

**BOWDOIN COLLEGE
COASTAL STUDIES CENTER**

Three-year Report
2013 - 2016



The Coastal Studies Center on Harpswell Sound, Casco Bay, Maine

Bowdoin

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Executive Summary, Director Dave Carlon

This has been a truly amazing three years. In this report we synthesize and summarize the major activities at the Bowdoin College Coastal Studies Center beginning in the Fall of 2013, a date that coincides with my arrival as the new director.

The Coastal Studies Center Mission - To promote interdisciplinary approaches for solving complex environmental problems affecting the coastal ecosystems of the Gulf of Maine.

The Gulf of Maine is at the forefront of environmental change, experiencing major impacts from global warming and sustained overfishing¹. Our coastal position provides our students, faculty, and visiting researchers with a complete immersion into the science, economics, and sociology of this rapidly changing environment. Students can learn how to apply the ecological and evolutionary theory they learn in the classroom to real life environmental problems at our doorstep. For example, how increasing ocean acidity and invasive species are impacting a troubled clam fishery? Working side by side with a gifted faculty, students may chose to push the boundaries of present knowledge, by tackling basic questions of organismal biology using marine organisms. Whether led by leaders of academia, or benefiting from the transgenerational culture of Harpswell fishermen, working at the Coastal Studies Center is a unique experience for student and seasoned researcher alike.



I am happy to report that both our programming and infrastructure has been growing at a healthy rate. While it is true that good marine science can be taught and researched with basic field and laboratory equipment, the complexity of today's environmental challenges often demands increased technological capabilities. Our scientific and technological capacity has significantly increased. Our students and professional users will soon be able to conduct cutting edge climate change experiments, in a new experimental seawater laboratory funded by the National Science Foundation and now under construction. This project is also building a pier-based instrument array for measuring ocean chemistry in real time. We will be able to see changes in ocean acidity over short (minutes) and long (years) time frames. A new dry laboratory space carved out of the Marine Laboratory footprint, is enabling microscopy and molecular biology in exciting ways. With leadership of former Doherty Marine Biology

¹ Pershing, A. J., M. A. Alexander, C. M. Hernandez, L. A. Kerr, et al., 2015 Slow adaptation in the face of rapid warming leads to collapse of the Gulf of Maine cod fishery. *Science* 350: 809-812.

Postdoctoral Scholar Sarah Kingston, classes and research projects are now commonly using a technique called reduced representation genomic sequencing to provide insights into the movements and evolutionary dynamics of marine organisms. In other words, “big data” has come to Harpswell and the Coastal Studies Center (CSC)! Outside our lab doors, we have greatly extended our reach to Casco Bay and beyond, with the purchase of a new research vessel, the 28’ R/V AOK.

Our expanding infrastructure is pushed by exciting programming. We started the Bowdoin Marine Semester in the Fall of 2015 with six brave students, and have doubled that enrollment for the 2016 iteration. The “BMSS” is unique to small liberal arts schools; it allows close study and research in marine science through unique laboratory and field contexts that are led by Bowdoin faculty and staff. Although we are programmatically very young, our alumnae are already making waves, with award winning research, new jobs at major marine laboratories, and admission into top graduate programs. The BMSS uses every available resource of the CSC, and classes are now knocking on the walls of our modest teaching and laboratory spaces. I look forward to working with President Clayton Rose and Dean Elizabeth McCormack in developing funding for new laboratory and living spaces.

While it always takes time to get established in a new academic environment (my last intellectual home was the University of Hawaii), these last few years have seen the development of new Coastal Studies Center partnerships. Marine laboratories and field stations are being increasingly appreciated as geographic sentinels of environmental change², and we are using Bowdoin’s field resources, including the Coastal Studies Center and the Kent Island Scientific Station as nodes within a larger network of small and large education and research institutions that span the Gulf of Maine. Physical and biological data emanating from this network, with a major portion ultimately collected by Bowdoin students, holds the key to understanding how climate change will impact our coastal communities and strategies to mitigate these impacts. Our research and teaching cultures will greatly benefit from the fact that the CSC is now firmly embedded in a wonderful Gulf of Maine research community.

Of course the Coastal Studies Center serves many functions for Bowdoin and beyond. From dawn to dusk every day of the year, our trails are open to the public, and last year we hosted over 800 recreational visitors. The Bowdoin Sailing Team has relocated to the CSC with the new Leighton Sailing Center, completed in the Spring of 2014. We are hosting an increasing number of meetings by local schools and nonprofits, and more diverse use by Bowdoin student clubs and classes. This is an area I am particularly interested in expanding. I have found that relatively few students, beyond those visiting the CSC for coursework, or sailing, visit the Center more than once in their four years at Bowdoin. Stay tuned for more innovation in general programming!

As you read this report, my hope is that it gives you a sense of the breadth and depth of where we have been these last few years. I have also included links to more detailed information

² National Research Council. 2014. *Enhancing the Value and Sustainability of Field Stations and Marine Laboratories in the 21st Century*. Washington, DC: The National Academies Press. <https://doi.org/10.17226/18806>.

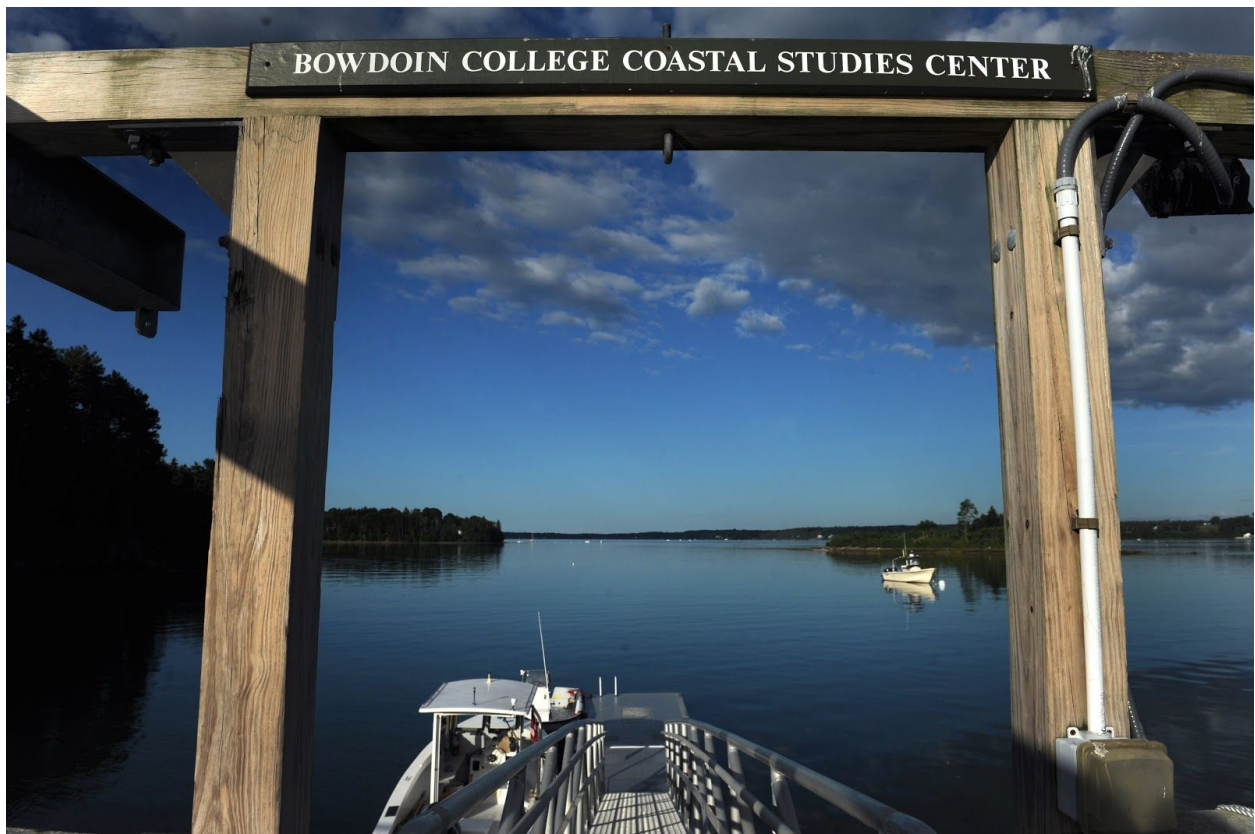
about specific activities/organizations, and in many cases featured stories by the Bowdoin media.

Now that the dust has settled some, I will be posting annual reports each Spring, starting in 2018. I hope you get a chance to visit the Coastal Studies Center soon. It is a true gem in any season!

Best Wishes,

Dave Carlon

Director, Coastal Studies Center & Associate Professor of Biology, dcarlon@bowdoin.edu



Highlights

- **New Marine Science Semester (p. 8)**
- **Sailing Team relocates to the new Charles M. Leighton Sailing Center (p. 16)**
- **The Marine Laboratory gets a \$500,000 facelift (p. 16)**
- **A \$215,000 NSF grant is building a world-class climate change laboratory (p. 18)**
- **The CSC welcomes five new staff (p. 19).**
- **Doherty Marine Biology Postdoctoral Scholar – Sarah Kingston (p. 21).**
- **Coastal Studies Scholars – Filmmaker David Conover and phytoplankton biologist Bobbie Lyon (p. 23)**
- **From Phytoplankton to Novella’s - over 80 Bowdoin summer fellowships awarded to support student research (p. 24)**
- **CSC based honors research receives national acclaim (p. 26)**
- **Faculty research on marine biology, remote sensing, and climate change (p. 27)**
- **The CSC hosts the 45th Benthic Ecology Society Meeting in Portland, ME March 16th-19th 2016 (p. 30)**
- **CSC faculty develop the Northeastern Coastal Stations Alliance to understand how coastal ecosystems of the Gulf of Maine are responding to climate change (p. 31)**
- **New research collaborations with the University of New Hampshire, Bigelow Laboratory of Ocean Sciences, and the Gulf of Maine Research Institute (p. 31)**
- **Dave Carlon is elected President of the Northeastern Association of Marine and Great Lakes Laboratories: NEAMGLL (p. 31)**



New Marine Science Semester

The Coastal Studies Center is now the intellectual home of a cutting edge, experiential learning program, called the Bowdoin Marine Science Semester (BMSS). First launched in the Fall of 2015 with 6 students, we doubled enrollment in 2016, and continue to attract a diverse and excited student body. The BMSS offers students with a scientific interest in the oceans an immersive experience in marine field-work, laboratory experiments, emerging technology, and independent research. Our new semester is modeled after other highly successful semester-in-residence programs, including the Boston University Marine Program and the Three Seas Program at Northeastern University. We feature an entirely 'place-based' learning experience with an off campus program designed and taught by Bowdoin faculty. Classes and laboratories are taught at the Coastal Studies Center and on the road as the BMSS takes extended field trip to islands in the Gulf of Maine and to the tropics and coral reefs with a 10-day trip to Baja California Sur. Each semester consists of 4 course modules taught in succession (reminiscent of Colorado College) via 3 – 4 week intensive learning blocks. An independent, student-generated research project begins with planning early in the semester, and finishes during the Fall finals week with a public presentation. The BMSS is open to all Bowdoin students as well as those from the participating institutions of the 12 College Program.

