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# Acquisition of an X-Band Satellite Data Groundstation for Regional Multidisciplinary Research, Training and Services in Maine

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**Final Report for Period:** 08/2007 - 07/2008**Submitted on:** 08/29/2008**Principal Investigator:** Thomas, Andrew C.**Award ID:** 0420393**Organization:** University of Maine**Submitted By:**

Thomas, Andrew - Principal Investigator

**Title:**

Acquisition of an X-Band Satellite Data Groundstation for Regional Multidisciplinary Research, Training and Services in Maine

### Project Participants

#### Senior Personnel

**Name:** Thomas, Andrew**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Beard-Tisdale, Mary-Kate**Worked for more than 160 Hours:** No**Contribution to Project:**

As co-PI, Beard's direct involvement did not require &gt; 160 hours over the past year.

**Name:** Sader, Steven**Worked for more than 160 Hours:** No**Contribution to Project:**

As co-PI, Sader's direct involvement did not require &gt; 160 hours over the past year.

**Name:** Resson, Habtom**Worked for more than 160 Hours:** No**Contribution to Project:**

As co-PI, Resson's direct involvement did not require &gt; 160 hours over the past year.

#### Post-doc

**Name:** Son, SeungHyun**Worked for more than 160 Hours:** Yes**Contribution to Project:**

Dr Son, a post doc here at U.Maine, was extensively involved in the data QC/QA and data analysis of the project.

**Name:** Henson, Stephanie**Worked for more than 160 Hours:** No**Contribution to Project:**

Dr. Henson was a post doc for 2 years in the Satellite Data Lab during this project. She participated in data use and analysis at a level less than 160 hours.

#### Graduate Student

**Name:** Legaard, Kasey**Worked for more than 160 Hours:** No**Contribution to Project:**

Kasey was a Masters student in the Satellite Data Lab, whose contributed to both the set up and maintenance of the data stream,

during his tenure. These efforts were less than 160 hours.

## Undergraduate Student

### Technician, Programmer

**Name:** Weatherbee, Ryan

**Worked for more than 160 Hours:** Yes

**Contribution to Project:**

Ryan is a professional data analyst and has been extensively involved in the set up, configuration, maintenance and data reception / delivery of the X band telemetry stream.

**Name:** Brickley, Peter

**Worked for more than 160 Hours:** Yes

**Contribution to Project:**

Dr. Brickley is a professional data analyst and has been extensively involved in the set up, configuration, maintenance and data reception / delivery of the X band telemetry stream.

## Other Participant

### Research Experience for Undergraduates

#### Organizational Partners

#### Other Collaborators or Contacts

Scott Glenn, Rutgers University  
 Jim Bisagni, U. Mass Dartmouth  
 Dennis McGillicuddy / Don Anderson, WHOI  
 Tom Shyka, GOMOOS, Portland ME  
 Daryl Williams, Canadian Navy, METOC Office, Halifax  
 Linda Mercer, Maine Dept. of Marine Resources

#### Activities and Findings

### Research and Education Activities:

We have acquired an X-Band satellite data groundstation from SeaSpace Corp. built, installed, and configured it at the University of Maine. After ~ 1 year of electronic debugging and technical issues, the system is presently quite stable and receives a continuous flow of daily satellite data from the NASA MODIS satellite series. For 2 years we also tracked and received data from the Indian Ocm ocean color satellite. At present, the Indian Space Agency has turned off transmission, due to satellite technical difficulties. The reception facility, both the physical infrastructure and its resulting data stream of earth observation satellite imagery, has been incorporated into our research, teaching and outreach/service activities.

These data provide operational imagery over the NE shelf region of ocean color, from which surface chlorophyll and suspended sediments can be viewed, and sea surface temperature, indicative of frontal zones, water masses and current structure. The MODIS data provide 1 color image per day and 4 SST images per day, 365 days per year. (For the past 2 years, the color instrument on MODIS TERRA has been suspect).

In addition to standard NASA products, we have also implemented a 'true-color' view of terrestrial and ocean study areas, using algorithms modified from those developed at U. Wisconsin (who operate a similar facility). These images provide a view of ocean surface turbidity / clarity, as well as a view of terrestrial color.

The data stream was the target of a cooperative NASA-SBIR project

with a local private company (MILCORD). The project focussed on the modification and demonstration of software presently used by the commercial financial sector to monitor and make decisions with stock market data streams, for use with real-time satellite data streams.

Data from the Groundstation have been incorporated into 3 School of Marine Sciences classes at the University of Maine. Two undergraduate classes, SMS 100 and SMS 302, make use of the real-time data posted on the web site to explore seasonal and spatial variability on the NE US shelf. A graduate class (SMS 540) makes use of both the data and the reception infrastructure to expose students to satellite tracking, data reception and raw data processing issues as well as ocean data analysis.

