Southern Connecticut State University

Werth Center for Coastal and Marine Studies

WCCMS Annual Report 2020-2021

Prepared by:

Vincent T. Breslin, Professor

James Tait, Professor

Emma Cross, Assistant Professor

Department of the Environment, Geography and Marine Sciences

Sean Grace, Associate Professor

Department of Biology

Prepared for:

The Werth Family Foundation, Woodbridge, CT

March 2021

CCMS Annual Benchmark/Evaluation Report 2020-2021

Each year the participating faculty of the WCCMS prepares and submits to the Werth Family Foundation an annual report describing the Center activities. This report is made available in both electronic and hard copy form. The report provides definitive information and detailed summaries of all yearly projects, events, activities, forums, and accomplishments conducted/achieved by the Center and its personnel. The WCCMS Annual Report is submitted to the Werth Family Foundation during March of each year. Contents of the WCCMS 2020-2021 Annual Report are described below.

We welcome Dr. Emma Cross to the Werth Center faculty. Dr. Emma Cross is an Assistant Professor of Coastal and Marine Science in the Department of the Environment, Geography and Marine Sciences since August 2019. Before SCSU, Dr. Cross completed her Ph.D. at the University of Cambridge and the British Antarctic Survey and then moved across the pond for a postdoctoral research fellow position at the University of Connecticut. Dr. Cross teaches a range of hands-on marine science and environmental studies classes covering topical issues such as climate change, plastic pollution, overfishing and habitat destruction. Her research focuses on the effects of ocean acidification, warming and hypoxia on seaweed, marine invertebrates, and vertebrates. Dr. Cross' current projects include climate change mitigation strategies for the aquaculture industry and the environmental impacts of aquaculture on water quality and biodiversity. Dr. Cross uses field analyses, long-term laboratory experiments and museum collections as well as collaborations with the aquaculture industry and non-profit organizations in New England to address topical marine science issues.

This past year has been especially challenging due to the corona virus pandemic. The Werth Center faculty and students have spent the past year conducting research and monitoring activities under strict Covid-19 protocols. In response to the rise in corona virus illnesses and deaths in early 2020, SCSU closed the campus to all but essential employees in March 2020. All classes were moved online and students were sent home. For a brief period in spring 2020, students and faculty were not allowed to work in the laboratories or participate in field activities. Dr. Breslin was deemed an essential employee to allow him access to the Academic Science Building to feed the fish house in the Werth Center aquaria. WCCMS faculty and students continued activities either by maintaining social distancing or virtually. The Covid-19 protocols extended through the summer and fall semesters. During the summer, some students and faculty were allowed back on campus to engage in research and educational activities on a case-by-case basis. This allowed some of our students an opportunity to continue their field and laboratory studies. The Covid-19 restrictions continue in the spring 2021 semester although in-person teaching and greater access to laboratory facilities was granted. In spite of these obstacles, WCCMS faculty and students have achieved success in making progress in their research, publishing, and participating in new research initiatives. Details of their efforts are described in this report.

I. Research Projects

Water quality monitoring in New Haven harbor

Faculty Dr. Vincent T. Breslin
Environment, Geography and Marine Sciences

Student Participants

Summer 2020; Fall 2020; Spring 2021

Nicole Woosley, Biology
Ian Bergemann, Environment, Geography and Marine Sciences

Spring 2021

Sara Gerckens, Undergraduate Student, ESSS
Sydney Peacock, Undergraduate Student, ESSS
Syrenitee Kee, Undergraduate Student, ESSS

Long Island Sound is an ecologically diverse environment with rich and varied ecosystems for marine organisms while also providing important environmental and recreational services for Connecticut and New York residents. Despite its ecological and economic importance, water quality throughout the Sound is vastly under-monitored, particularly in the especially vulnerable and densely populated coastal embayments. The Long Island Sound Study recently highlighted the importance of expanding and integrating water quality monitoring efforts throughout the Sound to provide uniform, reliable near-shore monitoring data to watershed managers and the broader scientific/technical community. The students and faculty of the Werth Center for Coastal and Marine Studies at SCSU established a long-term water quality monitoring program at Long Wharf Pier, New Haven harbor in January 2012. Weekly water quality testing at this location occurs once per week coinciding with high tide. Water quality and meteorological parameters measured include salinity (ppt), specific conductance (mS/cm), dissolved oxygen (mg/L), air and water temperature (°C), wind speed (m/s), relative humidity (%), light intensity (lux), secchi disk depth (m), turbidity (NTU), Chlorophyll *a* and pH.

Results to Date/Significance

The WCCMS recently completed the ninth year of water quality monitoring at the pier at Long Wharf, New Haven. The water quality monitoring at Long Wharf continued during the pandemic. All participants were required to wear PPE and maintain appropriate social distancing during water quality sampling. Our students were able to collect data at Long Wharf in 10 of the past 12 months, providing continuity for our monitoring program. Results of our monitoring show that water temperature (3.2 to 26.3°C) displays a seasonal trend. Dissolved oxygen concentrations (3.00 to13.00 mg/L) at this location also vary with temperature as oxygen solubility in water is a function of water temperature (greater solubility at lower water temperature). Additionally, there have only been three instances (7/16; 7/23; and 7/31) when the

dissolved oxygen level measured below the good water quality threshold (5 mg/L). Salinity at this location at high tide varies within a narrow range (22.9 to 29.0 ppt). Water clarity, as measured using a secchi disk, varies from 0.80 to 2.10 meters. The ranges of these values for these water quality parameters are typical for similar parameters reported for Long Island Sound coastal embayments.

The effects of depth, light and orientation on the flourescence of the symbiont *Breviolum psygmophilum* in the *Astrangia poculata*

Faculty Dr. Sean Grace
Biology

Student Participant(s)

Academic Year 2020, 2021

Nicole Woosley, Biology, Graduate Student

The effects of depth, orientation and light penetration on the photosynthetic ability of zooxanthellae in the temperate coral *Astrangia poculata* will be examined at Fort Wetherill in Jamestown, Rhode Island where a dense population of colonies exist. A 5m transect line will be laid at depths 2m, 7.5m,15m and 25m and the photosynthetic activity of the first 9 corals encountered along the line will be determined using a Walz Diving- PAM. The PAM will measure and record values for minimum, maximum, and variable fluorescence on individual coral polyps. Light will be determined near the corals using a Hobo-Temp/Light meter and orientation will be determined using a protractor. The coral examined will be collected, transported back to the lab and tissue examined for the concentration of zooxanthellae with a hemocytometer. The effect of depth, orientation and light will be examined using a 3-factor ANOVA where the independent variables are photosynthetic rate (as determined by the PAM) and concentration of zooxanthellae. The hypothesis of this thesis is that there will be a gradual decrease of photosynthesis with depth increases and orientation changes due to decrease in light levels.

Results to Date/Significance

In fall 2020, we investigated several sites in Rhode Island to complete the study. The study will be completed in Spring and Summer 2021 with a potential defense date planned for December 2021.

Quantifying biodiversity and water quality of regenerative ocean farming to assess the feasibility of developing an ecolabel certification to enhance marketing of sustainable aquaculture products

Faculty Dr. Emma L. Cross
Environment, Geography and Marine Sciences

Research Assistant

Fall 2020; Spring 2021

Lauren Brideau, BS Environmental Systems and Sustainability in Spring 2020

Student Participants

Spring 2021

Miranda Holland, Undergraduate, Environment, Geography and Marine Sciences

Unlike agriculture farming, regenerative ocean farms require zero inputs of feed, fertilizer or freshwater, and also sequester carbon and nitrogen more effectively. Seaweed could also raise seawater pH and dissolved oxygen through photosynthesis. Furthermore, they provide temporary and permanent habitats for other species, therefore, potentially increasing local biodiversity. Despite the potential beneficial environmental impacts of multi-species ocean farming, there is limited quantitative evidence to support these trends. In collaboration with academics at the Woods Hole Oceanographic Institute (WHOI), our aquaculture industry partners Cottage City Oysters and the non-profit organization GreenWave, this project is quantifying water quality and biodiversity before and after the deployment of aquaculture equipment at a new regenerative ocean farm off the coast of Martha's Vineyard, MA. Water quality parameters that are being measured are seawater temperature (°C), dissolved oxygen (mg/L), pH, specific conductivity (μS/cm), salinity (ppt) and turbidity (NTU) using unattended continuously logging Eureka multi-probes. Monthly water samples are also being collected for total alkalinity measurements to determine carbonate chemistry and nutrient analysis to determine nutrient extraction. Biodiversity is being quantified using environmental DNA metabarcoding of monthly water samples conducted at WHOI. If we find quantitative evidence of environmental benefits of regenerative ocean farms, then we can assess the feasibility of developing an ecolabel for sustainable aquaculture products produced in such ocean farms.