There are three themes that knit the diverse subject matter of the Marine Science Semester together: the analysis of environmental data, biodiversity, and climate change. The analyses of environmental data, from longitudinal ecological data to large genomic data sets, is taught through competence in the computer language R. Students get programming experience via the manipulation, analysis, and modeling of real data sets generated by the BMSS. Also included in this theme are learning the best practices principles of experimental design, emphasized through all three scientific modules, and culminating with student-driven research projects. An appreciation of biodiversity is emphasized from hands-on systematic, ecological, and evolutionary perspectives. BMSS students learn the evolutionary history, function, and inter-connections of marine organisms as small as plankton and as large as megafaunal marine mammals and sharks. Two sentinel marine systems present ideal natural laboratories to understand the impacts of climate change: our nearby Gulf of Maine and further afield coral reefs. Students of the BMSS learn the ecology of these systems, and how it is changing through national and international partnerships that are generating long-term ecological data. These three themes are greatly enriched with collaborations that have been established with friends at major marine science research institutions (see *Field Work* below). Students have opportunities to interact with our scientific neighbors at the Gulf of Maine Research Institute and at the Bigelow Laboratories for Ocean Sciences, and work shoulder to shoulder with graduate students from the Universidad Autonoma de Baja California. More formally, they present their independent research to peers and faculty in the form of an oral presentation, and are provided numerous opportunities to improve writing skills through iterative drafts of major assignments. This learning by doing approach, set in the context of the two sentinel marine systems: makes the BMSS an extremely timely and unique educational opportunity.

At this writing, we have completed two BMSS semesters. Students have majored in Biology, Environmental Studies, and Earth and Oceanographic Science. To say we have had two successful semesters since our program launch is an understatement. BMSS alums have gone on to graduate programs and research positions in governmental agencies. For a complete list of BMSS alums and an update on what where they have gone, see Appendix A.

Course Modules

New in 2016 BMSS Bootcamp! – The BMSS Bootcamp is a “pre-module” the week before the Fall Semester begins. BMSS students camp on site at the Coastal Studies Center, where the BMSS staff run an intensive field program that includes trips to the subtidal and rocky intertidal habitats of Harpswell Sound and a field sampling cruise on the University of Maine’s research vessel – the *Ira C*. We field-tested the BMSS Bootcamp in the Summer of 2016 with outstanding results. Evening science and social activities make our Bootcamp both a rigorous marine science introduction and social “ice breaker” for students in the semester long program.



a.



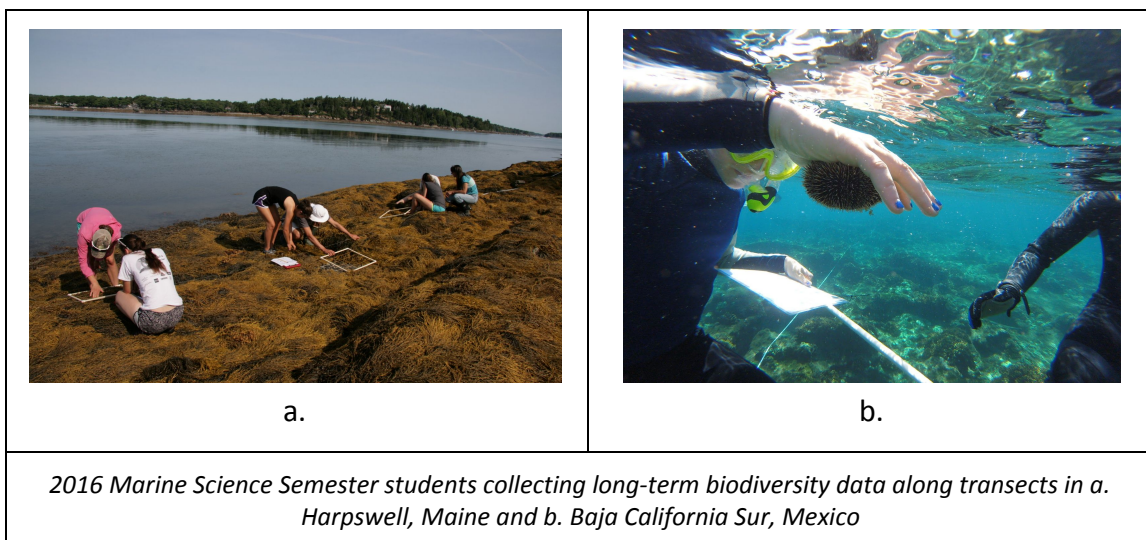
b.

a. Students arriving for the 2016 BMSS Bootcamp and b. BMSS student Bootcamp ‘icebreaker’

1. **Biological Oceanography** introduces students to the dominant physical and biological processes in the oceans. It is taught in the tradition of “all rounder” biological oceanography courses, so that students leave the module with a fundamental understanding of the processes that drive biological productivity in the sea; from tides to global patterns of phytoplankton productivity. The current instructor, Dr. Barbara “Bobbie” Lyon has been the Coastal Studies Center Scholar since 2015 and has taught this module twice (see p. 23). Bobbie emphasizes both field and experimental approaches to the controls on primary production using a highly molecular toolkit and

the experimental equipment of the CSC Marine Laboratory. A field transect on the Kennebec River introduces students to methods of data collection and data structures of biological oceanography.

2. **Benthic Ecology** taught by Dave Carlon, introduces marine biodiversity and ecology by contrasting the benthos of the Gulf of Maine with the rocky reefs of the Sea of Cortez. The course heavily leverages a long-term data set on intertidal community structure that is part of NeCSA network in (see p. 31). Students collect and analyze patterns of abundance from three sites in the Gulf of Maine, including data from field trips to the Kent Island Scientific Station and Hurricane Island. A second tropical data set was initiated in the 2016 BMSS in the Gulf of California. These invaluable field experiences in the Gulf of Maine and in the tropics illuminate a comparison in how boreal and tropical marine systems function, and how they are responding to climate change. Practical experience in identifying marine algae, invertebrates, and fish is emphasized on the journey to understanding the dominant benthic ecological processes.



3. **Writing about the Coastal Environment** is a writing-intensive humanities course. The course is designed as an environmental science-focused creative writing course. The students spend a month in a concentrated writing program involving intensive reading and composition. Their writing assignments are designed to help the students better communicate their scientific research to the larger world that their research involves and affects. Visiting Writer in Residence Russ Rymer, an award winning author and freelance journalist, has taught the course for two semesters.
4. **Marine Molecular Ecology and Evolution** has been by taught by Sarah Kingston. Sarah started at Bowdoin as the Doherty Marine Biology Postdoctoral Scholar (p. 21). This module highlights the application of molecular data to the ecological and evolutionary problems in the Gulf of Maine. Students are introduced to sampling, generation, and analysis of large molecular data sets with hands-on laboratory work. Using samples collected during the semester's field excursions, each class participates in a long-term

project that uses Next Generation Sequencing to understand temporal and spatial variation in marine populations.



Field Work

BMSS Field work is designed to provide hands-on experience for studying marine organisms in their natural environments, including understanding their systematics, ecological function, and dynamics. The work we conduct in the field is making key contributions to the greater good, in providing insights into how and why marine systems are responding to climate change. We are using the data collected from our field sites as the basis of a longitudinal study (fixed sites are sampled regularly in time) of how marine ecosystems are changing in response to climate change. By surveying the macroalgae, marine invertebrates, and fish at these sites on a yearly basis we can understand climate change in both its temporal and geographic dimensions. In the Gulf of Maine we are leveraging the [Bowdoin Scientific Station on Kent Island](#) in the Bay of Fundy to kick off our semester. We compare and contrast these patterns in the Bay of Fundy with similar measurements in Penobscot Bay at [Hurricane Island](#) and in our own backyard at the Coastal Studies Center on Harpswell Sound. Our 10-day trip to Baja California Sur features near-shore tropical ecosystems including coral reef and pelagic systems. Moreover, students are afforded a unique opportunity to interact with our collaborators and students from Universidad Autónoma de Baja California Sur. While in Baja, the class collects data on corals, invertebrates, and fishes to monitor and detect changes in the community structure driven by climate change.



a.



b.

a. BMSS Students on a research cruise in the Damariscotta River and b. BMSS students and Dave Carlon preparing parrot fish samples for genetic analysis.

Independent Research

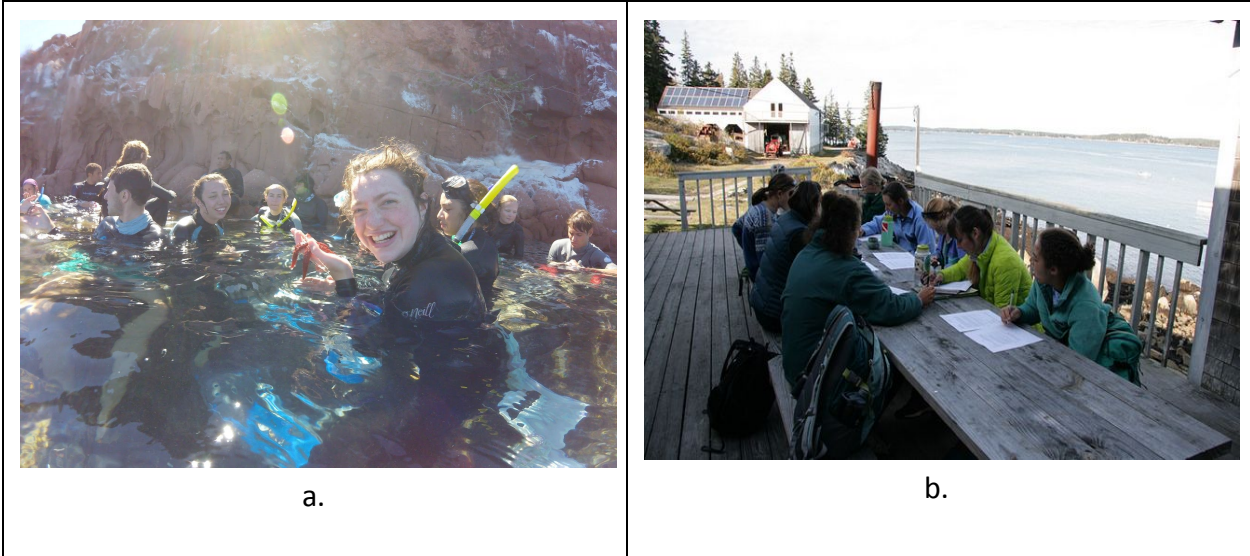
Starting with Bootcamp, students begin to develop and carry out independent research projects over the course of the semester. Students begin by pitching their ideas and interests to the BMSS faculty on the way to refining an important scientific question and a testable hypothesis. Systems range from stress-induced bioluminescence in phytoplankton, to the effect of ocean acidification on swimming behavior in fish. At the conclusion of each semester, students present their independent research in a symposium-style setting in front of the Bowdoin community, Maine scientific community collaborators, as well as our neighbors from Harpswell. A list of projects can be found [here](#).