Data from the X-Band satellite data are used in a number of research and operational activities by U Maine as well as others in the NE region. These are outlined under findings.

### **Findings:**

This project is an equipment acquisition, so the major findings are associated with activities involving the reception facility and the resulting data stream. The primary contributions of this project are to the ongoing synoptic surface temperature, color pattern, and chlorophyll monitoring of the Gulf of Maine. As such, these data are used across multiple, separately funded research and monitoring projects.

Active and consistent users of the data provided by the infrastructure are:

**GOMTOX:** a NOAA funded Harmful Algal Bloom project in the Gulf of Maine, led by WHOI with PIs from U Maine and U Mass Dartmouth. For a series of cruises (4 in summer 2008), active cruise support was provided by e-mailing image data to the ship to assist sampling design. In addition, the data is used for post-cruise research and data analysis.

**Maine Dept of Marine resources:** this group has been set up to allow access to all the data for use in their operational harmful algal bloom monitoring.

**GOMOOS:** The Gulf of Maine Ocean Observing System is delivered these data on an operational basis. The infrastructure has been incorporated into GoMOOS system, and satellite data products are served to users throughout the region from the GoMOOS server. ([www.gomoos.org](http://www.gomoos.org))

**My own research group:** ongoing research and monitoring of the Gulf of Maine

**Other PIs at the University of Maine,** especially Mary Jane Perry, David Townsend, Huijie Xue, Neal Pettigrew and Emmanuel Boss.

A 3-way data share and processing system has been implemented in the NE US, between my lab at U.Maine, the satellite data reception facility at Rutgers (Scott Glenn PI), and the satellite group at U.Mass Dartmouth (Jim Bisagni, PI). This system runs over an INTERNET 2 backbone and allows the dishes at Rutgers and U.Maine to act as mutual, and immediate back-up in the event of any technical issue, so no data is lost. In effect, the reception facilities boast 24/7 back-up capability. Received data are piped directly to U.Mass Dartmouth who run data processing software, allowing them to custom-process their own views, and saving this effort at the U.Maine receiving station.

U Maine has established a real-time operational link to the Canadian Navy METOC office in Halifax, supplying them with an ongoing stream of X Band data while they acquire their own X Band system. They anticipate they will have their own system up and running in the next 12 months. Meanwhile, they use U Maine data to train operators, gain experience with the data, and create ocean products. We have also spent considerable time with them, advising and helping with installation and processing issues.

Although difficult to quantify, the acquisition and operation of the ground station, and the ability to access real time data has played an important role in U Maine PIs being awarded a number of research grants. A few of the most obvious ones are listed below:

**GOMTOX.** Harmful algal bloom research, Don Anderson WHOI PI, funded by NOAA COP, \$7.5M (total budget)

**Lobster settlement forecasting in the Gulf of Maine.** Incorporation of real time environmental data, including satellite data, into an operational fisheries forecast model, Thomas PI, funded by NASA. \$430k

**Using Bayesian networks to link river inputs with ecosystem indicators in the Gulf of Maine.** New statistical approaches to linking HAB occurrence to forcing factors. PI, M.E. Borsuk, (Dartmouth College), funded by National Institute of Health, \$250K (U Maine portion)

**Reducing uncertainty in the marine carbon cycle by coupling satellite and in water robotic measurements.** PI, MJ Perry. funded by NASA.

\$695k

### **Training and Development:**

Direct access to the facility and resulting data is made available to the graduate students of the School of Marine Sciences, Spatial Information Engineering, Forestry, and Electrical Engineering. The strongest use is by the Marine Sciences group. As all image data is made publicly available from our web site, total usage is difficult to quantify. Web hits are discussed under the heading Web / Internet Site.

Two research associates assisted with the installation, and now have been trained in day-to-day operation and processing of data. One post doctoral fellow (now at NOAA, Washington DC) was directly involved in data analysis of the real-time data stream. A second post doc (now at Princeton) was peripherally involved in data processing and analysis. One high school student (a science student from Bangor High School), spent the summer (2007) in the Satellite Data Lab, where part of her responsibilities were assisting in processing the data stream. This student is now an Atmospheric Sciences major at Penn State.

The system itself and data are used as a teaching and demonstration tool for 2 undergraduate oceanography classes each year, and in 1 graduate level course, all within the School of Marine Sciences.

### **Outreach Activities:**

We have received extensive praise for our web site, which makes all the imagery collected by the system available to the public.... The site is designed to be easy to use, and facilitate browsing of a large number of images.

Please visit:

[www.seasurface.umaine.edu](http://www.seasurface.umaine.edu)

This site generates an average of 6500 visits per month totalling over 550000 hits per month.

The same data sets are again packaged and presented through the GOMOOS web site, where they are supported by a number of other ocean data sets and a strong outreach effort.

