

Coastal Studies Center

Annual Report Number 12 • September 2012–August 2013

Research, Teaching and Co-curricular activities

In late August 2012, a group of students from the incoming class of 2016 arrived on campus early to participate in an academic orientation program- Bowdoin Science Experience (BSE)- designed to encourage and support students in science and math. Some of the group joined Collin Roesler (Associate Professor, Earth & Oceanographic Science, EOS) at the Coastal Studies Center to embark on the RV Laine to visit the Bowdoin Buoy where she introduced them to basic estuary circulation using oceanographic equipment deployed in the water. They also measured the depth to which sunlight penetrates the water column and discussed the meaning of that depth, called the euphotic zone. The exercise illustrates how narrow the 'thickness' of surface water is that supports photosynthesis (10's of meters in coastal waters) and yet that supplies nearly all of the primary production that fuels our ocean's ecosystems. At the conclusion of the BSE program the group enjoyed a relaxing afternoon on the property, and met Dave Carlon, the new Bowdoin Marine Laboratory Director for a tour of the marine lab. Dave and his family, who had just recently arrived and moved into the farmhouse, joined the group for the annual BSE cookout.

Early in the Fall, biogeochemistry students, under the direction of Michèle LaVigne (Assistant Professor, EOS) and Cathryn Field (Lab Instructor) obtained water samples off the floating dock and conducted Biochemical Oxygen Demand (BOD) measurements in the marine lab. These measurements were used for a final research project for the class. Students taking Marine Biogeochemistry collected samples from the Coastal Studies shoreline, and filtered and processed these at the Marine Lab.

Spring semester, students in the class 'Mindfulness in Education' participated in a six-hour retreat at Coastal Studies that involved breath awareness meditation, loving-kindness meditation, small and whole group dialogue, mindful eating, journaling, mindful waiting, taiji, and gratitude practices.

At the end of March, fifteen students and four staff & faculty members Leana Amaez (Multicultural Programs), Kathryn Byrnes (Education), Sarah Seames (McKeen Center for the Common Good) and Kate Stern (Center for Sexual and Gender Diversity) convened at the Coastal Studies Center to dialogue and explore the role of privilege in our lives as individuals and community members at Bowdoin. Multiple activities at the farmhouse and outside on the trails and fields allowed participants to reflect on privilege (race, class, sexual orientation, gender, body, etc.).

The trails at the Coastal Studies Center take on a special aura in winter. Ice forms over the seaweed at low tide and breaks apart in the sun. The ground is frozen and silence occupies the trails we share in spring with small animals and birds. Students in 'Drawing on Science', a course taught spring 2013 by Coastal Studies artist in-residence Barbara Putnam braved a 15 degree morning and made drawings on

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Bowdoin Science Experience students with Dave Carlon, Bowdoin's new marine laboratory director



Bowdoin Science Experience picnic, August 2012

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Bowdoin

sheets of basswood, their observations enhanced by the unusual stillness and heightened attention needed to draw in the cold. Drawing directly onto the block preserves spontaneity and the mark making inspired by first impressions, like field notes made by a geologist or a botanist. Readings for the class focused on nature's strategies for survival and warmth: for example, the relationship between winter buds on trees, packed with nutrition, and the needs for food of wintering birds such as the Kinglet. To the artist, exposure to natural science writing gives access to valuable knowledge in addition to direct observation; taken together, they direct attention to important details and how various landscape elements relate to, and in fact, depend on one another.



'Drawing on Science' class at the Coastal Studies Center, January 2013

One assignment asked students to create a hanging three-dimensional object exploring the concept of flight or migration. Using their discarded prints and found objects, the students fashioned new art while considering elements such as skeletal structure, feather construction, anatomy, flight physics, orienteering, time and distance. Putnam encouraged the students to also touch on issues such as global warming, human interference with migratory flight routes, mythology, and other areas where birds and people come together, sometimes in conflict. This work was exhibited in the Visual Art Center.

Barbara and the class also worked with Master Printer Peter Pettengill, during a week-long printmaking residency.



Students in 'Drawing on Science' Harpswell Sound, Coastal Studies Center, January 2013

Coastal Studies Artist in-residence

Barbara P. Putnam, was this year's Coastal Studies Center Artist-in-Residence.

Barbara's primary artistic focus is on wetlands and fragile, transitional ecosystems. She is deeply concerned with environmental issues and the inter-dependence of elements such as the micro-organisms that begin the food chain to the lobsters we harvest. "Our oceans and forests are biomes that nature shapes constantly with indifference to their history; wind, water, and currents that nourish and destroy during a season and over the course of thousands of years." She sees "the making of art as research and the hard-edged properties of woodcut evocative of nature's hostility as well as its fragility, beginning with a close observation of shapes brought together with light."



"Cross Movements", print by Rachel Brooke, 2013

In October 2012 Barbara traveled to the Arctic Circle on a North Pole expedition-ary residency administered by the Farm Foundation for the Arts and Sciences.

