NUTRIENTS AND NITROGEN FIXATION ACROSS THE GULF STREAM

Primary productivity in the ocean’s subtropical gyres is limited by nutrient deficiencies. When nitrogen is scarce and phosphate and iron are available, microorganisms known as diazotrophs can fix elemental nitrogen gas into its bio-available form. This is an energetically costly process and therefore diazotrophs are thought to be out-competed when bio-available nitrogen is abundant. It is also often assumed that diazotrophs can only be found in warm, well-stratified waters; this assumption has not been vigorously tested. In the subtropical North Atlantic, excess phosphate is transported across the Gulf Stream by wind and eddy driven mechanisms, and may support nitrogen fixing organisms in the region just south of the jet. To investigate the flux of nutrients and nitrogen fixation across the Gulf Stream and in the subtropical gyre, data were collected from the top 1000 m of the water column along a transect across the jet during 25-30 April 2017. These data were analyzed for velocity, temperature, oxygen, salinity and nutrients. Nutrient content and physical characteristics agree with previous studies and in accordance with the Ekman transport, indicate a source of P* from outside of the subtropical gyre, north of the Gulf Stream. Historical data also show that at least one type of diazotroph is present in the region of interest. Various other methods are in process to quantify the nitrogen fixation rates in the water column and implement molecular analysis on the nifH gene abundance. These pending outcomes will help determine if and how much N₂ fixation is taking place.

Elana Ames is entering her final semester at Coastal Carolina University in Myrtle Beach, South Carolina this fall. She is majoring in Marine Science with a minor in Chemistry. Dr. Jaime Palter is her SURFO advisor and Afonso Goncalves is her graduate mentor.
Pseudo-nitzschia in Narragansett Bay: Identification Based on Morphology and Growth Response to Irradiance

Diatoms are microscopic, eukaryotic phytoplankton that carry out 20 percent of Earth’s photosynthesis. Only one genus of diatom, *Pseudo-nitzschia*, is known to contain toxic species that can cause harmful algal blooms. In the fall of 2016 and the winter of 2017 in Narragansett Bay, there were two *Pseudo-nitzschia* blooms that tested positive for domoic acid. This particular acid can accumulate in shellfish in the water; humans would later eat these shellfish and experience stomach pain, neurotoxic symptoms, specifically amnesia, and in rare cases death. One of the main objectives of this project is to gain insight on which species of *Pseudo-nitzschia* were present in the blooms of Narragansett Bay and to further understand its morphology by using light (LM) and scanning electron microscopy (SEM). Previous research has suggested that this genus may have an unusual ability to persist at low light levels. Therefore, our second objective is to experimentally determine the level of light that limits growth in *Pseudo-nitzschia*. If our results support this claim, then populations of cells residing in very low levels of light may have the potential to serve as an inoculum for *Pseudo-nitzschia* blooms.

Rosalie Cisse is a rising senior at Tougaloo College majoring in Biology/pre-med and minoring in English. She plans on attending medical school after graduating this upcoming May 2018 to pursue her dreams of becoming a physician in pediatrics. She is originally from Senegal, west Africa but resides in Madison, MS. This summer, she is working under the mentorship of Dr. Lucie Maranda and Dr. Jan Rines.
Hurricane Landfall

Salvatore Ferrone

June 27, 2017

The goal of this project is to evaluate the WAVEWATCH III model performance under landfalling hurricanes. WAVEWATCH III is a computer modeling system for predicting surface waves in the ocean whose development is maintained by the National Oceanic and Atmospheric Administration (NOAA). Previous versions of WAVEWATCH III accurately predicted waves under hurricanes over open-ocean depths, yet lost accuracy when hurricanes enter regions of shallow water, 30 m or less. A new version of WAVEWATCH III recently introduced by NOAA includes aspects of shallow water ocean physics such as bottom friction, depth-induced wave breaking, and wave refraction. We conduct simulations of waves under Hurricane Bonnie (1998) during its landfall in North Carolina and Hurricane Irene (2011) when it passed over the Bahamas and compare the model results to the NASA Scanning Radar Altimeter (SRA) and the National data Buoy Centers (NDBC) observational data. Accurate simulations of surface waves at hurricane landfall is important for predicting storm surges. Storm surge is the primary source of coastal flooding and property damage and the greatest threat to life in a hurricane. A potential impact of the project is helping state and local decision makers to improve resilience of coastal infrastructure and emergency response.
EXPLORING THE RELATIONSHIP BETWEEN GENETIC VARIANCE IN ComEC AND UPTAKE EFFICIENCY IN NATURAL TRANSFORMATION

