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

Michael Esty Lauren Hayden

UNE
UNIVERSITY OF NEW ENGLAND
INNOVATION FOR A HEALTHIER PLANET

Gulf of Maine

Fewer Atlantic salmon returning to rivers, report finds

www.pressherald.com/2017/06/18/fewer-atlantic-salmon-returning-to-rivers-report-finds/

First half of Maine's lobstering season 'painfully slow' for fishermen

www.pressherald.com/2017/10/04/first-half-of-maines-lobstering-season-painfully-slow-for-fishermen/

Scientists probe seabird deaths in New England

www.pressherald.com/2017/06/11/scientists-probe-seabird-deaths-in-new-england/

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

www.pressherald.com/2017/09/10/researchers-find-summer-lasting-longer-in-gulf-of-maine-creating-new-hurricane-and-ecological-risks/

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

www.pressherald.com/2017/09/04/river-herring-hurt-by-dams-and-climate-change-might-be-endangered/

Maine's mussel harvest in 2016 was worst in 40 years

www.pressherald.com/2017/10/12/maines-mussel-harvest-in-2016-was-worst-in-4-decades/

'Massive' Casco Bay algae bloom threatens marine life

www.pressherald.com/2017/09/26/casco-bay-algae-bloom-threatens-marine-life/

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

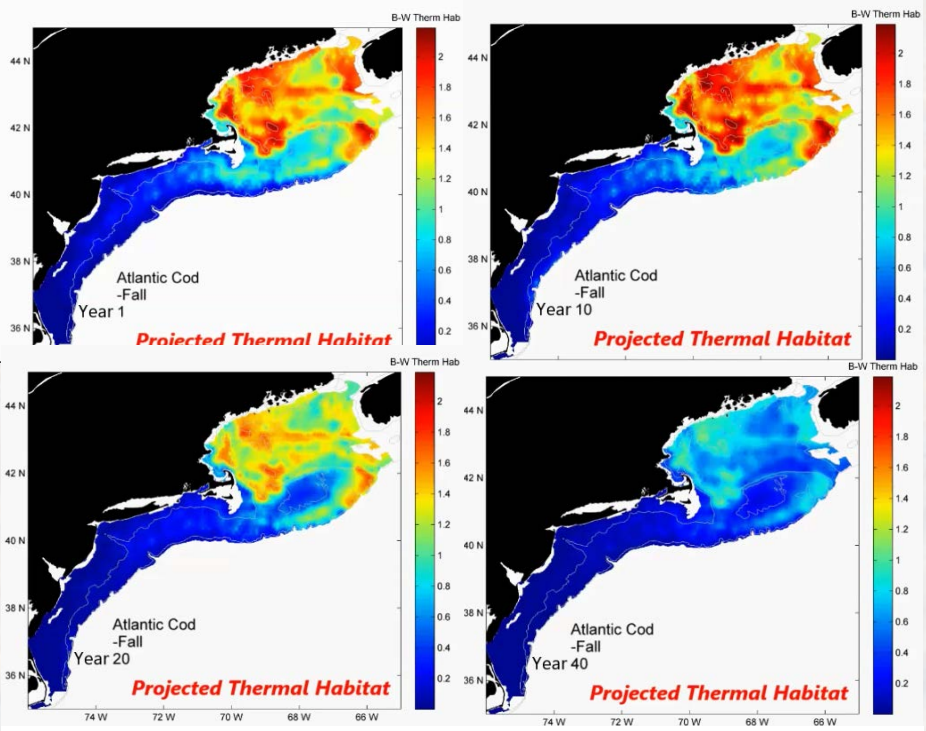
www.pressherald.com/2017/09/14/algae-bloom-forces-suspension-of-shellfishing-in-parts-of-down-east-maine/

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

www.pressherald.com/2017/07/04/steamers-out-of-steam-maines-beloved-bivalves-arent-happy-clams/

Little fish, big worry: Future of menhaden prompting concern

www.pressherald.com/2017/10/01/little-fish-big-worry-future-of-menhaden-prompting-concern/



NOAA https://www.nefsc.noaa.gov/ecosys/

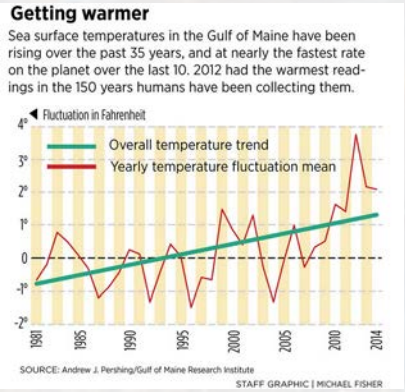


Table 2: *Marine invasive species in the Gulf of Maine.*

TAXONOMIC GROUP	NUMBER	SOURCE
Crustacea	13	Swan 1956; Beckman and Menzies 1960; Maurer and Wigley 1982; Larsen and Doggett 1991; Wethey 2002; Carlton 2003; Trott 2004; Pederson et al. 2005; Delaney et al. 2008
Rhodophyceae	11	Mathieson et al. 2008 a,b,c
Tunicata	7	Pederson et al. 2005; Harris and Dijkstra 2007
Mollusca	6	Carlton 1992; Carlton 2003; Pederson et al. 2005
Phaeophyceae	5	Hooper and South 1977; Mathieson et al. 2008 a,b,c
Hydrozoa	3	Smith 1964; Bayard 1999; Trott 2004
Bryozoa	3	Schreiblin et al. 1999; Pederson et al. 2005
Protista	3	Ford 1996; Cook et al. 1998; Bower 2007
Cnidaria	2	Trott 2004; Pederson et al. 2005
Polychaeta	2	Carlton 2004; Pederson et al. 2005
Platyhelminthes	2	Cone and Macnoglissa 1995; Rivest et al. 1999
Diatomacea	2	Carlton 2003; Martino and LaGrasley 2008
Kamptozoa	1	Wasson et al. 2000
Nematoda	1	Aiello and Oliveira 2009
Porifera	1	Pederson et al. 2005
Chlorophyceae	1	Pederson et al. 2005; Mathieson et al 2008b
Virus	1	Bouchard et al. 2001
TOTAL	64	

State of the Gulf of Maine Report: Marine Invasive Species June 2010

Gulf of Maine will become too warm for many key fish, report says

www.pressherald.com/2017/05/21/gulf-of-maine-will-become-too-warm-for-many-key-fish-report-says/

Our View: Ignoring higher risk of floods won't make them less likely

www.pressherald.com/2017/09/13/our-view-ignoring-higher-risk-of-floods-wont-make-them-less-likely/

State testing dead clams found in Old Orchard Beach

www.pressherald.com/2017/10/05/state-testing-dead-clams-found-in-old-orchard-beach/

Maine fishermen, scientists combine forces with goal to save shrimp fishery

www.pressherald.com/2017/08/20/maine-fishermen-and-scientists-combine-forces/

Group plans alewives' path from China Lake to ocean

www.pressherald.com/2017/05/29/group-plans-alewives-path-from-china-lake-to-ocean/

Fate of nation's 1st Atlantic marine monument likely headed to court

www.pressherald.com/2017/08/24/fate-of-nations-1st-atlantic-marine-monument-likely-headed-to-court/

Maine expands area closed to shellfish harvesting, and is gauging extent of mussel recall

www.pressherald.com/2017/09/18/maine-expands-shellfish-ban-as-department-continues-mussel-recall/

Interior secretary calls for commercial fishing in new Atlantic monument

www.pressherald.com/2017/09/18/interior-secretary-calls-for-commercial-fishing-in-new-atlantic-monument/

New England shrimp fishery likely to have new rules – if it reopens

www.pressherald.com/2017/09/07/new-england-shrimp-fishery-likely-to-have-new-rules-if-it-reopens/

Lobstering ban near coral gardens could cost industry almost $9 million a year, fishermen say

www.pressherald.com/2017/05/25/lobstering-ban-near-coral-gardens-could-cost-industry-almost-9-million-a-year-fishermen-say/

https://arcg.is/04ry1e

Makerspace

University of New England

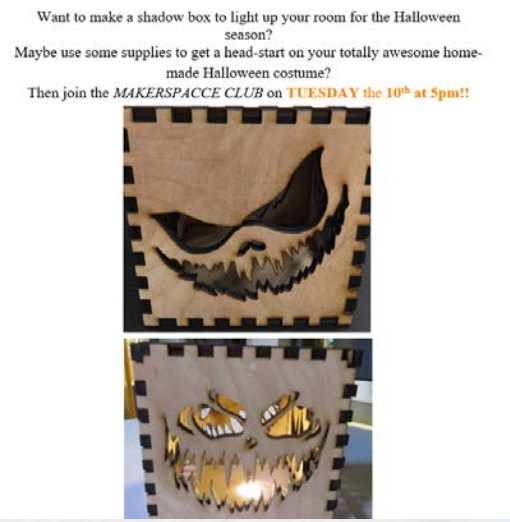
- Project based
- Student centered
- Career Intelligence