In the spring she taught 'Drawing on Science', which incorporated science writing into development of observational and printmaking skills. "It's always been my hunch that the two disciplines go together," Putnam said speaking in the Visual Arts Center among pieces made by her students for their first show. As a teacher, Putnam says the best way for students to develop their perception is through practice. Besides her regular teaching job at St. Mark's School in Southborough, Mass., Putnam has taught drawing to geology students at MIT. There, she helped a class learn observation strategies to sharpen their visual awareness as they studied and learned the differences between rocks.

To help her Bowdoin students hone their observations of their surroundings, Putnam brought her class to the Coastal Studies Center, to the bird collection in Druckenmiller Hall, and to Bowdoin's Arctic Museum.

Bowdoin Student Fellowships

Eighteen Bowdoin students were awarded fellowships for coastal or marine faculty-mentored summer research this year. Four of these students participated in a multi-year research collaborative with scientists and economists from Bowdoin, Bates, the University of Southern Maine, and Penobscot East Resource Center who are studying the ecological recovery of, and present and past alewife populations, in the Kennebec and Androscoggin watersheds.

All the Coastal Studies Fellows gave Pecha Kucha presentations (20 slides/ 20 seconds per slide) on their research over two days in July. To view these presentations visit 'Student research, summer 2013' on the Coastal Studies Center webpage.

Elizabeth Brown '15 (Rusack Fellow) and **Teresa Withee '15** (Sustainability Solutions Partners (SSP) Fellow) worked with **John Lichter** (Biology) on "Eelgrass Restoration in the local Coastal Ecosystems".

Eelgrass (*Zostera marina*), a species of submerged aquatic vegetation native to the Maine coast, is not as widespread as it once was. The lack of eelgrass along the coast threatens biodiversity because it provides nursery habitat for juvenile fish and a wide range of marine species while also improving water quality. In this project eelgrass beds at the mouth of the Kennebec River, were surveyed, and transplanted with forty shoots of intact rhizomes from healthy beds in Sagadahoc Bay. Biodegradable grids were used to secure the shoots in the sediment. The success of the transplanted bed will be monitored to determine the feasibility of a larger restoration effort. In light of the recent diebacks of eelgrass in previously healthy beds throughout Maine, future research should explore the effects of green crabs and global warming on eelgrass, as these factors will likely contribute to the future of eelgrass in Maine.

Sustainability Solutions Partnership (SSP) Fellow **Claude Patrick Millet, '14** also worked with professor Lichter and SSP Project students on the "Ecological Recovery in the Kennebec estuary and nearshore marine environment". This summer, Patrick studied the effects of submersed aquatic vegetation (SAV) on American eel (*Anguilla rostrata*) distributions in the system. Populations of *A. rostrata*, a catadromous fish, have been affected by habitat degradation (dams) and over-harvesting, despite a large geographic range and high fecundity. Knowledge of their habitat preference in freshwater may be useful in devising a plan for eel conservation. In order to investigate whether eels show a preference for patches of vegetation, baited eel traps were placed both within and outside of SAV beds at six different sites in Merrymeeting Bay and collected the next day. Captured eels were counted, measured, and released. A comparison of catch per effort from vegetated and unvegetated plots will determine whether more eels are found in SAV beds. Variation in the distribution of different size classes of eels will be investigated as well. The statistical analyses will be performed when data collection is completed.

Nathaniel Niles, '15 also received an SSP award and joined Elizabeth, Teresa, Patrick and professor Lichter. Nate's project examined American Shad and fish passage at the Brunswick Hydro dam.

American Shad (*Alosa sapidissima*) is an anadromous fish species of significant ecological and economic importance in the Androscoggin River. However, shad populations have seen declines due to over-fishing, industrial pollution, and dam building. Each year shad return to the Androscoggin River to spawn, but the Brunswick hydroelectric dam prevents their upstream passage. Although a fish ladder is installed on the dam, it passes only a handful of shad each year. In collaboration with the Androscoggin River Alliance and Brookfield Environmental, the dam owner, Nate conducted a study that aims to determine if a fish lift installed at the dam would attract shad into a collector bucket.



Coastal Studies Summer Fellows at the farmhouse for research presentations, July 2013



Biodegradable eelgrass bed used for eelgrass bed resoration research, Brown/Withee 2013



American eel (*Anguilla rostrata*) captured and released, Merrymeeting Bay, Summer 2013

A fish lift acts as an elevator for fish and could be the best solution short of removing the dam for increasing the annual shad migration on this river. As part of the study, an electrically powered flow inducer consisting of two spinning turbines was installed at the base of the dam. The flow inducer increased the flow of water to mimic the conditions of a fish lift. Underwater cameras were placed in the river to monitor and quantify shad entering near the flow inducer. Preliminary evidence suggests placement of a fish lift would have a significant effect on its efficacy.

Rusack Fellow **Johnathon de Villier**, '14 was mentored by **Barry Logan** and **Jaret Reblin** (Biology) on his project "Progressive Effects of eastern dwarf mistletoe (*Arcuthobium pusillum*) parasitism on white spruce physiology in Maine coastal forests".