Natural transformation is a process that allows for an organism to uptake free environmental DNA, a method of horizontal gene transfer, that serves as a mechanism for bacterial evolution. While the single stranded DNA transporter protein ComEC has been identified to be a core component of the transformation complex, little is known about the evolution of ComEC and how evolutionary variances are connected with transformation efficiency. This project aims to bridge this gap through computational studies of the comEC gene in complete bacterial genomes and experimentally study the constitutively competent model organism Thermus thermophilus via genetic modification. Computational analyses revealed the broad presence of ComEC proteins in 5,571 completely sequenced bacterial genomes. Identification of the domain structures of ComEC demonstrated variability among diverse phyla and revealed a small number that encode consistent structures of the ComEC proteins. Overall, genome size was found to be smaller in strains that lack ComEC or only contain the Competence domain and larger in strains containing the Competence domain and at least one additional domain. Using genetic modifications, a comEC knockout strain of T. thermophilus is being developed to study how the domain combinations in ComEC influences transformation efficiency. An expression vector was constructed to restore the wild type phenotype in the knockout strain. This will provide a foundation for future analysis of transformation efficiency with different ComEC types. Overall, the combined computational and experimental study of natural transformation and other mechanisms of horizontal gene transfer is critical to further understand bacterial ecology and evolution.

Maddie Flasco will be a senior at Otterbein University in the fall of 2017. She is a biology major and is also minoring in mathematics. Maddie's SURFO advisor is Dr. Ying Zhang and her SURFO mentor is Zachary Pimentel.
POLICY CHANGES THROUGH SOCIAL NETWORKS

Before a disaster occurs, there are different policies instilled to help during response and recovery. The long term impact of natural disasters depends on how well prepared a community is. Some researchers believe that a disaster is not likely to trigger better preparation. When the disaster occurs do the various policies prove effective or should they be revised? In Rhode Island, the Pawtucket River flooded causing damage to infrastructure including a sewage authority. It was determined that the increased rates of human development caused the flooding. These floods led decision-makers to adopt new zoning laws and insurance policies. The people involved in the development of the new policies are different organizations who represent different municipalities as well as state and federal governments. The project examines how the 2010 floods led to specific reforms creating a time line of events, gathering information from documents and press reports, and creating a social network map to showcase the various roles involved when discussing the new policies. The social network map is created by organizing various documents and forms of media and registering the names of individuals involved in the policy debate. The map can reveal the key influential people in the remodeling of the policies in the floods of 2010 or even annual updates of policy. Using social network mapping, I am seeking to learn and examine the social network of actors that show how a shift in leadership could be the downfall or the basis of securing an effective policy.

Courtney Hill will enter her junior year at Tougaloo College for the fall of 2017. She is majoring in psychology and minoring in disaster coastal studies and biology. Pam Rubinoff and Don Robadue are her SURFO advisors.
Climate change has been greatly attributed to the increased levels of greenhouse gases, such as atmospheric carbon dioxide, produced by the use of fossil fuels. As a result, Narragansett Bay temperatures have increased 1.5°C-2.5°C since the 1960’s. As temperatures increase, the metabolism of phytoplankton increases, but it is unknown how different species respond to increasing temperatures. Increased metabolism can affect global cycles of carbon, nitrogen, and phosphorus. To understand the effects of temperature on phytoplankton we will conduct growth rate experiments on isolates collected from the Narragansett spring bloom in March to note the thermal limits and identify how different species respond to different temperatures. Previously, these experiments required multiple incubators set to different temperatures. The incubator method is very time intensive and relies on having multiple incubators being accessible at different temperatures. We propose a method that includes creating a Multi-Environmental Growth Assessment (M.E.G.A.) plate that would allow growth rate experiments to occur at various temperatures in one setting. We tested the M.E.G.A. plate using diatom species collected from Narragansett Bay identified using molecular techniques. A statistical analysis of M.E.G.A. plate data was done to verify a temperature gradient and consistency. The data indicates that the M.E.G.A. plate will allow for analysis of several strains simultaneously under multiple thermal conditions. The data demonstrates the diversity of diatom thermal responses from species isolated during the winter/spring bloom in Narragansett Bay.

