the location of primary lobster fishing grounds (10-200 miles offshore) and the data being used to assess the stock (0-3 miles from shore). Furthermore, federal trawl surveys are not designed to capture lobsters and cannot be conducted in lobster fishing grounds due to gear conflicts and rocky seafloor features. In a recent statement, the Atlantic States Marine Fisheries Commission (ASMFC) asserted that *"Effective fisheries management requires data with sufficient spatial and temporal resolution to be able to track trends in the fishery and the stock."* The statement goes on to point out that *"…the resolution of [biological data collection] programs are lacking in federal waters where a substantial portion (>50%) of the Southern New England [lobster] fishery currently occurs."* The statement concludes that: "*The catch disposition for a substantial portion of the SNE lobster fishery which occurs in federal waters is poorly characterized.*" (ASMFC 2012). Thus, a better understanding of the fishery and biological characteristics of the SNE lobster stock is necessary to reduce uncertainties in the lobster stock assessment and to sustainably manage the iconic lobster fishery (ASMFC 2009, ASMFC 2012).

Complicating the issue of inadequate data and high uncertainties in lobster stock assessments are the potential impacts on the resource attributable to changing environmental factors, such as water temperature. In the Southern New England stock area, lobster abundance has drastically declined since 1999 (Figure 1a, Angell 2013, ASMFC 2015). At the same time, Southern New England waters have experienced dramatic and widespread warming, suggesting an environmental mechanism for the lobster population downturn (Figure 1b, ASMFC 2010, Wahle et al. 2015). Scientists have begun to theorize that female lobsters are moving out of their traditional sheltered bays to more open ocean environments in response to rising water temperatures, affecting juvenile lobster settlement (Glenn et al. 2011). Fishermen also report seeing juvenile lobster in significant numbers as far offshore as the continental shelf break, but scientists cannot explain why they are being seen in these areas or what the fate is of these juvenile lobsters (ASMFC 2013, CFRF 2014). Warming water, regional oceanographic events, and changes in ecosystem dynamics may be having profound effects on this resource. But the data to support the needed analysis, inform the management system, and enable the lobster

industry to adapt and prepare for changing environmental conditions, is lacking, particularly from offshore waters.

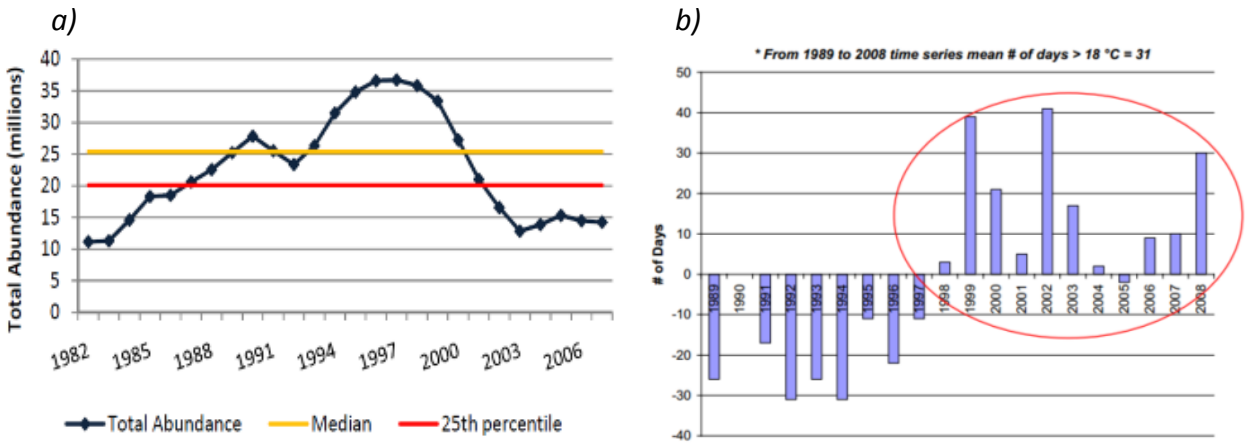


***Figure 1.*** *a) Total lobster abundance in Southern New England stock area as measured by the University of Maine Length Based Model (Source: ASMFC 2009); b) Anomalies from the mean number of days with bottom water temperature > 18°C at the mouth of Buzzards Bay 1989 -2008. (Source: ASMFC 2009).*

Since 2011, the Commercial Fisheries Research Foundation (CFRF) has organized and facilitated a series of ad hoc meetings on the subject of research needs and priorities as related to the southern New England lobster resource. Lobster industry leaders, state, regional, and federal agency staff, and lobster biologists from various academic institutions have all participated in these discussions and arrived at the same basic conclusion: additional data is needed, especially in the offshore area (federal waters), to reduce the uncertainties associated with lobster stock assessments and improve lobster management. This is particularly critical in some areas of the southern New England region where the lobster resource appears to be under stress (ASMFC 2015). The primary needs are: 1) more timely and site specific fishery dependent data, including biological catch characterizations, 2) updated recruitment and growth rates for inshore and offshore waters, and 3) expansion of fishery independent ventless trap surveys to offshore waters. Given the limitations associated with state survey programs and agency budgets, a collaborative approach between industry members and scientists needs to be developed and implemented to collect fundamental data about the lobster resource.