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

- Science:
  - Ocean
  - Environmental
  - Citizen

Customers

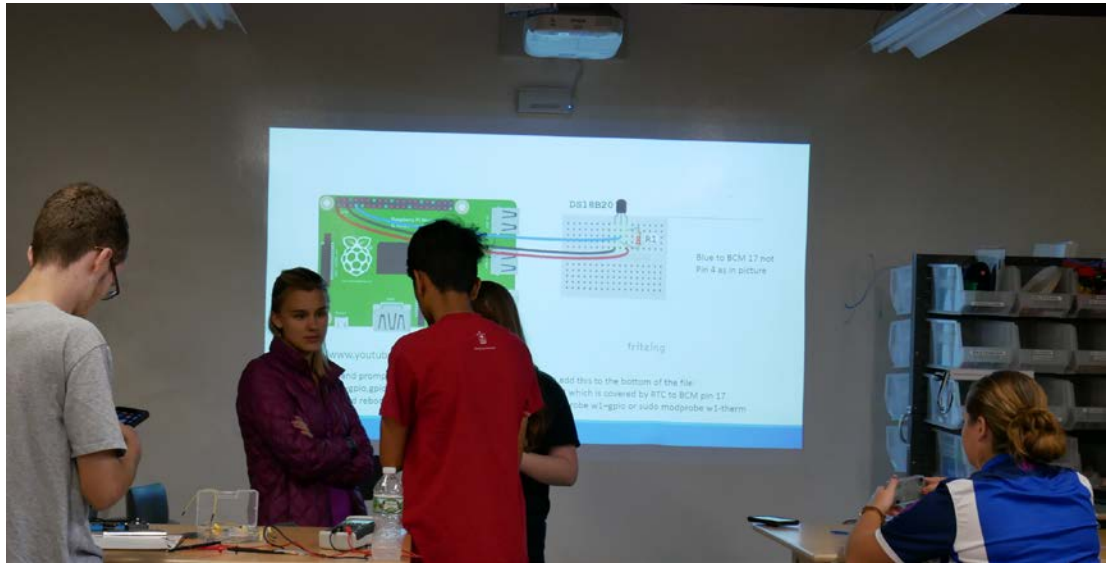
Innovation Research

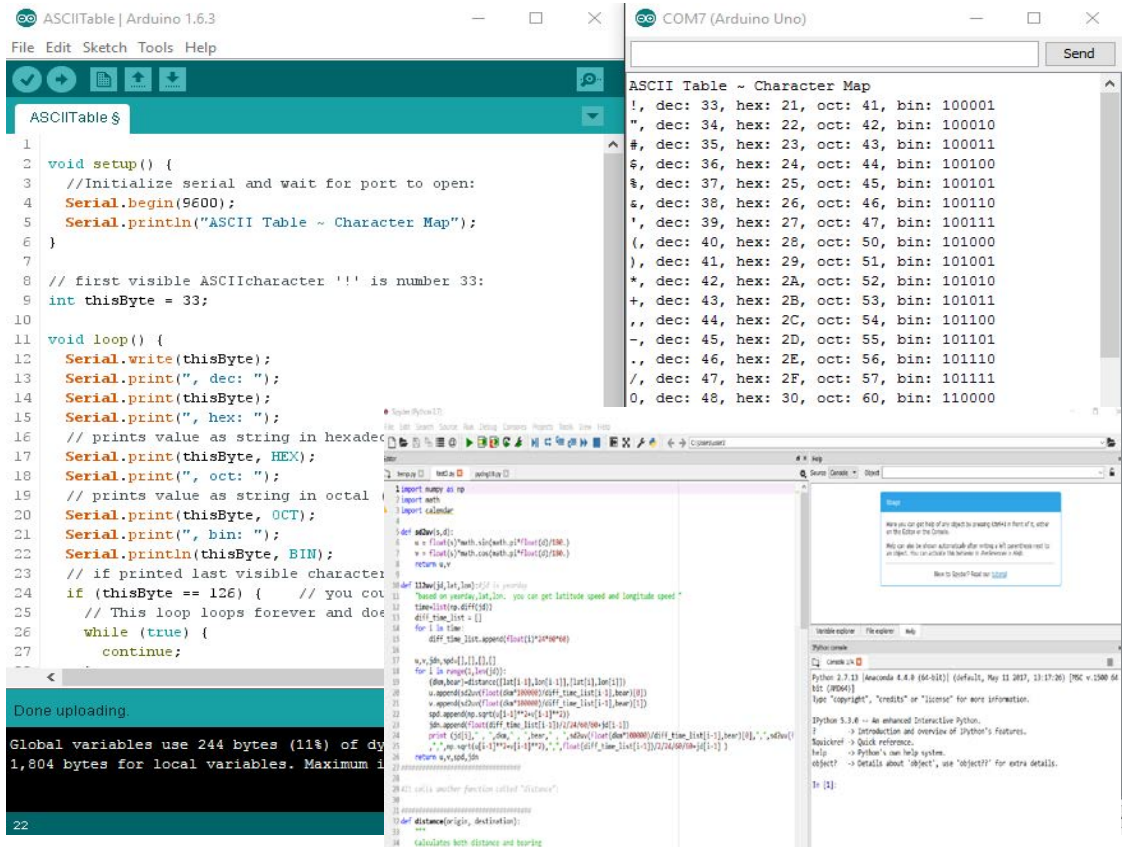


Makerspace Club

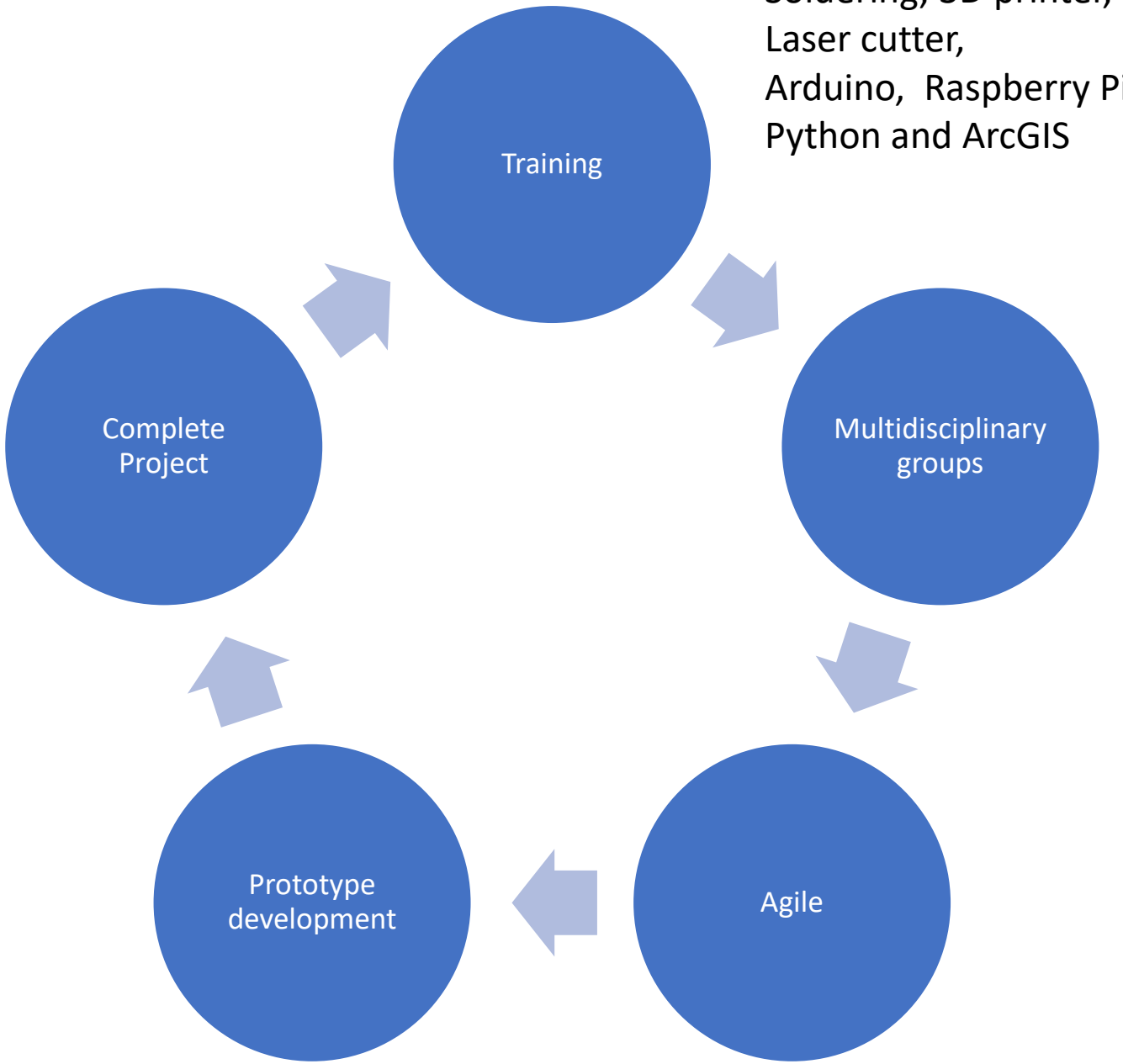
Classes and Class projects

Students Research





Soldering, 3D printer,
Laser cutter,
Arduino, Raspberry Pi,
Python and ArcGIS



Hardware, Software, Analysis, Presentation

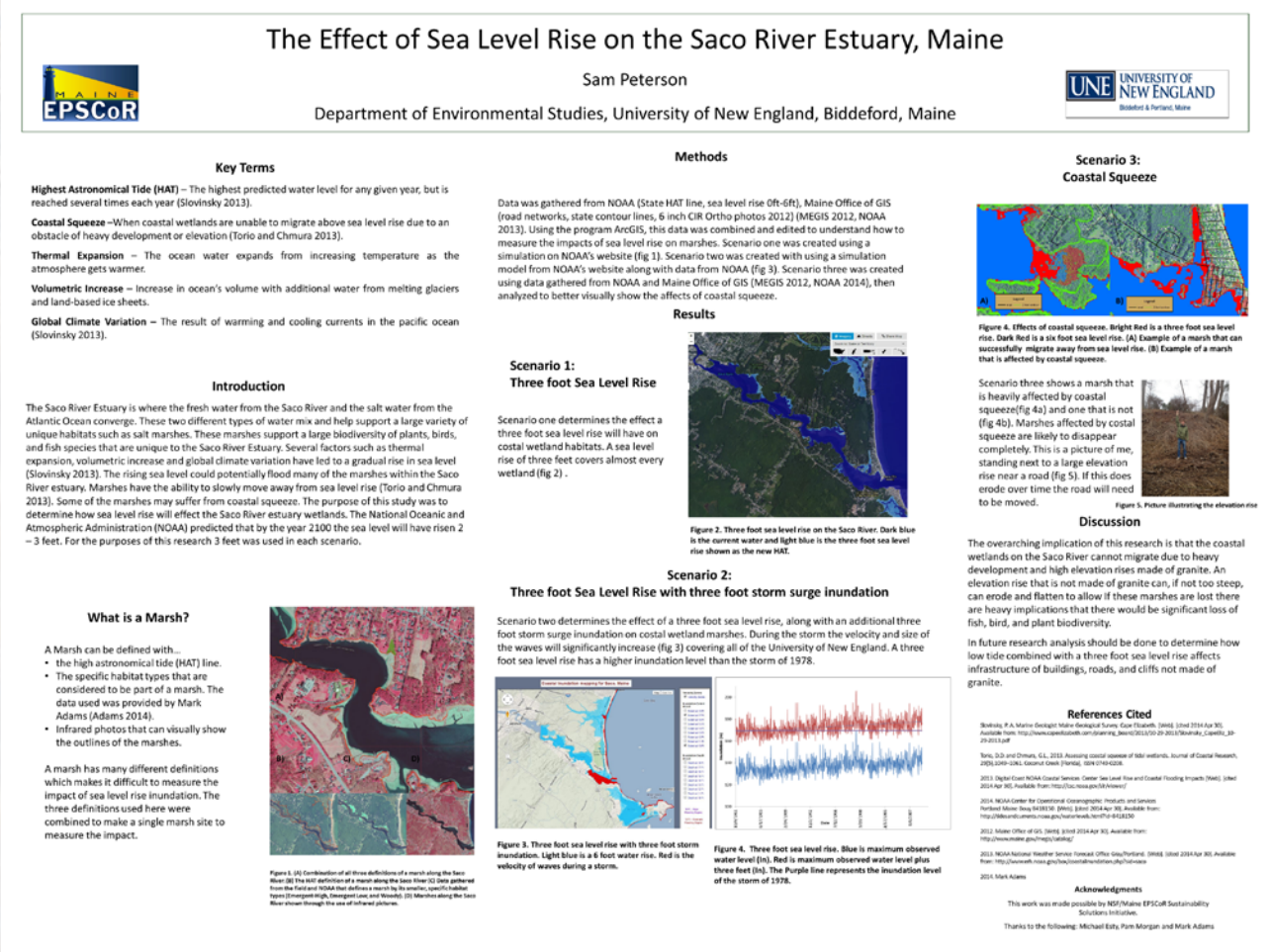
All translates into Spatial Information and Analysis!

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

CAS Undergraduate Research

Spring and Fall Symposiums

Summer Undergraduate Research Experience (SURE)



The Effect of Sea Level Rise on the Saco River Estuary, Maine

Sam Peterson

Department of Environmental Studies, University of New England, Biddeford, Maine

Key Terms

Highest Astronomical Tide (HAT) – The highest predicted water level for any given year, but is reached several times each year (Slovinsky 2013).

Coastal Squeeze –When coastal wetlands are unable to migrate above sea level rise due to an obstacle of heavy development or elevation (Torio and Chmura 2013).

Thermal Expansion – The ocean water expands from increasing temperature as the atmosphere gets warmer.

Volumetric Increase – Increase in ocean's volume with additional water from melting glaciers and land-based ice sheets.

Global Climate Variation – The result of warming and cooling currents in the pacific ocean (Slovinsky 2013).

Introduction

The Saco River Estuary is where the fresh water from the Saco River and the salt water from the Atlantic Ocean converge. These two different types of water mix and help support a large variety of unique habitats such as salt marshes. These marshes support a large biodiversity of plants, birds, and fish species that are unique to the Saco River Estuary. Several factors such as thermal expansion, volumetric increase and global climate variation have led to a gradual rise in sea level (Slovinsky 2013). The rising sea level could potentially flood many of the marshes within the Saco River estuary. Marshes have the ability to slowly move away from sea level rise (Torio and Chmura 2013). Some of the marshes may suffer from coastal squeeze. The purpose of this study was to determine how sea level rise will effect the Saco River estuary wetlands. The National Oceanic and Atmospheric Administration (NOAA) predicted that by the year 2100 the sea level will have risen 2 – 3 feet. For the purposes of this research 3 feet was used in each scenario.

What is a Marsh?

