Environmental Monitors on Lobster Traps:
Phase V Real-time Temperature
Final Report
2010

Award number: 07-051
Period of performance: 06/30/08-6/30/10
Date of final report submission: September 30, 2010

Contact information of the principal investigator:
Jim Manning
NOAA/NEFSC
166 Water St
Woods Hole, MA
02543
508-495-2211 james.manning@noaa.gov

Other key participants:

Erin Pelletier, 207-985-8088, erin@gomlf.org
Gulf of Maine Lobster Foundation

Dave Casoni, 508-224-3038, lobsterteacher@hotmail.com
Massachusetts Lobstermen

Abstract
With a grant from NOAA's Small Business Initiative Research Program (SBIR) in 2006, a bottom-temperature probe had been under development by the Advanced Design Consultant firm in Lansing, NY, that would wirelessly send data to a base station in the vessel's wheelhouse after being hauled on deck and then relay the information to a satellite. Given this potential development, we had proposed to NEC that same year to make use of this probe in the real ocean if and when it became a reality. Unfortunately, a reliable probe was never developed and we were forced to look for alternatives. Now, nearly five years later, we are still waiting. After talking and working with various other ocean engineers, we still do NOT have the instrument we need for our specific application. In the meantime, we have investigated a few off-the-shelf alternatives, that at least provide a compromise towards delivering semi-realtime data in the way we had originally imagined.

This report summarizes our experiences on this front with a description of the various trials undertaken. While the probe we need was never actually developed, the lobstermen did help test a set of experimental probes that ultimately failed. The lobstermen did fulfill their role in the project. Given the proper tools and technological breakthroughs, we still believe the lobstermen could make a significant contribution to NOAA's Integrated Ocean Observing System.

Introduction
Since the inception of the eMOLT project in 2001, many participants have become increasingly interested in monitoring temperature on their traps. After years of observing the surprisingly large variability that can occur over various time scales, many lobstermen have developed a more serious interest in the physical processes that are obviously exposing lobsters to variable conditions. Consequently, more and more participants are interested in seeing more daily realtime information as oppose to the standard annual feedback in the form of a few hardcopy plots.

While this interest is in environmental monitoring is evidently increasing given all the talk of climate change, it is not new. Many participants have told stories of their attempts (and those of many old-timers) at getting realtime information in the past. These included sending household kitchen thermometers down with their traps inside insulated Coke bottles and some embedded with the flesh of bait fish. There are stories of lobstermen who have boxes of old log books recording their findings. I have never met a lobsterman who did NOT believe that bottom temperature was an important regulator of their preys activity.

Project Objectives and Scientific Hypothesis
The primary objective of eMOLT Phase V was to deliver realtime lobster trap temperatures to a NOAA server and therefore to contribute to our region's observing system on a daily basis. Given the appropriate technological developments, we had hoped

to be able to supplement the existing realtime data stream from the GOMOOS moorings, for example, where users could click on a web-served map and obtain the latest readings of bottom temperature from around the region. In addition to providing the eMOLT participants a means of assessing the day to day changes in bottom conditions, we also hoped to provide numerical modelers a data stream for assimilation or validation of their simulated ocean. The hope was to have dozens of sites that were reporting a time series of hourly values updated as often as the traps were hauled.

We expected a probe would be developed that would automatically relay its data as it was hauled on deck. At the time of our proposal in 2006, the probe was well on its way as

Figure 1. ADC's first realtime temperature prototype in 2006 at the time of our proposal.

pictured in Figure 1. We imagined the probe could be triggered by either a light sensor, pressure sensor, or a conductivity sensor so that it would wirelessly download its memory since the last haul. The probe would need to have enough battery power to survive months on the trap before recharging, be accurate to about 0.2 degress Celius, sustain depths up to 300 meters, be unaffected by bio-fouling, and be small and light enough to not interfere with normal fishing operation.