In addition to addressing data gaps for the American lobster, there is also an urgent need to collect basic biological and fishery data to support a management plan for Jonah crabs (*Cancer borealis*), a currently unregulated species that supports a rapidly growing fishery (ASMFC 2013). The Jonah crab fishery has developed in response to a perceived increase in abundance, opening markets, and a need for fishermen to diversify, particularly in light of the declines in the SNE lobster resource. In Rhode Island alone, more than 70 fishing vessels harvest over 4 million pounds of Jonah crabs, with landings valued at over $3 million annually. In Massachusetts, this fishery has become the 7$^{th}$ most important fishery in the state based on landed value (> $10 million) and 6$^{th}$ most important based on on total weight (>9 million

pounds) (MADMF 2014). Across the east coast, the Jonah crab fishery is worth over $12 million with landings rising rapidly since the early 2000's (NMFS commercial fisheries statistics, Figure 2).

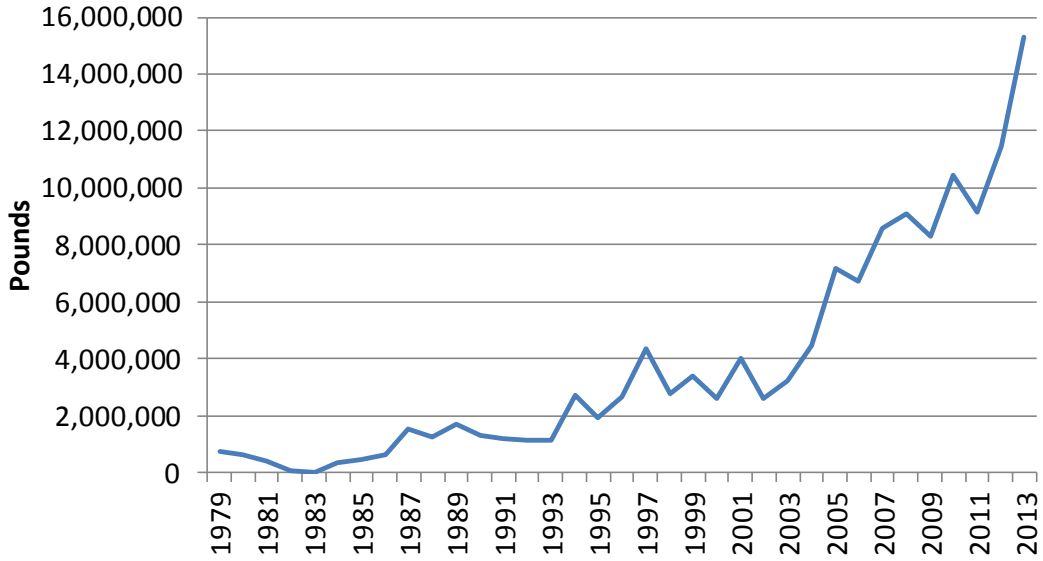


***Figure 2.*** *U. S. landings of Jonah crabs from 1979 through 2013 (Source: NMFS commercial fisheries statistics).*

As stated by the ASMFC in its "Public Information Document for the Draft Fishery Management Plan for Cancer Crab" issued in August 2014, "*while the Jonah crab has long been considered a bycatch of the lobster industry, in recent years there has been increasing targeted fishing pressure and growing market demand. The status of the Jonah crab fishery in federal or state waters is relatively unknown. In the absence of a comprehensive management plan and stock assessment, harvest of Jonah crab may compromise the sustainability of the resource."* The ASMFC document goes on to state that "*There is no range wide stock assessment for Jonah crab*", a necessary component of a sustainable fishery management plan. The development of a Jonah crab stock assessment is dependent upon the availability of spatially and temporally explicit biological and fishery data, which is currently lacking for this emergent fishery.

Like most emerging fisheries, there are little to no regulations in place to manage the Jonah crab resource. Management efforts for this fishery are hampered by major gaps in the understanding of the operational characteristics of the fishery (spatial and temporal distribution of fishing effort), the catch compostion (sex ratio and size distribution), and key life history parameters. This information is crucial in developing "stop gap" regulations, such as setting a minimum harvestable size, as well as developing a management program to keep this fishery sustainable.

In summary, there are important unanswered questions regarding the biological and fishery characteristics of both the Jonah crab and lobster resources in the northeast region. Coupled with these questions is the overall need to better understand the relationships between these

fishery resources and changing bottom water temperatures, and the application of this knowledge in stock assessments and management plans. Advancing the stock assessments of these two commercially important species is essential to maintaining these fisheries for the long term, but that cannot be accomplished without appropriate data from throughout their range.