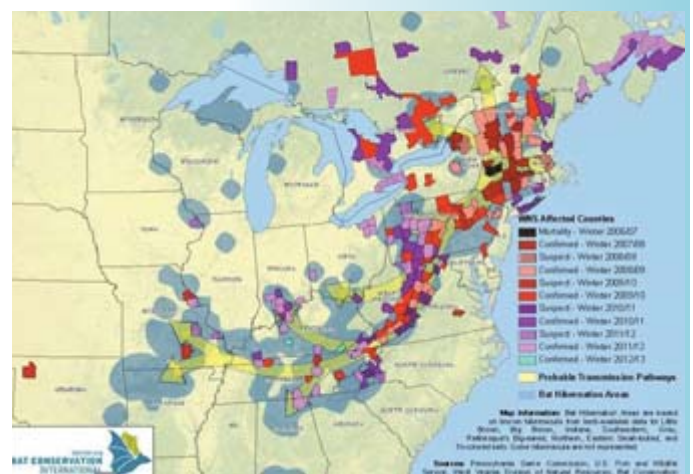
Eastern dwarf mistletoe (*Arceuthobium pusillum*) is a little-studied parasitic plant associated with the mortality of white and black spruce in the coastal spruce-fir forests of the eastern U.S. and Canada. White spruce favor coastal habitats and are therefore the most common host of *A. pusillum* along the coast of Maine. The precise mechanisms that lead to mortality in white spruce are not well understood. General patterns observed suggest that parasitism negatively impacts host physiology, which can influence rates of photosynthesis and water loss in the host's leaves, ultimately reducing its growth, fecundity and resilience to secondary stresses such as drought or insect pathogens. This lab's previous work has not found a significant effect of parasitism on these attributes in the early stages of mistletoe infection. In this project, analysis was expanded to include light-moderate-severe infection of white spruce on Monhegan Island. Measurements in the field and lab found that *A. pusillum* reduces needle size and rates of photosynthesis in severely infected white spruce. We also used high performance liquid chromatography to show that *A. pusillum* infection reduces the abundance of chlorophylls, nitrogen, and carotenoid pigments in the branches it infects. In many cases, reductions were greatest in severely infected trees, and moderate or statistically insignificant in the light and moderate infection classes. Our results reveal a link between eastern dwarf mistletoe parasitism and white spruce physiology that was not previously apparent, and suggest that rapid declines in host physiology precede mortality.



Representative white spruce from a) light, b) moderate, and c) severe infection de Villier 2013

Adam Eichenwald, '14 was awarded a Doherty Fellowship and was advised by **Damon Gannon** and **Vladimir Douhovnikoff** (Biology) on his project "The Effects of White-Nose Syndrome in Acadia National Park".

The recently discovered invasive fungus *Pseudogymnoascus destructans* has been implicated in the deaths of millions of cave-hibernating bats in North America. One possible outcome of these deaths is the sudden availability of foraging opportunities for migratory bats unaffected by the fungus. Adam and colleagues hypothesized that areas with dramatic losses of once-common bat species, such as the little brown bat *Myotis lucifugus*, would have increases in abundance of bat species that had been rarely detected or observed in the same areas, such as the eastern red bat *Lasiurus borealis*. Reduced competition would allow the numbers and periods of use to increase for the once-uncommon bat species, a phenomenon called competitive release. To test this hypothesis, they repeated an acoustic study of foraging bats at two locations in Acadia National Park, ME. Adam used Wildlife Acoustics ultrasonic recorders nightly to identify species and to quantify echolocation rates. These data were compared to recordings collected in the same months in 2010, prior to the fungus arrival in Acadia. There were no statistically significant differences in weather between 2010 and 2013. Detection of echolocation calls from little brown bats dropped from 1468 calls per night per month in 2010 to 37 in 2013, while recorded occurrences of eastern red bats increased from 16 calls per night per month in 2010 to 83 in 2013. These data are consistent with the competitive release hypothesis, suggesting that abundance of migratory bats is rising, in some part, due to increased mortality of cave-dwelling bats.



This map demonstrates how the disease has spread. White Nose was first discovered in New York in 2006; since then, it has spread to most of the bat hibernation sites in the East of North America. Sources: PA Game Commission, U.S. Fish & Wildlife Service, West VA Division of Natural Resources, Bat Conservation Int., National Atlas, North American Atlas.

Jonathan Held, '14 was advised by **John Lichter** (Biology) on his project "Evolving Norms in Environmental Governance: Toward Collaboration on the Androscoggin River" which was supported by a Surda Fellowship.

This project analyzed the evolution of formal and informal rules-in-use governing industry on Maine's Androscoggin River. Mills operated without pollution controls until the mid-twentieth century. The environmental movement and the passage of the federal Clean Water Act led to the enactment of state-based governance measures, from federal legislation to state legislation, local ordinances, and negotiated rule-making. In the last two decades, governance evolved to include voluntary and market-based rules and an increased emphasis on inter-stakeholder collaboration. A declining and competitive paper industry, heightened attention by customers to the environmental performance of their supply chains, increased local pressures, and shifting strategies by environmental NGOs continue to drive this shift. Recently, contention over wastewater discharge licenses prompted a mill to launch a series of community engagement events that resulted in an initiative to found the Androscoggin River Institute, intended to serve as a forum for collaboration among academic researchers and river stakeholders. The increased relevance of voluntary, market-based, and collaborative rules serves as a case study for broader shifts in United States environmental governance.