A Marsh can be defined with…

- the high astronomical tide (HAT) line.
- The specific habitat types that are considered to be part of a marsh. The data used was provided by Mark Adams (Adams 2014).
- Infrared photos that can visually show the outlines of the marshes.

A marsh has many different definitions which makes it difficult to measure the impact of sea level rise inundation. The three definitions used here were combined to make a single marsh site to measure the impact.

Methods

Data was gathered from NOAA (State HAT line, sea level rise 0ft-6ft), Maine Office of GIS (road networks, state contour lines, 6 inch CIR Ortho photos 2012) (MEGIS 2012, NOAA 2013). Using the program ArcGIS, this data was combined and edited to understand how to measure the impacts of sea level rise on marshes. Scenario one was created using a simulation on NOAA's website (fig 1). Scenario two was created with using a simulation model from NOAA's website along with data from NOAA (fig 3). Scenario three was created using data gathered from NOAA and Maine Office of GIS (MEGIS 2012, NOAA 2014), then analyzed to better visually show the affects of coastal squeeze.

Results

Scenario 1: Three foot Sea Level Rise

Scenario one determines the effect a three foot sea level rise will have on costal wetland habitats. A sea level rise of three feet covers almost every wetland (fig 2) .

Figure 2. Three foot sea level rise on the Saco River. Dark blue is the current water and light blue is the three foot sea level rise shown as the new HAT.

Scenario 2: Three foot Sea Level Rise with three foot storm surge inundation

Scenario two determines the effect of a three foot sea level rise, along with an additional three foot storm surge inundation on costal wetland marshes. During the storm the velocity and size of the waves will significantly increase (fig 3) covering all of the University of New England. A three foot sea level rise has a higher inundation level than the storm of 1978.

Figure 3. Three foot sea level rise with three foot storm inundation. Light blue is a 6 foot water rise. Red is the velocity of waves during a storm.

Figure 4. Three foot sea level rise. Blue is maximum observed water level (In). Red is maximum observed water level plus three feet (In). The Purple line represents the inundation level of the storm of 1978.

Scenario 3: Coastal Squeeze

Figure 4. Effects of coastal squeeze. Bright Red is a three foot sea level rise. Dark Red is a six foot sea level rise. (A) Example of a marsh that can successfully migrate away from sea level rise. (B) Example of a marsh that is affected by coastal squeeze.