In response to these needs voiced by both lobster managers and lobstermen, the CFRF initiated, with NMFS approval, a pilot project aimed at involving commercial lobstermen in data collection. This pilot project, the subject of this report, began in 2013 and focused on implementing a cost-effective method to collect critically needed biological data for lobster and Jonah crab and coincident bottom water temperatures in the southern New England region utilizing modern technology and lobstermen's time on the water. The project provided an opportunity to test methods aimed at integrating state of the art data collection and verification techniques into standard fishing vessel operations, while also developing a working partnership between scientists/managers and members of the lobster and Jonah crab fishery in the southern New England region that can serve as a model for other collaborative data collection efforts. Given these motivations and goals, the project aimed to address the following research questions:

1. Can new technologies enable lobstermen to reasonably incorporate biological data collection into their routine fishing practices and improve the quantity, quality, and timeliness of fishery dependent lobster data?
2. Can a lobster fishing vessel research fleet be used to cost effectively collect fishery dependent biological data to inform the lobster stock assessment?
3. Can biological data for Jonah crabs be efficiently collected by the research fleet as part of routine fishing practices utilizing the same equipment and protocols used for lobsters?
4. Can lobster traps be effectively utilized as platforms to record bottom water temperature data, and can new technologies be used to record and transmit this type of data efficiently?

Success of this pilot project was measured by the following criteria:

1. The performance of the technology tested;
2. The acceptance of the data collected;
3. The desire for participants to keep working together to build on the work accomplished.

**Methods:**

This pilot study for lobster data collection built upon on an existing consensus among fisheries managers, lobstermen, and outside scientists that additional data beyond routine state surveys and logbook reports is necessary to reduce uncertainties in lobster stock assessments, properly manage the fishery, and sustain the resource in the southern New England region. As such, the

objectives of the Lobster Research Fleet pilot project were to: 1) Identify and test new technologies to improve the quantity, quality, and timeliness of fishery dependent data in the American lobster and Jonah crab fisheries in the southern New England region; 2) Develop a data management system that provides important data to managers conducting stock assessments and developing management plans while also maintaining quality control, confidentiality, and access to individual data records by participating fishing vessels; 3) Develop a system to use lobster traps as platforms to record bottom water temperature data and relay the resultant data in an efficient manner; 4) Build credibility in the database supporting stock assessments and management plans for American lobster and Jonah crabs; and 5) Provide a model for how commercial fishermen and scientists can work together collaboratively to provide better information to support resource management.

First steps in the two year pilot program focused on developing a collaborative, well-coordinated data collection and management strategy that was implemented by a team of lobstermen, scientists, and managers utilizing agreed upon science protocols. The CFRF served as the main entity to facilitate working partnerships, and organize and oversee the many elements of the project, including data management, analysis, and sharing. A Project Steering Committee[1] comprised of representatives from the lobster fishery, state/regional/federal agencies (Rhode Island Department of Environmental Management, Massachusetts Division of Marine Fisheries, Atlantic States Marine Fisheries Commission, NOAA Northeast Fisheries Science Center), and the CFRF Board of Directors, provided expert input on sampling protocols, data parameters, technology, and data management, and monitored progress as the project advanced. Based on the sampling protocols developed by the Project Steering Committee, CFRF staff worked with a computer programmer to develop and test a data collection application (app) for Android tablets and a MySQL database into which data would be wirelessly deposited. The app was named "On-Deck Data". Coincidentally, CFRF staff researched and tested options for sampling equipment, including Android tablets, waterproof tablet cases, and calipers. Once On-Deck Data was fully developed, the CFRF worked with two lobster fishing vessels to conduct further testing of the app and sampling equipment at sea. App, database, and equipment adjustments were made during this time period based on input from the fishing vessel captains.

While the "On-Deck Data" app and sampling equipment were being developed, the CFRF issued a call for lobstermen fishing in Lobster Management Areas 2 and 3 to apply to participate in the Lobster Research Fleet. The CFRF utilized its contact list and worked with local lobstermen associations to relay this opportunity to the industry. A CFRF selection committee reviewed the applications and participants were chosen based on the location and times of year fished, experience with data collection, and a demonstrated desire to contribute to the science and management of the lobster fishery. The aim was to establish a fleet with as much spatial and

[1] Members Project Steering Committee for the CFRF Lobster Research Fleet Project include: Genevieve Nesslage, ASMFC; Robert Glenn, MA DMF; Mark Gibson, RI DEM; Burton Shank, NMFS NEFSC; David Spencer, AOLA; Lanny Dellinger, RILA; Greg Mataronas, Sakonnet Pt. Fishermen's Association; Norbert Stamps, AOLA; Heidi Henninger, AOLA.

temporal coverage as possible. In the end, a fleet of six lobster vessels fishing in Lobster Management Area 2 and six lobster vessels fishing in Lobster Management Area 3 was formed. The vessel names and home ports of Lobster Research Fleet participants include the following:

- F/V Ashley Ann - Point Judith, RI
- F/V Bluemoon - Newport, RI
- F/V Catherine Ann - Newport, RI
- F/V Debbie Ann - Point Judith, RI
- F/V Direction - Fairhaven, MA
- F/V Erika Knight - Point Judith, RI
- F/V Gladys Elaine - Newington, NH
- F/V Karen Ann - Point Judith, RI
- F/V Lady Clare - Point Judith, RI
- F/V Miss Julie - Hyannis, MA
- F/V Sakonnet Lobster II - Tiverton, RI
- F/V Sherri & Deke - Fairhaven, MA

All participant fishermen were trained how to use the sampling equipment and "On-Deck Data" app, and how to follow the sampling protocols developed by the Project Steering committee. The CFRF staff maintained regular communication with research fleet participants to help troubleshoot any issues that arose and to gather feedback on data collection efforts.