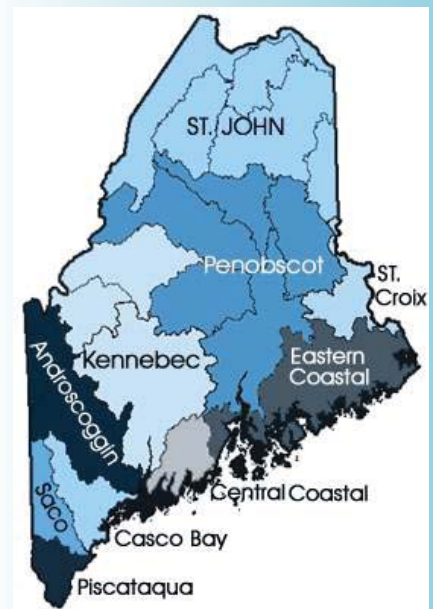


Androscoggin River, Photo credit: Ron Gay

Doherty Fellow **Alana Menendez**, '15, worked with **Collin Roesler** (Earth & Oceanographic Science) on the NASA Three Rivers Project: "Nutrient Flux to the Gulf of Maine".

This research is part of a three-year grant focused on Maine watersheds and the interactions between landforms, rivers, and the Gulf of Maine coastal waters. Four rivers were the focus of this study: the Saint John, Penobscot, Kennebec, and Androscoggin. Sampling sites were on tributaries leading up to the major rivers and on the main stems. Beginning in 2011, monthly samples were collected at ten to thirty sampling stations per river from April to November. Alana's component this summer focused on looking at inorganic nutrient concentrations in the four rivers: nitrate, ammonium, phosphate, and silicate. The goal was to quantify spatial and temporal patterns of nutrient loads within the individual rivers and between river systems. This would help reveal sources of nutrients (i.e., which tributaries) and sinks of nutrients (i.e., phytoplankton consumption) to eventually calculate fluxes to coastal waters.

Rusack Fellow **Hugh Ratcliffe** '15 also worked under professor Roesler's direction on the Three Rivers project. Hugh's research focused specifically on the optical and biogeochemical properties of dissolved organic carbon (DOC) and its flux out of each river system in relation to regional/ latitudinal trends driven by differences within each watershed. Only a fraction of DOC is colored (CDOM), and only a fraction of the CDOM actually fluoresces when exposed to UV light (FCDOM). Thus the goal of this project was to quantify a relationship between DOC and FCDOM in order to establish an optical proxy for DOC. Interestingly, fluorescence values were lower in relation to DOC concentrations during the summer months, which may be a trend driven by the presence of different organic compounds released from land or by variations in hydrologic mobilization, or by seasonally mediated photo-oxidation of the compounds in the river. DOC concentrations varied seasonally in conjunction with river discharge rates. However, hourly variations in fluorescence from buoy time-series indicates that fluctuations in DOC concentrations are driven by more than just river flow rate.



NASA Three Rivers Project in Maine. Study of the Saint John, Penobscot, Kennebec, and Androscoggin rivers. Ratcliffe, 2013

Ryan Peabody '14 researched the transport of "Coastal Water Masses in the Gulf of Maine" as a Rusack Fellow this summer with **Collin Roesler**.

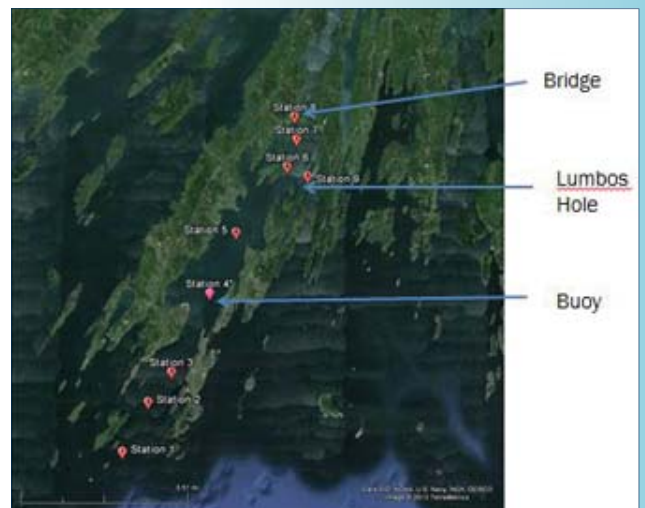
Blooms of *Alexandrium fundyense* in the Gulf of Maine cause paralytic shellfish poisoning annually along the coast. In order to understand how these populations are transported, researchers must quantify the advection patterns in the Gulf of Maine current system. In this project, Ryan made use of the hourly observations of hydrographic properties collected over the last decade from four coastal moorings available from the Northeastern Regional Association of Coastal and Ocean Observing Systems (NERACOOOS) buoy array. The long-term goals of this work were to quantify the climatological patterns in the along-shore and cross-shore current profiles and the non-seasonal variability in these currents, identify the underlying forcings and quantify advective transport for phytoplankton blooms. Progress on the first two goals was made this summer.