Participants

A variety of people and organizations have been involved with this quest for a real-time temperature probe. The initiative actually began with our one-page proposal to Beth Turner, the program manager for the Georges Bank GLOBEC project back in 2003. We suggested this probe be developed with the SBIR funds that were mandated for projects such as GLOBEC. The call for proposals subsequently went out and more than a dozen professional companies responded with a wide variety of solutions to the problem. After an extensive review of these proposals by a set of world class marine engineers such as Jim Irish and Dan Frye at the Woods Hole Oceanographic Institution as well as a few individuals in the lobster industry, the Advanced Design Consultants was chosen.

The ADC engineers, Eric Van Every and Dr. Johnson, visited Woods Hole a few times to discuss the problem and understand the specifications. In their first visit, they met with the representatives from various lobstermen association (McCarron, Casoni, Pelletier, and Spinazzola). Extensive communication and experimentation was conducted over the period of a few years. Multiple prototypes were sent to us. In the first phase of the project, we tested the range of the blue tooth communication on board a few of the larger

Atalantic Offshore Lobstermen Association boats in the Sandwich Boat Basin belonging to Marc Palombo and Bob Colbert to insure the instrument could wirelessly transmit from the fantail to the wheelhouse. We next tested some prototype off the dock in Woods Hole and then some were tested on lobster traps in Cape Cod Bay. The first prototypes were deployed on traps by lobstermen John Carver and Phil Mason in Mass Bay in 2006. Wayne Lambergini, a lobsterman out of Sandwich MA took Dave Casoni, another interested lobstermen, Kurt Oehme, and Jim Manning out for some experimentation.

Figure 2. Lobstermen involved in February 2007 experiments with ADC probe in Cape Cod Bay (Lambergini, Oehme, Weeks, and Casoni).

There were a series of failures, many of them having to due with the instrument housing leaking. At least one data point was successfully transmitted from a parking lot deployment, through the OrbComm satellite system, to our NOAA server in the form of an email. However, just when they appeared to have developed a probe that may work, the company was reorganized. Van Every was moved away from the bench to an administrative position and no longer responded to the project.

Since the ADC no longer responded to phone calls/emails and apparently decided to permanently drop the project, the real-time probe development has progressed on multiple other fronts. As described in various annual reports, one of the most promising work was being conducted by Jim Valdes. As an independent Woods Hole ocean engineer for multiple decades, he has been devising state-of-the-art solutions for large government-funded projects around the world. While he had very little time for this project, he has worked on a system for other projects where both the temperature sensor

and the satellite transmitter are sealed together in a housing and submerged as a package. Ruben Davis, an electronic engineer with DATIS Systems out of Catamet, MA also helped, as described in the methods section below, in our endeavors to develop a probe and communicated with Billy Lister, a lobsterman out of Barnstable Harbor.. Francesco Peri, an electronic engineers with UMASS Boston's Earth and Environmental Ocean Science Department, contributed some ideas as well but none of these individuals could generate working prototype with the funding we were offering. Given our experiences with ADC, we did not want to provide them money upfront. Finally, in the summer of 2010, the VEMCO Inc out of Halifax, Nova Scotia released a probe on the market that provided at least some of the functionality we needed. So, there were multiple people involved with this project as it evolved over the period of several years. The following section summarizes the methods these participants used in their development efforts.

Methods

As noted above, various methods were tried in the development of the realtime probe by multiple institutions/engineers. Despite several attempts, none of the solutions matched that of the proposed plan.

ADC/VanEvery

While ADC apparently had extensive practice in developing a variety of electronic sensors, their experience in the marine environment was limited. Their first two prototypes evidently failed due to a leaky housing seal. Even after an attempt to completely seal a subsequent prototype, the instrument leaked again (this time deployed off the dock in Woods Hole) evidently due to a hair-line fracture in the plastic sealing material. Finally, in February of 2006, the first marginally successful deployment was conducted in 70+ feet of water in Mass Bay. While the temperature was recorded the pressure sensor failed and therefore the automatic download trigger failed. The wireless data download had to be conducted with a manual sweep of a magnet by the sensor.