BMSS alumni are making waves!

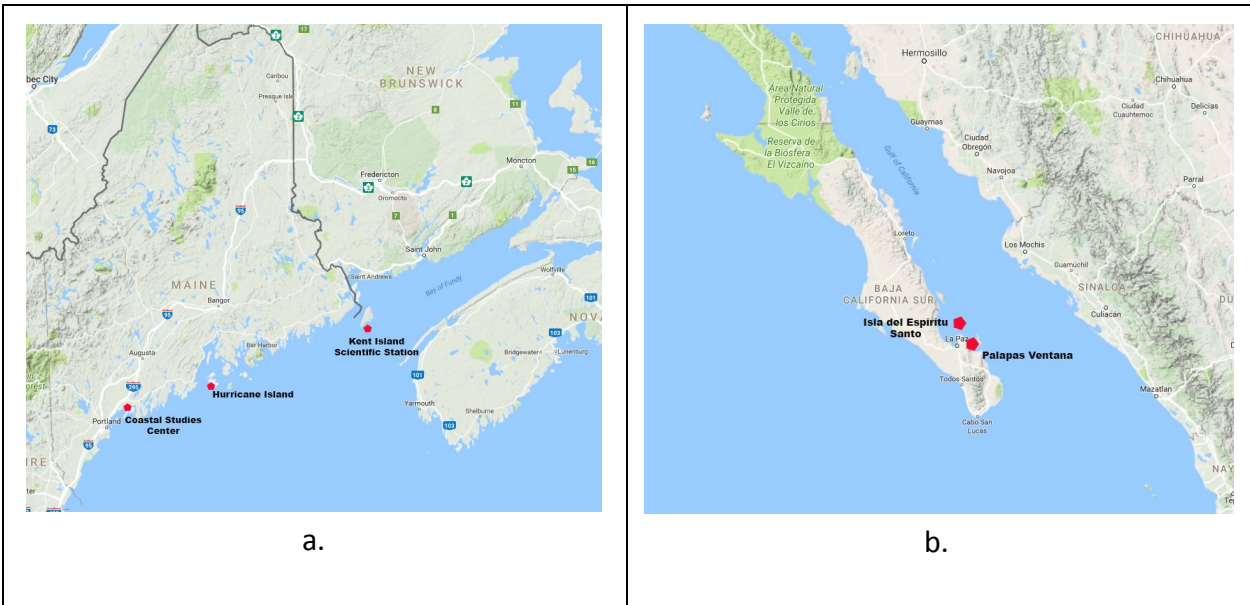
Three BMSS alumni presented their research at the annual Benthic Ecology Meeting in Myrtle Beach, SC this past spring: Alana Luzzio BMSS '15, Aidan Coyle BMSS '15, and Sam Walkes BMSS '16. Excitingly, Aidan Coyle '17 won the best undergraduate student paper award with his research establishing genetic links to cold tolerance in invasive green crabs (photo at right), featured [here](#). In addition, Alana Luzzio '17 has obtained over \$3,000 from the Maine Coastal Program's Maine Mapping Initiative to continue her research on the distribution



of micro-bivalves in the Gulf of Maine (tiny clams that live in offshore waters). Sam Garvey '16 (BMSS '15) is now working as a technician for the Maine Mapping Initiative, and Drew Villeneuve '16 (BMSS '15) will start an innovative PhD program in policy and marine science at the University of Maine this Fall.



a. *BMSS students learning about biodiversity in the field at Isla del Espiritu Santo in Baja California Sur, Mex and b. BMSS students discussing a scientific paper on Hurricane Island Penobscot Bay, ME*



a. *BMSS field sites in Maine(CSC and Hurricane Island) and Canada (Kent Island Scientific Station)and b. BMSS field sites in Baja California Sur, MEX*

Course Use

We have expanded course activity considerably since 2013. During the last three years, we have hosted 187 instructional days at the Coastal Studies Center (Table 1).

Table 1. Bowdoin courses that have used the CSC for instructional activities, and the number of instructional days.

Course Number	Course Name	Semester	Year	# of days
EDUC 3325	Mindfulness in Education	Spring	2014	1
ENGL 2850/ GWS 2605	Lit. of Adolescent Sexuality- Writing Retreat	Spring	2014	1
BIOL 3301/ ENVS 2234	Dimensions Marine Biodiversity	Fall	2014	14
BIOL 2330/ ENVS 2233	Marine Molecular Ecology & Evolution	Fall	2014	14
VART 2302	Landscape Painting	Fall	2014	1
BIOL 2175	Developmental Biology	Fall	2014	2
BIOL 2319/ENVS 2229	Bio of Marine Organisms	Fall	2014	2
VART/ENVS 2461/FILM 2110	Seashore Digital Diaries	Fall	2014	2
ENVS 2201/ BIOL 1158/CHEM 1105	Perspectives in Environmental Science	Spring	2015	3
CINE/VART 2120/ENVS 2463	Science to Story	Spring	2015	2
BIOL 2501/ ENVS 2231	Biological Oceanography	Fall	2015	19
BIOL/ENVS 2332	Benthic Ecology	Fall	2015	8
ENG/ENVS 2802	Writing about the Coastal Environment	Fall	2015	17
BIO 2230/ENVS 2333	Marine Molecular Ecology & Evolution	Fall	2015	20
BMSS	Bowdoin Marine Science Semester Final	Fall	2015	2

	Exam & Final Presentations			
ENVS 2201/ BIOL 1158/CHEM 1105	Perspectives in Environmental Science	Spring	2016	3
EOS 2625	Ocean Acidification	Spring	2016	3
BMSS	Bootcamp	Fall	2016	4
EOS 2665	Chemical Tracers of Oceans	Fall	2016	1
EOS 3525	Coastal Dynamics & Ecosystems	Fall	2016	1
BIOL 2315/ ENVS 2224	Behavioral Ecology & Evolution	Fall	2016	2
ENG/ENVS/GWS 2548	American Wilderness	Fall	2016	1
BIOL 2501/ ENVS 2231	Biological Oceanography	Fall	2016	19
BIOL/ENVS 2332	Benthic Ecology	Fall	2016	5
ENG/ENVS 2802	Writing about the Coastal Environment	Fall	2016	18
BIOL 2230/ENVS 2333	Marine Molecular Ecology & Evolution	Fall	2016	20
BMSS	Bowdoin Marine Science Semester Final Exam & Final Presentations	Fall	2016	2
Total				187

Expanding Infrastructure

Sailing Team comes to the Coastal Studies Center - In May of 2014, the sailing team relocated from their previous location on Bethel Point to a brand new facility at the Coastal Studies Center. The [Charles M. Leighton Sailing Center](#) includes a 1500 square foot building with meeting space, offices, changing rooms, and showers. Additions to the north end of the existing Research Pier have greatly expanded access to the water, including an ADA accessible gangway and floating dock that can service up to 24 FJ-class sailboats. The sailing team compliments the scientific and recreational activities, as well as culture of the CSC.



a.



b.

a. Charles M. Leighton Sailing Center and b. Sailing dock with FJ-class sailboats

\$500,000 renovation of the Marine Laboratory - With support from the Cargill Foundation, the Marine Laboratory got a major facelift during the Summer of 2014. Major improvements included a new seawater delivery system and new experimental seawater aquaria. With a 100 gallon per minute flow rate, a wide variety of marine organisms, from microscopic plankton to large fish can be accommodated. We also renovated and equipped a new dry laboratory space and field staging area, and these new spaces are being well utilized by summer research and for teaching.



a.



b.

a. Newly renovated Marine Lab and b. Renovated wet lab space with modular tank system

New Farmhouse teaching and computer spaces - With college support, we have been taking care of a backlog of maintenance at the Farmhouse, and adding new teaching capabilities. Internet connection speed has been increased, and plans for a fiber optic connection from the Brunswick campus are being considered. Twelve new Mac workstations with large format monitors form the nucleus of a new Farmhouse computer lab, that are being used to teach mathematical modeling, statistical applications, and bioinformatics. The first floor meeting space has new open format furniture and a large flat screen monitor for digital projection. All these resources are used heavily by the Bowdoin Marine Science Semester, and often by lab-based courses that visit the Coastal Studies Center.



a.



b.

a. Renovated teaching/meeting space in the Farmhouse and b. Farmhouse computer lab

\$215,000 NSF Field Station and Marine Laboratories Grant from the National Science Foundation – In the Fall of 2014, Dave Carlon (PI) and Michèle LaVigne (Earth and Oceanographic Science, Co-PI) wrote a successful grant to increase the research capabilities of the CSC to address questions on the impacts of climate change on marine ecosystems. This grant is building an experimental aquarium system that can precisely manipulate seawater temperature and chemistry to simulate future marine environments. Specifically, the system will allow researchers and students to chose values of pH (ocean acidity), temperature, dissolved oxygen, and planktonic food supply in individual aquaria. All of these variables have been identified to change dramatically over the next 50 years and are likely to exert strong forcing on marine ecosystems, particularly the shallow bays and inlets that characterize coastal Maine. The grant is also building a cutting-edge system of environmental sensors that will precisely track the temperature and chemistry of incoming seawater and stream this data in real time to the outside community, providing a much-needed coastal baseline for comparative studies and experiments. With these new improvements, we are joining a network of researchers monitoring ocean acidity in the Gulf of Maine, led by Joe Salisbury’s group at the University of New Hampshire. The system is scheduled for completion by Fall, 2017.

R/V AOK joins small-boat fleet - Thanks to the generous donation by an anonymous donor, we added a much needed 28’ Parker Hull equipped with twin Yamaha 250 HP outboards to our small boat fleet in the summer of 2014. The R/V AOK has sophisticated electronics, a starboard side hauler for nets, trawls, and traps, and a 400 watt 12V to 110V power inverter for computational or AC electrical needs. The R/V AOK is a superb all around vessel for the CSC, capable of making rapid and safe trips to offshore sites as well as working the shallow waters of Casco Bay with outboard power and shallow draft.