Results to Date/Significance

Monthly fieldwork for this three-year research project began in October 2020 through preliminary funding from Project Blue at SCSU from two external CTNext grants (co-PIs Dr. Patrick Heidkamp and Dr. Colleen Bielitz) that Dr. Cross is a named researcher on. Cottage City Oysters' newly acquired ocean plot currently has no aquaculture equipment deployed with the sampling site consisting of a sandy bottom with no obvious marine life. Preliminary water quality results demonstrate typical values and trends of a coastal region exposed to the open ocean. Specifically, seawater temperature demonstrates an expected seasonal trend gradually

decreasing from 17.2°C in October to 0.5°C in February. Dissolved oxygen concentrations have also exhibited an expected seasonal trend increasing from 7.9 mg/L in October to 11.5 mg/l in February. pH has fluctuated between pH 7.9 and pH 8.1, typical of the winter months in New England. Salinity and turbidity have remained constant between 32.0-33.2 ppt and < 5 NTU, respectively. Dr. Cross has applied to two external grant opportunities for this project as the Lead PI including to the National Oceanic and Atmospheric Administration (NOAA) Saltonstall-Kennedy Competition in August 2020 and the Atlantic States Marine Fisheries Commission (ASMFC) in January 2021, with the ASMFC proposal still under review. This project has created a new partnership between academics at SCSU and WHOI and with the aquaculture industry through collaborating with Cottage City Oysters, a shellfish and kelp aquaculture company in Martha's Vineyard. Lauren Brideau is currently leading a co-written book chapter on how academics and industry partners can provide different perspectives and co-create knowledge about topical environmental issues. Miranda Holland has recently started monthly fieldwork in Martha's Vineyard collecting biodiversity data using an underwater ROV as part of her Honors Thesis project. Miranda applied for an Undergraduate Research Grant ($2,995) for the Spring 2021 semester and was the alternate student. Upon positive feedback from the Research and Scholarly Advisory Committee (RSAC) chair, Miranda Holland applied for an Undergraduate Research Grant ($3,000) for summer/Fall 2021 semester to support her fieldwork for this project, which is currently under review.

Werth Center for Coastal and Marine Studies aquarium water quality

Faculty Dr. Vincent T. Breslin
Environment, Geography and Marine Sciences

Student Participants

Summer 2020; Fall 2020; Spring 2021

Melissa Beecher, Undergraduate, Biology
Ian Bergemann, Undergraduate, Environment, Geography and Marine Sciences

Fall 2020; Spring 2021

Nicole Woolsey, Graduate Student Biology
Owen Cassidy, Undergraduate Student, Chemistry
Sara Gerkins, Undergraduate Student, ESSS
Sydney Peacock, Undergraduate Student, ESSS
Syrenitee Kee, Undergraduate Student, ESSS

Werth Center facilities include two large (approximately 2500 gallon each) display aquaria, touch tank (500 gallons) and associated laboratory (SCI 111). WCCMS students and staff have supervised the conditioning of the aquarium system and the introduction of fish and invertebrates. Marine fish were first introduced to the aquarium in December 2015 (Tank #2 coastal aquarium) and January 2016 (Tank #1 open water aquarium). The aquaria were

designed to mimic Long Island Sound ecosystems and contain only local fish and invertebrate species. Student interns have performed frequent water quality testing (4-5 days per week) and fish and invertebrate condition observations (6-7 days per week). Student interns are also responsible for daily feeding of the fish and invertebrates in each aquarium and touch tank.

Results to date/Significance

WCCMs student interns have completed five years of water quality measurements on the aquarium system. These records show that during that time we have maintained water quality in the aquarium system to support the health and growth of the fish and invertebrates in the aquarium and associated touch tanks. We continue to add new fish and invertebrates to the aquarium facility. We have also established a relationship with the Marine Resource Center (https://www.mbl.edu /mrc/) at the Marine Biological Laboratory, Woods Hole, MA.

The aquarium temperature is tied into a chiller system that controls the flow of cold water to the aquarium heat exchanger in the Academic Science Building basement where the filter system for the aquarium is located. On Friday, SCSU experienced a power outage on campus. The aquarium system is serviced by the building generator and the aquarium system continued to function properly during the outage. Power was quickly restored, however, unknown to us at the time, the power outage temporarily discontinued power to the chiller system in the facilities building. Over the weekend, due to Covid-19 restrictions, students and faculty did not visit the aquarium knowing the power was restored. Compounding the situation was a winter storm that caused the campus to close on Monday and Tuesday. It was not until Tuesday afternoon that campus police were alerted to a problem by the temperature alarm system in the aquarium lab (SCI 111). Although we responded to the problem quickly, the aquarium water temperature had slowly risen to exceed 85 °F after four days resulting in the death of 13 fish housed in the aquarium. Facilities was alerted to the issue and the chiller system was reset causing the water temperatures to return to normal (66 °F).

To lessen the likelihood of a similar loss of cooling water to the system, we have installed a web camera and a Coralvue Hydros temperature monitoring system. The system sends text messages and emails to notify staff if the set temperature rises above a set threshold. We now have multiple, redundant systems to remotely monitor the aquarium water temperature. These systems should reduce the likelihood of a slow continuous rise in water temperature that could harm the aquarium fish and invertebrates. We are also exploring installing a stand-alone chiller system for the aquarium to better maintain control of water temperature.

We have already begun the process of replacing the fish that were lost. We have contacted the MBL specimen lab with a wish list of fish specimens (hake, scup, toadfish) for the large display tanks. The MBL will resume specimen collections in May 2021. We continue to maintain our IACUC certification and all our students conducting water quality and feeding the fish are now required to be IACUC trained and certified. We also submitted our annual invertebrate collection report to the CT DEEP and recently renewed our CT DEEP Specimen Collection Permit (6/1/2019-5/31/2022) allowing our students to continue to collect invertebrates and fish from local habitats.

The WCCMS aquarium laboratory continues to host SCSU Open House and public educational programming. Our student interns host SCSU students from throughout the campus and provide tours of the facilities allowing students to learn about LIS fish and invertebrates.

Macroalgae as bioindicators for mercury contamination in Long Island Sound

Faculty Dr. Sean Grace
Biology
Dr. Vincent Breslin
Department of the Environment, Geography and Marine Sciences

Student Participants

Summer 2020; Fall 2020; Spring 2021

Cassandra Bhageloo, Graduate Student (Chemistry)

Macroalgae are suitable bioindicators for metal contamination in marine environments due to their wide distribution and abundance, ease of collection and identification, year-round availability, and tolerance of a wide variety of temperatures and salinities. The use of macroalgae to monitor for marine pollution allows for the assessment of contamination on living organisms and their environment, as well as their potential application in bioremediation. Studies focused on macroalgae as bioindicators for trace metal contamination such as mercury show that the concentration of metal in the sediment, water column, and macroalgae are typically proportional.

This study focused on determining the mercury content of various divisions of macroalgae (brown, red, green) to identify potential temporal and spatial trends along the coast of CT. Macroalgae sampled in fall 2020 include *Fucus distichus* (brown), *Chondrus crispus* (red), *Spermothamnion repens* (red), *Daysa baillouvia* (red) and *Ulva lactuca* (green). As the affinity for macreoalgae to bind trace metals often increases relative to division (brown > reds > greens), the mercury content of the aforementioned species were investigated to identify which species can uptake the largest metal concentration. Additionally, this data will be cross referenced with data sampled from similar locations and species in fall 2017 to examine the presence of potential temporal trends. Due to the geography of Long Island Sound, the occurrence of spatial trends in mercury increasing from eastern LIS to western LIS will also be investigated. Freeze-dried algae tissue samples (0.100-0.250 g) were analyzed directly for mercury by thermal decomposition amalgamation and atomic absorption spectrophotometry using a Milestone DMA-80 direct mercury analyzer.

Results to Date/Significance

Results from data in 2017 showed that macroalgal tissue mercury concentrations varied by species but no significant west to east trends in algal tissue mercury were observed. Mercury concentrations were typically lowest in green algae species, intermediate in red algae species and highest in brown algae species. Preliminary data from 2020 also shows similar trends though

fewer species were sampled due to Covid-19 restrictions. Graduate student Cassandra Bhageloo recently completed her MS thesis proposal and is currently working on examining temporal variations noted in mercury concentrations of representative species of algae sampled from the same LIS locations in 2017. Researching the mercury levels in Long Island Sound and how they may vary with time will aid in understanding how water quality in LIS may affect the regional algal aquaculture industry.

