Use of Drone Technology in Ocean Research of the Saco River Estuary Supporting Student Research

Michael Esty        Lauren Hayden
## Gulf of Maine

### Fewer Atlantic salmon returning to rivers, report finds

### First half of Maine’s lobstering season ‘painfully slow’ for fishermen
- [www.pressherald.com](http://www.pressherald.com/news/2017/10/04/first-half-of-maine’s-lobstering-season-painfully-slow-for-fishermen/)

### Scientists probe seabird deaths in New England

### Researchers find summer heat’s lasting longer in the Gulf of Maine

### River herring, hurt by dams and climate change, believed to be at only 3% of historical numbers

### Maine’s mussel harvest in 2016 was worst in 40 years
- [www.pressherald.com](http://www.pressherald.com/news/2017/10/03/maine’s-mussel-harvest-in-2016-was-worst-in-40-years/)

### ‘Massive’ Casco Bay algae bloom threatens marine life

### Algae bloom forces suspension of shellfishing in parts of Down East Maine

### Steamers out of steam? Maine’s beloved bivalves aren’t happy clams

### Little fish, big worry: Future of menhaden prompting concern
- [www.pressherald.com](http://www.pressherald.com/news/2017/10/05/little-fish-big-worry-future-of-menhaden-prompting-concern/)

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### NOAA [https://www.nefsc.noaa.gov/ecosys/](https://www.nefsc.noaa.gov/ecosys/)

### Getting warmer

Sea surface temperatures in the Gulf of Maine have been rising over the past 20 years, and at nearly the fastest rate on the planet over the last 10,000 years. Data from the Gulf of Maine Report: State of the Gulf of Maine: Marine Invasive Species June 2019.

<table>
<thead>
<tr>
<th>Year</th>
<th>Temperature Increase (°F)</th>
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<tbody>
<tr>
<td>10</td>
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</tr>
<tr>
<td>20</td>
<td>0.20</td>
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<tr>
<td>30</td>
<td>0.25</td>
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### State of the Gulf of Maine Report: Marine Invasive Species June 2019
The Saco River: A Deluge of Dormant Research

Brenton Murphy, Kris Olson, Jess Stumper

https://arcg.is/04ry1e
Makerspace
University of New England

• Project based
• Student centered
• Career Intelligence

• Technology innovation:
  • Drone
  • Spatial-temporal
  • Open source

• Science:
  • Ocean
  • Environmental
  • Citizen

Customers

Innovation Research  Makerspace Club  Classes and Class projects  Students Research
Training

Multidisciplinary groups

Agile

Prototype development

Complete Project

Hardware, Software, Analysis, Presentation

Soldering, 3D printer, Laser cutter, Arduino, Raspberry Pi, Python and ArcGIS
All translates into Spatial Information and Analysis!

Students are trained to bring spatial technology and science into practice!

CAS Undergraduate Research

Spring and Fall Symposiums

Summer Undergraduate Research Experience (SURE)
At the Makerspace we have built several ROVS, drifters and underwater buoys.

Electrona is a Somerville-based startup focused on developing low-cost underwater drones. Our remote submersibles allow anybody to shoot HD video, collect scientific data, and recover objects beneath 300 feet of cold, dark water.

Matthew Scheuer (Marine Science, ’16) Innovation challenge winner started an ROV company.
Drone Technology and Software

- Python
- Arduino Sketches
- C++
- Ardupilot
- Mission Planner
- QC ground Control
- ArcGIS analysis
- Transect Software

- 123Design
- Fusion 360
- CURA
- Eagle
- Spyder
- Anaconda
- Node Red
Technology Innovation: Drones

Phytoplankton Collection
Carcinus maenas research

- Flysky FS-i6X 2.4GHz RC Transmitter TX
- iA6B Receiver
- 12 Volt 10 Ah LiFePO4 Lithium Battery
- 30A ESC
- T100 Thruster Brushless motors

Future ? Semiautonomous
Raspberry pi
Ublox NEO-M8N GPS Module
Built-in HMC5883L Compass
LoRa Radio Adafruit feather wing
Building and using remotely operated vehicles for underwater investigation at the University of New England

Allison Trutlting, Lauren Hayden
Department of Marine Science, University of New England, Biddeford, Maine

Introduction
Remotely operated vehicles (ROVs) are essential for underwater research and exploration. The high cost ($10,000-700,000) of ROVs has been a major barrier to citizens, students and research scientists alike. In recent years there have been major advances in the affordability and therefore accessibility of ROVs to the public. The open source and DIY movements have brought many new kits to market. Students here at UNE and around the world are building their own ROVs, examples of which are the miniROV, MIT Seafarers, OpenROV, and Blue ROVs.