Staff highlights

This past three years has been a whirlwind of new faces; **we have hired five, full time CSC positions since the fall of 2013**. As a result, we have an outstanding team in place that oversees the facilities, boats, and guides the new academic programming of the CSC. In the Spring of 2015, the CSC sadly said goodbye to our former caretaker, Mark Murray. Yet Mark is still with us at Bowdoin, we get a chance to see him every fall on Kent Island, where he remains the caretaker.



Joe Tourtelotte, Coastal Studies Center Caretaker, jtourt@bowdoin.edu

In the summer of 2015, we hired Joe to replace Mark Murray. Joe was born in Brunswick and grew up enjoying the Maine outdoors at an early age. Hiking, fishing and camping were common pastimes of his family. At some point, Joe developed a passion for cacti and succulents, which led him to attend school for horticulture. School opened his eyes to ecology, sustainable agriculture, and landscape design. After graduating, Joe spent a lot of time on a bicycle traveling around North America and as far as Patagonia. He now lives in Bowdoinham, a town where his family goes back many generations.

On the weekends, Joe and his wife are usually out hiking in the White Mountains, biking backroads along the coast, or working in their gardens.



Elizabeth Halliday Walker, Lab Instructor, ewalker2@bowdoin.edu

Since earning her PhD in Biological Oceanography from Woods Hole Oceanographic Institution in 2012, she has been teaching marine ecology in settings that value experiential, interdisciplinary learning. Elizabeth particularly loves teaching within the immersive structure of the Bowdoin Marine Science Semester, since our remarkable access to the field and resources at the Coastal Studies Center open up a world of possibilities for class and independent research. As the

Laboratory Instructor, she guides students as they conduct research in each of the course modules and independently – from phytoplankton experiments in the lab, to coral reef transects in Baja California Sur, to extracting and analyzing DNA as we compare intertidal snail populations in the Gulf of Maine. Elizabeth joined us in the summer of 2015.



Paul Joyce, Marine Operations Manager, pjoyce@bowdoin.edu

Paul has loved the outdoors ever since he was a little kid. He takes great pleasure in activities ranging from hiking, fishing, hunting, bicycling, and of course boating the great waters of Maine. Paul grew up just outside Boston, Massachusetts - in the Town of Brookline - and spent his summers on Cape Cod. During college, Paul worked the ferry line to Nantucket and landscaped both on the Cape

and in Brookline. After graduating from UMass Boston with a BA in Biology Paul joined the Massachusetts Army National Guard where he served in the Military Police. In 1983, he moved back to Maine and joined the Coast Guard Reserves as 'Port Security Officer.' From 1986 to 2011 Paul worked at Maine's Department of Marine Resources as a Marine Patrol Warden. After retiring from the DMR in 2011 Paul became a Security Officer and Casual Boat Operator at Bowdoin College. In the spring of 2016, Paul became the Marine Operations Manager and now maintains and captains the fleet of research vessels at the Coastal Studies Center.



Steven Allen, Assistant Director of the Coastal Studies Center,

sallen@bowdoin.edu

Steve has marine science written in his DNA, with more than 20 years experience on and in the oceans. He has a Masters in Marine Biology from the College of Charleston, South Carolina, where he studied oyster physiology and immune response. After graduate school, Steve worked for 7 years in the Chesapeake Bay for the [Oyster Recovery Partnership](#) where he oversaw large-scale oyster restoration activities in the Maryland portion of the Bay. Upon moving to Maine, Steve worked for the University of Maine at the Darling Marine Center doing research on lobster ecology. Steve is the president of the National Shellfisheries Association (www.shellfish.org). As Assistant Director, Steve oversees the day to day operations of the Coastal Studies Center and helps with the organization and execution of the Marine Science Semester. Steve joined the team during the Fall of 2016.



Nicholas Keeney, Marine Lab Technician/Manager,

nkeeney@bowdoin.edu

Nick joined CSC in the Spring of 2016 as the Marine Lab technician/manager—a new position which oversees lab operations, maintains equipment, and coordinates visitors. Nick's background includes marine science and engineering in Boston, where he worked for an aquarium, an environmental NGO, and nanoscience center. Nick received his Masters in oceanography from LSU, moonlighting on research vessels and in community radio. His interests are biological-physical interactions in the ocean, and computational models of collective fish intoxication.



Rosemary Armstrong, Coordinator for Environmental Studies Program And Coastal Studies Center

rarmstro@bowdoin.edu

Rosie has been at Bowdoin since 2001, and has enjoyed her position with the CSC since 2004. Before coming to Bowdoin Rosie was Assistant to the State Director at the Nature Conservancy of Maine.

Doherty Marine Biology Postdoctoral Fellowship

The Doherty Marine Biology Postdoc program is alive and well at the CSC. Our 4th Doherty Postdoctoral Fellow is Dr. Sarah Kingston, who followed Dr. Trevor Rivers (see [link](#) for full history of this program). Since her arrival at Bowdoin and the CSC in 2014, Sarah has launched several genome-scale projects aimed at answering ecological and evolutionary questions in marine systems. As climate changes, marine populations in the Gulf of Maine are facing warmer temperatures, ocean acidification, reduction in primary productivity (food sources), and incursions of non-native species from southern waters. Standing genetic variation in natural populations will have a tremendous influence on the ability of species to deal with these multifaceted challenges. Sarah's research focuses on groups of marine calcifiers native to the Gulf of Maine, organisms that are particularly vulnerable to changing ocean conditions. In collaboration with Dave Carlon, Sarah has taken advantage of the strengths of the Coastal Studies Center to address the question, are Gulf of Maine blue mussel populations able to adapt to rapidly changing ocean conditions? This blue mussel project leverages a large hybrid zone between two mussel species in the Gulf of Maine, as well as next generation sequencing techniques to collect data at both the genomic and transcriptomic scales. Sarah has presented this ongoing work at national and international meetings (The Congress for the European Society for Evolutionary Biology 2015, Annual Meeting of the National Shellfisheries Association 2016) and has recently submitted a manuscript to *Evolutionary Applications*. Several students have contributed to this project including Biology Honors student Pieter Martino '17 who has characterized the mussel's protein expression response to climate stress (using RNA). The team expects several more exciting publications from this ongoing project.

Sarah has also offered key contributions to the new Marine Science Semester by making environmental genomics a teaching platform for marine science. By leading BMSS students in collecting genomic and shell morphology data, her team is characterizing population variation in two native intertidal snail species in the Gulf of Maine. These course-based studies aim to link shell variation and the underlying genetic architecture – color or size/shape of shell and the genes that influence these traits – to relevant ecological pressures – wave exposure or predation pressure.

As part of a consortium of Maine researchers and fishing communities, Sarah is spearheading a project to utilize genomic data to identify source populations for the coastal Atlantic sea scallop fishery.



a.



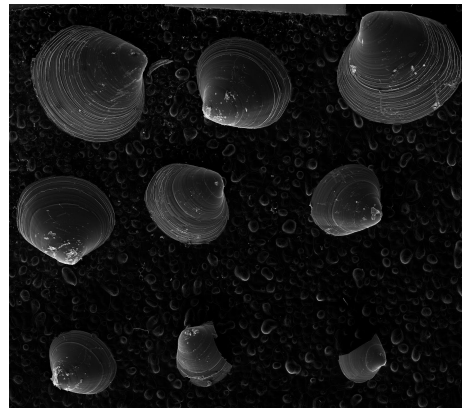
b.

a. Blue mussels filter an intertidal channel on Grand Manan, New Brunswick, CA and b. preparing mussel DNA for next generation sequencing

Sarah is currently advising Bowdoin Biology major Alana Luzzio '17, who won a competitive Maine Outdoor Heritage Fund grant (2016) to study genetic variation in populations of benthic bivalves and corresponding variation in water chemistry associated with the bivalves' habitats. The project is a collaborative effort with the Maine Department of Agriculture, Conservation and Forestry, Maine Coastal Mapping Initiative.



a.



b.

a. Alana Luzzio ('17) and b. *Arctica islandica*, the 'climate change clam,' shells imaged on a scanning electron microscope

Starting in 2017, Dr. Kingston is staying on the Bowdoin and CSC team as a Visiting Assistant Professor in Biology to continue to foster the growth of the BMSS as well as teach Computational Genomics on main campus. We will be searching for a new Doherty Marine Biology postdoc soon, so stay tuned for more exciting research based at the CSC!

Coastal Studies Scholars

We have continued the highly successful Coastal Studies Scholars program by matching the talents of exceptional artists, writers, and scientists to the natural resources, ethos, and culture of our land and sea on Harpswell Sound. The program greatly extends our scope and energy, by bringing in unique talent from Maine and beyond. Recent CSC Scholars include:

David Conover (2014 – 2015). Award-winning documentary filmmaker [David Conover](#) '83 taught two very popular film class in the context of the Maine coast and people: Seashore Digital Diaries (VART/ENVS 2461, FILM 2110) and Science to Story (CINE/VART 2120, ENVS 2463). See [link](#) for example of these student film projects.

Dr. Barbara "Bobbie" Lyon (2014 – present). Bobbie is phytoplankton biologist who has been with us on a seasonal basis since in the inaugural BMSS in the Fall of 2014. Bobbie is an expert in polar phytoplankton physiology and is interested in the intersection of art and science) but has many talents, including a very popular art series, called '[From a Drop of Seawater.](#)' When she is not teaching the Biological Oceanography module in the Fall, she holds an adjunct faculty appointment at the College of Charleston.

Research

Bowdoin Summer Fellowships

Our summer student research program thrives with major support from the **Rusack** and **Doherty** Fellowship endowments, and we are supporting about 20 students from Bowdoin and beyond each year (Table 1). The projects are diverse and reflect the expertise of faculty advisors, ranging from basic physiological research using marine models (Patsy Dickinson's Laboratory at Bowdoin), the evolutionary ecology of marine invertebrates (Jon Allen, William and Mary), and DNA sequence based projects that seek to characterize population dynamics, identify marine ichthyoplankton, or to understand the genetic basis of adaptations that will help populations respond to climate change (Dave Carlon and Sarah Kingston's laboratories at Bowdoin). There is also much in between that features the work of Bowdoin faculty and outside researchers who bring their own funding. For the complete list of student project titles see Summer Research Appendices (p. 40) or go to the [CSC website](#). Publications with work resulting from summer fellowship support are indicated by § in the Publications list on Page 38.

Each July, we run a one day summer research symposium that features student research projects based in Casco Bay. In 2016, we added a featured guest speaker - Dr. [Graham Sherwood](#) from the Gulf of Maine Research Institute. Graham joined us with a featured talk on that status of the local ground fish fishery, and offered his seasoned professional feedback on student projects. The result was a collegial and professional research environment for our students. We continue this trend by bringing Dr. [Benjamin Twining](#) from the Bigelow Laboratories for Ocean Sciences to our symposium in 2017. As always, our summer research symposium is open to our interested general community, and we personally invite our Bayview Road neighbors every year.

Table 2. The number of students conducting summer research based at the Coastal Studies Center, and sources of support.