Examining the beach dynamics of the Connecticut shoreline and their implications for coastal zone management

Faculty Dr. James Tait
Department of the Environment, Geography and Marine Sciences

Project Description

Ongoing multi-year research focused on testing for seasonal beach profiles on the Connecticut coast has been concluded with documentation of the lack of any significant seasonal beach profiles on five beaches that span the length of the Connecticut shoreline. The beaches include Sherwood Island State Park, Bayview Beach in Milford, Hammonasset Beach State Park, Rocky Neck State Park, and Ocean Beach in New London.

Previous studies by Werth Center researchers have pointed to lack of energy in the fair-weather wave field as being responsible for chronic erosion of Connecticut beaches and exposing coastal structures and infrastructure to damages. Geomorphic evidence for such a hypothesis is the absence of shoreward transport of sediment resulting in beach profile rebuilding. In other words, there is a lack of seasonal beach profiles.

This non-textbook behavior of Connecticut beaches calls for commensurate adjustments in Connecticut's coastal management policies. Current policies have been examined and recommendations for policy changes that enhance adaptive capacity have been articulated by Ms. Mercaldi.

Results to Date/Significance

The final analysis shows that Connecticut's beaches, and the structures located behind them, are particularly vulnerable to erosion and damages due to storm waves because erosion (narrowing of the beach) is not counter balanced by beach recovery during the non-storm season. Currently, eroding Connecticut beaches are periodically replenished by importing sand and placing it on the eroded beach to build the beach back out. This approach is becoming extremely expensive. *A more sustainable strategy to maintaining coastal resilience to storms is suggested by this research.* We have termed this *beach reclamation.* In this scenario, sand eroded from the beach and transported offshore into nearshore sand bars is reclaimed and returned to the beach using basic coastal engineering technology. In more general terms, our recommendation is that beach sand be subject to *sediment management* where high-quality sediment is placed on the

beach and subsequently managed rather than being replaced when it moves offshore during large storms.

This research has led to a series of policy recommendations for the State Legislature and for the Department of Energy and Environmental Protection. General recommendations included updating the language of Connecticut's most prominent policy documents, such as the *Connecticut Coastal Management Manual* and the *Overview of the Connecticut Coastal Management Program,* to reflect the unique dynamics of Connecticut's shoreline to ensure maximum policy effectiveness. Also, the language should be updated to emphasize the *urgency* of maintaining Connecticut's beaches.

Climate change mitigation strategies for the shellfish aquaculture industry

Faculty Dr. Emma L. Cross
Environment, Geography and Marine Sciences

Acidification and hypoxia threaten the future of the US $1 billion shellfish aquaculture industry by decreasing shell growth, weakening shells, reducing meat quality and increasing mortality. One potential approach to buffer these anthropogenic effects is regenerative ocean farming, which co-cultures seaweed and shellfish. The buffering capacity of seaweed raises seawater pH and dissolved oxygen, which could promote shell production and decrease mortality of the farmed shellfish. Despite these potential benefits, it remains unknown how shellfish produced in regenerative ocean farms will fare under future acidification and hypoxia conditions. It is crucial to assess the capabilities of this emerging aquaculture technique as an acidification and hypoxia mitigation strategy for the shellfish aquaculture industry before arguing for a scaling up of regenerative ocean farming practices. This project is in collaboration with our aquaculture industry partners Cottage City Oysters, a kelp and shellfish aquaculture company off the coast of Martha's Vineyard, MA. This is a three-year project involving a two-year field study to assess whether growing kelp with shellfish enhances shell and meat quality of the farmed shellfish and three two-month laboratory multi-stressor experiments at SCSU to identify if co-culturing seaweed and shellfish benefits shell and meat quality under predicted end-century acidification and hypoxia conditions.

Results to Date/Significance

This proposed project would begin in November 2021. Dr. Cross submitted an external grant pre-proposal to NOAA for $449,153 as the Lead PI in December 2020 to support his three-year project, which was highly reviewed and encouraged to submit a full proposal that was submitted in March 2021. Dr. Cross has also applied for two internal grant competitions, Faculty Research and Creative Activity Grant in December 2020 and 2021-2022 CSU – AAUP Faculty Research Grants in January 2021 as well as for 9 hours of reassigned time via the Joan Finn Junior Research Fellowship in January 2021, to support this research project which are all currently under review. Furthermore, Dr. Cross has recently been awarded a Research and Creative Activity Reassigned Time (RCART) award for 3 credits of reassigned time from the Dean of Arts & Sciences for the Spring 2022 semester, which would accelerate the beginning of this

project if funded by NOAA or provide preliminary data to strengthen future external grant proposals.

GIS maps of Connecticut coastal harbor sediment metal contamination

Faculty

Dr. Vincent Breslin
Department of the Environment, Geography and Marine Sciences

Student Participant

Summer 2020; Fall 2020; Spring 2021

Ethan Mehlin, Undergraduate, Geography

Over the past 18 years, researchers from the Werth Center for Coastal and Marine Studies (WCCMS) have examined the spatial trends of contaminant metals in surface sediments in every major harbor in Connecticut. This sediment database contains the results of the physical and chemical analysis of over 600 sediment samples collected from 14 different Connecticut harbors and is the largest, most comprehensive, sediment metal database for Connecticut coastal embayments. The database includes sediment metals (copper, zinc and iron) and physical properties (% organic matter) and each sediment station is geo-referenced (latitude and longitude). This database represents an excellent opportunity to resolve the physical and chemical factors controlling the spatial distribution of metals in regional coastal harbors. This project will focus on preparing a visualization of the harbor sediment metal contamination using GIS mapping software. The goal is to prepare contour maps for each Connecticut harbor showing the spatial trends in sediment grain-size, organic carbon and contaminant metals. The location of each of the harbor sediment samples collected over the years has been defined by latitude and longitude. This allows for the preparation of maps identifying the location of each sample in a harbor and the use of GIS software to prepare contour maps showing the trends of sediment physical and chemical properties within each harbor.

Results to Date/Significance

Sediment metal concentrations and physical properties (grain-size and loss on ignition) were mapped in ArcMap 10.5.1 according to categories defined using sediment quality guidelines and known sediment grain-size categories. These points were analyzed using inverse distance weighting, resulting in maps that were then edited in Arcmap to have the same color scheme and comparable scale categories. Each parameter scale was created with seven or eight categories; the highest range for metals was defined by the Effects Range Median for each respective metal while the lowest category was equal to or less than each metals' respective crustal abundance.

This past year, color contour maps have been completed for Norwalk harbor, Branford harbor/river, New Haven harbor, Greenwich/Cos Cob and the Housatonic river. These maps can be useful in identifying areas within harbors for shellfish habitat restoration/expansion,

identifying areas of concern for dredging projects, inform harbor development activities, and highlight areas of concern for sediment resuspension (storm events).

The lunar effect on the natural diet of the temperate scleractinian coral *Astrangia poculata*

Faculty Dr. Sean Grace
Biology

Student Participant(s)

Academic Year 2020, 2021

Leah Hintz, Biology, Graduate Student

The effects of the lunar cycle on the natural diet of the temperate scleractinian coral *Astrangia poculata* will be investigated. Since the 1700's, the diet of this species has been documented to be a large Corophium amphipod species that is never found in the plankton though found as a substratum associated species (stays on the substrate). Given that this coral, like its tropical relatives have long tentacles to capture prey from the water column, this study will examine the lunar effect on diet of corals and how the Corophium species is influenced by the lunar stages. This will be the very first study to examine the lunar effect on temperate corals.

Results to Date/Significance

This research will be completed in spring and summer 2021.

Comparison of the environmental impacts of different types of aquaculture in LIS

Faculty Dr. Emma L. Cross
Environment, Geography and Marine Sciences

The aquaculture industry is one of the fastest growing global food sectors with 17.3 million tonnes of shelled molluscs being produced globally in 2018, representing 56.2 percent of the production of marine and coastal aquaculture producing revenue of USD 34.6 billion. In recent years, global seaweed farming has increased rapidly with almost 40 million tonnes being produced globally in 2018. It is important to quantify the environmental impacts of shellfish aquaculture, seaweed farming and multi-species regenerative ocean farms that incorporate culturing seaweed and shellfish to determine the potential environmental and economic benefits of diversifying the crop of single species ocean farming. This project would quantify water quality and faunal and floral biodiversity at a control site with no aquaculture, a shellfish-only farm provided by Indian River Shellfish, a seaweed-only farm provided by New England Sea Farms, and a regenerative ocean farm provided by GreenWave within a 8.5 mile radius in central Long Island Sound. Water quality parameters that would be measured are seawater temperature (°C), dissolved oxygen (mg/L), pH, specific conductivity (μS/cm) and salinity (ppt) using unattended continuously logging Eureka multi-probes. Biodiversity would be quantified using

lift nets, and video and still photo surveys conducted using a ROV. This project would provide the opportunity to directly compare the effects of regenerative ocean farming to those of conventional single-species aquaculture and undisturbed seafloor. Quantifying the environmental impacts of regenerative ocean farming is a necessary next step in the maturation of this promising approach to aquaculture production.