Kierra Jones will enter her senior year at Tougaloo College in Tougaloo, Mississippi for the fall of 2017. She is majoring in Biology and Minoring in Public Health. Tatiana Rynearson is her SURFO advisor and Stephanie Anderson is her SURFO mentor.
NUTRIENT CYCLING OF THE SOUTHERN OCEAN DURING LATE SUMMER

The Southern Ocean plays a critical role in the exchange of carbon dioxide (CO₂) between the atmosphere and the oceans. High biological productivity during the summer is one way that CO₂ is drawn into the ocean. Tracking the year round nutrient cycles of this environment including nutrient abundance, production, and consumption will help us to understand the role of the Southern Ocean biological pump in regulating atmospheric CO₂. Water samples were collected along 170° W in the Southern Ocean on research expedition NBP17-02 between January and March 2017. NB17-02 transected the entire Southern Ocean, including the Polar Antarctic Zone, Polar Frontal Zone, and Subantarctic Zone. We measured nitrogen and oxygen isotopes of nitrate (δ¹⁵N and δ¹⁸O) and nitrate concentrations to track nitrate assimilation following the denitrifier method, where the bacterium, Pseudomonas aurefaciens, transfer nitrate nitrogen and oxygen present in the sample to nitrous oxide. The nitrous oxide produced was analyzed through gas chromatography-isotope ratio mass spectrometry to quantify the isotope ratios of δ¹⁵N and δ¹⁸O present in the original nitrate molecule. The equatorward increase in both the nitrogen and oxygen isotopes of nitrate reflect the progressive consumption of nitrate away from the major Southern Ocean upwelling zone. As predicted, the relationship between the nitrate concentration and nitrogen and oxygen isotopes in the Southern Ocean follow the Rayleigh model. Differences in the relative changes in nitrogen and oxygen isotopic ratios show nutrient recycling and/or the introduction of Subtropical water in some locations.

Amanda Love is currently a senior at Lake Superior State University in Sault Sainte Marie, Michigan. She will graduate in December with a degree in chemistry. Rebecca Robinson is her SURFO advisor and Collin Jones is her SURFO mentor.
Improved Bathymetric Mapping of Lake Azuei, Haiti, and the Use of Paleo-Shorelines as Markers of Vertical Deformation

Lake Azuei, one of the largest lakes in the Caribbean (10km×23km), is found at the eastern end of the Cul-de-Sac basin in Haiti. The southern half of Lake Azuei is located on the eastern extension of the Enriquillo-Plantain Garden fault zone. That fault marks part of the Caribbean plate's northern boundary and relative motion across its trace combines shortening and strike-slip components. Over the last fifteen years the water level of Lake Azuei has risen a remarkable ~5m, submerging villages, cultivated land, and roads, thus greatly disrupting the livelihoods of nearby inhabitants. Using new (2017) and existing (2013) sub-bottom seismic profiling (CHIRP) data we compiled an updated and improved bathymetric map of Lake Azuei that revealed young folds protruding from the lakebed. Additionally the CHIRP data highlighted several paleo-shorelines. We found a paleo-shoreline at ~5m depth, resulting from the recent lake level rise, and a prominent paleo-shoreline at ~10m, possibly signifying a long period where the lake level was ~10m lower than today's level. This ~10m paleo-shoreline is covered by a thin ~20cm sediment layer, suggesting that it was only submerged centuries to millennia ago. We are currently testing if this ~10m paleo-shoreline has been slightly warped away from horizontality due to tectonic activity. Lastly, using three core samples collected from the lakebed, we are radiometrically dating the sediment layers present in the lake to determine their ages and the rate of sedimentation. We are also applying grain-size and microscopic analysis to define the composition of the sediment layers.