Methods
In the UNE Makerspace we went through a series of trainings on soldering, electronics, arduino, raspberry Pi, software, and 3d assembly. We built a miniROV, MIT Sea farther, and Blue Robotics ROV. We also reviewed other ROVs including OpenROV, custom ROVs and various commercial ROVs. Upon completion we tested the ROVs in the water (sink, bathtub, pool).

Uses
• Summer 2017 Undergraduate Research Experience (SURE) funded project Swan River Estuary Study
• Surveying coral reefs
• Video survey around Hurricane Island
• Support local environmental groups, local associations
• Aquaculture farm monitoring

“Who knows more about the surface of the Moon and about Mars than we do about [the deep sea floor], despite the fact that we have yet to extract a gram of food, a breath of oxygen or a drop of water from those bodies.”
— Paul Sutning, Oceanographer

Discussion
The Gulf of Maine is warming faster than 99% of the world’s oceans (Pershing et al., 2013). This warming and the environmental changes it brings lead to changes in the benthic and pelagic community structure. ROVs are a useful tool in the monitoring of native and invasive species in lakes, rivers and coastal oceans. One thing all environmentalists can agree upon is that if people can not see the problems occurring they are less likely to care. Monitoring of pollutants, track, as well as biological and chemical contamination, is key to raising awareness among the public. Access to the underwater environment is often very limited for schools, lakes association and citizen scientist groups.

We have successfully made and tested several low cost ROVs. These low cost ROVs can facilitate access to these fragile and changing habitats.

Acknowledgements
Thank you to our Professors Stephanie Oceana, the UNE Makerspace and Michael Esty.
Science and Education

Using a ROV in Student Undergraduate Research

- Building a Blue Robotics ROV
- Hardware and Software debugging
- Use in research
- Training new students
GIS mapping of the Saco River Estuary using remotely operated vehicles
combining multibeam sonar data and captured image rasters

Lauren Hayden
Department of Marine Science, University of New England, Biddeford, Maine

Introduction
The Gulf of Maine is warming faster than 99.8% of the Earth’s oceans (Portingl et al. 2013). Invasive species such as green crabs (Carcinus maenas) have threatened eelgrass (Zostera marina) beds (Octavio 2015) and are compromising the edges of the saltmarshes. The loss of these nursery habitats can have a major impact on biodiversity and populations of commercially important fish species. In this time of rapid climate change, it is important to collect baseline data.
The Saco River is a dynamic system, originating in the White Mountains and terminating in Casco Bay between the towns of Biddeford and Saco, Maine. The Saco River is a source of drinking water, hydroelectric power and is habitat for the threatened Atlantic sturgeon (Acipenser oxyrinchus) as well as many recreationally exploited fish species. The Saco River is also the primary source of brush used (Kelly et al. 2005). The Saco River Estuary encompasses the brush areas from the Casco Dam to Saco Bay.

Using light and sound in topographic mapping
Bathymetry: river bottom contour. This data is collected using sound waves with a multibeam sonar.
LI DAR: Light, Distance and ranging. This data is collected using light, in this form of pulsed lasers. Survey is done from an airplane.

Methods
Using ArcGIS we created a map of the Saco Bay Estuary which incorporates:
- Orthophoto mosaic
- Multibeam sonar data
- Eelgrass areas
- LIDAR imagery

Data sources:
- Maine Office of GIS (MOGIS)
- Maine Coastal Monitoring Initiative (MCM)
- Maine Department of Marine Resources (MDMR)

Results

Discussion
The MCM survey was performed at the request of the towns of Biddeford and Saco and the Army Corps of Engineers in preparation for federally mandated navigable waterway dredging. Working in ArcGIS we have made a composite map of the Saco River estuary which incorporates finds orthophotos, benthic and bed form data from the MOGIS multibeam sonar survey (figure 1), and historical eelgrass bed cover polygons from the MCM (figure 2). Many anomalous points were identified (figure 3) and potential areas are in need of further investigation. Comparing the estimated eelgrass bed cover between the two most recent surveys by the Maine Department of Marine Resources (MDMR) in 1997 and 2010 (figure 3) we conclude that there has been a major reduction in eelgrass cover. This follows the trend in eelgrass loss throughout the Gulf of Maine (GOM). The biggest losses in GOM were recorded in 2010 (Dickie 2012). There has not been a survey since this record breaking year.

