# **Coastal Resilience and Sustainability Initiative**

# Lightning Talks: Part II

## October 13, 2021



# **Mobile Robots for Coastal Aquaculture**

## **John-Paul Ore**

jwore@ncsu.edu

### Mobile Robots for Coastal Aquaculture

John-Paul Ore, Assistant Professor, Dept. of Computer Science (jwore@ncsu.edu)



The Center for Marine Sciences and Technolog

### Mobile Robots for Coastal Aquaculture

John-Paul Ore, Assistant Professor, Dept. of Computer Science (jwore@ncsu.edu)

NSF NRI: Development of a Customizable Fleet of Autonomous Co-Robots for Advancing Aquaculture (2020-2024)

![](_page_3_Picture_4.jpeg)

Dr. Sierra Young BAE

![](_page_3_Picture_6.jpeg)

Dr. Steven Hall BAE

BAE

![](_page_3_Picture_8.jpeg)

![](_page_3_Picture_9.jpeg)

![](_page_3_Picture_10.jpeg)

![](_page_3_Picture_11.jpeg)

![](_page_3_Picture_12.jpeg)

Dr. Celso Castro-Bolinaga BAE

![](_page_3_Picture_14.jpeg)

Dr. John-Paul Ore

Dr. Natalie Nelson

![](_page_3_Picture_17.jpeg)

![](_page_3_Picture_18.jpeg)

![](_page_3_Picture_19.jpeg)

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![](_page_3_Picture_26.jpeg)

![](_page_3_Picture_27.jpeg)

![](_page_3_Picture_28.jpeg)

# Measuring coastal floods & impacts

### Katherine Anarde

Assistant Professor, Coastal Hazards Lab Dept. of Civil, Construction, and Environmental Engineering

kanarde@ncsu.edu

## At the beach, during high surge & wave events

![](_page_5_Picture_2.jpeg)

**Goal:** Capture perishable observations of storm processes to improve predictive models of landscape change

> CoAStal Community IAnDscape Evolution (CASCADE) model

> > human-dynamics model

Barrier3D

geomorphic model

## In storm drains, to capture "sunny day" floods

![](_page_6_Picture_2.jpeg)

# Should Sunny Day Floods Trigger Swim Advisories?

### Natalie Nelson

**Biological and Agricultural Engineering** 

nnelson4@ncsu.edu

Stormwater runoff is a dominant form of pollutant transport to coastal waters, and leads to shellfish harvest area closures and beach closures

![](_page_8_Figure_1.jpeg)

Our team develops predictive models to anticipate public health threats in coastal waters and support **precision management** of coastal water quality

![](_page_8_Picture_3.jpeg)

Rainfall is the primary management trigger for coastal water closures, but what about other "flushing" events, like sunnyday floods?

![](_page_9_Picture_1.jpeg)

# **Executive Order 80 and post-Florence**

efforts at the state level

Sarah Spiegler Coastal Resilience Specialist | NC Sea Grant NCSU Center For Marine Sciences and Technology | Morehead City sespiegl@ncsu.edu

![](_page_10_Picture_3.jpeg)

# Post-Hurricane Florence: New Resilience Efforts in NC

- Gov. Cooper's **Executive Order 80**: NC's Commitment to Address Climate Change and Transition to a Clean Energy Economy (2018)
- NC Office of Recovery and Resilience (NCORR) created: Jessica Whitehead--first NC Chief Resilience Officer (2019); Dr. Amanda Martin (2021)
- NC Climate Risk Assessment and Resilience Plan (2020)

![](_page_11_Picture_4.jpeg)

# NC Resilient Coastal Communities Program

![](_page_12_Picture_1.jpeg)

Access the NC RCCP Program Planning Handbook here: https://files.nc.gov/ncdeq/Coastal%20Management/Resilience/20 -21-phase-1---2-applications/RCCP-Planning-Handbook.pdf

![](_page_12_Figure_3.jpeg)

# Co-Designing Communication and Control Systems for Resilient Operation of Electric Microgrids

# Aranya Chakrabortty

Electrical and Computer Engineering achakra2@ncsu.edu

![](_page_14_Figure_0.jpeg)

### Some research keywords for this co-design:

- Combinatorial optimization
- Distributed optimization
- Data-driven optimization
- Optimal control
- Wireless communications
- Bandwidth allocation
- Graph theory
- System Identification, topology identification
- Distributed Resource Allocation
- Weather Forecasting
- Smart charging for electric vehicles

Please email me if you are interested to hear more! Email: <u>achakra2@ncsu.edu</u> NSF FREEDM Systems Center, Keystone 200

![](_page_16_Picture_1.jpeg)

Achieving Decarbonization and Reliability in Future Power Grids

Jeremiah Johnson

Civil, Construction & Environmental Engineering

October 13, 2021

![](_page_16_Picture_6.jpeg)

# It helps to be flexible!

![](_page_17_Figure_1.jpeg)

# Generation and demand must be balanced in real time.

We get solar and wind generation when it is sunny and windy.