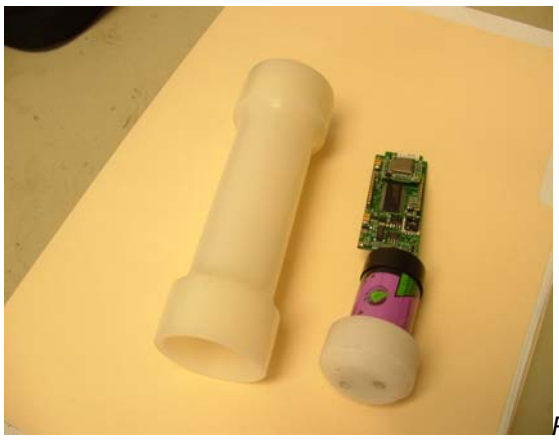

Figure 3. ADC Prototpye #2.

Figure 4. ADC handheld device to plot data on board.

Multiple protypes were produced such as that pictured in Figure 3. After the 1st prototype failed a more rugged housing was designed and tested. These successfully communicated to the handheld HP computer (Figure 4).

WHOI/Valdes

The advantage of Jim Valdes's strategy is that the entire system is contained in a single unit and does not need a shipboard base station. The disadvantage is that the lobstermen would not get immediate access to the readings and the expense of the satellite transmitter will prohibit lobstermen from deploying multiple units. Valdes did make some unpaid steps in devising a solution. He reported at one point that he had the logger averaging temperature and that he is working on getting data to/from the AXONN STX2 satellite-modem module. He had planned to use "Delrin P-Case" to house the complete unit. We hope that the final modifications to this technology may one day be made to provide the lobstermen with wireless realtime readings but since Valdes's primary fudning comes from large scale global programs, he has yet to find time for this development, perhaps in his semi-retirement years.

Figure 5. DATIS surface buoy proposed to house radio beacon.

DATIS/Davis

A third party, DATIS Systems of Catamet, Massachusetts became involved in 2008. They had proposed a number of alternative solutions including deploying a cable to the ocean bottom that continually transmits to either a) a satellite-modem, b) a radio-transmitter or c) a cell-phone system mounted on a surface buoy. Either case does not require routine lobstermen intervention. The unit could be deployed on its own and left for months at a time. The advantage of option "a" is maximum range, the advantage of option "b" is reduced cost, and the advantage of option "c" is that a lobstermen may be able to call for data as needed. Much of the DATIS effort had involved designing a surface buoy that is stable enough to transmit data. A couple prototypes are pictured in Figure 5 and 6.

Figure 6. DATIS prototype surface buoy for radio receiver.

In early 2009, a few attempts were made to transmit temperature data from unit attached to a boat house in Woods Hole Harbor to a 3rd floor office at the NEFSC lab. Both battery power and range apparently limited the reception. In October 2009, an experiment was conducted on Buzzards Bay where Manning and Davis deployed a

free drifting unit with a radio transmitter. The unit worked sending GPS and temperature to the vessel but the range was limited to a few hundred meters.

After significant research, DATIS found much of the relevant technology can be derived from the agricultural world where sensors are deployed in the field. One such unit called the Moritor System (see www.moritor.com), for example, may one day be applied to the marine environment . ONSET Corp in Pocassett MA, for example, has recently developed a such a system which would be cost prohibitive for own needs as it exist today.

UMASSB/Peri

In the spring of 2010, we communicated with Franciso Peri at UMASS Boston and his company the Charybdis Group. After a few visits to Boston and more than a dozen email exchanges, it was decided there was not enough money in the budget to do what was needed in the time allowed. Their solution, similar to the DATIS approach, was to use low power microprocessor and radio communication chip that would transmit data to the vessel via a ZigBee IEEE802.15.4 Star network topology. The vessel would have a "GSM or Satellite uplink".