Between June 2013 and September 2015, the CFRF Lobster Research Fleet followed a fishery-dependent sampling protocol to collect biological lobster data from a subset of randomly selected commercial traps. Specifically, participating fishermen aimed to conduct at-sea sampling of commercial gear during three trips per month, with a sampling minimum of 100 lobsters or 20 traps during each sampling session. Sampling locations were selected randomly by the On-Deck Data app. The date and time of sampling, the location (latitude/longitude), the depth, and soak time of sampled traps, and the number of traps sampled were recorded for each sampling session using the "On-Deck Data" app. Fishermen were then prompted to record the carapace length (mm), sex (male/female/unknown), egg-bearing (eggs/no eggs) and v-notch status (v-notch, on v-notch), shell disease severity (none, mild, moderate, severe), shell hardness (soft, hard), and disposition (kept/discarded) for each lobster sampled (Figure 3). Electronic calipers were used to measure lobster carapace length to the nearest millimeter. Fishermen also had the ability to record notes and take photos of lobsters using the "On-Deck Data" app. Upon returning to the dock, fishermen uploaded their data via WIFI to a SQL database managed by the CFRF. The lobster database was regularly monitored by the CFRF staff for quality assurance and quality control.


***Figure 3.*** *Lobster sampling screen within the On-Deck Data tablet application*

In addition to commercial trap sampling, each participant fishermen also monitored lobster catch in three ventless traps that were provided by the CFRF and incorporated into commercial trawls. To maintain consistency with other ventless trap sampling programs in Rhode Island, Massachusetts, and Maine, the Lobster Research Fleet deployed ventless traps with the following configurations (Figure 4):

- 40” length × 21” width ×14” height
- Single parlor
- 1” square rubber-coated 12-gauge wire
- Standard shrimp mesh netting
- Cement runners
- 4” × 6” disabling door

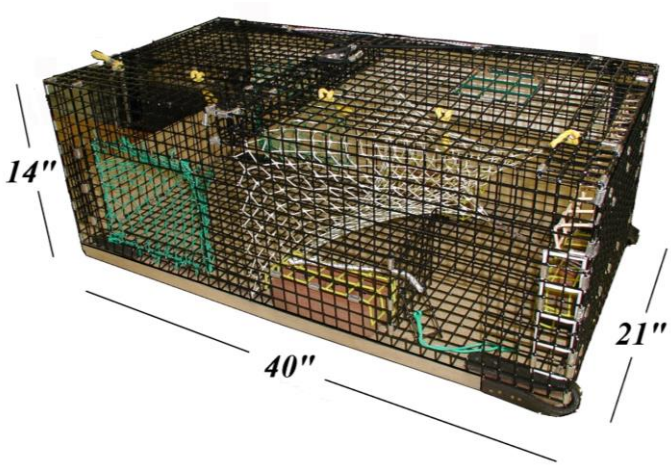


***Figure 4.*** *Ventless trap design. Image provided by Bob Glenn, MA DMF.*

As the pilot study progressed, CFRF received requests from lobstermen, scientists, and managers to expand the data collection to include basic biological information on Jonah crabs (*Cancer borealis*), an emerging fishery in the southern New England region that did not yet have a fishery management plan in place. In response to this request, the CFRF revised the "On-Deck Data" app to include the ability to record Jonah crab biological data, in addition to lobster biological data. The Jonah crab data collection component of this project followed the same sampling protocols as lobster, with each participant fisherman aiming to conduct three sampling sessions per month (100 Jonah crabs or 20 traps per session). Within the Jonah crab sampling component of the "On-Deck Data" app, participants recorded the carapace width (mm), sex (male/female/unknown), egg-bearing status (eggs/no eggs), and disposition (kept/discarded) of all sampled crabs (Figure 5). Modified electronic calipers, developed in collaboration with Lobster Research Fleet participants, were used to ensure a consistent measure of Jonah crab carapace width.