Results to Date/Significance

This proposed project would begin in February 2022. Dr. Cross submitted an external grant pre-proposal to Connecticut SeaGrant for $147,546 as the Lead PI in February 2021 to support this two-year project. This project would strengthen links between SCSU and the University of New Haven in addition to developing new collaborations with aquaculture industry partners based in Long Island Sound, including New England Sea Farms, Indian River Shellfish and GreenWave.

Seasonal variations in microplastic abundance in treated wastewater from the Meriden and North Haven wastewater treatment facilities

Faculty

Dr. Vincent Breslin
Department of the Environment, Geography and Marine Sciences

Student Participant

Summer 2020; Fall 2020

Anthony Vignola, Graduate Student, Environment, Geography and Marine Sciences

Municipal wastewater treatment facilities have been identified as primary sources of microplastics to tributary rivers and coastal estuaries through the direct discharge of treated wastewater. At present, little is known about the composition and quantity of microplastics discharged from WWTFs into tributary rivers flowing into Long Island Sound. Additional studies are necessary to better understand and quantify the magnitude of the effluent as a source of microplastics. Previous studies have shown the WWTFs may remove as much as 95-99% of microplastics in wastewater entering WWTFs. However, the large quantity of effluent discharged from these facilities still results in significant quantities of microplastics entering receiving bodies of water. Five WWTFs discharge treated wastewater into the Quinnipiac River, contributing tens of millions of gallons of treated effluent to the river daily.

The goal of this proposed research is to determine the seasonal variation in the composition and quantity of microplastic particles discharged in the effluent from two WWTFs along the Quinnipiac River: Meriden and North Haven. These WWTFs were selected based on differences in the plant design, wastewater capacity, the size of the populations served, and the ease of access to effluent discharge channels for sampling. It is hypothesized that microplastic

concentrations and composition will differ among the WWTFs sampled and vary within each facility seasonally (summer, fall, spring and winter).

Results to Date/Significance

Seasonal sampling of wastewater for microplastics was completed for both the Meriden and North Haven WWTFs. Over 6,000 microplastics were collected during this study. The majority of the microplastics identified were microfibers (74%), while lower quantities were classified as films (21%) and fragments (5%). Microfibers were also categorized by size, with 72% being ≤ 600 µm in length. These findings coincide with a study that found that microfibers released during wash cycles were commonly found at lengths of 360 µm–660 µm. Average seasonal wastewater microfiber concentrations ranged from 0.007–0.019 mf/l and average seasonal microplastic concentrations ranged from 0.009–0.025 mp/l. Box and whisker plots showed that there was no significant difference between total mean microfiber or microplastic concentrations between facilities. Linear regression analysis showed that Meriden WWTP had a statistically significant trend between microplastic/microfiber concentrations and seasonal temperature. North Haven WWTP shared a similar relationship with microplastic/microfiber concentrations and temperature, but it was not statistically significant. Based upon each WWTPs discharge volume and the mean microplastic concentration (0.017 mp/l), it was estimated that Meriden WWTP discharges 746,000 microplastics daily and over 272 million microplastics annually, while North Haven WWTP releases 200,000 microplastics daily and over 73 million microplastics annually. Continual research and awareness will hopefully encourage more mitigation efforts and reveal new ways to combat our reliance on plastics, emphasizing the primary goal of significantly reducing the amount of plastic debris presently released into the environment.

Creation of a gamefish occurrence dataset from public-focused informational newsletters

Faculty Dr. Sean Grace
Biology

Student Participant(s)

Academic Year 2020

Rebecca Hedreen, Biology, Graduate Student

In order to properly assess current ecological conditions, we need long-term ecological data. Historical ecology focuses on that long term, including the need to synthesize data from diverse sources. In the Long Island Sound, the Connecticut Department of Energy and Environmental Protection has been collecting data for both scientific and recreational purposes for decades, but the format of the recreational data (narrative) isn't suitable for scientific analysis. This project is to collate and annotate game fish occurrence data from the Fishing Report newsletters put out by

DEEP every week during the fishing season and the DEEP Trophy Fish annual reports, over a 12-year period.

Results to Date/Significance

Species, location, and measurement data (as available) have been compiled into a data set, with geolocation coordinates added for the identifiable locations. This thesis consists of the machine-readable data-set, the protocol for collating this data, and an assessment of the suitability of the data for different kinds of analysis. The expected defense date is April 2021.

Assessment of the Walk bridge construction on the sediment quality of the Norwalk river and harbor

Faculty Dr. Vincent Breslin
Department of the Environment, Geography and Marine Sciences

Student Participant

Summer 2020; Fall 2020; Spring 2021

Renee Chabot, Undergraduate, Chemistry

The Walk Bridge in Norwalk, CT is notorious for its aged mechanical mechanisms that have failed time and time again, delaying transportation on and below it on the Norwalk River. The DOT Walk Bridge Project is designed to greatly increase the dependability of service rail, but presents a challenge to the ecology of the Norwalk Harbor. The Harbor's active shellfishing industry has a large economic and cultural importance to the area; civic leaders and shellfish industry representatives are calling for water quality monitoring to protect the natural resources and shellfish beds during bridge construction. WCCMS researchers have shown that the sediment below the bridge is contaminated with metals of environmental concern. Bridge construction activities may re-suspend contaminated river sediment and transport the sediment to the outer harbor oyster beds. The re-suspended sediment may be ingested by the oysters and cause unacceptably high metal contamination in their tissues. The goal of this study is to determine the potential adverse consequences to the Norwalk River's water and outer harbor sediment quality during bridge replacement construction.

Results to Date/Significance

Sediment metal contamination (copper, zinc, and mercury) for the Norwalk river area is particularly high around the Walk bridge. Contaminant point sources include the sewage treatment plant, the highway (I95), the marinas, and the abandoned landfill. Furthermore, contaminated metals in sediment tended to co-vary. Where copper concentration was high, zinc and mercury concentration were also high. Mercury is extremely high, ranging from 0.248-1.17 mg/kg, while copper exceeds 100 mg/kg. In comparison, sediment metals in the outer harbor are presently at or slightly above their crustal (natural) abundance, which is 0.06 mg/kg for mercury

and 25 mg/kg copper. These high metal concentrations in the river directly correlate to the presence of silt-to-clay grain-size of the sediment. This is important because once construction on the bridge starts, these fine sediment grains may be resuspended into the river water and may be transported downstream. The river is tidal influenced, so sediment can flow both north and south in the river away from the construction site, affecting marine life and estuary habitats. This study has also expanded to include an analysis of both temporal and spatial variations in Norwalk river and harbor sediment.

Renee Chabot received an Undergraduate Summer Research grant ($3,000) for summer 2020 to continue her research. Her research focused on the variations in harbor sediment metal concentrations and the important physical and chemical properties in sediment determining spatial trends in sediment contamination. In addition, previous harbor sediment metal data sets are being analyzed to determine changes in sediment metal (copper, zinc and mercury) since the 1970s.

Energetic cost of maintaining calcification in marine calcifiers

Faculty Dr. Emma L. Cross
Environment, Geography and Marine Sciences

Student Participants

Spring 2021

Sara Gerckens, Undergraduate, Environment, Geography and Marine Sciences

Brachiopods possess a large calcium carbonate shell in relation to their little animal tissue. Despite this, Dr. Cross' Ph.D. research revealed that brachiopod calcification is resilient under future predicted climate change. This, however, must come at a cost to the animal as calcification is an energetically expensive process. Brachiopods are found in all of the world's oceans, albeit in a patchy spatial distribution. This project will collect brachiopods from Maine, the only accessible brachiopod collection site along the New England coastline, and reared under predicted future acidified and warming conditions in a new climate change experimental system that Dr. Cross is building in her research lab at SCSU. At designated time intervals, physiological processes such as feeding efficiency, animal tissue growth rate, metabolic rate, respiration and reproduction will be measured to reveal any modifications to their energy budget. It is crucial to determine the level of acidification and warming which will critically impact energy required for vital physiological processes.