Oliver Lucier will enter his senior year at Rice University in Houston this upcoming fall. He is majoring in earth science and history. Marie-Helene Cormier is his SURFO advisor.
Graduate School of Oceanography
2017 SURFO Final Presentation
August 4, Corless Auditorium
Seminar Abstract

Nicholas Piskurich, University of Notre Dame

Mentors: Dr. Peter Cornillon, University of Rhode Island; Dr. Baylor Fox-Kemper, Brown University; Dr. Broadie Pearson, Brown University

SPECTRAL CHARACTERISTICS OF A VARIETY OF OPEN OCEAN REGIONS

Spectral analysis of satellite oceanographic data is an ubiquitous, powerful tool used in examination of macroscale and microscale turbulence regimes, ocean dynamics, and submesoscale processes. Specifically, the shape of the power spectra concomitant with open ocean characteristics (i.e. satellite-derived sea surface temperatures (SST), velocity components) can aid in understanding ocean dynamics in a specific region. Via data from the Advanced Very High Resolution Radiometer (AVHRR) and Moderate Resolution Imaging Spectroradiometer (MODIS) and more recent high quality data from the Visible Infrared Imaging Radiometer Suite (VIIRS), spectral analysis can be performed on spatial scales of 1 to hundreds of km. Currently, spectral analyses exists for regions at significantly coarser spatial resolution of ~10km. However, spectra from the AVHRR and VIIRS SST fields (both 750m and 375m) can be calculated and analyzed for many open ocean regions with spectral slopes that vary temporally, spatially, and seasonally. Data collected from the VIIRS Moderate Resolution Band was processed using algorithms developed in MATLAB involving the Fast-Fourier Transform (FFT) method for clear 256-pixel along-scan and along-track cloud-free segments from 1 degree × 1 degree to 20 degree × 20 degree. An ensemble average of segments was conducted seasonally and regionally to develop a global climatology of spectral slopes in the 5 to 50-km range. Spectral results were compared to the results obtained from the container ship Oleander in the 5 to 50-km range. Global temporal, zonal, and meridional spectral slopes via the FFT method have been obtained for the four seasons and the year of

Nick Piskurich will enter his senior year at the University of Notre Dame in South Bend, Indiana for the fall of 2017. He is a double major in Environmental Engineering and Earth Sciences. Dr. Peter Cornillon is his SURFO mentor, and Dr. Baylor Fox-Kemper and Dr. Broadie Pearson are his SURFO advisors.
Euphausiids, commonly called krill, are an important group of zooplankton frequently found in and near oxygen minimum zones (OMZs), midwater depth zones of very low oxygen. Some euphausiid species are adapted to live in or migrate through these zones; others are not. Climate change is predicted to cause vertical and horizontal increases in OMZ size. This may impact euphausiids’ ability to live at particular depths or alter their vertical migration patterns. Vertically-stratified and horizontally-sequenced zooplankton samples were collected in the Eastern Tropical North Pacific in early 2017 on the R/V Sikuliaq with a MOCNESS net system. Euphausiids and other crustaceans were removed from the samples, classified into groups and identified to species when possible. Euphausiid abundance and distributional data were analyzed relative to depth, oxygen, and temperature. Comparing day and night vertical tows revealed that although many euphausiid species spent daylight hours at the same midwater depth, they separated to different depths when migrating towards the surface at night. Horizontal tows at ~430 m showed strong differences in euphausiid abundance associated with changes in oxygen concentration. Habitat diagrams illustrating interactions between temperature, oxygen, and abundance showed that most species had highest daytime abundances in the same temperature water, but were separated by different oxygen concentrations. In fine-scale vertical tows, peak euphausiid abundance occurred during a rapid decline in oxygen concentration over a short depth interval. Because euphausiids are important prey for many animals, changes in their abundance or distribution could impact other populations, including commercially valuable species such as tuna.