Fellowship Series	2014	2015	2016	2017
Rusack Coastal Studies Fellowship	5	4	4	4
Doherty Coastal Research Fellowship	10	7	11	7
Freedman Summer Fellowship	1	1		1
Hughes Family Summer Research Fellowship	1	1		1
Biology Life Sciences Fellowship		1		
Cooke Environmental Research Fellowship	1	1		
Phocas Family Fellowship		1		1
Maine Mapping Initiative, Coastal Program		2	1	
Coastal Studies Research Grant			1	1
Langbein Summer Fellowship				1
College of William and Mary		3	3	2
Faculty grants	3		1	2
Total	21	21	21	20

Bowdoin Honors Research

In the last three years, 10 honors projects have been completed with a focus on Maine coastal environments. These projects are either experimentally based at the CSC, or have used the marine habitats of Harpswell, Phippsburg, and the greater Casco Bay as field sites. Many of these projects are publication quality, so look for these young student authors on papers published in major marine science journals in the next few years!

Ryan Pebody, 2014. "Coastal currents in the Gulf of Maine : a mechanism for algal bloom transport." (Earth and Oceanographic Science) Advisor - Collin Roesler.

Claude Millet, 2014. "Submerged aquatic vegetation as habitat for American eels (*Anguilla rostrata*) in Merrymeeting Bay (ME, USA)." (Biology) Advisor -John Lichter.

Lloyd Anderson, 2016. "Investigating non carbonate alkalinity in salt marsh ecosystems." (Earth and Oceanographic Science)Advisor - Michèle LaVigne.

Sabine Berzens, 2016. "Impacts of eelgrass (*Zostera marina*) on pore-water sulfide concentrations in intertidal sediments of Casco Bay, Maine." (Biology) Advisor - John Lichter.

Simonetta Harrison, 2016. "Juvenile alewife (*Alosa pseudoharengus*) production under different restoration scenarios in Maine's watersheds." (Biology)Advisor - John Lichter.

Julia Maine, 2016. "The chemical responses of oyster shell composition to ocean acidification." (Earth and Oceanographic Science) Advisor - Michèle LaVigne.

Erin Voss, 2016. "Conflicting geography of mitochondrial and nuclear markers in a green crab hybrid zone in the Gulf of Maine." (Biology) Advisor - Dave Carlon.

Aidan Coyle 2017 "Some like it cold: the relationship between thermal tolerance and mitochondrial genotype in an invasive population of the European green crab, *Carcinus maenas*." (Biology) Advisor - Dave Carlon.

Hannah Miller, 2017. "Seasonal variability in carbonate chemistry on Kennebec Estuary clam flats." (Earth and Oceanographic Science) Advisor - Michèle LaVigne.

Pieter Martino 2017 "Linking stress phenotype to standing genetic variation amidst a changing climate." (Biology) Advisor - Sarah Kingston

Faculty Research

Our location on Casco Bay sits on an important environmental transition that divides the warmer water of the Cape Cod region from the colder waters of the Gulf of Maine. This transition is creeping further northward as the Gulf of Maine warms. Our site therefore puts us in an excellent location to understand the impacts, and possible mitigation of climate change in coastal systems. We have several faculty actively working on climate change problems, but also a number of projects that use marine organisms as models to test basic hypotheses in the biological sciences of physiology, ecology, and evolution. As is common at marine stations, we are diverse in our intellectual approaches, but we share a love of marine systems and the Coast of Maine.

Dave Carlon, Bowdoin <https://research.bowdoin.edu/carlon-lab/>

The Carlon laboratory continues to use a variety of molecular tools to answer ecological and evolutionary questions. Here in the Gulf of Maine (GoM), we have become very interested in the dynamics of the green crab invasion, including the causes and consequences of hybridization between a cold and warm adapted populations at the northern edge of the GoM. Two honors students, Erin Voss '16 and Aidan Short '17 have revealed that different genes are moving at different speeds across this hybrid zone, and that natural selection can explain some of this variation. A second research focus is using the CSC and Harpwsell Sound as ecological field sites in a project that is using a “next generation” approach to unravel complexity in benthic food webs. The diets of the major omnivorous consumers on the seafloor bottom, including green crabs, rock crabs, and lobsters, are poorly known because of the difficulty in visually identifying digested foods. By combining the precision of next generation sequencing to identify food items, and stable isotope analysis to determine assimilated foods, we will precisely determine individual diets and how they vary with ecological context. This new approach holds promise for determining how energy is moving through the Gulf of Maine ecosystem, and the potential negative impacts of invasive species like green crabs. Finally, I have been collaborating with Sarah Kingston on applying new genetic methods to the problem of whether blue mussel populations can adapt to climate change.

Jon Allen, College of William and Mary <http://wmpeople.wm.edu/site/page/jdallen/home>

The Allen Lab studies the evolutionary ecology of marine invertebrate animals. At the CSC, our work is supported by a grant from the National Science Foundation Division of Environmental Biology to study the evolution of maternal investment in bryozoans, echinoderms, hemichordates, gastropods and flatworms. Our work examines the role that changes in maternal investment plays in determining the larval and juvenile ecology of marine invertebrates. We focus on ‘basic’ biological research into the way that animals work, an interest that is driven by the natural curiosity of the PI and students in the lab. However, our work frequently touches on areas of ‘applied’ research including the roles that the animals listed above play in structuring ecological communities with economic importance to the State of Maine. We apply the lessons we learn at the CSC to diverse habitats outside of the region, including in the Chesapeake Bay and Puget Sound regions of the US and the Great Barrier Reef

in Australia. Thus, while our work at the CSC is local, the reach of that work is in fact global in scale.

Patsy Dickinson, Bowdoin <https://www.bowdoin.edu/faculty/p/pdickins/>

Patsy's research focuses on the ways in which the nervous system controls behavior. In particular, she has been studying the control of relatively simple, rhythmic behaviors, and the modulation or alteration of these behaviors. The goal of these studies is to understand how flexibility in behavior is controlled at the level of the nervous system. Students in her lab and Patsy have been examining the ways in which several small peptides alter the activity of the nerve cells that control the rhythmic movements of the lobster stomach. Because the lobster nervous system is relatively simple, it can be studied in much more detail than is presently possible with vertebrates; we can thus elucidate general principles which can later be applied to more complex species. In studying these problems, they record the electrical activity of individual neurons with microelectrodes and the activity of whole nerves with extracellular electrodes.

John Lichter, Bowdoin <http://www.bowdoin.edu/faculty/j/jlichter/>

John's two recent coastal projects are: examining the historical and projected changes in carbon export to the Gulf of Maine from land use and climate change, funded by a NASA Earth Science Division Research Grant (2011-14); and the ecological and economic recovery and sustainability of the Kennebec and Androscoggin rivers and their common estuary and nearshore marine environment, a collaborative EPSCoR project (2009-14; NSF-EPSCoR Program)

Sarah Kingston, Bowdoin <https://research.bowdoin.edu/kingston-lab/>

Sarah established her research program as the Doherty Postdoc, and continues to build in a visiting role (pg 21). The Kingston lab focuses on population genomics, phylogenomics, and the links between genotype and an organism's response to dynamic marine environments. Members of the lab leverage next generation sequencing techniques and bioinformatic tools.

Michèle LaVigne, Bowdoin <http://michelelavigne.tumblr.com/research>

The LaVigne Lab collaborates with biologists, ecologists, oceanographers, and geochemists to investigate the natural chemical variability of intertidal ecosystems and the effects on the geochemistry and mineralogy of calcifiers. This involves fieldwork, geochemical analyses, and culturing of organisms. In Casco Bay, her students have been exploring the drivers of coastal ocean acidity, with a focus on the abundant soft-sediment habitats that have traditionally supported productive clam fisheries but are now negatively impacted by increasingly acidic water chemistry.

Collin Roesler, Bowdoin <http://www.bowdoin.edu/faculty/croesler/index.shtml>

Collin's research focuses on the response of ocean ecosystems to environmental forcing. Her research foci include: environmental optics with specialization in bio-optical modeling of phytoplankton biomass, production, ecophysiology, functional groups, particularly with respect to Harmful Algal Blooms; inherent optical properties of seawater and sea ice, particle-specific

optics, optical instrumentation, ocean observing systems. In Casco Bay, Collin has been studying the dynamics of Harmful Algal Blooms for the ten years.

sets on climate change that spans the Gulf of Maine. This year, participating reserves and marine stations are collecting the first year of biological data based on a protocol developed by Bowdoin's Dave Carlon and Sarah Kingston. Bowdoin's CSC and the [Kent Island Scientific Station](#) are sentinel sites in this environmental network.

As our climate continues to change, the environmental network theme is hot at marine laboratories and field stations. With our new NSF FSML funded laboratory improvements (see Infrastructure, p. 18), we will provide a new node for measuring ocean acidity in nearshore environments. The best measurements of ocean acidity, require the quantification of CO₂ gas in seawater (as partial pressure, or pCO₂) because 1/3 of the CO₂ released into the atmosphere rapidly diffuses into the oceans and acidified seawater. The technology we are using for measuring pCO₂ in seawater was developed by [Joe Salisbury's Laboratory](#) at the University of New Hampshire, and we are collaborating with Joe's group to provide the highest quality measurements to the greater scientific community.

Over the last three years, the CSC has had an active dialogue with colleagues at [Bigelow Laboratory of Ocean Sciences](#) on how we can work together and develop shared strengths. This summer Madeline Schuldt is collaborating on a project that seeks to understand the epidemiology of an oyster disease called "MSX" with Bigelow staff scientist José A. Fernández-Robledo. This project originates from Madeline's independent research in the 2015 Marine Science Semester, and is being advised by Bowdoin's Sarah Kingston. Further south in Portland, the Director has been working on a collaboration with Graham Sherwood of the [Gulf of Maine Research Institute](#). This summer, the CSC will begin participating in a component of the Casco Bay Aquatic Survey ([CBASS](#)) by surveying groundfish in Harpswell Sound along a river-to-sea transect. This partnership will provide Bowdoin students with opportunities for fieldwork and analysis of long-term ecological data sets. Collin Roesler is leading several student projects at the CSC this summer characterizing the oceanography in the New Meadows River Watershed as the Bowdoin PI on a project funded by the NSF-EPSCOR program called the Sustainable Ecological Aquaculture Network ([SEANET](#)).

In the Spring of 2017, Director Dave Carlon was elected president of the Northeastern Association of Marine & Great Lakes Laboratories, (NEAMGLL) the regional chapter of the [National Association for Marine Laboratories](#) (NAML). The CSC is the regional host of the biennial NEAMGLL meeting to be held at the CSC Summer 2018. Also during 2017, Assistant Director Steve Allen was inaugurated as president of the [National Shellfisheries Association](#) (NSA). Our participation in leadership roles on the national level continues to grow Bowdoin's presence in the environmental sciences.