Results to Date/Significance

Dr. Cross is currently purchasing equipment from her start-up funds and starting to build a fully automated recirculation system consisting of 40 independent units that allow the manipulation of carbon dioxide and dissolved oxygen levels via computer-controlled solenoid valves to simulate future ocean acidification and hypoxia conditions. Dr. Cross was awarded a Research and

Creative Activity Reassigned Time (RCART) award from the Dean of Arts and Sciences for 3 credits of reassigned time for the Spring 2021 semester to build this experimental system and to start research with SCSU undergraduate Sara Gerckens in the summer on this project for her Honors Thesis. This will provide preliminary data to strengthen a National Science Foundation Grant that she plans to submit in Winter 2021.

Examination for the presence of microplastics within the gills and digestive tract of Atlantic menhaden (*Brevoortia tyrannus*)

Faculty

Dr. Vincent Breslin
Department of the Environment, Geography and Marine Sciences

Student Participant

Summer 2020; Fall 2020

Maeve Rourke, Undergraduate, Environment, Geography and Marine Sciences

Microplastics, plastics < 5 mm diameter, are an emerging contaminant and represent a growing threat to coastal ecosystems due to their ability to accumulate hydrophobic contaminants and their ingestion by pelagic and benthic marine organisms. One of the keystone species in Long Island Sound is the Atlantic Menhaden (*Brevoortia tyrannus*), commonly known as Bunker. As the fish feed, they filter water through their gills which prevent harmful algal blooms, providing an important ecosystem service. Additionally, due to resource competition, Atlantic Menhaden have achieved large regional populations and support many different predatory bird and fish species. Since Menhaden are filtering the water for microscopic plankton, it is likely they are also ingesting microplastics. It is important to monitor this species because there is potential for microplastics to be ingested and the toxins they contain to bioaccumulate up the Long Island Sound food chain through predation. The purpose of this research was to determine if there are microplastics present within filter feeding fish by examining the alimentary canal and gill tissue of Atlantic menhaden (*Brevoortia tyrannus*). This study sampled 15 fish from Connecticut and Rhode Island. To examine menhaden for the presence of microplastics, the fish were dissected in order to obtain the gills and the digestive tract. These tissues were then digested separately in nitric acid and the microplastics were isolated from the digest solutions using a density separation and filtration process. Finally, microplastics were characterized by type (fiber, fragment) using a dissecting microscope and polymer composition determined by IR-ATR spectroscopy.

Results to Date/Significance

Microfibers were the predominant form of microplastic identified in menhaden. In total, 49 discrete microfibers and one microplastic fragment were found in the 15 menhaden examined (3.26 microplastics per fish). Overall, more microplastics were identified in the intestinal tissues

of the menhaden compared to the gill tissue. The majority (60%) of the fibers identified were clear. Red (17%) and blue (15%) fibers were also abundant, while there were significantly fewer black (8%) fibers. IR-ATR analysis of a fiber isolated from menhaden tissues was positively identified as polyester. The presence of microplastics within Atlantic menhaden raises concern about the potential for chemicals from the microplastics to be incorporated in fish oil supplements from reduction plants. Strategies to minimize the abundance and toxicity of microfibers in the environment include the combination of better laundering techniques, the use of natural or recycled fibers, and using bio-sourced additives within synthetic fibers.

II. Center-Directed/Sponsored Seminars

A goal of the Center is to conduct interactive faculty/student research and educational outreach programs that elucidate findings and provide public education on Long Island Sound and environs at all levels, including public schools, parochial schools, communities, and governmental agencies. As such, the Center sponsors an annual seminar series in the spring of each year. Center faculty invited three regional experts during the spring 2020 to discuss topics concerning the health and quality of Long Island Sound and its environs as part of the Fifteenth Annual Seminar Series on Environmental Issues of Long Island Sound 2020.

The seminar series consisted of three separate one-hour seminars by invited experts on Long Island Sound environmental issues during the spring 2020 semester. A number of faculty teaching marine science, marine biology, geography, zoology, environmental science and earth science courses during the spring 2020 semester attended and encouraged their students to attend the seminar series. A primary goal of the seminar series is to distribute information about Long Island Sound research among faculty and to encourage interdisciplinary collaborative research at SCSU.

Wednesday, March 4th, 1:00 - 2:00 pm, Academic Science Building 222

Dr. LaTina Steele, Associate Professor, Department of Biology, Sacred Heart University

Reef Balls as a tool for restoring salt marsh structure and function in Long Island Sound

Reef Balls as a tool for restoring salt marsh structure and function in Long Island Sound The worldwide decline of salt marshes has resulted in the loss of critical ecosystem services ranging from sequestering carbon and reducing coastal erosion to supporting a diverse and economically valuable food web. An increasing focus on coastal resilience has improved efforts to mitigate marsh loss by restoring these coastal wetlands. Rock sills and other solid structures are often installed during restoration to reduce wave energy reaching newly planted marshes, but such structures can also alter sediment transport in undesirable ways. Porous structures may minimize wave reflection and the resulting erosion while still reducing wave energy enough to allow for successful marsh replanting. This project explored the use of Reef Balls in the intertidal zone as a novel tool for reducing wave energy to facilitate *Spartina alterniflora* marsh restoration. A pilot reef was installed at Stratford Point, Connecticut in 2014, with marsh

replanting in 2014 and 2015. A larger reef was constructed along the remaining exposed shoreline at Stratford Point in 2016, with marsh replanting in 2017. Annual monitoring surveys of *Spartina alterniflora* densities and stem heights were conducted in both restored marsh areas and in a natural reference marsh at nearby Milford Point. There were substantial increases in both stem density and stem height in restored locations after just one year, especially at higher tidal elevations. Although *S. alterniflora* stems in restored locations were shorter than at the reference site, stem densities were similar after five years. To assess marsh function, Asian shore crabs (*Hemigrapsus sanguineus*) were tethered in the restored marsh locations, the reference marsh, and unvegetated areas at each site. Crab survival was low in vegetated marsh areas, suggesting that marsh restoration may reduce invasive crab abundances. These results show that Reef Balls deployed in the intertidal zone are effective at promoting successful establishment and growth of replanted *S. alterniflora*, potentially reducing invasive crab populations.

Dr. Catherine M. Matassa, Assistant Professor, Department of Marine Sciences, University of Connecticut and Dr. Maria Rosa, George & Carol Milne Assistant Professor of Biology, Connecticut College were both invited to present seminars during the spring 2020 semester but had to be canceled due to Covid-19 closure of the university. Both speakers have been invited to participate in the spring 2021 WCCMS seminar series.

III. Collaborations and Partnerships

The sound of silence; environmental benefits of solar powered pump-out boats in Branford Harbors: Dr. Grace is collaborating with Michael Pascucilla M.P.H., CF-SP, R.S., Director of Health (East Shore District Health Department, serving East Haven, Branford, and North Branford) to determine the difference in sound produced by the new solar powered pump-out vessel versus the traditional motorized pump-out vessel and relating sound to the health of local marine invertebrates.

Evaluation of Biofouling Communities on Wind Turbine Foundations at the Block Island Wind Farm, Rhode Island: Dr. Grace is collaborating with Drs. John King and Zoe Hutchinson (University of Rhode Island), Paul English (Fugro GB Marine Ltd.) and Anwar A. Khan (HDR) to re-examine (year 3) the community structure of sessile and mobile organisms on the offshore wind mill farm at Block Island, Rhode Island. This is part of a U.S. Department of the Interior, Bureau of Ocean Energy Management, Office of Renewable Energy Programs Grant. A preliminary report was submitted on 2-14-20 and results were presented at the OSM (Ocean Sciences Meeting) in San Diego a week thereafter. A final report for publication was submitted by May 1, 2020.

Similarities and differences between genomes of temperate and tropical corals: Dr. Grace is collaborating with Drs. (Ilaina Baums, Katie Barott, Kathryn Stankiewicz, Sheila A. Kitchen, and Meghann K. Devlin-Durante: Department of Biology, Pennsylvania State University; Koty Sharp: Roger Williams University; Hollie Putnam: University of Rhode Island; Randi Rotjan, Sarah Davies, John Finnerty, and Leslie Kaufman: Boston University) to determine the genome of the temperate coral *Astrangia poculata*. By determining the order of DNA nucleotides (the genome) in this corals species which, unlike tropical corals, exists over a large geographic and

temperature range (0° – 30° C) we will be able to examine the factors that are expected to affect corals and their survival in the future when sea-water temperatures and pCO2 levels are expected to increase. As of January 23rd, 2018 Dovetail has completed the sequencing and have begun the initial assembly of the genome. By late November 2019, we found that the genome a complex genome which will require more editing. At present the genes sequences are in Jean-François Flot's research laboratory at the Université Libre de Bruxelles. Jean Francoise is well known for his skills in "weird genome assemblies" which is not surprising for this unique coral. This work is complete and the current results have been presented internationally. Additionally, a publication is currently in preparation for submission to Coral Reefs.