Scenario three shows a marsh that is heavily affected by coastal squeeze(fig 4a) and one that is not (fig 4b). Marshes affected by costal squeeze are likely to disappear completely. This is a picture of me, standing next to a large elevation rise near a road (fig 5). If this does erode over time the road will need to be moved.

Figure 5. Picture illustrating the elevation rise

Discussion

The overarching implication of this research is that the coastal wetlands on the Saco River cannot migrate due to heavy development and high elevation rises made of granite. An elevation rise that is not made of granite can, if not too steep, can erode and flatten to allow If these marshes are lost there are heavy implications that there would be significant loss of fish, bird, and plant biodiversity.

In future research analysis should be done to determine how low tide combined with a three foot sea level rise affects infrastructure of buildings, roads, and cliffs not made of granite.

References Cited

Slovinsky, P.A. Maine Geologist. Maine Geological Survey. Cape Elizabeth. [Web]. [cited 2014 Apr 30]. Available from: http://www.capeelizabeth.com/planning_board/2013/10-29-2013/Slovinsky_Capeelizabeth_10-29-2013.pdf

Torio, D.D and Chmura, G.L. 2013. Assessing coastal squeeze of tidal wetlands. Journal of Coastal Research. 29(5):1049–1061. Coconut Creek (Florida). ISSN 0749-0208.

2013. Digital Coast NOAA Coastal Services Center Sea Level Rise and Coastal Flooding Impacts [Web]. [cited 2014 Apr 30]. Available from: http://coast.noaa.gov/slr/viewer/

2014. NOAA Center for Operational Oceanographic Products and Services Portland Maine Tide Gauge 8418150. [Web]. [cited 2014 Apr 30]. Available from: http://tidesandcurrents.noaa.gov/noaatidewebs/html/tf-8418150

2012. Maine Office of GIS. [Web]. [cited 2014 Apr 30]. Available from: http://www.maine.gov/megis/catalog/

2013. NOAA National Weather Service Forecast Office Gray/Portland. [Web]. [cited 2014 Apr 30]. Available from: http://www.weh.noaa.gov/ow/coastalinundation.shp?id=ewce

2014. Mark Adams

Acknowledgments

This work was made possible by NSF/Maine EPSCoR Sustainability Solutions Initiative.

Thanks to the following: Michael Esty, Pam Morgan and Mark Adams

BY THE NUMBERS

4

Number of undergraduate researchers awarded the prestigious **Goldwater Scholarship** in the past five years

200+

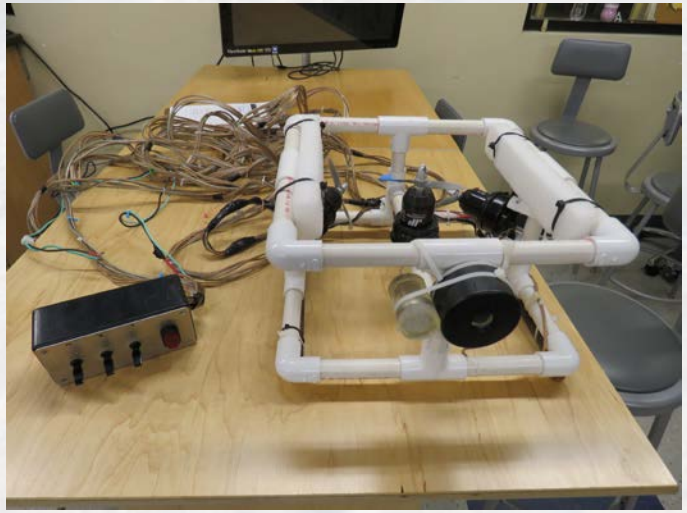
Number of undergraduate students who have given presentations at regional and national conferences during the last six years

41%

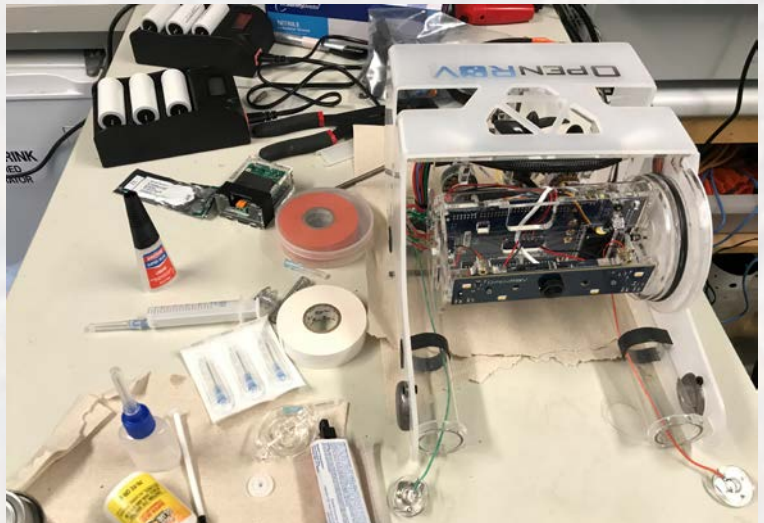
Percentage of UNE seniors who have worked with faculty on research projects, compared with 23% at all colleges surveyed by the NSSE

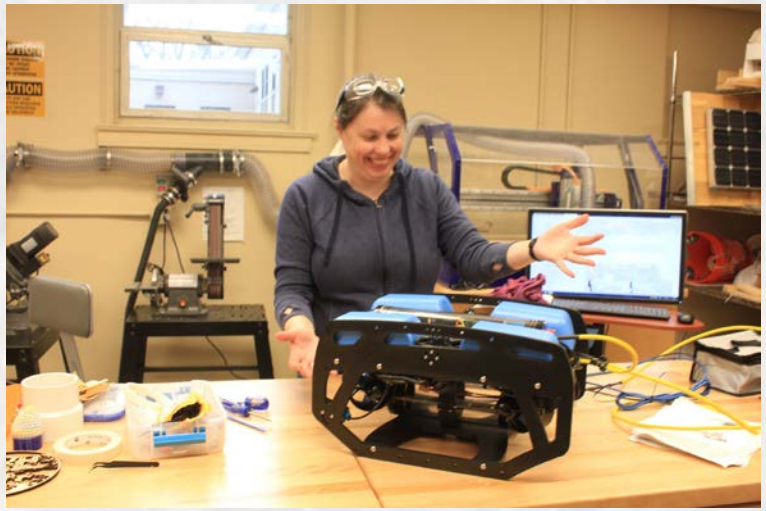
Technology Innovation

ROVs, Bouys and Drifters



At the Makerspace we have built several ROVS,Drifters and Underwater buoys.





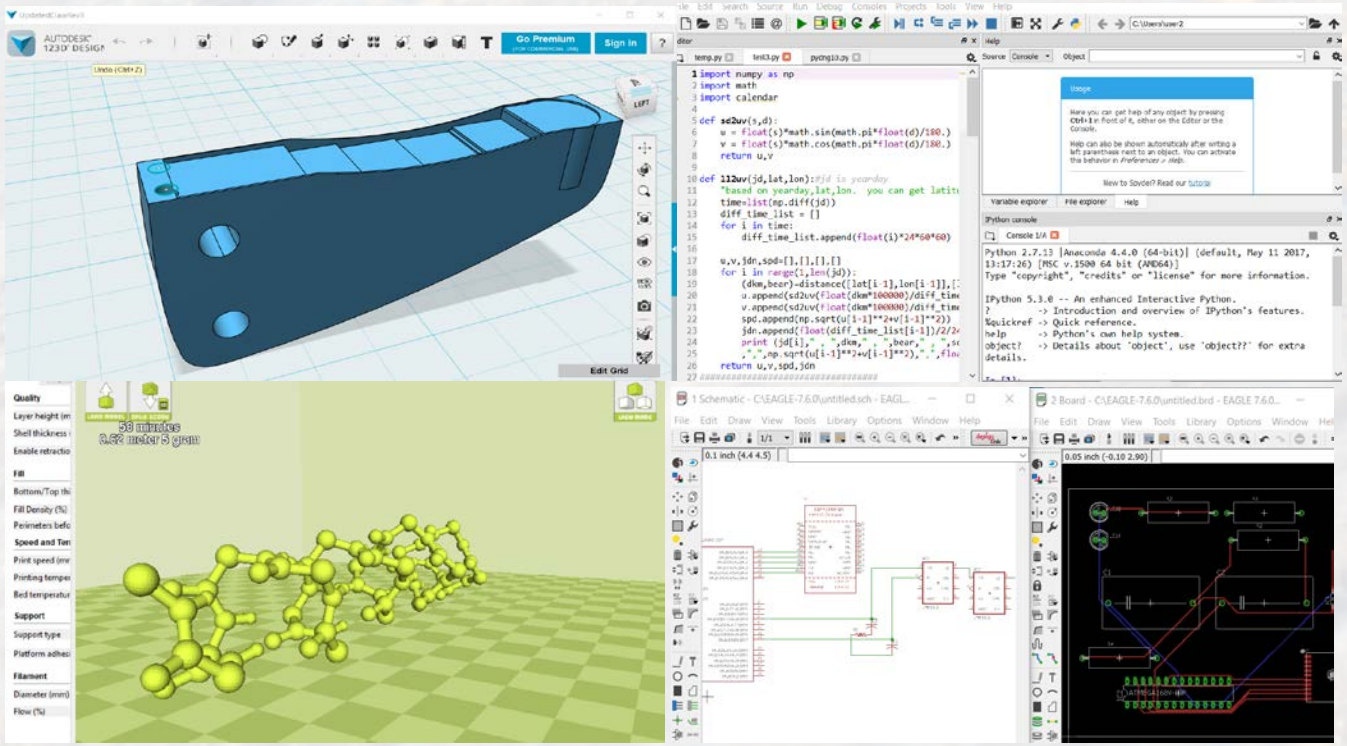
Electrona is a Somerville-based startup focused on developing low-cost underwater drones. Our remote submersibles allow anybody to shoot HD video, collect scientific data, and recover objects beneath 300 feet of cold, dark water.