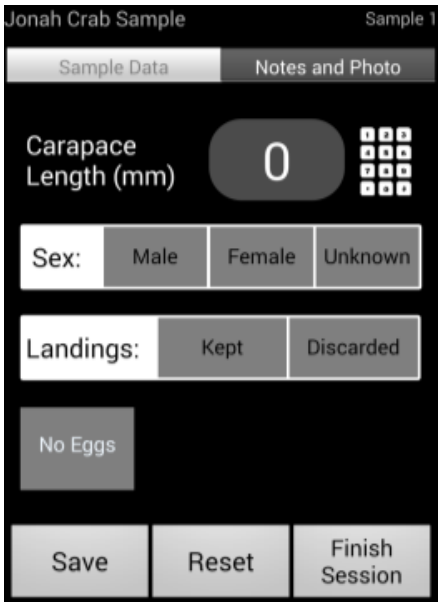


***Figure 5.*** *Jonah crab sampling screen within the On-Deck Data tablet application*

In addition to Jonah crab sampling, the fishing industry and scientific community also expressed interest in utilizing the fleet approach to record bottom water temperature data from lobster traps. To incorporate this idea into the pilot study, an additional tablet application, named "Ocean Temps", was developed and each participant fishermen was asked to deploy a Vemco Minilog temperature sensor in a ventless trap incorporated into a commercial trawl of lobster traps. After at least one month of deployment, participant fishermen retrieved the temperature sensors from the traps, downloaded the data to a Vemco Field Reader in the wheelhouse, and redeployed the temperature sensors on their fishing gear. The "Ocean Temps" app was then used to wirelessly retrieve the temperature data from the field reader, view the data in

graphical form, and send the data to the CFRF database via WIFI. Participant fishermen also used "Ocean Temps" to make notes about the bottom temperature monitoring location or time period, including storm events, unique currents, or surface water temperature measurements.

**Results:**

The approaches piloted by the CFRF Lobster Research Fleet focused on testing the easiest, most cost-effective ways to collect and verify biological lobster and Jonah crab data and bottom water temperatures, as well as the best methods to share such data with state, regional, and federal scientists/managers in an efficient manner. The techniques developed in this pilot program were overwhelmingly successful and offer the potential to serve as a model for other fisheries in southern New England and elsewhere.

The project research questions were addressed as follows:

*Research Question: Can new technologies enable lobstermen to reasonably incorporate data collection into their routine fishing practices and improve the quantity, quality, and timeliness of fishery dependent lobster data?*

The CFRF Lobster Research Fleet Pilot Project demonstrated the value of utilizing modern technology to aid in the collection and communication of lobster biological data by commercial lobster fishermen. Based upon reliability, durability, and performance at sea, the following equipment was found to be the most effective for industry-based lobster and Jonah crab data collection: 10" Google Nexus Android tablets, DryCase waterproof tablet case with vacuum seal, and Mitutoyo IP67-rated digimatic calipers. The CFRF also tested Fowler Sylvac digital calipers with Bluetooth capability, but the Bluetooth connection was unreliable and the caliper body did not hold up to the conditions at sea.

The On-Deck Data app for Android tablets proved be a reliable and effective means for fishermen to record lobster and Jonah crab biological data from commercial and ventless traps with specifics on location of catch. The On-Deck data app also demonstrated an expedient method for data communication from participant vessels to the project database and to end user groups. The app underwent a number of revisions based upon feedback from fleet participants and improved in functionality as the project progressed.

*Research Question: Can a lobster fishing vessel research fleet be used to cost effectively collect fishery dependent biological data to inform the lobster stock assessment?*

Over the course of the project, Lobster Research Fleet participants used the "On-Deck Data" app to efficiently and accurately record and communicate biological lobster data from southern New England, George's Bank, and the Gulf of Maine. This project provided critically needed lobster data from areas and times of year that had never before been sampled by federal observers or other fishery dependent sampling programs (personal communication, Burton Shank, NOAA NEFSC). Furthermore, it is believed that this approach costs far less than other

sampling approaches, although at the time of writing a cost-benefit comparison had not yet been completed.

Between June 2013 and September 2015, biological lobster data were collected from 14 statistical areas (Figure 6). Lobster data from 981 commercial trap sampling sessions (20 traps or 100 lobsters each) and 1,217 ventless trap sampling sessions (1 trap each) were uploaded to the CFRF database. These data collection efforts resulted in 61,851 individual lobster records (length, sex, shell disease, eggs, v-notch, shell hardness, disposition). Of these lobsters, approximately 32% were male and 68% were female. Approximately 16% of female lobsters were carrying eggs and 4% were v-notched. Of all lobsters sampled, 10% had shell disease. Lobsters ranged in size from 22mm to 210mm, and had an average length of 85.2mm.