Please visit:

[www.gomoos.org](http://www.gomoos.org).

In addition to real-time daily imagery, we also make available a series of derived research products (climatologies and time-averages).

The installation of the system was the subject of a front page photograph and article in the local section of our newspaper (Bangor Daily News).

As part of the 2008 summer harmful algal bloom monitoring program in the state of Maine, Thomas, citing these data and images, had frequent interviews in both the local newspaper and local radio.

### **Journal Publications**

Pettigrew, NR; Churchill, JH; Janzen, CD; Mangum, LJ; Signell, RP; Thomas, AC; Townsend, DW; Wallinga, JP; Xue, HJ, "The kinematic and hydrographic structure of the Gulf of Maine Coastal Current", DEEP-SEA RESEARCH PART II-TOPICAL STUDIES IN OCEANOGRAPHY, p. 2369, vol. 52, (2005). Published, 10.1016/j.dsr2.2005.06.03

Luerssen, RM; Thomas, AC; Hurst, J, "Relationships between satellite-measured thermal features and Alexandrium-imposed toxicity in the Gulf of Maine", DEEP-SEA RESEARCH PART II-TOPICAL STUDIES IN OCEANOGRAPHY, p. 2656, vol. 52, (2005). Published, 10.1016/j.dsr2.2005.06.02

Townsend, DW; Pettigrew, NR; Thomas, AC, "On the nature of Alexandrium fundyense blooms in the Gulf of Maine", DEEP-SEA RESEARCH PART II-TOPICAL STUDIES IN OCEANOGRAPHY, p. 2603, vol. 52, (2005). Published, 10.1016/j.dsr2.2005.06.02

Xue, HJ; Shi, L; Cousins, S; Pettigrew, NR, "The GoMOOS nowcast/forecast system", CONTINENTAL SHELF RESEARCH, p. 2122, vol. 25, (2005). Published, 10.1016/j.csr.2005.04.01

Xue, HJ; Incze, L; Xu, D; Wolff, N; Pettigrew, N, "Connectivity of lobster populations in the coastal Gulf of Maine - Part I: Circulation and larval transport potential", ECOLOGICAL MODELLING, p. 193, vol. 210, (2008). Published, 10.1016/j.ecolmodel.2007.07.02

### Books or Other One-time Publications

D.W. Townsend, A.C. Thomas, L.M. Mayer, M.A. Thomas and J.A. Quinlan, "Interdisciplinary oceanography of the northwest Atlantic continental shelf waters", (2006). Book, Published  
 Editor(s): A.R. Robinson and K.H. Brink  
 Collection: The Sea  
 Bibliography: Harvard University Press

### Web/Internet Site

**URL(s):**

www.seasurface.umaine.edu  
 www.gomoos.org

**Description:**

All data captured and processed by the system are made available to other researchers and the public through these sites.

### Other Specific Products

#### Contributions

**Contributions within Discipline:**

The ground station has contributed to the overall ocean observing infrastructure of the NE US, a region recognized as one of the leaders in the country. Real time and operational satellite data streams are an integral part of integrated ocean observing. Successful delivery of these data streams within an academic institution demonstrates one approach to US coastal ocean observation. A publication has been submitted (currently in review) to Marine Technology Society Journal entitled 'The Gulf of Maine Ocean Observing System: Generic Lessons Learned in the First Seven Years of Operation (2001-2008)', authors Neal R. Pettigrew, Huijie Xue, James D. Irish, Will Perrie, Collin S. Roesler, Andrew C. Thomas, and David W. Townsend. This article includes overviews of the operational reception and processing of X band satellite data for ocean observing.

**Contributions to Other Disciplines:**

**Contributions to Human Resource Development:**

One Post Doc was directly funded by this project. Dr SeungHyun Son was actively involved in the quality control and data analysis of image data received by the NSF sponsored system. He is now located at NOAA, DC. A second Post Doc participated in data reception and processing in minor capacity, with enough exposure to operations and maintenance to gain appreciation of the effort and steps necessary. Two Research Associates at the University of Maine received partial funding from this project. In the beginning for installation, and later for configuration, maintenance and operations. These RAs are involved with the operation of the system and analysis of the data streams on a daily basis. One grad student was peripherally involved in operations and maintenance of the system. One high school student spent a summer internship at the Satellite Data Lab and assisted with data reception and processing.

**Contributions to Resources for Research and Education:**

Large time series data sets resulting from the equipment are made available to the public through our web site (www.seasurface.umaine.edu) on a daily basis. These image data are a visual representation of the present and past surface chlorophyll patterns and surface temperature in the Gulf of Maine.

**Contributions Beyond Science and Engineering:**

**Categories for which nothing is reported:**

Organizational Partners

Any Product

Contributions: To Any Other Disciplines

Contributions: To Any Beyond Science and Engineering