ELECTRONA
REMOTE SUBMERSIBLES

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



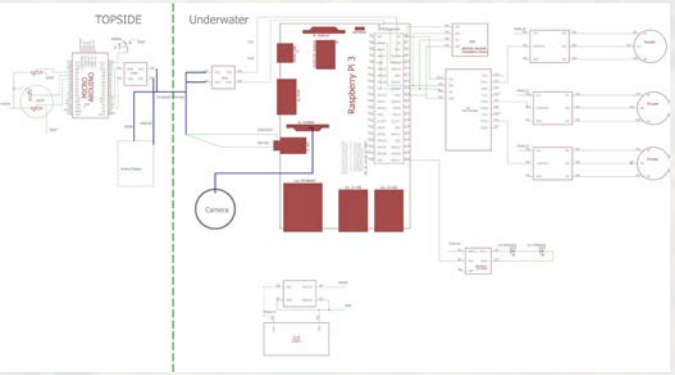
- 123Design
- Fusion 360
- CURA
- Eagle
- Spyder
- Anaconda
- Node Red

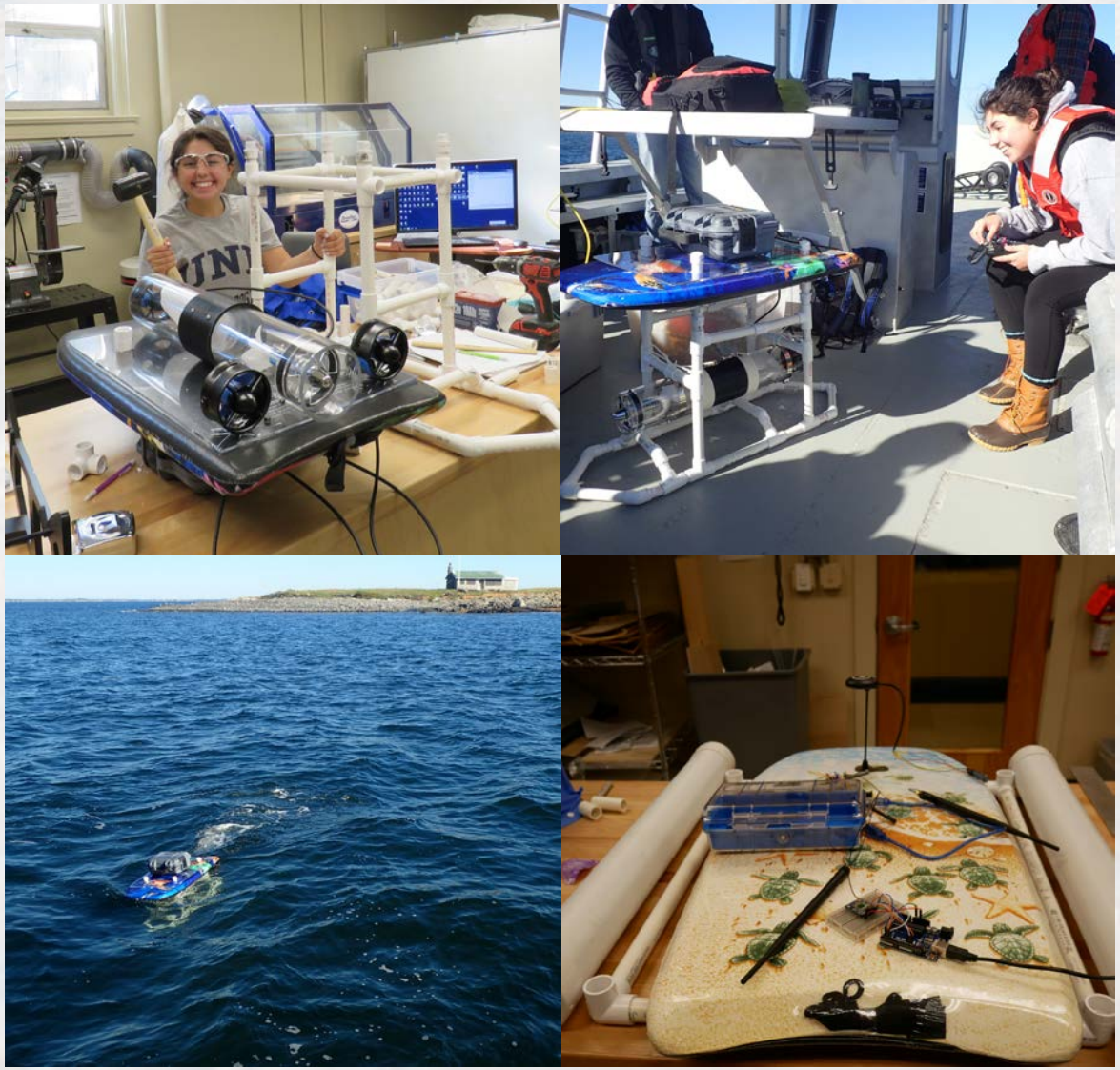
Technology Innovation: Drones

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





Technology Innovation and Design

Building and using remotely operated vehicles for underwater investigation at the University of New England

Allison Truttling, Lauren Hayden

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

UNE UNIVERSITY OF NEW ENGLAND
Biddeford & Portland, Maine

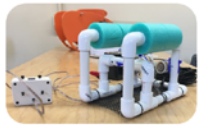
Introduction

Remotely operated vehicles (ROVs) are essential for underwater research and exploration. The high cost ($10,000- millions) 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 SeaPerch, OpenROV, and Blue Robotics.

Methods

In the UNE Makerspace we went through a series of trainings on soldering, electronics, arduinos, raspberry Pi, software, and kit assembly. We built a miniROV, MIT SeaPerch, 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).

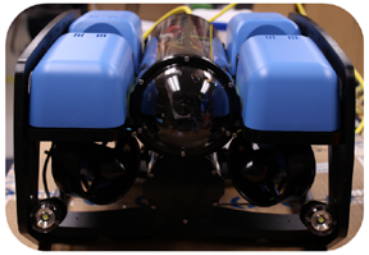
SeaPerch kit



SeaPerch

BlueROV2 kit

miniROV



Post dive inspection, no leaks!

BlueROV2 at UNE pool

Uses

- Summer 2017 Undergraduate Research Experience (SURE) funded project Saco River Estuary Study
- Survey eelgrass beds
- Video survey around Ram Island
- Support local environmental groups, lake associations
- Aquaculture farm monitoring

"We know 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 Snelgrove, Oceanographer

Discussion

The Gulf of Maine is warming faster than 99% of the worlds oceans (Pershing et al. 2015). This warming and the environmental changes it brings lead to changes in the benthic and pelagic community structures. 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 pollution, trash 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 associations 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.

