RUTGERS

2020 RIOS REU Projects

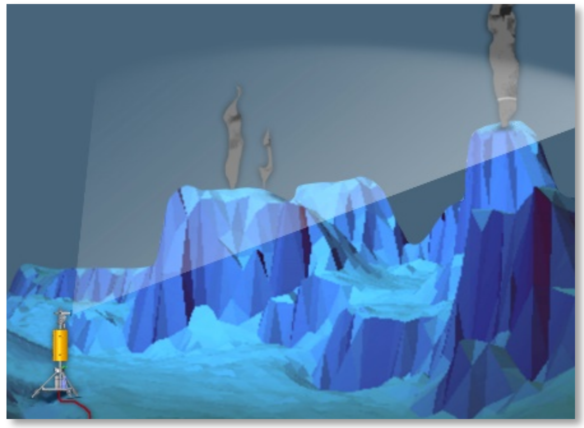
Project Titles:

1. Patterns of Water-carried Heat Discharge at Underwater Volcanoes
2. Visualizations of Mesoscale Ocean Eddies
3. Shellfish Ecology and Pathology
4. Caribbean Sea Ocean Processes during Hurricanes from Autonomous Underwater Robots
5. Fish Habitat Use at Oyster Farms
6. The Biology of a Warming Antarctica
7. How the Ocean Exhales: Examining Climate Change Controls from the Southern Ocean
8. Genetics of Bivalve Molluscs
9. The Effect of Power Plant Cooling Water Shutdown on the Ecology of Estuarine Fish
10. Machine Learning for Classification of Algae Farm Growth and Health Patterns as Imaged by an Autonomous Underwater Vehicle (AUV)
11. Mechanisms Driving Estuarine Exchange
12. Zooplankton and Microplastic Interactions in the Delaware Bay
13. Development of Geochemical Paleo-proxies in Cold-water Corals
14. Impacts of Ocean Warming, Waves, and Turbulence on Virtual Snail Larvae
15. The Impact of Ocean Acidification on Phytoplankton Host-virus Interactions

1. Patterns of Water-carried Heat Discharge at Underwater Volcanoes

Karen Bemis

Rutgers Vizlab



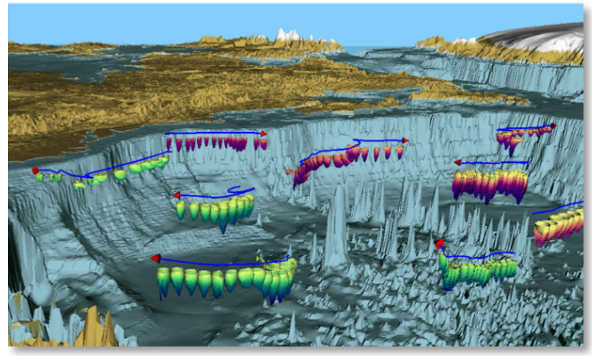
Sound can be used to detect hot water rising from the seafloor at mid-oceanic ridges and other underwater volcanoes, whether the outflow is focused into hot jets or widely distributed cool springs. The patterns and changes in such plumes and other hot spring like features relate to geologic processes such as fracture and fault development and oceanographic processes such as tidal currents and storm-driven internal waves. Measuring the heat transported by these hydrothermal (hot spring) systems is important to understanding the heat and chemical balances in the ocean that relate to climate controls, the supply of nutrients to deep sea ecological systems, and the changes in the volcanic systems supplying heat. In summer 2018, our acoustic instrument COVIS (Cabled Observatory Vent Imaging System) was deployed at Axial Volcano on the Juan de Fuca Ridge as part of the operations of the Ocean Observatories Initiative's Cabled Array. COVIS has previously been deployed from Oct 2010 to Sept 2015 at Grotto Vent in the Main Endeavour Field on the Endeavour segment of the Juan de Fuca Ridge. Both deployments involve a variety of direct thermal, flow and optical measurements.

An REU student with this theme could investigate the distribution of hydrothermal discharge, using the comprehensive video coverage of the ASHES vent field to locate signs of fractures, discharge and related biota and extracting discharge indicators from acoustic remote sensing (COVIS) data. Alternatively, a student could investigate either empirical relationships between thermal and acoustic measurements by combining thermal, acoustic and navigational data or chimney stability on top of the major sulfide mounds using acoustic imaging data.