Future work
We will be using the BlueROV2 (figure 4), assembled by the Zemetra ROV group at UNE, as part of a Summer Undergraduate Research Experience (SURE) funded project. Photo and video data will be collected as well as water character data such as temperature and salinity.

This project will include:
- Eelgrass bed survey
- Investigations of anomalies in the upper portion of the estuary
- Video survey around Rum Island
- Interpretive video and photos into an interactive database

Acknowledgments
Thanks to BlueROV2 and the MOGIS. Thanks to UN Stumpf and Michael Frey.
Using underwater vehicles to investigate underwater ecosystems in the Saco River estuary before dredging

Lauren Hayden*, Michael Esty**, Stephan Zeeman*

*University of New England Department of Marine Science; **University of New England Makerspace

Introduction

The Saco River is a dynamic system, originating in the White Mountains and meandering to its braided mouth in the town of Saco and Biddeford, Maine. The Saco River watershed is part of the larger tributary system of the upper Casco Bay basin, and the Saco River is a major source of drinking water, hydroelectric power, and habitat for the terrestrial Atlantic salmon (Salmo salar) as well as many seasonally migratory fish species. It is also the primary source of beach sand (Burch et al., 2015).

The sediment transported in the Saco river is such that dredging is required to maintain the relatively undisturbed navigable channel (Wells, 2013). The dredge spoil sand, etc. is often used to replenish beaches and lost to erosion, if it is in the proper size and composition, or disposed of undersea (O’Corry-Crowe, 2015).

In 2016, the Maine Coastal Mapping Initiative (MCMI) performed a multibeam sonar survey of the Saco River (fig. 1) at the impact of the systems of Biddeford and Saco in preparation for dredging of the navigable channel. Using the 2018 multibeam data, provided by MCMI, the Bathymetric Keyhole (BKH) areas of interest and potential obstructions (fig. 2) in the upper region of the Saco River estuary, near the Cunard site, were selected for investigation with ROV Sally (fig. 3).

Recently, small vessels (ROVs) are an effective tool in coastal habitat monitoring. Small ROVs allow detailed data ROV-optimized video can be used to capture high-resolution images. These images, in turn, can be used to determine accurate locations and identify new species and populations (Weatherly et al., 2014).

In addition to active disposal of dredging spoil, there is a seaweed plant and a harbor in Cunard Bay (fig. 1). This plant area was lost used for disposal was dredged of the Cunard River in 1993. Data, in the form of on-site video, was collected with ROV Sally from within the designated seaweed placement area.

Discussion

Maintaining dredging within the Saco River estuary has been determined to pose a significant impact to the environment and harbor to humans (O’Corry-Crowe, 2016). The work in simulated sediments in November 2017. The subaqueous habitat in the upper portion of the river has been investigated by the MCMI for the purpose of investigating the behavior and distribution of underwater vegetation (O’Corry-Crowe, 2016). In another investigation with ROV Sally, in the river, we can sense of those potential obstructions, large wooden piles (fig. 4), metal frames (fig. 5a and 5b), construction debris including bricks and cinder blocks, and a hole which previously mentioned (fig. 5a and 5b). We were surprised to find organisms growing in the vicinity of AIS and AS5. Further investigation of this area is recommended.

We have examined the area within the named fluorescent area to be sandy. It was, in fact, sand, shell, and covered with debris at some areas. In 1997 and again in 1998 the area was investigated with MBARI (Marine Biological Laboratory), but despite the investigation, there were no organisms identified. We concluded that this area was not suitable for further investigation until more data were collected to determine the impact of the dredging to the habitat.

We have determined that ROV Sally is a useful tool with great potential to be of service in investigating and knowledge of our local estuary.