The Maritime Aquarium at Norwalk and SCSU have developed and signed a memorandum of understanding to facilitate collaborations among faculty, staff and students of our two institutions. At present, Maritime Aquarium staff are assisting Dr. Breslin with the stocking and maintenance of the two large display aquaria associated with the Werth Center in the new science building. This past year, Maritime Aquarium Research Scientist David Hudson collaborated with Renee Chabot and Vincent Breslin in conducting the Walk bridge research in Norwalk harbor. Maritime Aquarium staff are also collaborating with Maeve Rourke by providing herring and bunker in support of her work with microplastic accumulation in LIS fish. We have submitted a Environmental Education Grant to the Mitsubishi Corp. to develop a display concerning microplastics in collaboration with the Maritime Aquarium.

Long Island Sound Coastal Embayment Water Quality Monitoring Program: WCCMS researchers are participating partners in the Long Island Sound Study funded Long Island Sound Embayment Monitoring Project. This program, now referred to as the Unified Water Study, is organizing and standardizing water quality measurements in the region to assure reliable, high quality water monitoring data for researchers and managers. This program is a collaboration between WCCMS, the Long Island Sound Study, New England Interstate Water Pollution Control Commission, The Maritime Aquarium, UCONN, Save the Sound and the Citizens Campaign for the Environment.

Marine heatwaves and the collapse of marginal North Atlantic kelp forests
Dr. Grace is collaborating with a team of international researchers to examine the collapse of kelp forests in the North Atlantic. This collaboration with Dr. Karen Filbee-Dexter (University of Western Australia; Laval University; Institute of Marine Research, Norway), Thomas Wernberg (University of Western Australia), Dr. Colleen Feehan (Montclair State University) and others are examining the ecological consequences of a change in the dominant macroalgal species in local coastal waters caused by marine heatwaves. We experimentally demonstrated a relationship between strong and severe 2018 heatwaves and high kelp mortality in both regions. Patterns of kelp mortality were strongly linked to maximum temperature anomalies, which crossed lethal thresholds in both regions. Translocation and tagging experiments revealed similar kelp mortality rates on reefs dominated by healthy kelp forests and degraded sediment-laden algal 'turfs', indicating equal vulnerability to extreme events. These results suggest a mechanistic link between MHWs and broad-scale kelp loss, and highlight how warming can make ecosystem boundaries unstable, forcing shifts to undesirable ecosystem states under episodically extreme climatic conditions. Please see Publications section.

Woods Hole Oceanographic Institute (WHOI)
Dr. Cross is collaborating with Dr. Annette Govindarajan at WHOI to conduct environmental DNA (eDNA) metabarcoding analysis to quantify biodiversity before and after the deployment of aquaculture equipment at Cottage City Oysters' new open ocean plot in Martha's Vineyard, MA. Water samples have been collected and eDNA extracted and frozen monthly since October 2020. Dr. Cross and Dr. Govindarajan are writing external grant proposals to fund this research on a long-term basis and to support a SCSU graduate student to gain training in eDNA analysis at WHOI.

Cottage City Oysters
Dr. Cross has developed a new partnership with Cottage City Oysters, a shellfish and kelp aquaculture company in Martha's Vineyard, with the ultimate goal of developing an ecolabel for sustainable aquaculture products produced in regenerative ocean farms. This collaboration began after meeting at the National Seaweed Symposium in Providence, RI in March 2020 and discussing our shared interests of providing environmental and economic resilience to the aquaculture industry. Collaborative monthly fieldwork began in October 2020 to start collecting baseline water quality and biodiversity datasets of a new open ocean plot that has had no previous aquaculture activities. This partnership has strengthened links between the seafood industry and academia and will provide fieldwork experiences for SCSU students outside of CT. It will also provide opportunities for SCSU students to be exposed to the aquaculture industry to broaden their future career prospects.

GreenWave, New England Sea Farms and Indian River Shellfish
Dr. Cross is collaborating with GreenWave, the non-profit organization who are the pioneers of the regenerative ocean farming model, to provide their expertise to Cottage City Oysters as they develop a new regenerative ocean farm. GreenWave will also be providing access to one of their regenerative ocean farms in Branford, CT to measure water quality and biodiversity of this emerging aquaculture technique if the Connecticut SeaGrant proposal gets funded. Similarly, Dr. Cross is collaborating with New England Sea Farms who would provide access to their seaweed farm in Guilford, CT and Indian River Shellfish who would provide access to their shellfish farm in Madison, CT. Combining the different perspectives of academics, conventional aquaculture farmers and emerging regenerative ocean farmers allows a transdisciplinary approach to build environmental and economic resilience for the aquaculture industry in our changing oceans. These new partnerships with a non-profit organization and the aquaculture industry in Long Island Sound will provide plentiful research experiences for SCSU students and expose the students to varied local career options.

University of New Haven
Dr. Cross is collaborating with Dr. Chris Conroy at the University of New Haven on conducting biodiversity surveys of different types of aquaculture in Long Island Sound. Biodiversity will be quantified using lift nets and video and still photo analysis using an ROV and analyzed at the University of New Haven using Dr. Conroy's expertise in biodiversity surveys.

IV. Community Outreach, Education, and Research Communication

Grace, S. Co-Organizer with Drs. Koty Sharp (Roger Williams University) and Randi Rotjan (Boston University). 6th Annual Astrangia Working Group Conference on Temperate Corals. May 2021. Roger Williams University, Bristol, Rhode Island. Astrangia History; *Arbacia punctulata* opening space for temperate corals; Marine heatwaves and species distributions.

Cross, E. L. (Invited) *Paths Converge to Purpose: Mitigating Climate Change.* Blue Earth Podcast by Future Frogmen (December, 2020). https://anchor.fm/blueearth/episodes/Paths-Converge-to-Purpose-Mitigating-Climate-Change-eorb3l

Cross, E. L. *Kelp Save the World! Quantifying Environmental Benefits of Multi-Species Ocean Farming to Generate an Ecolabel for Aquaculture Products.* Seventh Annual Fall Faculty Tapas, Southern Connecticut State University, New Haven, CT, USA. Virtual Conference (November, 2020).

Cross, E. L., Brideau, L., Triay, G., Krak, L. & Heidkamp, C. P. *Strengthening links between the aquaculture industry and academia: an action research approach to develop an ecolabel for regenerative ocean farming*. Coastal Transitions: Blue Economy Conference, New Haven, CT, USA. Virtual Conference (November, 2020).

Axon, S., Bertana, A., Graziano, M., Cross, E. L., Smith, A., Axon K. & Wakefield, A. *The Blue New Deal: Potential value, content, limitations, and implications*. Coastal Transitions: Blue Economy Conference, New Haven, CT, USA. Virtual Conference (November, 2020).

Brideau, L., Cross, E. L., Triay, G., Krak, L. & Heidkamp, C. P. *Kelp save the world: Quantifying the environmental benefit of multi-species ocean farming to generate an ecolabel to promote sustainable aquaculture products.* New England – St. Lawrence Valley Geographical Society Annual Meeting, Salem State University, Salem, MA, USA. Virtual Conference (November, 2020).

Axon, S., Bertana, A., Graziano, M., Cross, E. L., Smith, A., Axon K. & Wakefield, A. *The Blue New Deal: Potential value, content, limitations, and implications*. New England – St. Lawrence Valley Geographical Society Annual Meeting, Salem State University, Salem, MA, USA. Virtual Conference (November, 2020).

Cross, E. L. (Invited) *Resilience of marine organisms to future climate change*, Women in Ecology Seminar Series, Saint Mary's College, Indiana, USA. Virtual Seminar (November, 2020).

Cross, E. L. (Invited) *Pressing Ocean Issues*, Guest Lecture for Blue Economy Knowledge Bootcamp, Southern Connecticut State University, New Haven, CT, USA (February, 2020).

Vignola, A. (Poster). Seasonal Variations in Microplastic Abundance in Treated Wastewater from the Meriden and North Haven Wastewater Treatment Facilities. New England – St.

Lawrence Valley Geographical Society Annual Meeting, Salem State University, Salem, MA, USA. Virtual Conference (November, 2020).

Breslin, V.T. (Invited). Microplastics in Long Island Sound: From emerging contaminant to potential threat. Guest Virtual Seminar for the Friends of Outer Island, March 30, 2021.