Bowdoin Arts, Athletics, and Retreats

The CSC continues to see a high level of use from a variety of groups in our Bowdoin Community. In the Fall of 2016, the [Bowdoin Orchestra](#) visited our Terrestrial Laboratory (the “T-Lab”) for a musical retreat on a fine fall day. Lead by Beckwith Artist -in-Residence [George Lopez](#), the orchestra brought amazing sound quality and high level of musicianship to the far edge of our 118 acre property. The T-Lab is also popular for dance, and the Vague Dance Team, a student-run, audition-based jazz dance performance group, regularly visits the CSC.

The CSC has a legacy of visual arts, including the photography of Michael Kolster and his students. We were therefore very excited to host acclaimed filmmaker David Conover as a Coastal Studies Scholar in the 2015 - 2016 academic year. David’s two courses were completely booked, and students used the CSC property extensively for projects.

Club use is also up at the CSC, with regular visits by Peer Health, the Women’s Ice Hockey Team, the McKean Center for the Common Good, and the Bowdoin Outing Club. The Bowdoin Outing Club makes the CSC their “field” headquarters before the Fall Semester, where they conduct leadership training and first year orientation.

Funded through the U.S. Department of Education, Upward Bound programs help high school students succeed in college. The [Upward Bound Program](#) at Bowdoin has offered several courses at the CSC in the last three years, including Oceanography in 2015 and 2016 and a writing workshop in 2017. Students come from 11 Maine schools and represent the first generation in their families to seek a college education.

The Bowdoin Sailing team has been thriving at the CSC since their move from Bethel Point to the CSC in 2014. This year, the Women's team qualified for nationals this year, winning [17th place in the Sperry Women's Nationals in Charleston](#).



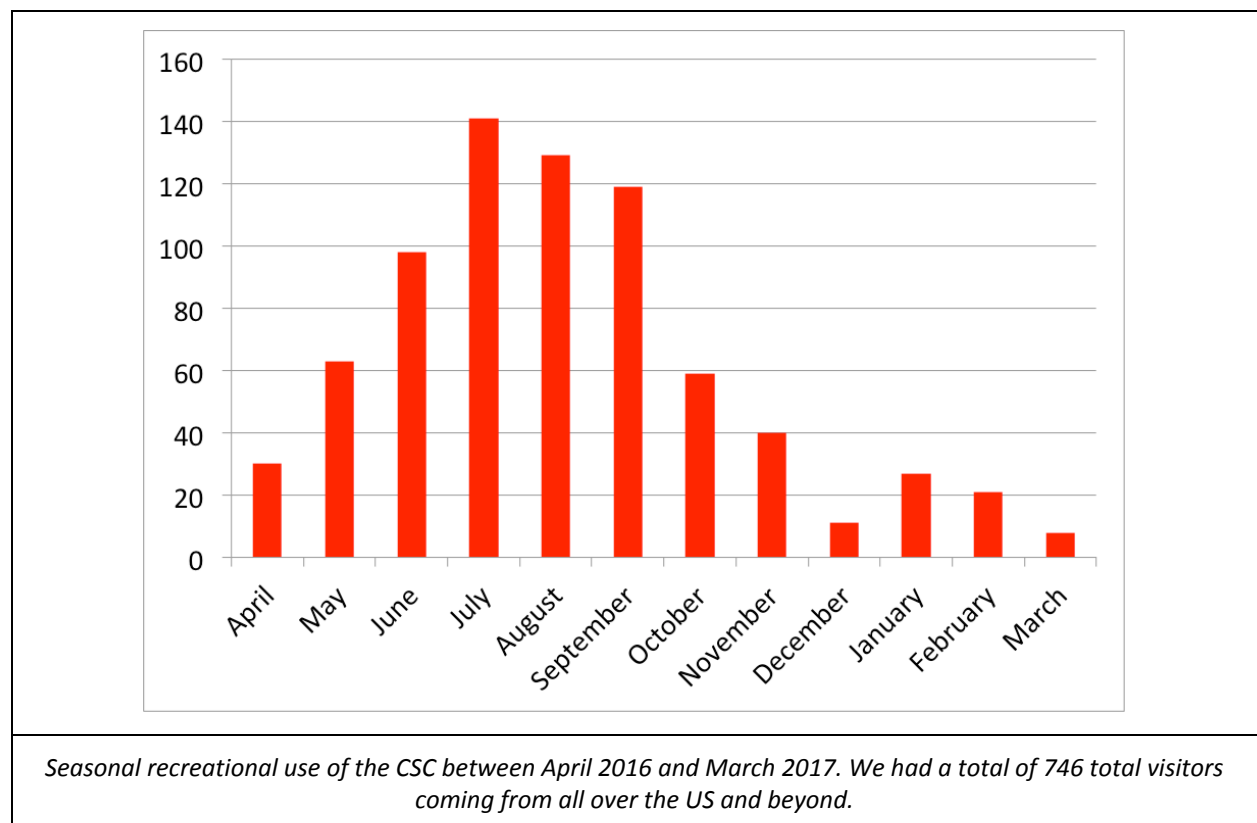
Bowdoin's Sailing Team in action

Finally, Bowdoin Faculty and Administration regularly hold departmental retreats and writing workshops at the CSC. We offer a unique environment and atmosphere to think differently about complex issues.

Outreach

During the last three years, we hosted over 20 meetings by community organizations and nonprofit groups. During 2016/17 we hosted groups from the New Meadows River Watershed Partnership, the Northeastern Coastal Stations Alliance, Coastal Studies for Girls, Deer Isle High School, Harpswell Heritage Land Trust, Brunswick Junior High School, and a local children’s art camp. In the Spring of 2017 we hosted a large group (45) of teachers and administrators from the Brunswick and Harpswell school districts who met at the CSC to plan new marine science STEM programming. At the marine lab, staff provided research space and support to a Haldale high school student allowing her to complete her senior capstone project.

Between dawn and dusk, the CSC grounds are open to the public and we are seeing a very healthy number of recreational users. In April 2016, we started a visitor log to track basic information on our recreational visitors. As of the Summer 2017, we have had 870 logged visitors, representing 34 US states, Canada, the United Kingdom, and even Bahrain. The majority of our visitors are from New England and New York (55% ME, 6% MA, 5% NY, and 4% NH) and not surprisingly our peak activity is in the summer and fall months (Figure 1). Even so we have a very loyal crew of walkers who live on Orr’s and neighboring Bailey Island who come out in the short days of winter. We had 20 visitors during January and February of 2017.



Maine Calling - In late April of 2016, Bowdoin's own Dave Carlon, Matt Klinge, and Eileen Johnson had the opportunity to focus NPR's listenership on Bowdoin's unique environmental position in Maine on the weekly NPR program "[Maine Calling](#)." Dave pointed out that we are unique among our liberal arts peers to operate the coastal marine laboratory of the CSC as well as the uniquely positioned Kent Island Scientific Station in the Bay of Fundy.

Looking Forward

The CSC Director is extremely grateful to Bowdoin alumnae and parents for their gifts and donations to the CSC and related programming over the last three years. We are thankful for the strong support from the Bowdoin administration, including former President Barry Mills and former Dean Cristle Collins Judd, and our new administration led by President Clayton Rose. As we look forward towards the next few years, we have five major goals.

Attract more external research and teaching - The last three years have been excellent for showcasing the scientific potential of the CSC to a national community of researchers. Events like the Benthic Ecology Meeting in Portland, brought over 100 marine scientists and students to the property in March of 2016. New collaborations with scientists from neighboring institutions, like the Gulf of Maine Research Institute and Bigelow Laboratories for Ocean Sciences, are also demonstrating new opportunities at the CSC. We now have many of the most desirable tools for the best quality marine science, including high quality seawater through a world-class aquarium setup, a boat fleet capable of inshore and offshore operations, and IT connectivity to the outside research community. We are poised to attract an initial cohort of marine scientists that can establish a thriving marine laboratory culture. To make this important leap from a marine laboratory that mostly serves Bowdoin, to a facility that also serves the greater community, we will need a residential program.

A residential program opens the doors to expanding student opportunities and increasing our visiting community. There are two steps in developing a sustainable residential program. The first is building infrastructure for accommodating students, scientists, and their families, on site. We are making progress in new infrastructure by working with President Rose on securing funding to build a new dormitory and dry lab space. The second step to sustaining more outside users is to establish a marine laboratory culture at the Coastal Studies Center. By culture, I mean a group of creative and motivated scholars and scientists who think of Harpswell as their summer home, who will return, year after year, for the intellectual camaraderie built from working with like minded and interesting people in our very special environment at the Coastal Studies Center on Harpswell Sound. This step is as critical as putting the buildings in place, because it results in sustainable operations over many years, both in terms of a revenue stream to maintain buildings and the site, and in the sense of value of an external community to our own students and faculty.

For Bowdoin students, there are many benefits to expanding our community to include visiting scientists. First, it exposes our students to research topics beyond Bowdoin and establishes new professional connections for those next formative steps. Second, an outside community will stimulate more summer teaching activities, like offering short courses and workshops that are the hallmark of marine laboratories nationwide. Lastly, the work done by outside researchers and visitors will be the key to maintaining extramural funding. We will need to demonstrate to

state and federal funding agencies that our resources are reaching a broad group of end users beyond our campus.

Increase teaching and research activity by Bowdoin faculty - We continue to host existing laboratories and some new programming as well (Table 1). However, there is still much potential to expose students at critical junctions, for example introductory science labs, to the resources and environments of the CSC. Timing class visits can be challenging given existing campus schedules. However taking advantage of fewer campus offerings on Fridays is an excellent way to bring large groups out to the CSC. Dave Carlon has had excellent success with bringing his course “Understanding Climate Change” to the CSC for a spring intertidal laboratory. Bowdoin students who have had few academic opportunities to see the site respond very positively. Large enrollment classes like this one (35 - 40 students) have a huge impact. George Lopez has clearly shown that more performing arts is also possible. This year, George and his Bowdoin Orchestra proved they could pull off an off campus rehearsal in our modest Terrestrial Laboratory space.

We have a regular and loyal group of Bowdoin faculty who use the CSC for research (Faculty Research, p. 19) and collaborations have been increasing among faculty. For example, this year paleochemist Michèle LaVigne and evolutionary biologist Dave Carlon have submitted a SeaGrant proposal that will both build a historical record of ocean acidification (OA) in the Gulf of Maine, and experimentally examine the impacts of different OA baselines on shellfish performance using the new experimental seawater system being built in the Marine Laboratory.

Develop partnerships with local schools - This year, we hosted an initial gathering of teachers and administrators from the Brunswick School District that has begun a discussion of how to implement a new program in marine science in their district. We have also hosted several visits by the Harpswell Coastal Academy for teaching activities. In this next year, we would like to work towards ways in which the CSC can become an integral component of these K - 12 teaching programs. For example, as the locus for laboratories or field trips that are eventually built into these programs.