2. Visualization of Mesoscale Ocean Eddies

Karen Bemis

Rutgers Vizlab



The transport of nutrients, chemicals, and heat in the ocean occurs by a variety of mechanisms including mesoscale eddies. Mesoscale (meaning of middle size – that is, around km wide) eddies are swirls of water that break off of ocean currents, often transporting warm water into colder areas or vice versa. They are characterized by contrasts in rotation, temperature, and salinity. Physical measurements of such eddies are sparse – such eddies can persist for months and travel over 1000's of kms making measurements from ships and gliders challenging. Most physical data are satellite and surface based. Regional Ocean Models (or ROMS) are used to investigate the longer term and three-dimensional measurements. At Vizlab, we have developed methods to detect and visualize ocean eddies in 3D using ROMS model outputs (or other 3D data) and capture changes in physical properties as such eddies evolve.

An REU student with this theme could explore the connections between physical properties (such as temperature, salinity, rotation direction, and rotation rate) and eddy transport (travel duration, direction, and speed as well as potential for vertical transport). The student would be joining a team of computer and marine scientists working on the development of novel visualizations of mesoscale eddies for a model data set from the Red Sea region. The larger project is focused on both long-term development of feature-tracking software and on an IEEE SciVis contest with submission of a short paper (by the whole team) in July.

3. Shellfish Ecology and Pathology
Dr. David Bushek

Shellfish are important components of coastal ecosystems and coastal economies. They create habitat, protect shorelines, filter water, and support fisheries and aquaculture. They are challenged by climate change, sea level rise, habitat loss, disease, and many other factors. My lab investigates how shellfish respond to these challenges and what can be done to enhance shellfish populations for their ecological value and develop sustainable fisheries and aquaculture. Multiple opportunities are available to participate in ongoing projects at field stations located on the Delaware Bay investigating shellfisheries, shellfish propagation and aquaculture, living shorelines, and the ecology of selected shellfish diseases. Interns would experience daily life at a research station as they gain experience in both field and laboratory investigations.

RIOS students in my laboratory are assigned a specific project to investigate what matches their interests, the needs of the lab, and available support. For 2020, a RIOS intern may be investigating the physical processes that can transport protozoan pathogens to oysters in various parts of an estuary or may be helping with monitoring fish and invertebrate communities colonizing and utilizing living shorelines established to protect shorelines.

4. Caribbean Sea Ocean Processes During Hurricanes from Autonomous Underwater Robots

Travis Miles

Landfalling hurricanes result in the greatest amount of deaths and economic losses of all US national disasters (read more). Communities in the Caribbean Sea are particularly vulnerable to rapidly intensifying and powerful storms supported by warm ocean temperatures. While significant improvements in forecasting storm track have been made over the past few decades, hurricane intensity forecast errors remain large. The ocean represents the heat engine that provides energy to these storms and in coastal regions can lead to significant uncertainty in storm intensity.

In this project we will use data from underwater robots to investigate processes in the ocean ahead of and during hurricanes to better understand the ocean's impact on storm intensity. For the intern this will include data investigation of previous and newly deployed ocean robot data, comparisons of these data with ocean models, and preparation, deployment, and recovery of ocean glider systems alongside personnel of the Center for Ocean Observing Leadership (COOL).

5. Fish Habitat Use at Oyster Farms
Daphne Munroe
NOAA Milford Lab Study

Off-bottom oyster cages and floating aquaculture gear are an increasingly common method for culturing large numbers of oysters on a small footprint. These cages create complex 3-dimensional structure that may provide habitat for fish and other organisms; shellfish growers routinely observe fish and invertebrates at a variety of life stages interacting with aquaculture gear. Oyster cages placed on relatively featureless bottom may provide the only complex habitat in low relief areas, and large numbers of oyster cages may act as artificial reefs attracting and aggregating fish and invertebrate species typically associated with natural structured environments. Use of point-of-view (GoPro) cameras offers a state of the art method for video surveillance to document fish activity in and around oyster cages and comparison to natural structured habitat.

A RIOS intern will analyze underwater video collected at a New Jersey oyster farm during the summer of 2019, and assist with field video data collection in 2020. Examples of video clips from these deployments can be viewed here: Munroe Lab YouTube channel. Analysis will follow methods already established and in use by a team of scientists and collaborators at NOAA's Milford Laboratory. The resulting oyster cage habitat data will be compared to video collected at control sites, and with regional datasets being collected by NOAA Milford.

6. The Biology of a Warming Antarctica
Oscar Schofield
RUCOOL
Palmer Station LTER

The West Antarctic Peninsula is one of the fastest winter warming locations on Earth, and our group has been studying the ecological implications of these changes on food webs. Our team has been part of a time series project that has been studying those changes for 29 years, spanning from plankton to the higher trophic levels (penguins to whales). For this project we want to work with the RIOS intern to analyze long term climate trends and their role in changing marine food webs.