Publications

Axon, S., Bertana, A., Graziano, M., Cross, E. L., Smith, A., Axon, K. & Wakefield, A. (under review). The U.S. Blue New Deal: What does it mean for Just Transitions, Sustainability and Resilience in the Blue Economy?. *The Geographical Journal.*

Concannon, C. A., Cross, E. L., Jones, L. F., Murray, C. S., Matassa, C., McBride, R. S. & Baumann, H. (under review). Whole-life, high CO_2 exposure does not alter temperature-specific fecundity and oocyte development in a coastal forage fish. *ICES Journal of Marine Science.*

Pessarrodona, A., K. Filbee-Dexter, T. Alcoverro, J. Boada, C. J. Feehan, S. Fredriksen, S. P. Grace, Y. Nakamura, C. A. Narvaez, K. M. Norderhaug, and T. Wernberg. (submitted). Global flattening of marine forests in the Anthropocene. Nature Communications.

Filbee-Dexter, K., S, Augustine, F. de Bettignies, M. Burrows, J. Byrnes, J. Campbell, D. Davoult, K. Dunton, C. J. Feehan, J. N. Franco, I. Garrido, S. P. Grace, K. Hancke, L. E. Johnson, B. Konar, K. Krumhansl, P. J. Moore, M. F. Pedersen, K. M. Norderhaug, A. O'Dell, A. Salomon, D. Smale, I. Sousa-Pinto, S. Tiegs, T. Wernberg, and D. Yiu. (in review). Kelp carbon sink potential increases with latitude due to slowing decomposition. PNAS

Filbee-Dexter, K., T. Wernberg, S.P. Grace, J. Thormar, S. Fredriksen, C.N. Narvaez, C.J. Feehan, and K.M. Norderhaug. 2020. Marine heatwaves and the collapse of North Atlantic kelp forests. Scientific Reports. https://doi.org/10.1038/s41598-020-70273-x

S.P. Grace, and C.J. Feehan. 2020. Temperate urchins clearing space for corals. Frontiers in Ecology and the Environment. https://doi.org/10.1002/fee.2168

Grants

Astrangia poculata as an Aquatic Symbiosis Model System. Pre-proposal submitted to the Gordon and Betty Moore Foundation Symbiosis Model Systems Solicitation. (November 18, 2019). Sean Grace collaboration with Koty Sharp (Lead Investigator-Roger Williams University), Randi Rotjan (Boston University), Frank Stewart (Georgia Institute of Technology), and Colleen Cavanaugh (Harvard University).

A Documented Phase-Shift on Temperate Reefs in Long Island Sound: from Kelp to Turf Dominance. CSU-AAUP, Faculty Research Grant. PI- S. Grace. Total Funds $4,000.

Evaluation of Biofouling Communities on Wind Turbine Foundations at the Block Island Wind Farm, Rhode Island. $19,279.00. Sean Grace collaboration with John King (University of Rhode Island Graduate School of Oceanography).

Exploring the potential of co-culturing macroalgae and shellfish as an acidification and hypoxia mitigation strategy for the shellfish aquaculture industry. National Oceanic & Atmospheric Administration (NOAA) Addressing the Impacts of Multiple Stressors on Shellfish Aquaculture through Research/Industry Partnerships ($449,153, under review, Letter of Intent submitted December 2020, highly reviewed Letter of Intent and encouraged to submit a full proposal in January 2021 and full proposal submitted in March 2021). PI – Emma Cross, co-PIs – Patrick Heidkamp (SCSU), Dan Martino (Cottage City Oysters), and Greg Martino (Cottage City Oysters).

Holland, M. (under review). *The Impact of Regenerative Ocean Farming on Biodiversity.* Undergraduate Research Grant. Southern Connecticut State University. Summer/Fall 2021. ($3,000).

Quantifying the Environmental Impacts of Regenerative Ocean Farming Compared to Conventional Shellfish and Seaweed Monoculture to Build Environmental and Economic Resilience to the Long Island Sound Aquaculture Industry. Connecticut SeaGrant Omnibus 2022 - 2024 ($147,055, under review, submitted February 2021). PI – Emma Cross, co-PIs – Patrick Heidkamp (SCSU), and Chris Conroy (University of New Haven).

Quantifying the Environmental Impacts of Regenerative Ocean Farming to Assess the Feasibility of this Emerging Sustainable Aquaculture Technique. Atlantic States Marine Fisheries Commission (ASMFC) Regional Pilot Projects in Support of Sustainable Aquaculture ($119,056, under review, submitted January 2021). PI – Emma Cross, co-PI – Patrick Heidkamp (SCSU).

Exploring the potential of multi-species ocean farming to build environmental resilience for the shellfish aquaculture industry. 2021-2022 Joan Finn Junior Faculty Research Fellowship (9 hours of reassigned time, under review, submitted January 2021).

Does multi-species ocean farming improve meat and shell quality of farmed shellfish compared to shellfish-only aquaculture? 2021-2022 CSU – AAUP Faculty Research Grants ($4,995, under review, submitted January 2021).

Does multi-species ocean farming improve the quality of shellfish aquaculture products? 2021-2022 Faculty Creative Activity and Research Grant (FCARG, $2,474, under review, submitted December 2020).

Holland, M. (Not funded – alternate student). *The Impact of Regenerative Ocean Farming on Biodiversity.* Undergraduate Research Grant. Southern Connecticut State University. Spring 2021. ($2,995).

Engaging the Long Island Sound Blue Economy. CTNext Higher Education Entrepreneurship and Innovation Fund ($118,337, funded for 01/01/2021 – 12/31/2021). Co-PIs: Patrick Heidkamp (SCSU) and Colleen Bielitz (SCSU). Named researcher – Emma Cross.

Quantifying the environmental impact of 3D ocean farming to generate an ecolabel for niche market development. National Oceanic & Atmospheric Administration (NOAA) FY21 Saltonstall-Kennedy Competition ($299,765, not funded, submitted August 2020). PI – Emma Cross, co-PI – Patrick Heidkamp (SCSU) and Annette Govindarajan (Woods Hole Oceanographic Institute).

Project Blue at SCSU Engaging the Long Island Sound Blue Economy. CTNext Higher Education Entrepreneurship and Innovation Fund ($177,946, funded for 01/01/2020 – 12/31/2020). Co-PIs: Patrick Heidkamp (SCSU) and Colleen Bielitz (SCSU). Named researchers – Emma Cross and Michaela Garland.

Examination of Atlantic Herring (*Clupea harengus*) for the Presence of Microplastics. 2019 CSU-AAUP Research Grant. Project Duration: June 1, 2019– May 30, 2020. PI – V.T. Breslin. Total Funds $5,000.

Microplastics in Long Island Sound: Pollution and Health Issues. Mitsubishi Corporation Foundation for the Americas. Co-PIs - Kalk, B. and Breslin V.T. Submitted March 2021. Total funds requested $210,000.

Outer Island Research and Education Programs. Community Foundation for Greater New Haven, Outer Island Executive Committee. (Submitted March 2020; funded May 2020-April 2021. $13,931. PI-V.T. Breslin.

Chabot, Renee. Assessment of the Walk Bridge Construction on the Water Quality of the Norwalk River. Undergraduate Research Grant. Southern Connecticut State University. Summer 2020. ($3,000).

Rourke, Maeve. Examination for the Presence of Microplastics within the Gills and Digestive Tract of Atlantic Menhaden (*Brevoortia tyrannus).* Undergraduate Research Grant. Southern Connecticut State University. Summer 2020. ($3,000).

Participation

Grace, S.P. 2020. Dr. Grace is co-host and co-organizer for the 5th Annual Temperate Reef Ecology Meeting held at Roger Williams University in summer 2021 (May 28-29). This meeting introduced over 100 coral scientists/students to temperate corals and how these corals may be used as a model system to study tropical reef systems that are currently under threat.