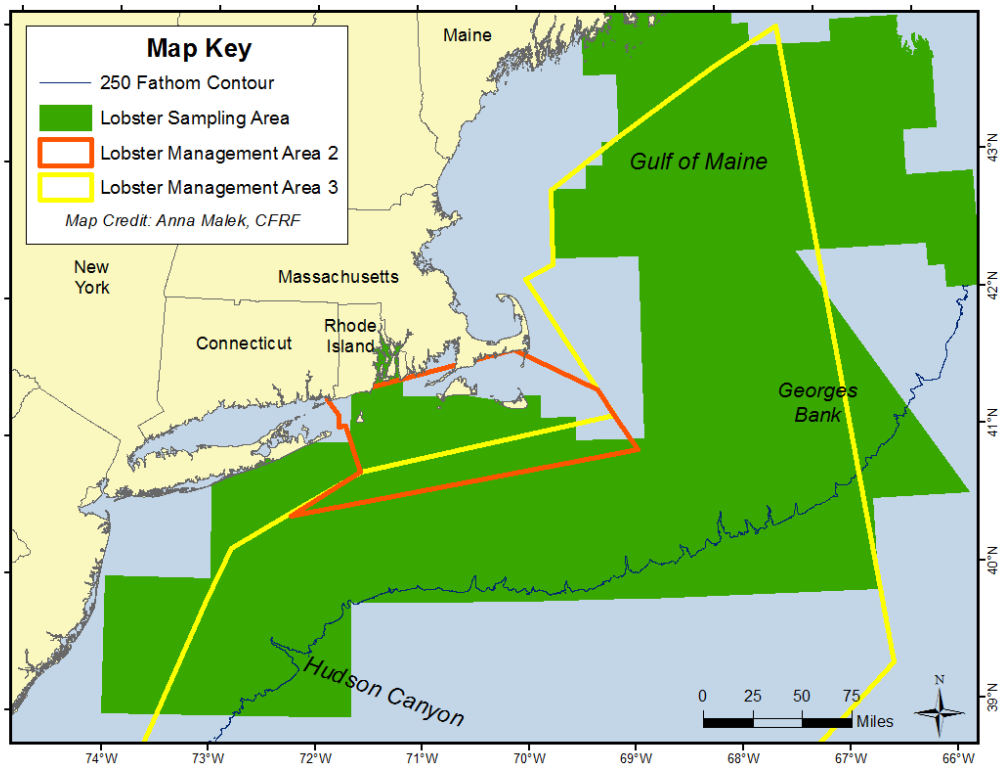


***Figure 6.*** *Map of the areas sampled for lobster by the CFRF Lobster Research Fleet.*

In an effort to provide regular feedback to fleet participants, the CFRF staff compiled and distributed data reports to the 12 participating vessels every three months. In addition to summary statistics, including the size and sex distributions of lobster catch, Lobster Research Fleet participants were also provided with copies of the photos that they upload to the CFRF database as well as digital versions of their raw data (MS Excel format). Printed versions of raw data records were provided upon request.

On a semi-annual basis, CFRF staff compiled and transferred the lobster data collected by the CFRF Lobster Research Fleet to the Atlantic Coastal Cooperative Statistics Program (ACCSP) lobster biosamples database. ACCSP codes and table structures were followed to ensure rapid assimilation into the ACCSP databases. Vessel-specific data were kept confidential via a vessel ID system.

In the end, the lobster biosamples data collected by the CFRF Lobster Research Fleet was incorporated into the 2015 lobster stock assessment, filling critical data gaps, particularly in offshore waters. Specifically, Burton Shank, NOAA NEFSC Research Fisheries Biologist stated that "*The CFRF lobster fleet provided data for 2013 and 2014 that were used extensively in the assessment model inputs for all stocks, often providing the only data for certain locations. The CFRF data were included to characterize the last two years of the model, which ran through 2014, but also used to gap fill many of the previous years in these areas because catch composition is less variable across years than across space. As a result, the data collected by CFRF in the first two years of the project were very informative for the stock assessment*."

*Research Question: Can biological data for Jonah crabs be efficiently collected by the research fleet as part of routine fishing practices utilizing the same equipment and protocols used for lobsters?*

Lobster Research Fleet participants used the "On-Deck Data" app and modified Mitutoyo calipers to collect biological Jonah crab data during routine fishing practices between June 2014 and September 2015. The user-friendly interfaces and wireless data transmission capability of the "On-Deck Data" app enabled accurate and timely sampling of Jonah crabs, while the modified Mitutoyo calipers, developed in collaboration with Lobster Research Fleet participants, enabled efficient measuring of Jonah crabs (Figure 7).


***Figure 7.*** *Modified Mitutoyo calipers used for Jonah crab measurement.*

Between June 2014 and September 2015, ten vessels conducted 232 commercial trap sampling sessions (20 traps or 100 Jonah crabs each) and 76 ventless trap sampling sessions (1 ventless trap each) for Jonah crabs. A total of 15,542 individual Jonah crab records (length, sex, eggs, disposition) were collected. Of these Jonah crabs, approximately 90% were male and 10% were female. Approximately 4.5% of female crabs were carrying eggs. Jonah crabs ranged in size from 28mm to 170mm, and had an average carapace width of 125.1mm. Biological Jonah crab data were collected from seven statistical areas (Figure 8).