Specifically for the effort this year, we will work as a team to explore how the diversity of the marine plankton is responding to changes in the sea ice in our study location. The sea ice is regulated by a range of climate scale forcing functions, and we want to unravel how these processes drive phytoplankton diversity. The focus will be on using existing long term data sets that are documenting ongoing climate change in one of the planet's most impacted regions.

7. How the Ocean Exhales: Examining Climate Change Controls from the Southern Ocean

Liz Sikes

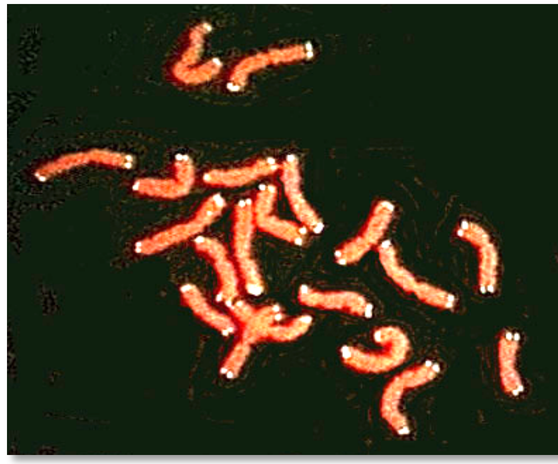
My research is in the field of paleoceanography—paleoclimatology. An important aspect of our research concentrates on the exchange of carbon between different reservoirs on the earth and how that affects climate. Photosynthesis fixes the greenhouse gas carbon dioxide removing that carbon from the atmosphere as organic carbon that sinks into the deep ocean where it is sequestered away from the atmosphere. Deep ocean circulation brings this carbon back to the surface and one of the main places the ocean releases this carbon back to the atmosphere ("exhales") is the Southern Ocean. This is why my lab studies the past levels of carbon dioxide in the Southern Ocean using stable isotopes in foraminifera fossils in sediment cores. Variations in circulation changes the ocean-atmosphere balance of carbon dioxide. We know these circulation fluctuations lowered the atmospheric carbon dioxide in the last ice age – contributing to ice age cooling.

A RIOS student working with our group would speciate microfossils (foraminifera) and prepare them for isotope ($\delta^{18}O$ and $\delta^{13}C$) analyses to determine past temperatures and CO_2 levels in our new cores from the Southern Ocean.

Photo Caption: Sediment coring gear on the R/V *Thomas Thompson* during our coring voyage to the Southern Ocean in November – December 2019.

8. Genetics of Bivalve Molluscs

Ximing Guo



Bivalve molluscs are descendants of a Cambrian lineage that have become superbly adapted to marine benthic life. They are widely distributed in the world's oceans and play important roles in estuary and coastal ecology. Many bivalves are also economically important species and support major aquaculture industries worldwide. Some bivalve species such as oysters are remarkably tolerant to environmental stresses including prolonged air-exposure and extreme salinities and temperatures. They lack adaptive immunity but thrive in microbe-rich environments as filter-feeders. Understanding the genetic bases of these adaptations has been a major area of my research. We conduct genetic studies to identify genes and genetic variations that affect the fitness and economically important traits such as disease resistance. The applied goal is to improve cultured stocks through selective breeding as well as advanced genetic manipulations. One genetic manipulation that has proven to be useful is the production of triploid (with 3 sets of chromosomes) oysters using tetraploids (with 4 sets of chromosomes). We breed and supply tetraploid oysters to the oyster industry for the production of triploids that are desired by farmers due to their fast growth and improved quality.

A RIOS student in my lab could conduct focused studies related to the genetics of diploid and polyploid oysters. Studies may include assessing the effects of various genetic changes such as polyploidy and inbreeding on the fitness of oysters. Students could learn how to spawn, culture, sample and evaluate experimental oysters, extract DNA, and conduct genotyping and other genetic analyses.

9. The Effect of Power Plant Cooling Water Shutdown on the Ecology of Estuarine Fishes

Thomas (Motz) Grothues
Rutgers University Marine Field Station

Until decommissioning started in September 2018, the Oyster Creek Nuclear Generating Station was the oldest operating nuclear power plant in the USA. It used once-through passage of water from Barnegat Bay to cool reactors, discharging the heated effluent into the estuary. Passage through the pumps and heat exchanger killed larval fish but hot water provided winter refuge to warm-water fish. Additionally, shutdown changed local salinity and currents. Five percent of the original flow will remain for years. We have sampled sites for fish near and away from the plant for several years before shutdown, and sampling will resume in spring through summer with gillnets, trawls, and plankton nets to assess changes that might be related to the return of the bay to a more natural state.