Future work

- Mount water character sensors
- Design propeller-sensors to reduce algal entanglement
- Navigational aids such as sonar and scaling lasers
- Design and mount sampling apparatus
- Develop an underwater vehicle to track the exact location of the ROV; while it is underway
- Return to surveyed locations in the river and the bay after dredging
- Further identification of algae and invasive species
- Eelgrass survey at mouth of river and investigate eelgrass in upper portion of river (fig. 6)

Methods

- Build and learn to drive the blue robotics 8inROV2, 8ROV
- Select sites of interest from MCMI multibeam survey data
- Create GIS maps (ArcGIS, desktop) centers of sites of interest
- Dive on sites with ROV Sally
- Record video with onboard Raspberry Pi cameras and external Akasa EK100
- Process video (FoveonDive 1.5)

Results

Fig. 1: Schematic drawing of the main areas of interest determined by the MCMI’s benthic keyhole (BKH) surveys of the Saco River estuary within the designated seaweed placement area.

Fig. 2: The area of intertidal habitat (5a) and the bottom of the river (5b) observed with ROV Sally on August 15, 2017. Saco River estuary, Maine (photo: C. W. O’Corry-Crowe).

Fig. 3: Comparison of depth profiles with 8 in ROV2 (left) and ROV Sally (right) in the Saco River estuary, Maine (photo: C. W. O’Corry-Crowe).

Fig. 4: The area of the intertidal habitat (5a) and the bottom of the river (5b) observed with ROV Sally on August 15, 2017. Saco River estuary, Maine (photo: C. W. O’Corry-Crowe).

Fig. 5: Comparison of depth profiles with 8 in ROV2 (left) and ROV Sally (right) in the Saco River estuary, Maine (photo: C. W. O’Corry-Crowe).

Fig. 6: Photos of the intertidal habitat (5a) and the bottom of the river (5b) observed with ROV Sally on August 15, 2017. Saco River estuary, Maine (photo: C. W. O’Corry-Crowe).

Acknowledgments

This research was supported by the Maine Coastal Mapping Initiative, Marine Biological Laboratory, and the University of New England. C. W. O’Corry-Crowe (University of New England) and C. W. O’Corry-Crowe (MBARI) provided valuable assistance with ROV Sally operations.

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References

Collecting scientific/spatial data using drifters

Drifter Construction
Tiny circuits
Arduino
GPS
Data logger

Improvements
555 timer Cree LED

Drone Xenon Strobe Flash Light
LoRa Radio with mapping app
A Lagrangian Study on the Physical Components of Current in the Biddeford Pool
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Introduction
Understanding the current patterns of water flowing in and out of the Biddeford Pool is important in order to understand the effect of physical water properties on the transport of the species of the ecosystem. This includes not only species present in the pool, but also those that might influence the ecosystem. The study aims to investigate the current patterns of water flowing in and out of the Biddeford Pool, and to understand the effect of these patterns on the species present in the pool.

Materials and Methods

**Materials:**
- TinyGadGET Global Positioning System (GPS)
- Oakfield
- Computer Programs
  - Matlab
  - R2D2
  - ArcGIS Software
  - Google Earth

**Methods:**
1. TinyGadGET GPS units were deployed, programmed, and tested.
2. Buoys were built to include weights and floats in order to properly balance the drift in the water column.
3. Drifters were deployed and time and distance were collected.
4. Data were analyzed using Matlab to determine the speed, direction, and time ranges.

Using National Oceanic and Atmospheric Association (NOAA) data and University of New England/Weather Buoys data, wind patterns were made using Matlab.

A new technique was mapped using Google Earth and Matlab.

Acknowledgments
This project was funded by the University of New England and the author of this marine science career. We would like to thank James White for the initial data collection.

Conclusions
- Results show that the current patterns of water flowing in and out of the Biddeford Pool are highly influenced by wind patterns.
- The current patterns of water flowing in and out of the Biddeford Pool are highly influenced by wind patterns.

References
Drifter's spatio-temporal data using ArcGIS

Long Distance Drifter analysis

Longitude and Latitude data CSV
Python Haversine formula
to get distance and angle each point

Read into excel

Read excel into ArcGIS

Change symbiology to shade by date

Add different online maps for analysis
Meteorological, Sea surface
temperature and wind.
Future Mapping and multispectral analysis of coral reefs

GPS
GO Pro
Surf Board
Drone 2 map
Multispectral light source
Direction indicator
Acknowledgements

Lauren Hayden
Kristen Falcinelli
Ariella Danziger
Allison Truttling
Matthew Scheuer
Brenton Murphy
Kris Olson
Jess Stumper
Sam Peterson

Anthony Santella M.A., B.A.
Stephan I. Zeeman Ph.D.
Jeri L. Fox Ph.D.
Markus Frederich Ph.D.
Charles Tilburg Ph.D.
Marcia Moreno-Baez Ph.D.