Develop an on site aquaculture facility - As wild stocks of seafood continue to decline, the future of fisheries will be in coastal aquaculture. There is so much excitement now about growing seaweeds, shellfish, and even returning salmon to the Maine Coast. This year, Dave Carlon and Steve Allen have been exploring ways to bring experimental aquaculture to the CSC. Specifically, we are looking into external funding to start a student-driven aquaculture facility, with the aim of bringing seaweeds and/or shellfish (oysters and mussels) from Harpswell Sound to local markets and restaurants.

Masterplan - To make sure the future of the CSC is developed sustainability it is timely to develop a Masterplan for the site. New buildings and supporting infrastructure have many co-dependencies that are best served by a landscape view of all activities.

Publications

* Denotes student authors

§ Funded in part w/ Summer Fellowship Awards

Kingston S. E., *Martin P., Melendy M., Reed F. A. and Carlon D. B. Linking genotype to phenotype in a changing ocean: estimating standing genetic variation in a blue mussel stress response with genome-wide association" In Review at Evolutionary Applications.

*Harmon E.A. and Allen J.D. Predator-induced plasticity in egg capsule deposition in the mudsnail, *Tritia obsoleta*. In Review at Marine Ecology Progress Series.

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Horch H. W., Pfister A., Ellers O., & Johnson A.S. 2017. *Plasticity in the Cricket Central Nervous System*. In The Cricket as a Model Organism (pp. 105-128).

§*Dickinson E.S., Johnson A.S., Ellers O., Dickinson P.S. 2016. Forces generated during stretch in the heart of the lobster *Homarus americanus* are anisotropic and are altered by neuromodulators. Journal of Experimental Biology, 219:1187-1202.

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§Horch H.W., Johnson A., Ellers O., *Pfister A. 2013. Quantification of dendritic and axonal growth after injury to the auditory system of the adult cricket *Gryllus bimaculatus*. *Frontiers in Physiology* 3:367.

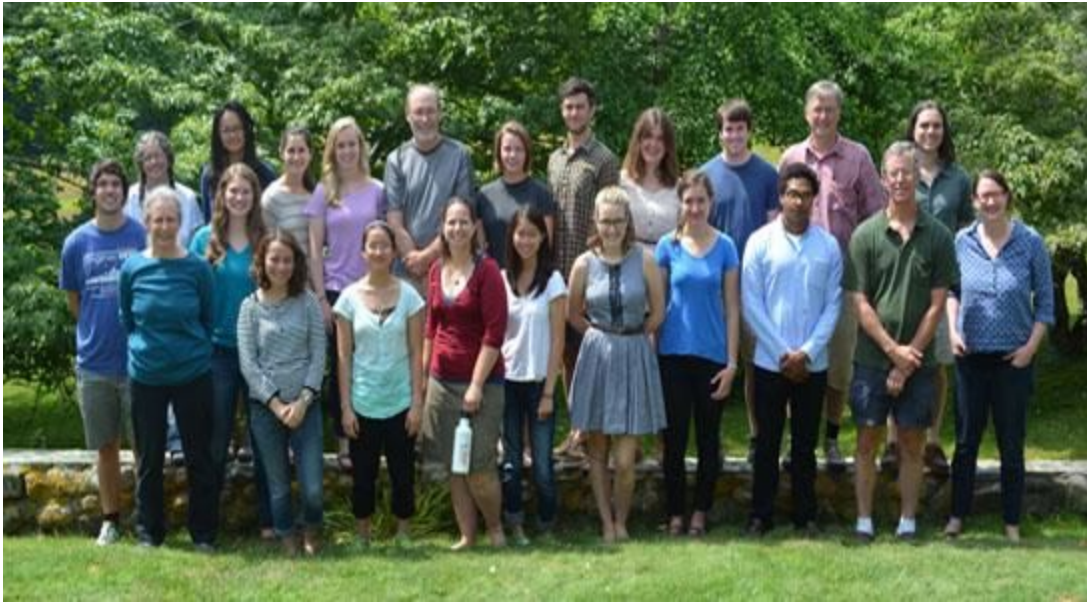
§Johnson A.S., *Salyers J.M., *Alcorn N.J., Ellers O., Allen J.D.. 2013. Externally visible fluorochrome marks and allometries of growing sea urchins. *Invertebrate Biology* 132:251-269.

Rivers T.J., Morin J.G. 2013. Female ostracods respond to and intercept artificial conspecific male luminescent courtship displays. *Behavioral Ecology* 24(4):877-887.

SUMMER RESEARCH APPENDICES

Summer 2014

Nineteen Bowdoin students received fellowships for coastal or marine faculty mentored research during the summer of 2014. The Coastal Studies Center hosted a research symposium on July 14 where most of the students and many faculty advisors gave research talks. Emily Tucker '15 and Biology Professor Nat Wheelwright joined the symposium and shared their research findings with the group.



The 2014 Coastal Studies Research Symposium participants

Sarah Kingston, Doherty Marine Biology Postdoctoral Scholar
Project: *Genotype and phenotype in a changing ocean, how much is standing genetic variation influencing mussel populations' reaction to ocean acidification?*

Michèle LaVigne, Assistant Professor, Earth & Oceanographic Science
Project: *Acidification Research on Maine Clam Flats: A Partnership between Bowdoin and the Kennebec Estuary Land Trust*

Lloyd Anderson, '16
Advisor: Michèle LaVigne, Award: Rusack Coastal Studies Fellowship
Project: *An Assessment of pH and the Effects of Ocean Acidification in Phippsburg, Maine Clam Flats*

Anna Bearman, '16
Advisor: Soren Eustis, Award: Doherty Coastal Studies Research Fellowship
Project: *Characterization of Dissolved Organic Matter in Local Marine and Terrestrial Waters*

Sabine Berzins, '16

Advisor: John Lichter, Award: Rusack Coastal Studies Fellowship

Project: *Vulnerability of Soft-shell Clams and Eelgrass to Green Crab Invasion*

Benjamin Eisenberg, '17

Advisor: David Carlon, Award: Faculty Student Research Fellowship

Project: *Invasive Bryozoan and Ascidian Recruitment and Growth in Harpswell Sound, Maine*

Samantha Garvey, '16

Advisor: Amy Johnson, Award: Doherty Coastal Research Fellowship

Project: *A study of escape-response locomotion in Maine intertidal seastars: Asterias rubens and Asterias forbesi*

Anna Hall, '15 Advisor: Phil Camill, Award: Freedman Summer Research Fellowship

Project: *Investigating the effects of climate change on peatland C accumulation and fire dynamics in coastal Labrador, Canada*

Tricia Hartley, '15 Advisor: Patsy Dickinson, Award: Doherty Coastal Studies Research Fellowship

Project: *Does the neuropeptide GYS modulate stretch feedback pathways in the lobster cardiac neuromuscular system?*

Nora Hefner, '16 Advisor: John Lichter, Award: Cooke Fellowship

Project: *GIS analysis of the Historical Ecology of Gulf of Maine Cod Fisheries*

John Lichter, Professor of Biology & Environmental Studies (ES), ES Program Director

Project: *Ecological Recovery of Maine Waterways and Coastal Fisheries*

Amanda Howard, '15 Advisor: Elizabeth Stemmler, Award: Doherty Coastal Studies Research Fellowship

Project: *Quantification and Characterization of AST-C Peptides in Homarus americanus Using Mass Spectrometry*

Sophie Janes, '16 Advisor: Patsy Dickinson, Award: Doherty Coastal Studies Research Fellowship

Project: *Does nitric oxide alter the modulation stretch feedback pathways in the lobster cardiac neuromuscular system?*

Christine Jewett, '16 Advisor: Patsy Dickinson, Award: Doherty Coastal Studies Research Fellowship

Project: *Does the presence of modulators alter the ability of the American lobster heart to generate a stable output pattern over a range of temperatures?*

Sasha Kramer, '16 Advisors: Collin Roesler, Award: Doherty Coastal Studies Research Fellowship

Project: *What is the relationship between nitrate concentration and phytoplankton blooms in Harpswell Sound, Maine?*

Jack Mitchell, '17 Advisor: David Carlon, Award: NSF Faculty Student Research on Computational Sustainability Fellowship
Project: *Analysis of long-term trends in DNA barcoding sets from tropical marine zooplankton from the Hawaiian Islands*

Bailey Moritz, '16 Advisor: Michèle LaVigne, Award: Rusack Coastal Studies Fellowship
Project: *Effects of Alkalinity and Ocean Acidification on Clam Shell Development in Phippsburg, Maine*

Schuyler Nardelli, '15 Advisor: Collin Roesler, Award: Rusack Coastal Studies Fellowship
Project: *Using data from the LISST-100 to recreate phytoplankton size distribution and processes in Harpswell Sound, Maine*

Xuan (Circle) Qu, '17 Advisor: Patsy Dickinson, Award: Doherty Coastal Studies Research Fellowship
Project: *Pyrokinin peptides' effect on the stomatogastric nervous system in the American lobster, Homarus americanus*

Aidan Short, '15 Advisor: David Carlon, Award: Doherty Coastal Studies Research Fellowship
Project: *What's for Dinner? A molecular analysis of the feeding habits of the green crab Carcinus maenus in Harpswell Sound, Maine*

Brendan Soane, '16 Advisor: Amy Johnson, Award: Doherty Coastal Studies Research Fellowship
Project: *Examining Up and Down Motions and Relative Podial Movements in Asterias rubens (common sea star)*

Emily Tucker, '15 Advisor: Phil Camill, Award: Hughes Fellowship
Project: *Effects of Climate Fluctuations in Labrador on Indigenous Populations, 8,000 BCE-present*

Christine Walder, '15 Advisor: Damon Gannon and Amy Johnson, Award: Rusack Coastal Studies Fellowship
Project: *Impact of Harvest Area of Ascophyllum nodosum (Rockweed) on Biodiversity*

Jenna Watling, '16 Advisor: David Carlon, Award: Faculty Student Research Fellowship
Project: *The evolutionary response of populations of the blue mussel (Mytilus edulis) populations to climate change*

Nathaniel Wheelwright, Professor of Biology
Project: *The effect of trait and strength of selection on heritability and evolvability in an island bird population*

Summer 2015

There was a diverse array of faculty mentored research projects underway during the summer of 2015 affiliated with the Coastal Studies Center. Sixteen Bowdoin students were joined by three students from the College of William and Mary working with Assistant Professor of Biology Jonathan Allen at the marine lab, and one student from Stony Brook University, under Scott Santagata's direction. Scott is an Assistant Professor of Biology at Long Island University. High school student Patrick Friend joined John Lichter's research team working on restoration of fish habitat in local rivers.