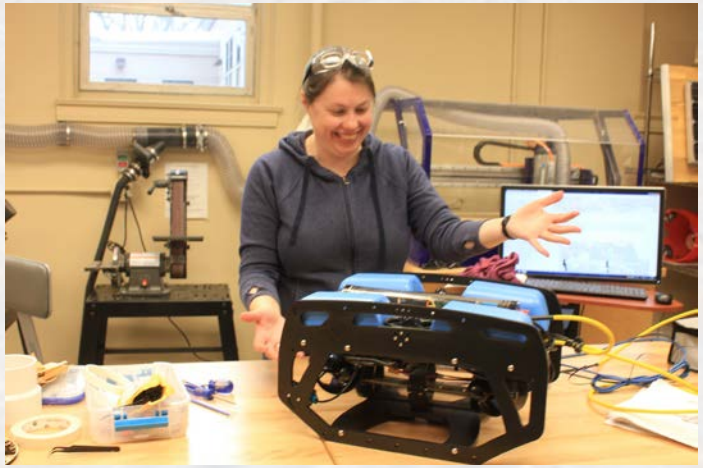
Pershing AJ, Alexander MA, Hernandez CM, Kerr LA, Lebris A, Mills KE, Nye JA, Record NR, Scannell HA, Scott JD, Sherwood GD, Thomas AC. 2015. Slow adaptation in the face of rapid warming leads to collapse of the Gulf of Maine cod fishery. Science. 350(6262):809-812.

Acknowledgments
Thank you to our Professor Stephan Zeeman, the UNE Makerspace and Michael Esty.

Science and Education
Using a ROV in Student Undergraduate Research

Using ROV in Student U

- Building a Blue Robotics ROV
- Hardware and Software debugging
- Use in research
- Training new students



Spatial Planning

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 99.9% of the Earth's ocean (Pershing et al. 2015). Invasive species such as green crabs (*Carcinus maenas*) have devastated eelgrass (*Zostera marina*) beds (Neckles 2015) and are undermining the edges of the saltmarshes. The loss of these nursery habitats can have a major impact upon 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 Saco Bay between the towns of Saco and Biddeford, 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 beach sand (Kelly et al., 2005). The Saco River Estuary, encompasses the brackish waters from the Cataract 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.

LIDAR: Light, Distance and Ranging. This data is collected using light, in the form of pulsed lasers. Survey is from an airplane.

Methods

Using ArcGIS we created a map of the Saco Bay Estuary which incorporates:

- Orthophoto mosaic
- Multibeam sonar data
- Eelgrass cover
- LIDAR imagery

Data sources:

- Maine Office of GIS (MGIS)
- Maine Coastal Mapping Initiative (MCMI)
- Maine Department of Marine Resources (MDMR)

Results

Figure 1. Orthophoto image of the Saco River estuary (2012) with bathymetry data collected with multibeam sonar by the MCMI in 2016 superimposed.

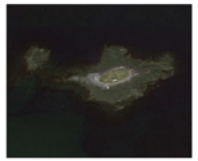


Figure 2. Ram Island. Recently acquired by the University of New England.

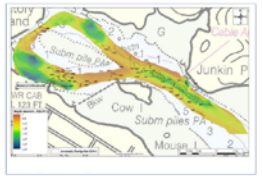


Figure 3. Bathymetric and anomaly (outlined in red) footprint map. MCMI 2016

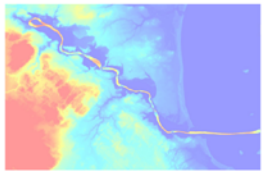


Figure 4. LIDAR image of the Saco River estuary (2012) with bathymetry data collected with multibeam sonar by the MCMI in 2016 superimposed.

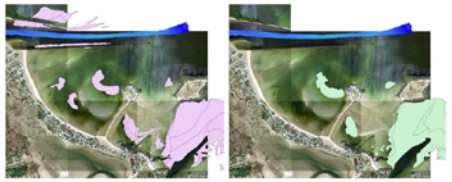


Figure 5. Saco Bay, south of the mouth of the Saco River. A composite of Orthophotos collected in 2012 overlaid with eelgrass bed extent data from 1997 (purple) and 2010 (green). Extent of eelgrass cover has decreased.

Discussion

The MCMI 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 6inch orthophotos, bathymetric data from the MCMI multibeam sonar survey (figure 1.), and historical eelgrass bed cover polygons from the MGIS (figure 5.). Many anomalous points were identified, (figure 3.) as potential hazards to navigation. We think these anomalies deserve 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 5) 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 2012 (Neckles 2015). There has not been a survey since this record breaking year.

Figure 6. BlueROV2

Future work

We will be using the BlueROV2 (figure 6), assembled by the Zeeman 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
- Investigation of anomalies in the upper portion of the estuary
- Video survey around Ram Island
- Incorporate video and photos into an interactive database

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Spatial Research

Using underwater vehicles to investigate underwater ecosystems in the Saco River estuary before dredging

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*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 terminating in Saco Bay between the towns of Saco and Biddeford, Maine. The Saco River Estuary, encompasses the brackish waters from the Cataract Dam to Saco Bay. 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. It is also the primary source of beach sand (Kelly et al., 2005).

The sediment transport in the Saco river is such that dredging is required to maintain the federally mandated navigable channel (-8 feet, MLLW). The dredge spoil (sand, etc.) is either used to replenish beach sand lost to erosion, if it is the proper size and composition, or disposed of underwater (USACE, 2016).

In 2016, the Maine Coastal Mapping Initiative (MCMI) performed a multibeam sonar survey of the Saco River (fig.1) at the request of the towns of Biddeford and Saco in preparation for dredging of the federal channel. Using the 2016 multibeam data, provided by MCMI Hydrographer Kerby Dobbs, areas of interest and potential obstructions (fig. 3), in the upper region of the Saco River estuary, near the Cataract dam, were selected for investigation with *ROV Sally* (fig.2).

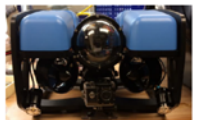
Remotely operated vehicles (ROV) are an effective tool in benthic habitat surveying. Much like diver collected data, ROV captured video can be used to create photo-mosaics. These images, in turn, can be used to determine substrate composition and identify submersed aquatic vegetation (McHenry et al., 2016).

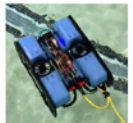
In addition to in-river disposal of dredging spoils there is a nearshore placement area adjacent to Ram Island (fig. 5). This placement area was last used for disposal from dredging of the Scarborough River in 1995. Data, in the form of recorded video, was collected with *ROV Sally* from within the designated nearshore placement area.

Fig. 1. Overall 2016 Maine Coastal Mapping Initiative (MCMI) multibeam survey coverage area. (Dobbs, 2016)

Methods

- Build and learn to drive the blue robotics *BlueROV2, ROV Sally*
- Select sites of interest from MCMI multibeam survey data
- Create GIS maps (ArcGIS, desktop) of sites of interest
- Dive on sites with *ROV Sally*
- Record video with onboard RaspberryPi camera and external Asako EK7000
- Process video (PowerDirector 15)





Results

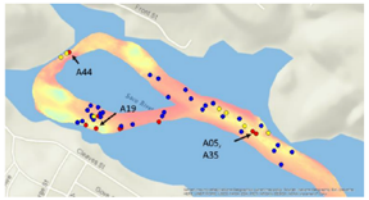


Fig. 3. Anomalies identified by Maine Coastal Mapping Initiative within the multibeam survey of federally mandated navigational channel. Priority indicated by color, red for highest priority, yellow medium and blue lowest priority. A05, A35, A44 and A19 are the sites we investigated.

Fig. 4. Images of underwater anomalies and potential obstructions in the Saco River within 100 meters of anomalies A05 and A35. Images A and B are of building debris, images C and D are metal cabling, image D includes large wooden planks, and image E is of a tire.

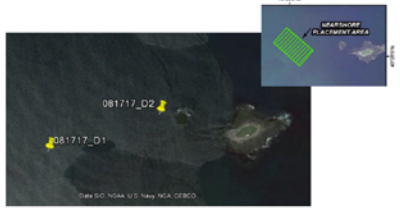


Fig. 5. Ram Island. Yellow pins indicate the location of *ROV Sally* dives on August 17, 2017. 081717_D1 is within the Nearshore Placement Area.

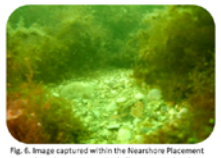


Fig. 6. Image captured within the Nearshore Placement Area. The substrate is mostly shell and covered with dense growth of macroalgae.

Fig. 7. Image captured at location 081717_D2, near Ram Island. Notice the silhouette of a fish, potentially Striped Bass (*Morone saxatilis*), in the upper right.

Sources

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Discussion

Maintenance dredging within the Saco River estuary has been determined to pose no significant impact to the environment and no harm to humans (USACE, 2016). The work is scheduled to begin in November 2017. The submerged debris in the upper portion of the river has been located and classified by the MCMI. The recommendation by the MCMI is for further investigation of all anomalies and potential obstructions (Dobbs, 2016). In our investigations with *ROV Sally* in the river we saw some of these potential obstructions, large wooden planks (fig. 5-d), metal cables (figs. 5-c and 5-d), construction debris including bricks and cobbles, and a hill which resembled cement (figs. 5-a and 5-b). We were surprised to find eelgrass growing in the vicinity of A35 and A5. Further investigation of this area is recommended.