Over the next year, the spatial (buoy to buoy) and depth variations in the seasonal parameters will be quantified to construct the annual patterns of coastal transport and to relate the transport to seasonal fluctuations in water temperature and salinity. The transport model will then be used to estimate the advection of phytoplankton populations along the coast and to compare with observed patterns. Using past work on harmful algal blooms (HABs) in the Gulf of Maine, it may be possible to use this model to shed light on the movements of HABs in the Gulf of Maine.

Karl Reinhardt '15 was awarded a Freedman Fellowship to work with **Collin Roesler** on his project "Determining and Modeling *Alexandrium Fundyense* Growth Patterns in Harpswell Sound".

Harpswell Sound experiences annual paralytic shellfish poisoning (PSP) events each spring and appears to be a sentinel site for the region (Bean et al. 2005). Blooms of the toxic phytoplankton species *Alexandrium Fundyense* cause these events (also known as Red Tide). This species is a dinoflagellate, which along with diatoms, are the two most dominant types of algae in Harpswell Sound. This project was an investigation of the factors that affect the biomass and productivity of phytoplankton in Harpswell Sound as observed through measurements taken during the spring and summer of 2013.

To determine phytoplankton biomass Karl analyzed temperature, salinity, irradiance, and multichannel chlorophyll fluorescence by sampling the Sound. He observed a seasonal increase in phytoplankton biomass that is spatially patchy and ever changing with respect to composition well into mid summer. Lombos hole remained an environmentally favorable location for phytoplankton growth. The progression of blooms from the coastal Maine currents being pushed into the sound by the flow of the freshwater from the Kennebec was observed as it has been in previous years as well. Future steps in this project would include developing a method to differentiate between the growth patterns of the different species. This research could lead to revision of the model to incorporate nutrients, as it appears to be an important factor for phytoplankton growth, especially during the summer months.



Sampling sites in Harpswell Sound, Reinhardt 2013

Patsy Dickinson (Chemistry) advised **Mara Chin-Purcell**, '14 on her Faculty Research Fellowship "Stretch Sensitivity in the Cardiac Ganglion of *Homarus americanus*".

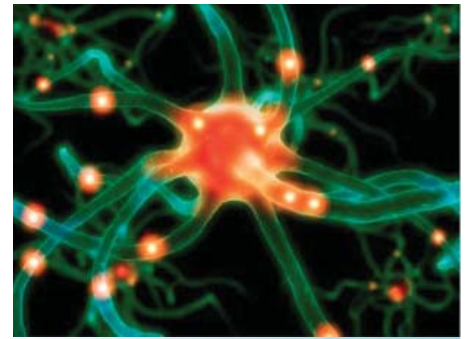
Central pattern generators are neuronal networks that endogenously produce rhythmic motor output. The heart of the American lobster, *Homarus americanus*, contains a simple central pattern generator, called the cardiac ganglion (CG), which initiates the beating of the heart. Previous studies have suggested that stretch feedback relays information to the cardiac ganglion about the degree of filling in the heart and that this feedback is mediated by stretch-sensitive dendrites of the CG neurons. The goal of this research is to determine if and how dendrites carry stretch information in the lobster, at a whole heart and cellular level.

Doherty Fellow **Elizabeth Owens** '14, also worked in the Dickinson Lab this summer on her project: "The interaction of Proctolin and RPCH on the Lobster *Homarus americanus* Cardiac Neuromuscular System".

The American lobster, *Homarus americanus*, inhabits a large oceanic range spanning from Labrador, Canada, to North Carolina. This geographic range varies in temperature by as much as 25 C, and daily temperature fluctuations of up to 12 C may occur at a single location depending on season, water depth, and tides. The cardiac system of the lobster is sensitive to these temperature changes and has been shown to adjust its functioning over a large temperature range. A previous study shows that various cardiac factors have different patterns of temperature dependence, resulting in stable cardiac output over the range of 2-20C. At this point, the mechanism of temperature-dependent functioning is unknown. It has been hypothesized that feedback pathways present in the whole heart, but absent in the isolated ganglion, would provide protection against thermal stress. However, results from this project indicate that the cardiac ganglion can withstand higher temperatures when isolated than when in the intact heart, before it suffers from functional failure. These data suggest that the intact heart contains other feedback mechanisms that facilitate cardiac failure.

Mina Chelsea Youn, '14 received a Doherty fellowship to work in the Dickinson lab on her project: "Distribution of AST-C and AST-C-Like Peptides in the American Lobster".