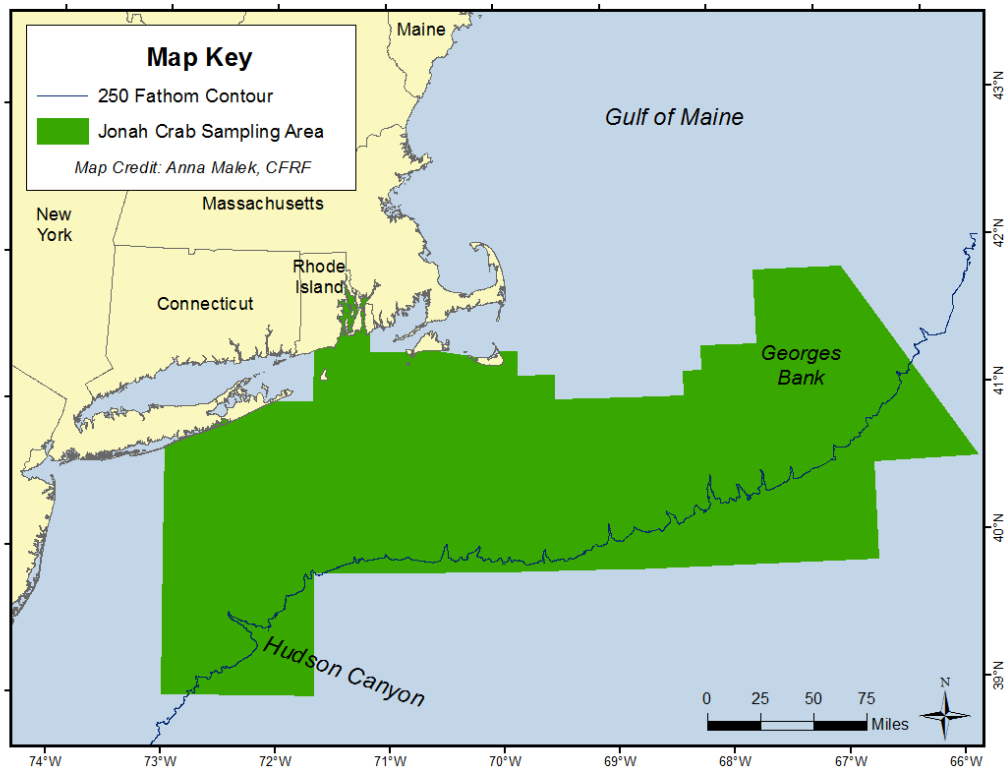


***Figure 8.*** *Map of the areas sampled for Jonah crab by the CFRF Lobster Research Fleet.*

Fleet participants that collected Jonah crab data were provided with a copy and summary of their data, including the size and sex distribution of Jonah crab catch, every three months. Jonah crab data was also compiled and sent to the Atlantic Coastal Cooperative Statistics Program (ACCSP) Jonah crab biosamples database every six months.

In the end, the Jonah crab biosamples data collected by the CFRF Lobster Research Fleet was used to guide the development of the Jonah Crab Fishery Management Plan. Specifically, Burton Shank, NOAA NEFSC Research Fisheries Biologist noted that "*The CFRF lobster fleet provided valuable data on Jonah crabs for the development of the ASMFC Jonah crab fisheries management plan (FMP). It was decided early in the development of the FMP, that Jonah crabs were going to be largely managed using minimum sizes and limited take of female crabs, both of which are valuable for maintaining a healthy brood stock. Because Jonah crab fishing is more*

*of a volume-based fishery, making it is difficult to measure each crab individually, it was difficult to determine how to set management controls that would simultaneously have minimal impact on the efficiency of the fishery, sufficiently protect the wild population, and be enforceable. The 2014 Jonah crab data were analyzed along with Mass DMF port sampling and limited NMFS observer data to characterize the raw catch and landings of crab fishermen. The data provided information on the size composition of females and males, sorting behavior of fishermen, variability among trawls and differences between inshore and offshore. The results of the analysis were discussed at a meeting with managers, law enforcement, and industry, submitted to the ASMFC and distributed to the lobster committee prior to the August meeting where decisions on the FMP were finalized. For this analysis, CFRF was the only data source that effectively allowed for characterizing inshore vs offshore catch compositions and the variability among trawls, allowing for more informed management decisions."*

*Research Question: Can lobster traps be effectively utilized as platforms to record bottom water temperature data, and can new technologies be used to record and transmit this type of data efficiently?*

The VEMCO Minilog and Field Reader system proved to be an effective means for lobster fishermen to collect and communicate bottom water temperature data from lobster traps. The CFRF initially experienced difficulties while setting up the Bluetooth connection between the VEMCO Minilog/Field Reader system and the "Ocean Temps" app, but once this was overcome the equipment proved to be reliable and efficient. The "Ocean Temps" app enabled lobstermen to record bottom water temperature in a given fishing location, wirelessly transfer and view their temperature data on an Android tablet, and remotely upload data to a secure database. A number of participant fishermen used this information to develop a better understanding of the relationship between bottom water temperature and lobster catch and, thus, inform their fishing practices over time. A unique component of the Lobster Research Fleet temperature monitoring initiative is the use of wireless technology that does not require an onboard computer or water-sensitive cables. This feature is critically important for applicability on fishing vessels, which require cost-effective and user friendly tools for environmental data collection. Furthermore, the ability for fishermen to upload bottom water temperature data to a secure database with the touch of a button promotes the timely review and use of the data without the high costs of satellite communication.

Between June 2014 and September 2015, Lobster Research Fleet participants collected bottom water temperature time series from nearly 100 different locations, for a total of 718,750 temperature records (Figure 9).