Summer projects included mapping Maine's seafloor, ecology and evolution of marine invertebrates, restoration ecology in the Gulf of Maine, neurophysiology of lobsters, a sociological/educational project with a rural Maine Island community, biomechanics of sea stars, evolutionary ecology, writing about the coast, and invasive green crabs. Students and faculty gathered at the Coastal Studies Center farmhouse on Thursday, July 23 to discuss their summer work with each other. Many final reports from students are also available.



The 2015 Coastal Studies Research Symposium participants

Ivy Ozmon, Principal Scientist, and Emily Norton, NOAA Coastal Management Fellow, Maine Mapping Initiative, Maine Coastal Program

Alana Luzzio '17, and Dana Bloch '17

Advisers: Ivy Ozmon and Emily Norton

Awards: Maine Mapping Initiative (Alana) and Cooke Environmental Research Fellowship (Dana)

Project: *Maine Mapping Initiative*

Jonathan Allen, Assistant Professor of Biology, College of William and Mary
Presentation: *Development plasticity in a variable environment: lessons from marine invertebrates*

Emily Harmon '16, College of William and Mary
Adviser: Jonathan Allen
Project: *Predator-prey interactions on the coast of Maine*

Karina Brocco French '16, College of William and Mary
Adviser: Jonathan Allen
Project: *Phenotype plasticity in juvenile echinoderms on the coast of Maine*

Stacy Trackenberg '16, College of William and Mary
Adviser: Jonathan Allen
Project: *How do changes in egg provisioning influence larval and juvenile development in seastars?*

Sabine Berzins, '16
Adviser: John Lichter, Award: Rusack Coastal Studies Fellowship
Project: *Restoration and recovery of eelgrass (*Zostera marina*) to green crab (*Carcinus maenas*) invasion*

Sam Mayne '16
Adviser: John Lichter, Award: Rusack Coastal Studies Fellowship
Project: *Evaluation of sturgeon populations in the lower Kennebec and Androscoggin estuary*

Simonetta Harrison '16
Adviser: John Lichter, Award: Hughes Family Summer Research Fellowship
Project: *Quantification of juvenile alewife, *Alosa pseudoharengus*, populations*

Patsy Dickinson, Professor of Natural Sciences, Biology and Neuroscience
Project: *Generating flexible rhythmic movements in the lobster*

Jillian Burk '16
Adviser: Patsy Dickinson, Award: Doherty Coastal Studies Research Fellowship
Project: *Permeability of the cardiac ganglion sheath to endogenous concentrations of neuropeptides in the American lobster, *Homarus americanus**

Devlin Shea '18, Meredith Stanhope '18, and Megan Chi
Adviser: Patsy Dickinson, Award: Doherty Coastal Studies Research Fellowship
Project: *Mechanisms underlying differential responses to neuropeptide allatostatin-C (AST-C) in the cardiac ganglion (CG) of the lobster, *Homarus americanus**

Katelyn Suchyta '16 Adviser: Patsy Dickinson, Award: Doherty Coastal Studies Research Fellowship
Project: *Mechanisms of stretch feedback and interactions with neuromodulators of the American lobster's cardiac ganglion*

Steve Cho '16 Adviser: Amy Johnson, Award: Doherty Coastal Studies Research Fellowship
Project: *The contribution of sarcomere length to the passive mechanical properties of cardiac muscles in the lobster Homarus americanus*

Kendra Novak '16, and Do Yeum Kim '18 Adviser: Amy Johnson, Award: Doherty Coastal Studies Research Fellowship

Project: *Characterization of the locomotion of Asterias forbesi based on body size*

Abby Roy '16 Adviser: Charles Dorn, Award: Rusack Coastal Studies Fellowship

Project: *Thinking about College in a Coastal, Rural Community*

Sarah Kingston, Doherty Marine Biology Postdoctoral Scholar

Presentation: *Linking genotype and phenotype in a changing ocean: population genomics of the blue mussel in the Gulf of Maine*

Pieter Martino '17 Advisers: David Carlon, and Sarah Kingston, Award: Biology Life Science

Project: *Linking stress phenotype of blue mussels to standing genetic variation amidst a changing climate*

Robert Barron '17 Adviser: David Carlon, Award: Doherty Coastal Studies Research Fellowship

Project: *Mapping a parrotfish hybrid swarm: the world's largest hybrid zone*

Charlotte Ruddy '16 Adviser: Clark Brock, Award: Rusack Coastal Studies Fellowship

Project: *Sardines: A Novella*

Scott Santagata, Assistant Professor of Biology, Long Island University

Presentation: *Experimental demonstration of the regulative developmental properties and phototactic abilities of ectoproct embryos and larvae*

Weijia Lu, Stony Brook University Adviser: Scott Santagata

Project: *Larval development and settlement of the bryozoan Membranipora membranacea*

Erin Voss '16 Adviser: David Carlon, Award: Freedman Coastal Studies Fellowship

Project: *Examining the hybrid zone between two subspecies of invasive green crab in Harpswell Sound*

Patrick Friend, Volunteer intern Adviser: John Lichter

Project: *The Migration of American Shad (Alosa sapidissima) in the Tidal Androscoggin River*

Summer 2016

Coastal Studies Summer research fellowships during the summer of 2016 included sixteen Bowdoin students, three students from the College of William and Mary, and a student from Barnard College. Summer projects included creating flood risk maps associated with sea level rise, research on the ecology and evolution of marine invertebrates, neurophysiology of crustaceans, DNA barcoding of invasive green crabs, and the population dynamics and density of horseshoe crabs during breeding season on Cape Cod. Due to scheduling challenges, we had a smaller summer research symposium than in past years with students and faculty gathering at the Coastal Studies Center farmhouse in July to discuss their summer. Graham Sherwood, research scientist at the Gulf of Maine Research Institute, joined us and gave a presentation titled: *A Fisheye View into our Changing Coastline*.



The 2016 Coastal Studies Research Symposium participants

Abdul-Latif Armiyaw '18 Adviser: Amy Johnson
Award: Henry L. and Grace Doherty Coastal Studies Research Fellowship
Project: Influencing factors on the anisotropic mechanical response of cardiac muscles in *Homarus Americanus* (Lobster) Hearts

Garrett Carver '17 Advisers: Laura Toma and Eileen Johnson,
Award: Rusack Coastal Studies Fellowship
Project: *Identifying Building Footprints in Aerial LiDAR Data for Coastal Maine*

Hugh Cipparone '19 Adviser: David Carlon
Award: Rusack Coastal Studies Fellowship
Project: *A DNA barcoding approach to green crab (*Carinus maenas*) consumers in the Gulf of Maine*

Caroline Corban '17 Adviser: Elizabeth Stemmler
Award: Henry L. and Grace Doherty Coastal Studies Research Fellowship
Project: *Characterization and quantification of molt-related hormones in crustaceans using mass spectrometry*

Nicholas Funnell '17 Adviser: Amy Johnson
Award: Rusack Coastal Studies Fellowship
Project: *Population density and distribution of the Atlantic Horseshoe Crab (*Limulus polyphemus*) during breeding season on Cape Cod*

Helen Gandler '17 Adviser: Patsy Dickinson
Award: Henry L. and Grace Doherty Coastal Studies Research Fellowship
Project: *Differential responses to neuromodulator allatostatin-C (AST-C) in the central pattern generator (CPG) of the lobster, *Homarus americanus*, explored through transcriptomics*

Angus Gorman '18 Advisers: Laura Toma and Eileen Johnson
Award: Rusack Coastal Studies Fellowship
Project: *Creating Flood Risk Maps with Sea Level Rise*

Scout Gregerson '18 Adviser: Patsy Dickinson
Award: Henry L. and Grace Doherty Coastal Studies Research Fellowship
Project: *Modulatory effects of neuropeptides on the stomatogastric nervous system of *Hyas araneus**

Lydia Grote, College of William and Mary Adviser: Jonathan Allen

Sarah Kingston
Doherty Marine Biology Post-Doctoral Scholar

Catherine Liu '19 Adviser: Patsy Dickinson
Award: Henry L. and Grace Doherty Coastal Studies Fellowship
Project: *Myosuppression's effect on the stretch-sensitive dendrite feedback system in the crustacean cardiac neuromuscular system*

Alana Luzzio, '17 Advisor: Ivy Ozmon, ME Coastal Prgm, Dave Carlon and Sarah Kingston, Bowdoin
Award: Maine Mapping Initiative, Maine Coastal Program
Project: *Assessing the genotypic variation in a population of bivalves from the Gulf of Maine*

Pieter Martino '17 Adviser: Sarah Kingston
Award: Student Faculty Summer Research Fellowship
Project: *Linking stress phenotype of blue mussels to standing genetic variation amidst a changing climate*

Alexandra Miller '18 Adviser: Patsy Dickinson
Award: Henry L. and Grace Coastal Studies Research Fellowship
Project: *Modulatory effects of neuropeptides on the stomatogastric nervous system of Hyas araneus*

Elizabeth Miller '18 Adviser: Patsy Dickinson and Amy Johnson
Award: Henry L. and Grace Coastal Studies Research Fellowship
Project: *Do interneurons and motor neurons in the cardiac ganglion of Homaris americanus differ in their response to a neuropeptide?*

Xuan (Circle) Qu '17 Adviser: Patsy Dickinson
Award: Henry L and Grace Doherty Coastal Studies Research Fellowship
Project: *Identification of stretch-sensitive ion channels in the American lobster, Homarus americanus using a physiological approach*

Emily Richardson, College of William and Mary, Masters Adviser: Jonathan Allen
Project: *Latent effects of larval feeding on seastar development and ecology*

Kharis Schrage '17, College of William and Mary Adviser: Jonathan Allen
Project: *Hemichordate ecology and larval biology*

Devlin Shea '18 Adviser: Patsy Dickinson
Award: Doherty Coastal Studies Research Fellowship
Project: *Transcriptome analysis of neuropeptide receptor expression in the cardiac neuromuscular system of the American lobster*

Meredith Stanhope '18 Adviser: Patsy Dickinson
Award: Doherty Coastal Studies Research Fellowship
Project: *Investigating the molecular underpinnings of peptidergic signaling in the cardiac ganglion of the American lobster, Homaris americanus through the in silicoanalysis of small cell and large cell transcriptomes*

Vanessa Van Deusen, Barnard College Adviser: David Carlon
Award: Coastal Studies Center Research Grant Fellowship
Project: *A DNA barcoding approach to green crab (Carcinus maenas) consumers in the Gulf of Maine*

Patrick Walsh, '17 Adviser: Patsy Dickinson
Award: Henry L. and Grace Doherty Coastal Studies Fellowship
Project: *Characterization of the mechanisms underlying the differing responses to the neuropeptide, C-AST, by the American lobster, H. Americanus, central pattern*