The C-type allatostatins, one family of the allstostatin neuropeptides, originally characterized by their ability to inhibit juvenile hormones, were initially thought to exist only in holometabolous insects. However, recent studies using transcriptomics and mass spectrometry have identified C-AST and an AST-C-like peptide in decapod crustaceans (Stemmler et al. 2010; Dickinson et al. 2009). Although the two peptides are hypothesized to have similar bioactivities in a given species by acting upon the same set of receptors in cells, researchers have found that in a subgroup of lobsters, C-AST decreased heart contraction amplitude while AST-C-like increased it. This disparity raised a question about the extent to which these two peptides are regulated together or independently. Chelsea labelled the nervous system with antibodies against these peptides to determine their distributions, which differ in at least the stomatogastric nervous system.



Neuropeptide (Chelsea Youn)

Peter Tracy, '14 received a Doherty Fellowship to work with **Elizabeth Stemmler** (Chemistry) on the "Identification and Function of Protokin Peptides in *H. americanus*".

The Pyrokinin family of neuropeptides are defined by the conserved sequence of amino acids, FXPRLamide, present at the c-terminus of the peptide (the end with the carboxyl group), with X representing a variable in the sequence. Pyrokinin peptides have been identified in a number of insect and crustacean species, and have shown to have effects on the rhythmic systems such as the heart and gastric mill system. *Homarus americanus* has had one Pyrokinin peptide identified as FSPRLamide (Ma et al., 2008, Gen. Comp. Endocr), but this had no effects on the heart or gastric mill system of *Homarus* and is much smaller than all of the other Pyrokinin peptides identified in other species. Peter hypothesized is that this is just a fragment of a Pyrokinin peptide in the *Homarus*, and that, just like the other crustacean species, there should be two located in *Homarus*. His goal was to identify the sequence of the Pyrokinin peptides of *Homarus americanus* so that, in another lab, it can be synthesized to test its effects on the *Homarus* nervous system. In this project he and his colleagues and were able to obtain a tandem mass spectrum of a peptide whose mass and fragment masses proved the peptide's sequence to be ADFAF-SPRLamide. This is in fact a peptide of the Pyrokinin family, and is very similar to one of the Pyrokinin peptides found in *P. vannamei*, with just one difference in the amino acid sequence. In his analysis of the experimental setup of this project, he developed mass spectrometric methods of extracting what he calls a full peak profile and qualitative view of the mass spectral data obtained from eyestalk ganglia. This is to be used in the further verification of previous findings and the discovery of a second pyrokinin for *Homarus americanus*.

Summer at the Marine Lab

Christine Hayes '14 (Rusack Fellowship), **Marisa Browning-Kamins** '16 (Bowdoin Life Sciences Fellowship, Biology), and **Molly Rose** '15 spent the summer following up on Anna Chase's research (2012) at the Bowdoin Marine Laboratory with **Trevor Rivers** (Doherty Marine Biology Postdoctoral Scholar) where they studied "Anthropogenic Light Pollution and the Settlement of Benthic Fouling Communities".

Anthropogenic light sources are increasingly affecting much of the Earth's surface. Although previous work indicates that light pollution can influence all levels of ecology, little research has been geared towards establishing community-wide effects, in either terrestrial or marine systems. This study focused on the effects of nocturnal light on the settlement of benthic fouling communities, or communities of sessile organisms that settle on natural and man-made submerged marine surfaces. They performed both lab and field experiments. Unglazed ceramic tiles were placed at sites (mostly at marinas) in Harpswell, with some in lit and others in unlit areas. In addition, tiles were placed in the flow-through marine lab tanks at the Coastal Studies Center and exposed to nighttime LED light treatments.



Anthropogenic Light Pollution Photo credit: <http://visibleearth.nasa.gov/view.php?id=55167>

In an attempt to minimize confounding effects of plates in marina settings and in the lab, solar-powered experimental buoys with acrylic plates were exposed to red, blue, white, and white strobe LEDs in Harpswell Sound in front of the Bowdoin Marine Lab. Plates were photographed every week and analyzed with Coral Point Count software to find percent cover of organisms and species diversity. These findings will elucidate any differences of communities exposed to different lighting conditions.

Doherty Fellow **Christine Rholl** '14 worked with Trevor Rivers on the role of vision in predator response to luminescence of *Harmothoe imbricata* and LED mimic displays. Bioluminescence plays a vital role in the marine environment, aiding in camouflage, predation, mating, and defense. Luminescent displays come in a variety of forms, with glows hypothesized to act as lures and flashes as deterrents. *Harmothoe imbricata* is an intertidal polynoid polychaete worm that utilizes both

flashing behavior and autotomization of glowing scales or body segments when approached or attacked by predators. They studied the role of vision in the response of predators to these displays to determine how successfully bioluminescence affects worm survivorship. The eyes of the nocturnal crustacean predator green crab and American lobster were painted with black or clear nail polish while others were left unpainted, and allowed to interact with *H. imbricata*. The survivorship of *H. imbricata* was compared between attacks by predators that could see the displays and blinded predators. Attacks were recorded with infrared cameras, a night vision device, and photomultipliers. Blinded predators were 5-15% more successful attacking worms than predators that could see the displays. In a number of trials, unblinded predators pursued the glowing

autotomized scales and segments, indicating luminescence may successfully function as a decoy. To further investigate how light affects predator behavior, they isolated vision as a sensory modality in predators by exposing crabs and lobsters to green LEDs that mimic the various bioluminescent displays of *H. imbricata*. From this, they may be able to determine how predators respond to only light that mimic the various bioluminescent displays of *H. imbricata*.