We had been expecting the substrate within the nearshore placement area to be sandy. It was, in fact, mostly shell and covered with dense macro algae. In 1997 and again in 1998 this area was investigated with SHOALS (Scanning Hydrographic Operational Airborne Lidar Survey). The disposal mound was shown to have migrated inshore and to the south (Irish et al., 1999). The longshore transport of sand north of the river is to the north (Kelly et al. 2005). Further investigation, before and after the planned dredging spoils disposal, is recommended.

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

Future work

- Mount water character sensors
- Design propeller shields to reduce algae entanglement
- Navigational aids such as sonar and scaling lasers
- Design and mount sampling apparatuses
- Develop methods to track the exact location of the ROV while it is underwater
- 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. 8)

Fig. 8. Eelgrass (*Zostera marina*). Image captured within 100 meters of site A05.

Acknowledgments

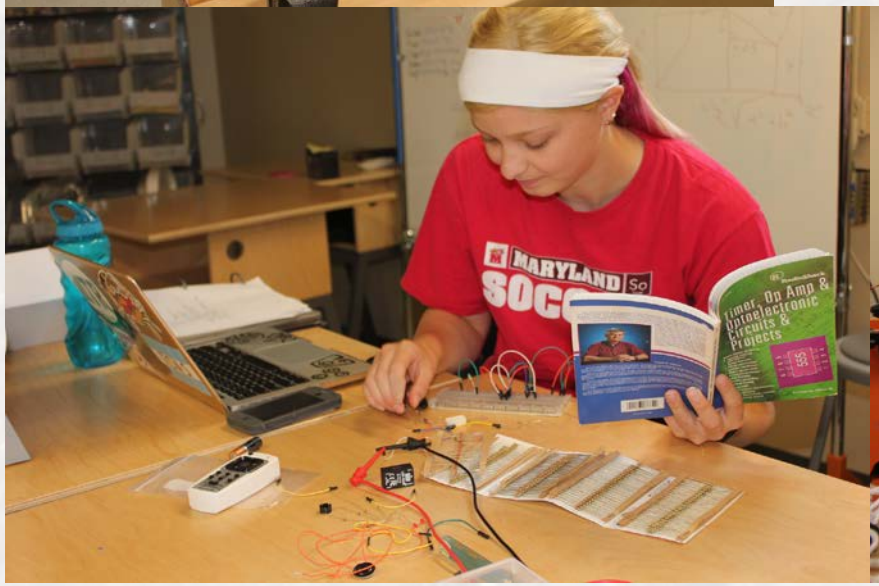
Collecting scientific/spatial data using drifters

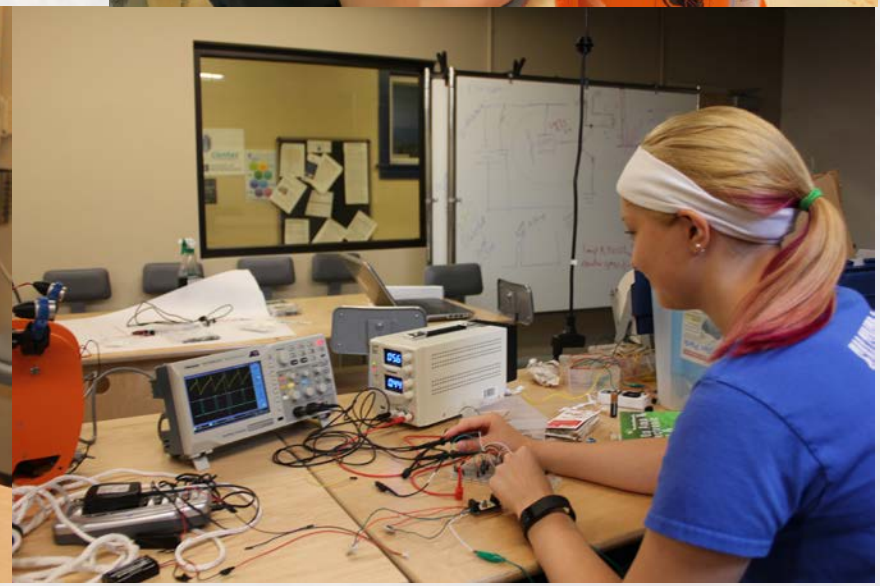
Drifter Construction
Tiny circuits
Arduino
GPS
Data logger

Improvements
555 timer Cree LED

Drone Xenon Strobe Flash Light

LoRa Radio with mapping app





Research

A Lagrangian Study on the Physical Components of Current in the Biddeford Pool

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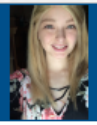
*KFalcinelli@une.edu



Introduction

Understanding the current pathways of water flowing in and out of the Biddeford Pool is important in order to understand the effects of physical water properties on the transport of the larvae of the invasive crab, *Carcinus maenas*. This invasive species has proved to disrupt ecosystems along the east coast of North America. In the Prince Edward Island region of Canada, *C. maenas* preys on species of clam that are also preyed on by native crab species in addition to mussel species that are not typically consumed by native species (Miron et al. 2005). Further studies show that the *C. maenas* is capable of outcompeting native species, such as the economically important *Callinectes sapidus*, for food (MacDonald et al. 2007). In commercial clam flats in New England, *Mya arenaria* populations have decreased in areas where *C. maenas* is common (Glude 2011). Patterns of decreasing *M. arenaria* populations and overall ecosystem imbalance may be observed in the Biddeford Pool, where *C. maenas* has been found. In order to study the movement of *Carcinus maenas* larvae and other particles in the Biddeford Pool, data has been collected by constructing and releasing global positioning system (GPS) drifters in the Biddeford Pool during different phases of the tidal cycle. It is important to recognize that there are multiple physical factors to take into consideration when analyzing current pathways from drifter data, including time in the tidal cycle, wind, and other weather. Research has been conducted to observe the pathways drifters take when entering the Biddeford Pool during a flood tide, and when exiting on an ebb tide. MatLab and Google Earth were used in the analysis of data. Further work will be conducted to improve the drifters and to determine what major patterns are responsible for currents in the Biddeford Pool.

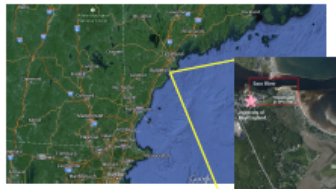


Figure 1.1. Google Maps image of the New England Coast.

Figure 1.2. Google Maps image of the Biddeford Pool at low tide. During high tide, the pool is completely full, but during low tide it empties almost completely.

Materials and Methods

Materials:

- TinyCircuits Global Positioning System (GPS) Drifter
- Computer Programs
  - Excel
  - Matlab (version R2014a)
  - Arduino Software for the GPS
  - Google Earth

Figure 2. TinyCircuits GPS. The GPS itself is composed of three circuit boards attached to a 3.7 Volt Lithium battery. The penny is included as a reference to size.

Methods:

1. TinyCircuit GPS units were assembled, programmed, and tested.
2. Bucket drifters were built to include weights and floats in order to properly balance the drifter in the water column.
3. Drifters were deployed and position and time were collected.
4. Data were analyzed using MatLab to determine the speed, direction, and time elapsed.
5. Using National Oceanic and Atmospheric Association (NOAA) data and University of New England Weather Buoy data, wind plots were made using MatLab.
6. Trajectories were mapped using Google Earth and MatLab.

Acknowledgements

This project was funded by the University of New England and the Arthur P. Girard Marine Science Center. We would like to thank James Havu for the initial data collection.

Materials and Methods

Figure 3.1 and 3.2. These pictures show the constructed bucket drifters. Figure 3.1 shows the drifters out of the water before deployment. Figure 3.2 shows one of the drifters in the water during a test.

Results

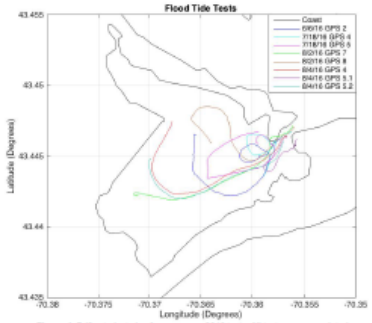


Figure 4. Drifter trajectories from summer 2016 tests. All tests were completed during flood tide, and thus the starting points of all drifters are at the mouth of the pool.

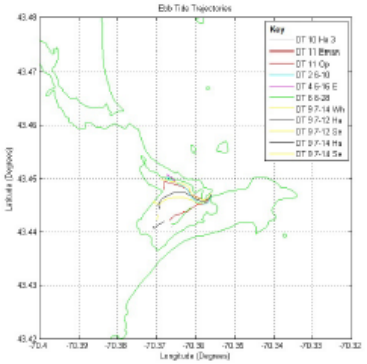


Figure 5. Drifter trajectories from previous research. These drifters were set out during ebb tides. The drifters started in the upper reaches of the pool and moved to the mouth of the pool.