Cross, E. L. Seventh Annual Fall Faculty TAPAS, Virtual (Internal; 11/23/20)

Cross, E. L. Coastal Transitions: Blue Economy Conference, Virtual (International; 11/4/20 – 11/6/20)

Cross, E. L. New England – St. Lawrence Valley Geographical Society Annual Meeting, Virtual (Regional; 11/13/20 – 11/14/20)

Cross, E. L. Ocean Acidification Week, Virtual (International; 09/08/20 – 09/11/20)

Cross, E. L. The 1st Virtual Larval Fish Science Town Hall, Virtual (International; 06/23/20)

Cross, E. L. National Seaweed Symposium, Providence, RI (National; 03/02/20 – 03/04/20)

Breslin, V.T. (Participant). Long Island Sound Science and Technology Committee meeting, Virtual. (Regional; 2/19/2021)

Workshop Attendance

Cross, E. L. Northeast Coastal Acidification Network (NECAN) Webinar, Virtual (National; 01/27/21)

Cross, E. L. Mid-Atlantic Coastal Acidification Network (MACAN) Webinar, Virtual (National; 01/26/21)

Cross, E. L. Coastal Acidification Adaptation and Mitigation Strategies Webinar, Virtual (National; 12/3/20)

Cross, E. L. National Seaweed Hub Marketing Opportunities Group Meeting, Virtual (National; 10/29/20)

Cross, E. L. New Zealand Marine Science Society Webinar, Virtual (International; 07/22/20)

Cross, E. L. Future Frogmen Webinar, Virtual (National; 06/10/20)

Cross, E. L. Ocean Acidification Alliance Webinar #3, Virtual (National; 05/14/20)

Cross, E. L. Blue Economy Innovation Bootcamp, Southern Connecticut State University, New Haven, CT (Regional; 03/06/20)

Cross, E. L. Blue Economy Knowledge Bootcamp, Southern Connecticut State University, New Haven, CT (Regional; 02/21/20)

Student Theses and Reports/Advisors

Student	Thesis Title	Completion Date
Rebecca Hedreen	Creation of a gamefish occurrence dataset from public-focused informational newsletters.	May 2021
Miranda Holland	The Impact of Regenerative Ocean Farming on Biodiversity	Dec 2021
Anthony Vignola	Seasonal variations in microplastic abundance in treated municipal wastewater from North Haven and Meriden wastewater treatment plants	Aug 2020
Maeve Rourke	The presence of microplastics in the gills and digestive tract of Atlantic menhaden (*Brevoortia tyrannus*)	Dec 2020
Renee Chabot	Spatial and temporal patterns in Norwalk harbor sediment contamination	May 2021

Werth Center Fellows Alumni Update

Lauren Brideau graduated with her BS in Environmental Systems and Sustainability from SCSU in Spring 2020 and is currently working with Dr. Cross as a research assistant for the biodiversity and aquaculture research project in Martha's Vineyard. Lauren applied for the National Science Foundation Graduate Research Fellowships Program (NSF GRFP) to continue her geomorphology research conducted with the Werth Center in graduate school and was awarded an Honorable Mention. Lauren has also recently accepted a fully funded Ph.D. position at the University of Virginia where she will be working with Dr. Max Castorani on biodiversity in seagrass beds from Fall 2021.

V. Accounting, Budget Expenditures and Grant Writing

Academic Year 2020-2021 Itemized Budget Justification

Funds totaling $75,000 were requested for Year 15 (2020-2021) to support the research and educational mission of the Center (see attached budget spreadsheet). Three columns are shown in the budget sheet showing the Werth Foundation request, the Werth Foundation Fund Disbursement (how dollars were actually spent) and the SCSU Matching Funds (dollars committed by the University or obtained from other sources).

Professional Salaries and Honoraria ($11,800 expended)

Werth Foundation funds were used in support of salaries for faculty mentoring students during the summer 2020. Professors Breslin ($4,000), Tait ($3,000) and Grace ($3,000) were compensated for mentoring student research projects ($1,800 fringe benefits). The SCSU Dean of Arts & Sciences provided faculty reassigned time (3 credits time each for Breslin, Grace and Tait) during the academic year in support of managing the CCMS activities and programs. Reassigned time (9 credits) for faculty in support of CCMS management totaled $20,100.

Student Research Fellowships ($26,000 expended)

A major portion of the Center budget consists of funds in support of undergraduate and graduate student research stipends. A major goal of the Center is to increase undergraduate student participation in the processes of "doing science" through participation in faculty guided research projects. The CCMS awarded fellowships during summer 2020 (6 students; $9000), Fall 2020 (9 students; $9,000) and spring 2021 (8 students; $8,000). Fellowship amounts per student ranged from $500-$2,000 per semester (50-200 hours @ $10/hour). The CCMS has a system-wide mission to support student research. This past year, the CCMS supported thirteen different students in six different academic fields (Biology, Chemistry, Environmental Systems and Sustainability Studies, Marine Studies, Geography, and Honors) in support of faculty-directed research projects during this past year totaling $26,000.

Analytical Equipment Service Contracts ($22,006 expended)

Funds in the service contract budget category ($22,006) were used to purchase a service contract for fiscal year 2020-2021 for the PerkinElmer AAnalyst 800 Atomic Absorption Spectrophotometer ($10,292). Werth funds were also used to purchase a one-year service contract (2019-2020) for the Milestone DMA 80 Direct Mercury Analyzer ($4,500). This year the WCCMS assumed the service contract fees ($7,214) for the ICP-OES instrument in Analytical laboratory SCI 211. The ICP-OES was donated to the university by the PerkinElmer corporation and has now become an important analytical instrument for the determination of metals in environmental samples.

Ship Time ($0 expended)

Funds for chartering ship time were budgeted ($4,500) to provide access to field sample sites for research and education along the Connecticut shoreline and in Long Island Sound. No funds were expended in support of research cruises during 2020-2021. Covid-19 resulted in the canceling of field-based classes and regional boats were kept in port due to the pandemic protocols. We are hopeful that the current relaxing of Covid restrictions will allow for the chartering of boats in 2021 in support of our research programs.

Long Island Sound Seminar Series (SCSU Grant $3,000)

Funds were allocated to support the annual spring Long Island Sound Seminar Series. This year marks the 17th consecutive year that the Werth Center for Coastal and Marine Studies has hosted the seminar series. The annual spring seminar series was solely supported through a grant to Grace, Tait and Breslin by the Office of Faculty Development at SCSU ($3,000). We were only able to schedule one seminar speaker ($1,000) during March 2020 prior to the university closure.

Travel and Conference Funds ($0 expended to date)
Travel funds totaling $1,500 were budgeted to reimburse costs associated with travel in support of attendance at local, regional and national scientific meetings. Travel was largely prohibited during the pandemic.

Publication Costs ($0 expended)

A total of $600 was budgeted for publication costs for FY 2020-2021. Funds are allocated primarily in support of printing large format posters (3' x 4') for student research posters for scientific meetings. All recent meetings have been virtual and printing large format posters for presentations has been unnecessary.

New Equipment/Software Purchases ($10,207)

The DR6000 is a benchtop UV-VIS (190 - 1100 nm), split beam spectrophotometer that delivers top performance for both routine laboratory tasks and demanding applications. It offers high speed wavelength scanning across the UV and Visible Spectrum, and comes with over 250 pre-programmed methods, which include the most common testing methods used today (including nutrients). The instrument will be used in support of the Long Wharf, New Haven water monitoring program and in our instrumental/field classes in the marine studies program.

Expendable Supplies ($5,106 expended)

Funds for laboratory and office supplies ($5,000) were budgeted to allow the purchase of materials in support of the WCCMS research and educational initiatives. Supply funds were used to purchase laboratory chemicals, tank gas for instrumentation, cartridges for water purification systems, standard reference materials for laboratory instrument calibration, supplies for the sediment metals research and laboratory and field supplies for the sediment grain size and beach surveying research. Additional funds were used for the purchase of chemicals, supplies

and reagents for water quality and aquarium supplies and general office supplies. New this year was the purchase of personal protection equipment including hand sanitizer, facemasks and latex gloves. Supplies were also purchased to support educational and aquaculture activities in the Werth Center aquarium laboratory. Supplies include filter cartridges for 30-gallon aquaria, water quality test kits, and water quality meters.

WCCMS faculty purchased an additional site license for Sigma Plot 14 ($599 per license). Sigma Plot software is used in support of statistical analysis of data and as a scientific graphing software package.

Supply purchases exceeded the budgeted amount as supply needs were increased due to new research initiatives.

Balance of Funds

To date, CCMS has expended $75,219 of the $75,000 funds budgeted for FY 2020-2021. The overage is covered by funds carried forward from remaining funds in FY 2019-2020.

Matching Funds

Each of the following grant awards listed have been used in support of CCMS research and education activities.

Connecticut State University Research Grant Award 2020-2021

A Documented Phase-Shift on Temperate Reefs in Long Island Sound: from Kelp to Turf Dominance. CSU-AAUP, Faculty Research Grant. PI- S. Grace. Total Funds $4,000.

Examination of Atlantic Herring (*Clupea harengus*) for the Presence of Microplastics. 2019 CSU-AAUP Research Grant. Project Duration: June 1, 2019– May 30, 2020. PI – V.T. Breslin. Total Funds $5,000.

Chabot, Renee. Assessment of the Walk Bridge Construction on the Water Quality of the Norwalk River. Undergraduate Research Grant. Southern Connecticut State University. Summer 2020. ($3,000).

Rourke, Maeve. Examination for the Presence of Microplastics within the Gills and Digestive Tract of Atlantic Menhaden (*Brevoortia tyrannus).* Undergraduate Research Grant. Southern Connecticut State University. Summer 2020. ($3,000).