AXONN/Manning

One option we investigated is the use of the AXONN Axtracker transmitter. These are the same GPS units we had used on the drifters that allow users to plug in temperature sensor and have the data telemetered with the position. The primary limitation of this method is the accuracy of the existing probes is near 1 degC where we need accuracy closer to 0.1 degC. We had hope to interface more accurate sensors but the Axtracker T2 model was phased out by AXONN so that these instruments are now difficult to obtain. The other difficulties with this method are a) waterproofing the input port that is not designed for units submersed in seawater and b) a cable is required through the water column.

VEMCO/Manning

In the end, the compromise solution is to use recently released by VEMCO field Reader and the Minilog-II (Figure 7). This system wireless transmits data from the sensor to either a handheld unit or directly to a laptop. So, with just months to go in the contract we purchased three of these systems to be deployed in the coming months. It is a fairly easy system to use. Initial test were successful in the lab.

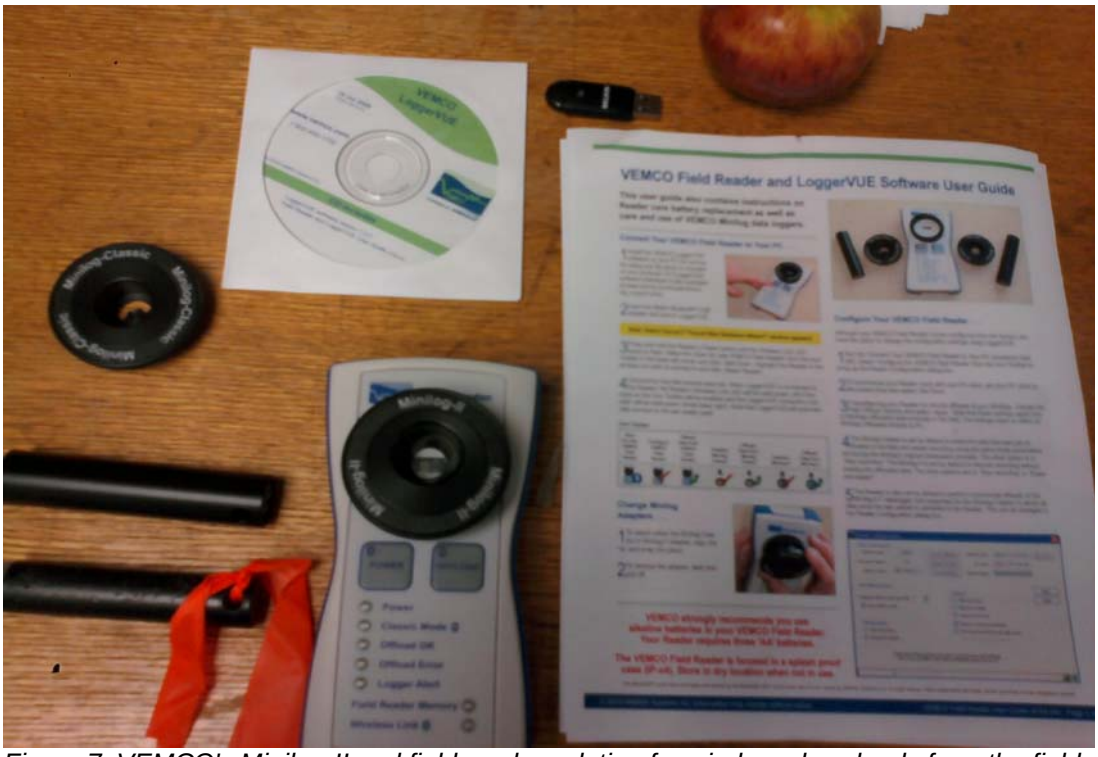

Figure 7. VEMCO's Minilog-II and field reader solution for wireless downloads from the field.

Data

While we failed to collect the "realtime data" expected in phase V, we have successfully continued the data collection associated with the internally-recording instrumentation deployed in phase I. Given the additional funding cycles, we were able to replenish the supply of instruments needed to maintain the existing network of samples. The dataset is now approaching at total of 5 million hourly observations of temperature from over 200 locations in various depths around the Gulf of Maine. Since the first year of the program, these data are publicly accessible at http://emolt.org.