Results

Figure 6. June 6, 2016 drifter trajectory plotted on Google Earth. The drifter started at the mouth of the pool, and took a spiraling path inward.

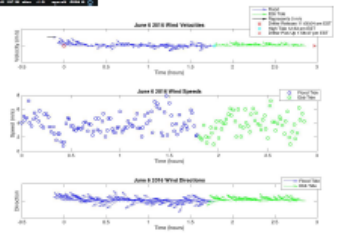


Figure 7. June 6, 2016 wind plots. The top graph indicates velocities and directions with vectors. The second indicates wind speeds in m/s and the third indicates the direction of the wind.

Conclusions and Future Work

Conclusions:

- The path a water parcel takes upon entering Biddeford Pool is determined by a number of factors, including time in the tidal cycle and wind.
- The path a water parcel takes when exiting the pool depends on several factors including its starting location and wind.
- During flood tides, the water parcels coming in to the pool begin as one current but can split into multiple currents and go different directions.
- During ebb tides, water parcels may start at different spots in the pool but eventually meet near the mouth of the pool to form one current flowing out into the ocean.

Problems:

- Drifters cannot be easily seen by other boats.
- Drifters are hard to find if the water is rough or if it is foggy.
- Wind data are not always available or accurate.

Future Work:

- A reliable method for collecting wind data must be implemented in order to fully understand the effects wind has on currents in the Biddeford Pool.
- More tests must be completed during flood and ebb tides to fully understand how water moves in the pool.
- The drifters must be made more visible or able to communicate with the researcher on the boat. Methods to be tested include the use of LED lights, buzzers, radio signal, and phone applications.
- Further analysis will be done to create mathematical models using the properties of fluid dynamics

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Drifter's spatio-temporal data using ArcGIS

Long Distance Drifter analysis

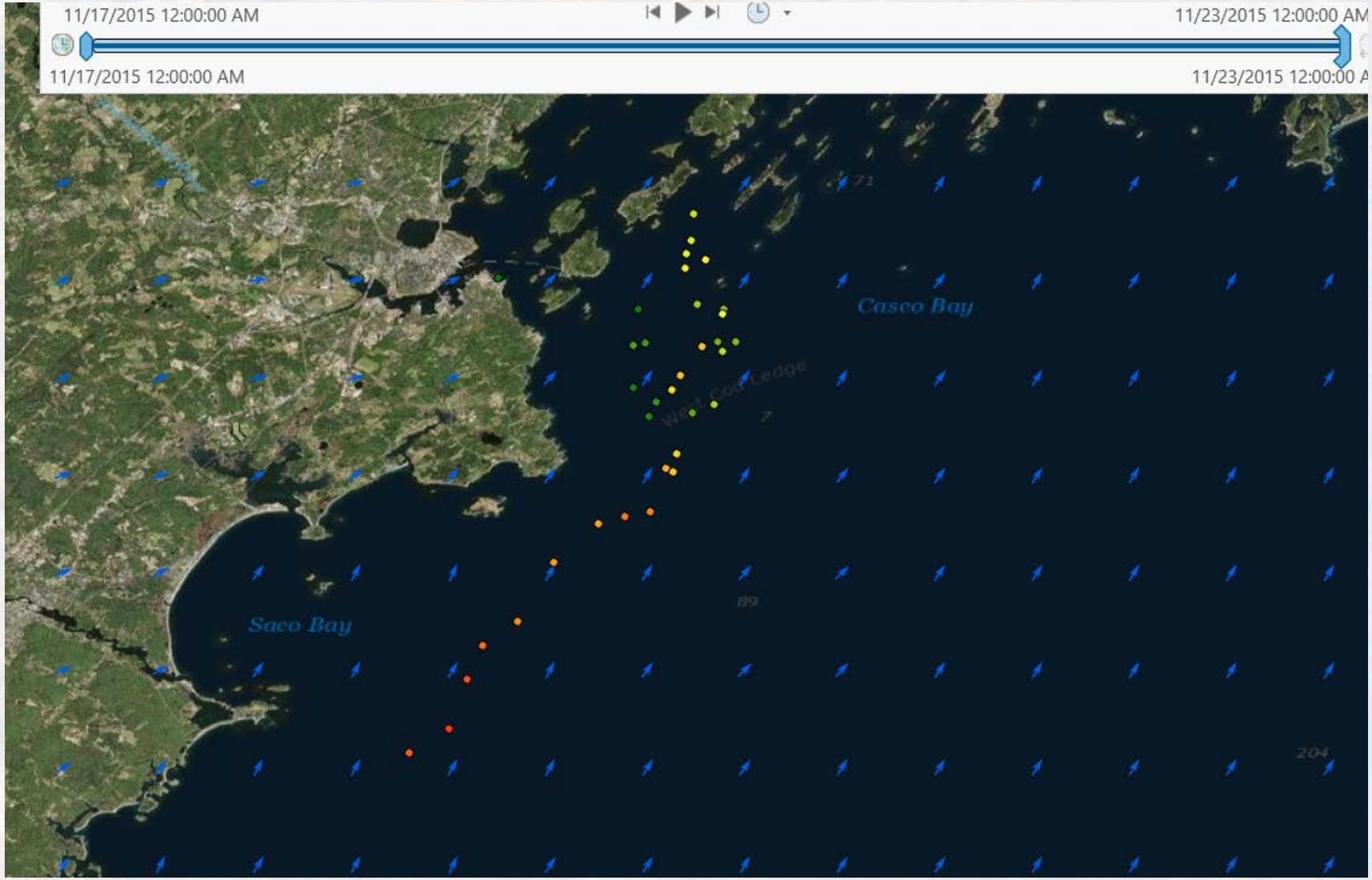
Longitude and Latitude data CSV
Python Haversine formula
to get distance and angle each point

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

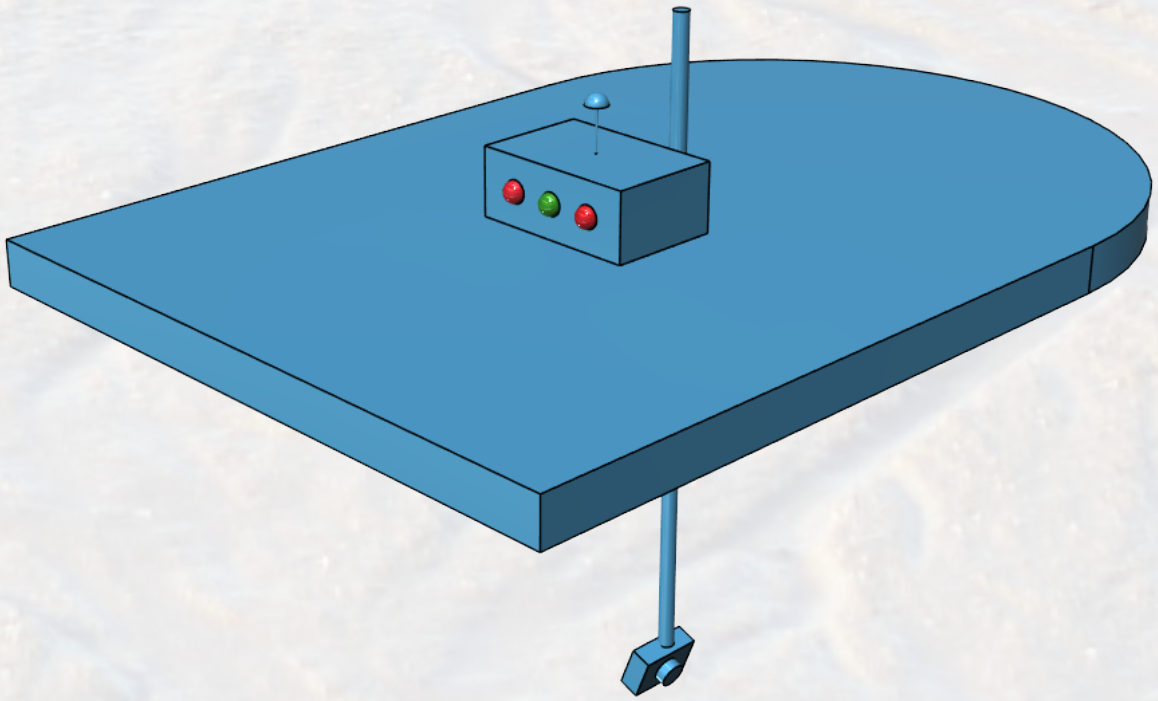
GO Pro

Surf Board

Drone 2 map

Multispectral light source

Direction indicator



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