Julia Livermore continued research for her honors project on bioluminescence at the marine lab throughout the 2012-2013 academic year. Julia used a dark room set-up at the lab to continue conducting behavioral recordings.

Doherty Postdoctoral Scholar

Trevor Rivers (Doherty Marine Biology Postdoctoral Scholar 2010-2013) taught 'Senses in the Ocean' Fall 2012 and continued his research on light and invertebrate behavior at the Maine Lab. Trevor has developed basic and applied research around how light influences behavior using invertebrate models. Trevor and his students have found that luminescence acts as a predator decoy, glowing scales left behind by some ostracods distract crustacean predators as the ostracod escapes. Further, modeling light displays with LED lights in the lab has shown predators change their behavior in the presence of light signals, even in the absence of any other sensory modality (Rivers and Morin 2012). This research was published in the Journal of Experimental Biology, and earned the summer issue's cover image (to right).

A second applied project focused on the effects of anthropogenic light on marine fouling communities. Dr. Rivers' group have exposed settlement plates in the lab and in the field to light sources of different spectral wavelengths. They are finding that there are differences in biomass and diversity among the treatments. Field aspects of this project continued in the Spring 2013 using 30 solar-powered buoys. Chrissy Hayes '14, Marisa Browning-Kamins, Molly Rose, Christine Rholl and Julia Livermore contributed to these research projects. Julia's research informed her honors project.



Examples of marine fouling; organisms and



Cover: Predation attempt of a dusky cardinalfish, *Phaeoptyx pigmentaria*, on the luminescent ostracod *Photeros annecohenae*. The ostracod was expectorated, and is seen swimming away unharmed at the bottom of the luminescent cloud. Male *P. annecohenae* also use luminescence for highly complex courtship displays, and Rivers and Morin discuss the relative costs of the mating and defensive displays. Reproduced/adapted with permission. Rivers, T J, Morin, JG. 2012. The relative cost of using luminescence for sex and defense: light budgets in cyprinid ostracods. *Journal of Experimental Biology* 215: 2860-2868 (with cover photo)

Honors Projects

* Indicates College of William and Mary student

Holly Blackburn* (2013, Biology) Maternal effects on seastar cloning rates/
Delay of hatching in echinoids

Anna Lindsey Chase (2013, Biology) Effects of light on the settlement of
marine fouling organisms in the Gulf of Maine

Julia Christine Livermore (2013, Biology) Interspecific interactions between
luminescent scale worms and their crustacean predators

Noelle Abbott Schoettle (2013, Biology) Foraging and prey availability for
harbor porpoises (*Phocoena phocoena*) on the mid-Atlantic coast of the United
States

Presentations & Exhibitions

* Indicates undergraduate coauthor ** College of William and Mary student

Allen, J.D. and A.F. Armstrong**. Developmental flexibility in a variable environment:
lessons from sand dollars and sea urchins. Society for Integrative and Comparative
Biology (SICB) Jan 2013

Armstrong**, A.F., H.N. Blackburn** and J.D. Allen. Delay of hatching in the sand
dollar *Echinarachnius parma* in response to reduced salinity. (SICB) Jan 2013

Blackburn**, H.N. and J.D. Allen. Maternal effects on cloning frequency, larval
development and juvenile size in the seastar *Asterias forbesi*. (SICB) Jan 2013

Allen, J.D. and A.F. Armstrong**. Developmental flexibility in a variable environment:
lessons from sand dollars and sea urchins. Benthic Ecology Meeting. March 2013.

Blackburn**, H.N. and J.D. Allen. Maternal effects on cloning frequency, larval
development and juvenile size in the seastar *Asterias forbesi*. Benthic Ecology Meeting. March
2013.

Chase*, A.L. and T.J. Rivers. 2013 Testing the influence of light on the settlement of ma-
rine fouling organisms. Poster: Presented at the 2013 Benthic Ecology Meeting, Savannah
GA.

Livermore*, J.C. and T.J. Rivers. 2013. Effect of luminescent behavior on the
survivorship of the intertidal scale worm *Harmothoe imbricata*. Poster: Presented at the
2013 Benthic Ecology Meeting, Savannah GA.

Putnam, B.P. 2013. Exhibition as a conversation between artist Siri Beckman's woodcuts
and Barbara Putnam's. PHO-PA Gallery, Portland ME June-August 2013.

Putnam, B.P. 2013. "Golden Ratio: marine Patterns and Change", an exhibition of prints
and quilts.. Exhibition with sculptor Gar Waterman, Mattatuck Museum, Waterbury, CT.

Putnam, B.P., 2013. "Compass Points: Science, Art, and the Arctic" presented at Bowdoin
Faculty Seminar Series, Feb 26, 2013.