Results and Conclusions

While more time/effort was spent on the development of this probe than any other phase of eMOLT, it has been the least successful in terms of results. Taken from the annual report from 2007, the only partially successful deployment from a lobster trap is plotted in Figure 8 below. While the ADC instrument did not function exactly as programmed and reported very little pressure/depth readings, it did transmit the hourly record of temperature and displayed the values on the handheld unit in the wheelhouse. The triggered response to low pressure failed due to bad pressure records. Approximately 10% of the temperature readings were also bad. So, while the deployment was generally successful, there was obviously more work to be conducted. The unit was returned to ADC for inspection and further development.

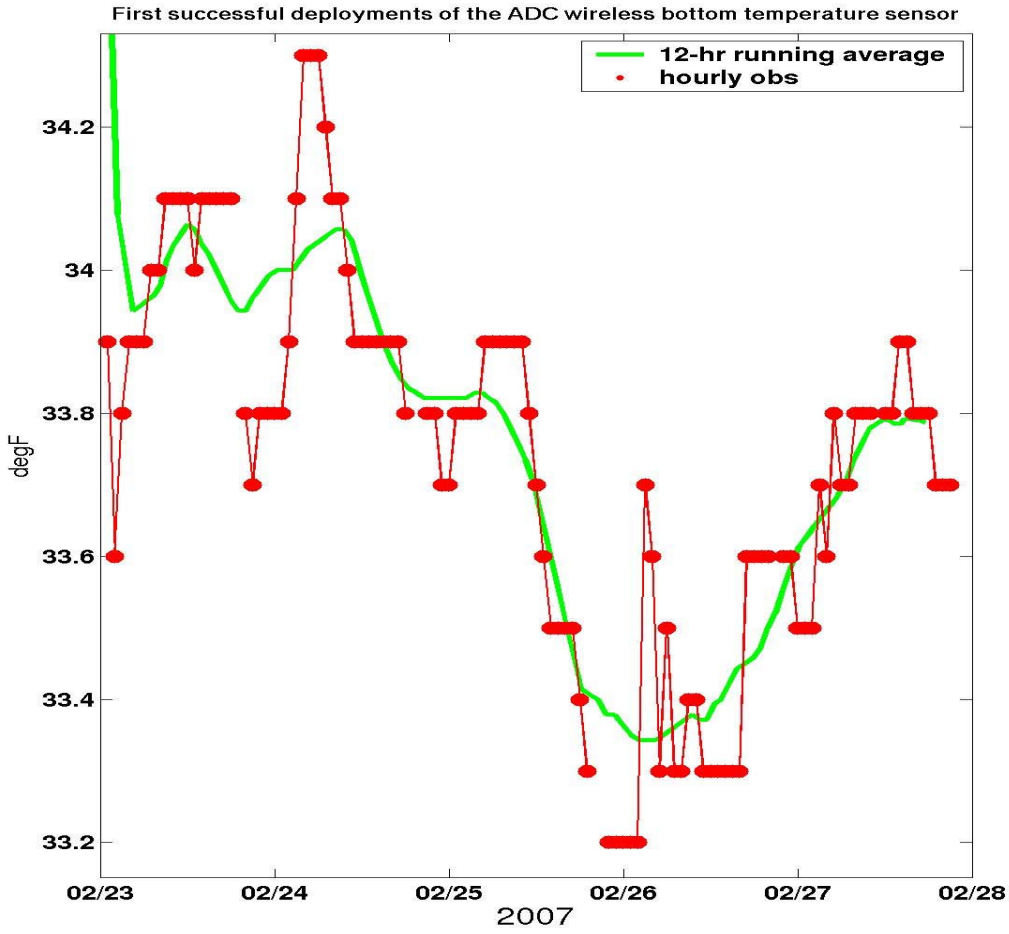

Figure 8. Time series of ADC realtime probe after deployment in Feb 2007 and a wireless download.