Shannon Riley will enter her senior year at Oregon State University for the fall of 2017. She is majoring in marine biology and ocean science with a minor in chemistry. Karen Wishner is her SURFO advisor and Dawn Outram is her SURFO mentor.
A MINature IsOpycNal float [MINION] has been developed to observe sinking particle flux in a Lagrangian frame. The floats are constructed with off the shelf parts to minimize cost. Each Wi-Fi enabled Minion is equipped with temperature, pressure and acceleration sensors, real time clock and a macro lens camera to capture images of marine snow particles as they land on a transparent settling surface. The goal, be able to resolve episodic variations in carbon flux on time scales from hours to days. Deployments of Minion fleets will allow for sampling over a wide area to improve understand the spatial variations of particle size and composition. One of the defining characteristics of the Minion is its reliance on passive buoyancy control which allows for targeting of specific isopycnals without relying on any moving parts or spent power. Optimizing power efficiency will extend endurance of a single deployment while minimizing size. Future Minion iterations will include salinity probes and the ability to adjust photographic light field by sensing ambient light in the euphotic zone. This platform is based on a single expandable Linux computer allowing for continuous and specialized modification for future unforeseen applications.
Optics and Phytoplankton in Narragansett Bay, RI

Deriving accurate and useful information from satellite spectral measurements of optically-complex coastal waters remains a challenging research question. Optical properties and phytoplankton variability of Narragansett Bay are examined using existing data sources, in situ sampling, laboratory analysis, and historic satellite imagery. Surface seawater samples are collected daily at the University of Rhode Island’s Graduate School of Oceanography (GSO) dock, and surface and bottom samples are collected weekly at Narragansett Bay Station 2, the regular sampling site of GSO’s long-term plankton survey (LTPS). Samples are processed for particulate absorption, chlorophyll a (Chl-a), and colored dissolved organic matter (CDOM). High-resolution images of individual phytoplankton cells are obtained with an Imaging FlowCytobot (IFCB). Phytoplankton variability and abundance from IFCB and LTPS measurements are compared. Medium Resolution Imaging Spectrometer (MERIS) full resolution (300m) imagery of Narragansett Bay and the surrounding region is obtained and processed with three atmospheric correction methods, and compared to in situ radiometric measurements from the Aerosol Robotic Network - Ocean Color (AERONET-OC) site at Martha's Vineyard Coastal Observatory (MVCO). MERIS remote-sensing reflectance ($R_{\text{rs}}$) values for Narragansett Bay Station 2 seem to show responses to LTPS Chl-a concentration, however, other constituents, such as non-algal particles, seem to have a strong influence on the reflectance signal. These investments will help to improve understanding on the influence of different optically significant constituents in Narragansett Bay on the spectral signal measured by satellites, and help facilitate continued optical and imaging observations in the bay using a full suite of in situ optical instrumentation.

Kyle Turner is a senior at George Mason University in Fairfax, Virginia. He plans to graduate in December 2017 with a B.S. in Earth Science, Oceanography and Estuarine Science concentration. Collen Mouw is his SURFO advisor. He has previously interned at NASA Goddard Space Flight Center in Greenbelt, Maryland, and has been working as an undergraduate researcher at the Center for Ocean-Land-Atmosphere Studies (COLA) at George Mason University.
Determined the accurate location of earthquakes in areas with poor coverage of local seismic stations is a big challenge. Remote sensing data, specifically, the interferometric synthetic aperture radar (InSAR), have been proven to be a useful tool for locating earthquakes because it can measure the surface deformation caused by the earthquakes. This technology is most useful for events that are shallow (less than ten kilometers) and large (with a magnitude greater than 5 on the Richter scale). For this research, I will use InSAR data to search for earthquakes in Iran between 2013 and present. I will provide my findings to a current postdoc Sam Bell for a larger project supported by the Air Force. Collectively, we hope to constrain tens of earthquakes with accurate location, depth, origin time, and moment tensor. Later on, these events can be used as references to relocate other events. Together, this will improve the earthquake locations in Iran, which are critical in seismic monitoring and discrimination between earthquakes and nuclear tests.

Melanie Wallace will be a senior at Purdue University in the fall of 2017. She is majoring in Multidisciplinary Engineering with an emphasis in visual design, and minoring in computer graphic technology. Her SURFO advisor is Dr. Meng “Matt” Wei.