Putnam, B.P. 2012. 5th International Experimental Engraving Biennial, Brancovan Palace,
Bucharest, Romania December –March 2012-2013.

Thank you Eco-Reps !

"Each year Sustainable Bowdoin hires sixteen
Eco Reps who are responsible for their dorm's
sustainability initiatives. In the fall, the Eco
Reps go through training that includes over-
views such as recycling, programming, and
changing behavioral norms. We want our
employees to know what they're "selling" and
to be a resource for their peers. To cap off
training, we all gather at the Coastal Studies
Center for an afternoon of volunteering and
an evening of BBQ (with hamburgers from
Bisson Farm, of course). Mark Murray
usually leads the Eco Reps in pruning trees,
clearing brush, and trail maintenance.



Sustainable Bowdoin Eco-reps, 2012-2013

Most afternoons end in the creation of a
satisfyingly large burn pile. For many, this is
their first time at the Coastal Studies Center,
and I believe that this immediate interaction
with the landscape serves as a powerful
introduction. When they leave,
bellies full, the Eco Reps have
experienced Bowdoin's gem and, I hope too,
reached an understanding about the
dedication it takes to keep the property look-
ing as good as it does."

Andrew Cushing '12, Sustainability
Outreach Assistant

Putnam, B.P. Cornell, D.C. 2012. "Navigating (storms in) the Sea of Tranquility", An exhibition that examined our human environmental imprint, New Orleans Center for Creative Art, LA, March 2012.

Putnam, B.P. 2012. "New Works" invitational participation at Haystack Mt. School of Craft, for past instructors in the program, Sept 2012.

Rivers, T.J., and A.L. Chase*. 2013. The effects of anthropogenic light on marine fouling communities TALK: Presented at the 2013 Benthic Ecology Meeting, Savannah, GA.

Rivers, T.J., Livermore*, J.C. and T.R. Perreault*. 2013. Luminescence reduces mortality of the scale worm *Harmothoe imbricata* when attacked by crustacean predators. TALK: Presented at the 2013 SICB meeting, San Francisco, CA.

Smithson**, M.W. and J.D. Allen. Size-specific differences in predator-induced mortality in juvenile green urchins. Benthic Ecology Meeting. March 2013.

Ziegler**, S.L. and J.D. Allen. Developmental responses to multiple stressors in echinoid echinoderms. Benthic Ecology Meeting. March 2013.

Rivers, T.J. 2012. The Luminescent response to predation by the scaleworm *Harmothoe imbricata*. Talk: Presented at the Marine Ecology in the Gulf of Maine Symposium, Bowdoin College.

Publications

* Indicates undergraduate coauthor **College of William and Mary undergraduate author ^alumni author

Armer, MC, Nilaweera, WU, **Rivers, TJ**, Dasgupta, NM, and Beloozerova, IN. (2013) Effect of light on the activity of motor cortex neurons during locomotion. *Behav Brain Res.*

**Armstrong AF, **Blackburn HN, Allen JD (2013) A novel report of hatching plasticity in the phylum echinodermata. *Am Nat* 181:264-272

Johnson AS, **Salyers JM, ^Alcorn NJ, Ellers O, Allen JD (2013) Externally visible fluorochrome marks and allometries of growing sea urchins. *Invert. Biol.* 132:251-269.

*Pfister, A, **Johnson, A**, **Ellers, O**, **Horch, HW** (2013) Quantification of dendritic and axonal growth after injury to the auditory system of the adult cricket *Gryllus bimaculatus*. *Front. Physio.* 3:367. doi: 10.3389/fphys.2012.00367

Allen, JD. (2012) Effects of egg size reductions on development time and juvenile size in Three species of echinoid echinoderms: implications for life history theory. *J. Exp. Mar. Biol. Ecol.* 422-423: 72-80.

Rivers, TJ, Morin, JG. 2012. The relative cost of using luminescence for sex and defense: light budgets in cypridinid ostracods. *Journal of Experimental Biology* 215: 2860-2868 (with cover photo).

* We report with sadness that Richard Johnston, from the mechanical services team passed away March of 2013.



A small group of students joined poet and essayist Thorpe Moeckel '93 for an outdoor-inspired writing get-away to the Coastal Studies Center in early October. They spent a couple of hours on a beautiful autumn Maine afternoon with some quiet time to think, talk about, and do some writing guided by an accomplished alumnus writer. Moeckel is a seasoned outdoorsman and organic farmer who teaches creative writing at Hollins University. He was a recent National Endowment for the Arts Literary Fellow in poetry.

Thank you to Chuck and Nancy Boothby for a gift honoring Charles M. Boothby '43 which enabled the crafting of a stone patio and gathering place



behind the barn and farmhouse at the Coastal Studies Center. This is already a favorite picnic spot for summer researchers, and other visitors looking for a sunny spot to sit and enjoy an expansive view of the woods and fields.

COASTAL STUDIES CENTER
FACULTY & STAFF*

Mark Murray

Mike Chipman and Dave Labbay

Dennis Luescher

Marko Melendy

Rosie Armstrong

Student Assistant Daniel Eloy