In September 2007, another prototype was tested on land that successfully transmitted data to a ORBCOMM satellite and automatically emailed the result to the NOAA server. While the transmission was successful this one time, subsequent attempts failed. We continued working with the engineers at ADC to make the system reliable enough to pass on to fisherman but nothing ever materialized. While some of our time was spent in learning the ORBCOMM satellite system (which is different from the GLOBALSTAR system used in our drifter work to date), the primary issues to be solved in this case was battery life and waterproofing.

So, in general, over the course of multiple years, we did learn what not to do. It is difficult to base a research project around a technology that has not yet been proven. It is advisable to NOT rely on a single commercial outfit for the tools needed as this company may dissolve or refocus on other more profitable endeavors. We should have learned this lesson in eMOLT phase III where we invested our time and money on a

company to produce a electronic logbook only to have them go out of business a year later.

Partnerships and Related Projects

eMOLT is connected with a variety of projects around the gulf. A short list of them is provided in Table 1.

Project	Contact
GoMOOS/NECODP/NERACOOS	Tom Shyka
DMF Ventless	Bob Glenn
GoMLF VentTS	Erin Pelletier
FSRS monitoring	Patty King
Lobster Conservancy	Diane Cowan
S Maine Comm. College	Brian Tarbox
ASFMC Ventless Trap	Carl Wilson
RIDEM	Tom Angel
Bigelow Lab	Rick Wahle

Impacts and Applications

Given the failures associated with this phase of eMOLT, very little impact or applications can be recorded. While there is certainly a demand for "realtime" information, it is clear that it comes with a price. Our experience does demonstrate why it is so difficult to fund longterm monitoring when realtime telemetry is needed.

Presentations

eMOLT results have been presented at dozens of meetings in the last few years. These include annual meetings of the Maine Fishermen Forum and the Mass Lobstermen. It has been discussed at multiple meetings of the ICES Steering Group on Global Ocean Observing Systems (2008-2010). It was presented at the Northeast Fisheries Science Center Science Symposium in Newport RI in January 2008. It is mentioned in the annual meetings of the Gulf of Maine Toxicity (GoMTOX) program. It will be presented at the annual Regional Association for Research in the Gulf of Maine (RARGOM) meeting on 6 Oct, 2010 as well as at the annual NEC meetings.

Published Reports and Papers

The most significant international documentation of eMOLT was published in the Journal of Operational Oceanograpy (Manning and Pelletier, 2009) but it also appeared in the ICES newsletter in 2006. Stories that mention eMOLT operations have appeared in several local newspapers including the Cape Cod Times, the Falmouth Enterprise, the Patriot Ledger, the Cohasett Mariner, the Salem News, the Boston Globe, the Southcoast Today Standard Times, Commercial Fisheries News, and the Fall River Herald News. The emolt.org site posts all the near-seasonal newsletters to participants, the annual progress reports, and the final reports such as this.

Images
The very few images are available from Phase V emolt are included in this report.

Future Research
In the last several years, NOAA's Integrated Ocean Observing Systems has become a reality and, as of March 2009, mandated by law. While the existing network of assets (such as the GoMOOS buoys) are expected to be maintained in the next few years, new observations will be limited given the funding currently available. However, if and when the Northeast Regional Association of Coastal Ocean Observing Systems is able to "enhance" the existing structure, the eMOLT system is solidly in line to supplement the operation. Proposals to IOOS have included eMOLT-related work in the last few cycles and again this year in the 2011-2015 plan. It is hoped that New England lobstermen may someday be making a significant contribution to the collective system.

Given the proper resources, a real-time temperature will one day be developed. It is hoped that the lessons learned in eMOLT V will not be lost and that this document will be read and considered by those who, along with us, attempt the same endeavor in the future. We have learned that real-time telemetry is NOT something you do with limited funds at least not with technology that is "under development".