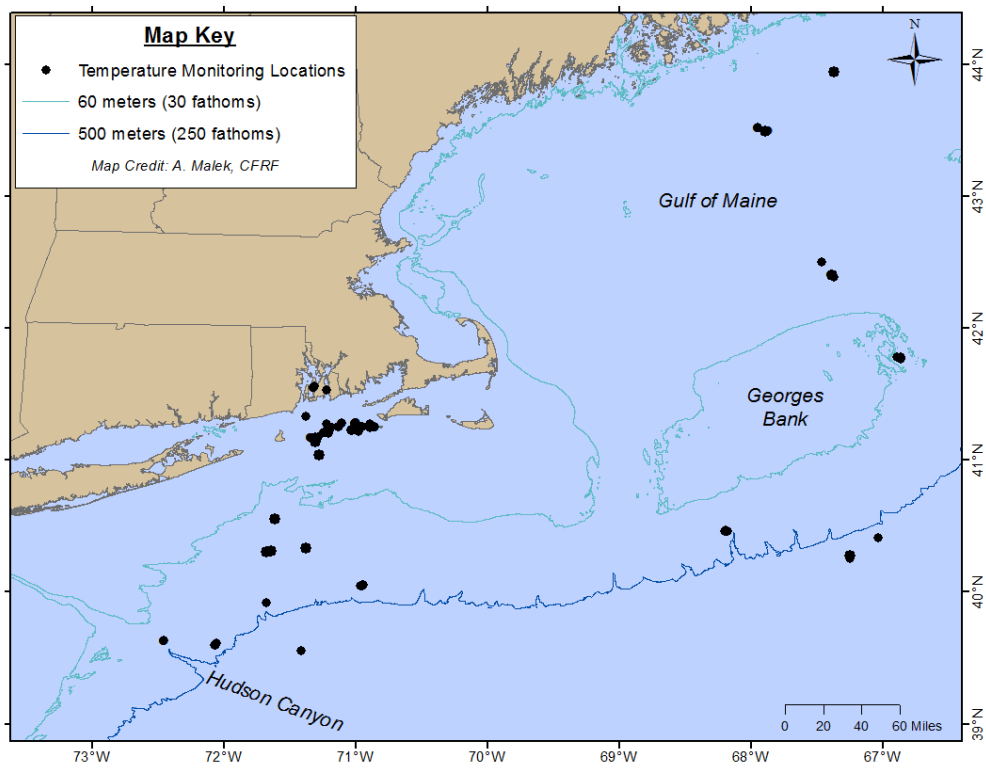


***Figure 9.*** *Map of bottom water temperature monitoring locations by the CFRF Lobster Research Fleet between June 2014 and September 2015.*

**Conclusions:**

The CFRF Lobster Research Fleet Pilot Project has demonstrated the value of integrating a collaborative approach from the very start of a project. In the beginning of the pilot project, members of the commercial fishing industry, scientists, and managers worked together to finalize data parameters and sampling protocols, and this created a sense of meaningful involvement from all parties early on. As the project progressed, the CFRF staff worked closely with ASMFC and ACCSP staff to make sure the data transfers would be seamless and timely. This was critically important in enabling the data to be used in the 2014 lobster stock assessment and early efforts to begin managing the Jonah crab fishery. Data management strategies also ensured that industry members felt confident that they could maintain a copy of the data they collected while at the same time knowing that data was being relayed to and used by stock assessment scientists. Confidentiality concerns were addressed and data was able to be managed and shared in a way consistent with agreed upon guidelines.

In terms of data collection technology, an appropriate set of technical equipment was identified and tested in the field, and has proven to be reliable and easy to use over the course of this two year project. The amount of data collected from a fleet of 12 fishing vessels during this relatively short pilot project study was very impressive, and covered a number of Statistical Areas in LMAs 2 and 3, extending from the Gulf of Maine to Hudson Canyon, off of New Jersey. It should also be noted that more lobstermen wanted to participate in this pilot project than

could be accommodated with available resources, highlighting the fact that the geographic area covered and the amount of data coming from each Statistical Area could have been even more expansive. This points to the potential for extending this successful data collection approach and developing the resultant database even further in terms of temporal and spatial coverage.

The ongoing communication that was maintained by the CFRF throughout the project helped build trust and confidence by all involved that the data was credible and was being used. The fishery dependent data collection approach successfully modeled in this pilot study has the potential to serve as a model for other fisheries. It might also serve as a foundation on which to build more fishery-independent data collection efforts involving fishing industry members, especially in hard to reach areas offshore and for species not readily sampled by federal trawl surveys.

Overall, the Lobster Research Fleet pilot project was successful in 1) piloting modern technology (tablets, electronic calipers, Bluetooth temperature sensors) on lobster fishing vessels to collect biological and environmental data, 2) Developing efficient data sharing protocols that supported the direct use of project data by state, regional, and federal scientists/managers while also ensuring that lobster industry members retained access to the data, and 3) Building an engaged and committed research fleet that wants to continue working together to collect critically needed biological lobster and Jonah crab data and bottom water temperatures to reduce uncertainties in stock assessments and begin to better understand the influence of environmental factors on the abundance and distribution of these species.

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