RIOS students interested in this larger project will join other interns and technicians as part of a team pursuing all of these sampling modes, but will individually concentrate on analysis of before/after comparisons of various components, such as juvenile fish, crabs, adult fish, or larvae.

10. Machine Learning for Classification of Algae Farm Growth and Health Patterns as Imaged by an Autonomous Underwater Vehicle (AUV)

Thomas (Motz) Grothues
[Rutgers University Marine Field Station]

Through Department of Energy Funding, a state-of-the art farm for growing marine algae as biofuel is being piloted in shallow coastal waters of Puerto Rico. Demonstration of automation is a key aspect of the project, and this includes the use of an autonomous underwater vehicle (AUV) to measure growth, crop health, and environmental impact in an analog to the way that large terrestrial croplands are monitored by aerial drones. A RIOS intern interested in computational science and marine technology and with some early coding skills (MATLAB preferred) will work towards producing, testing, and optimizing workflow designs that geo-reference photo images taken by an AUV and classify them through supervised multi-labeling algorithms to produce color coded, spatially-explicit maps of algae farm or benthic habitat condition. Although this stage of the work will predate deployment in Puerto Rico, an intern will take part in local AUV test missions. Work on algorithms for positioning transmitter-tagged fish from the AUV is also possible.

RIOS students interested in this project will join other interns and technicians as part of a team pursuing sampling for fishes on another project, but will individually concentrate on analysis of image classification via machine learning.

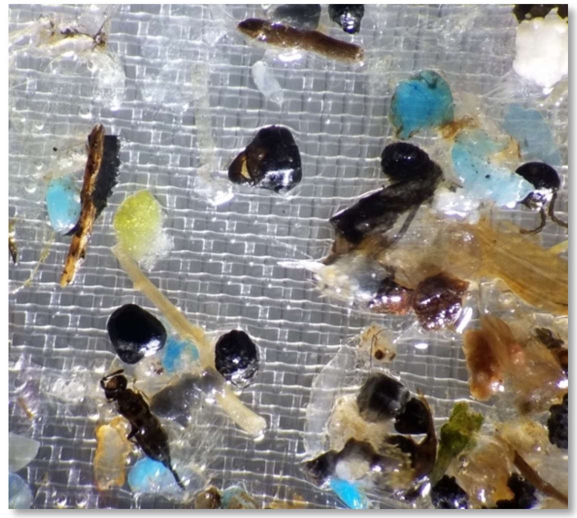
11. Mechanisms Driving Estuarine Exchange
Bob Chant

Estuarine systems are flushed by tides, winds, and buoyancy driven circulation. Recent advances in estuarine physics have developed new methods to estimate the Total Estuarine Flow (TEF) by weighing transport as a function of salinity classes. This method is found to be advantageous over traditional methods because it highlights which salinity classes are involved in exchange processes. TEF analysis can be applied to both observations and model output and provides insights into estuarine residence time and the temporal and spatial structure of mixing.

This project would use output from numerical simulations of both realistic and idealized estuarine systems to quantify the total exchange flow, its variability and provide insights into the spatial and temporal variability of mixing in estuarine systems. Estimates of TEF from the realistic simulations can be put in context with estimates made with shipboard and moored observations. Moreover, recent simulations run by our group have calculated the trajectory of particles that have been released within Delaware Bay and these too can be used to estimate flushing time of the bay based on the time-rate of change of particles in the bay. One goal of the project would be to link estimates of TEF to flushing times estimated by the particle release experiments. Ideally the student would have experience with MATLAB or Python and be comfortable working with large data sets and mathematical equations.

12. Zooplankton and Microplastic Interactions in the Delaware Bay

Grace Saba



Microplastics, observed frequently in seawater, are emerging contaminants in the marine environment with the potential to enter the food chain. Smaller diameter plastics are of concern given the bioavailability to zooplankton that play a key role in potential transport of microplastics up to higher trophic levels. The interactions between zooplankton and microplastics are thought to be elevated in estuarine frontal systems given their elevated biological activity and their tendency to concentrate material (i.e. food). Thus, we require new knowledge on the roles of river plume fronts in microplastic fate and transport in the marine environment. These research gaps are currently being addressed in the Delaware Bay through a combination of field research and laboratory experiments.

A RIOS student with this theme could compare zooplankton ingestion of microplastics inside and outside of a Delaware Bay frontal system or how low and high flow conditions impact zooplankton-microplastic interactions. The student could also investigate the impact that packaging microplastics into zooplankton fecal pellets has on the effective settling velocity of microplastics.

13. Development of Geochemical Paleo-proxies in Cold-water Corals
Robert Sherrell

The skeletons of deep-dwelling cold-water corals are promising tools that offer windows into Earth's past climate and improve our understanding of the climate system. The chemistry of the ocean, which reflects numerous atmospheric and oceanic processes, is recorded in their skeletons, preserved, and can be used to reconstruct aspects of the environment in the past. The relationship between the geochemistry of the calcium carbonate skeleton and the seawater needs to be established before fossil skeletons can be used as proxies for past ocean conditions. This relationship is often complicated by biological processes but can be unraveled by analyzing corals grown in natural waters or in culture under controlled experimental conditions.

The REU student will use various analytical methods, including laser ablation ICP-Mass Spectrometry and confocal microscopy, to analyze natural and cultured coral skeletons, and seawater collected from culturing experiments. These data will be used to build a proxy calibration, which will then be applied to fossil corals from New Zealand waters to reconstruct ocean conditions in the subantarctic during the last glacial period.

14. Impacts of Ocean Warming, Waves, and Turbulence on Virtual Snail Larvae

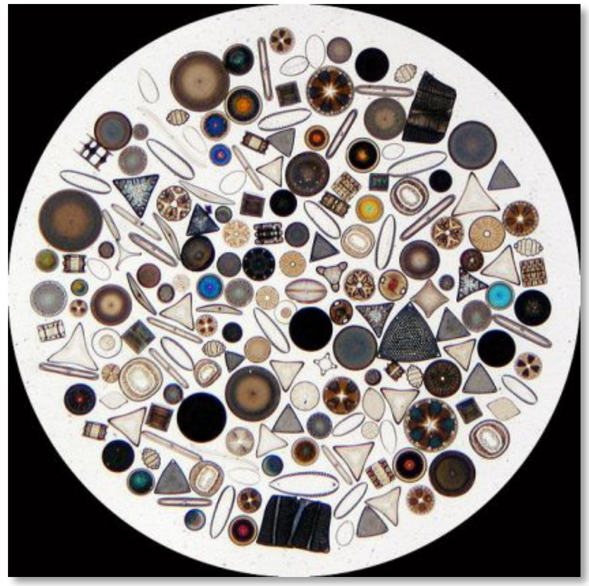
Jessica Carriere-Garwood, Heidi Fuchs, & Bob Chant

Project Website

Snail larvae have the ability to sense and respond to flow signatures produced by certain ocean conditions such as waves and turbulence. However, larval responses can differ between species, which can influence their relative transport in the ocean. In the Mid-Atlantic Bight, ocean warming may cause snail populations to spawn early, resulting in their larvae experiencing different flow conditions. Moreover, snail larvae may develop faster in warmer waters and be ready to settle sooner. Thus, ocean warming has the potential to affect the distribution of adult snail populations.

A RIOS student associated with this project could use output from model simulations to investigate how spawning time, larval development, or larval response to flow conditions may impact the distribution of adult snail populations. Other possible lines of inquiry can be discussed, based on a student's interests. With this project, the student will gain valuable programming and data analysis skills, under the mentorship of a postdoc. An enthusiasm for quantitative methods is strongly recommended.

15. The Impact of Ocean Acidification on Phytoplankton Host-virus Interactions
Kim Thamatrakoln & Grace Saba



Ocean acidification refers to a reduction in the pH of the ocean that is primary caused by an increase in the uptake of carbon dioxide from the atmosphere. Phytoplankton are the dominant organisms responsible for that uptake and the impact of ocean acidification on phytoplankton physiology is a hot topic of study. Diatoms are one of the most dominant groups of phytoplankton, responsible for almost 20% of global primary productivity and thus understanding the factors that mediate growth and mortality in these organism has global implications for the carbon cycle. Viral infection is one mechanism of mortality in these organisms and we are interested in understanding how environmental conditions impact host-virus dynamics.

A RIOS student associated with this project would explore the impact that ocean acidification will have on diatom host-virus interactions. Viral infection experiments on model laboratory host-virus strains will be done under a range of ocean acidification scenarios. Students will learn phytoplankton culturing techniques and gain experience counting hosts and viruses using various techniques, as well as the application of diagnostic fluorescent staining to assess host physiology.

Figure Caption: Light microscopy of different diatom species. Source: unknown.