We need dispatchable, fast ramping resources to balance the grid.

Deep decarbonization of power systems will require off-peak generation, demand response and/or energy storage. Can we use geologically stored CO<sub>2</sub> in sedimentary basins to generate flexible geothermal power?

![](_page_18_Picture_1.jpeg)

Bielicki et al, Joule, revise & resubmit, 2021 Funding: Sloan Foundation Can solar power and grid-scale batteries help meet peak power demand?

![](_page_18_Figure_4.jpeg)

Can we use buildings' heating and cooling systems

to provide flexible demand to the power system?

Can we operate our power plants differently to reduce adverse human health impacts?

![](_page_18_Figure_6.jpeg)

Luo et al, Environmental Research: Infrastructure & Sustainability, in press, 2021 Funding: NSF

![](_page_18_Figure_8.jpeg)

![](_page_18_Figure_9.jpeg)

Keskar et al, Environmental Research: Infrastructure & Sustainability, in review, 2021

Funding: Department of Energy

![](_page_19_Picture_0.jpeg)

# Citizen Utilities For Coastal Resilience and Sustainability

Mo-Yuen Chow, Ph.D., Professor

Advanced Diagnosis, Automation, and Control (ADAC) Laboratory Department of Electrical and Computer Engineering North Carolina State University Raleigh, North Carolina U.S.A.

chow@ncsu.edu https://moyuenchow.wordpress.ncsu.edu/

![](_page_19_Picture_5.jpeg)

![](_page_19_Picture_6.jpeg)

## Citizen Utilities and Distributed Energy Resources

(\$ Millions)

A Đ

- Coastal Grid vulnerability
  - Affected by weather
  - Impacts social and economic growth ٠
  - Critical for coastal communities ٠
- Citizens Utilities •
  - Citizens forming nano- and micro-grids
  - Sustainable energy locally/regionally
  - Community and grid resilience
  - Stable economic growth, disaster recovery and population growth

![](_page_20_Figure_11.jpeg)

![](_page_20_Picture_12.jpeg)

## Citizen Utilities for Coastal Resilience and Sustainability

Collaborative Resilient and Intelligent resource Management for a SUstainable human-Nature ecosystem (CRIMSUN)

![](_page_21_Figure_2.jpeg)

### • Seeking collaborators to form a multi-disciplinary team:

Engineers, economists, climate change and weather scientists, urban/rural planners, human behavior and psychologists, statisticians, extension specialists, the local economic development councils, electric utilities, and other key stakeholders to explore the interactions between nature, people, essential services, and disaster recovery.

![](_page_21_Figure_5.jpeg)

# Carolina Alternative Fuel Infrastructure for Storm Resilience

Heather Brutz, NC Clean Energy Technology Center hmbrutz@ncsu.edu

![](_page_22_Picture_3.jpeg)

## **Overview**

- Project partners are working together to create a plan for NC and SC for alternative fuel infrastructure to enhance resilience in the face of storms.
- Core project partners: E4 Carolinas (lead), NC Clean Energy Technology Center, Triangle J Council of Governments, Centralina Council of Governments, Duke Energy, Advanced Energy
- We are looking at the infrastructure needed to both support EV drivers during evacuations and to support the ongoing operations of first responders using alternative fuel vehicles during natural disasters.

![](_page_23_Picture_5.jpeg)

## **Components of Project**

- Mapping current infrastructure and alternative fuel using first responder fleets in the Carolinas and identifying potential disruptions
- Modelling wait times at public chargers for EV drivers during an evacuation depending on different assumptions
- Investigating best practices used elsewhere in the United States and the world
- Formulating recommendations for public agencies to aid them in increasing the robustness of fueling infrastructure.

![](_page_24_Picture_6.jpeg)

## **Open Source Energy System Modeling**

Coastal Resilience Lightening Talk October 13, 2021

Joe DeCarolis Civil, Construction, and Environmental Engineering NC State University jdecarolis@ncsu.edu; @jfdecarolis

![](_page_26_Figure_1.jpeg)

We're examining technology and policy pathways to achieve deep decarbonization in the United States using open source tools and data.

### Analyzing the Technical and Economic Performance of Offshore Energy

![](_page_27_Figure_2.jpeg)

![](_page_28_Picture_1.jpeg)

## New approach for oceanic energy harvesting

Veena Vallem, <u>vvallem@ncsu.edu</u> Advisor: Michael Dickey, <u>mddickey@ncsu.edu</u>

Dept. of Chemical and Biomolecular Engineering NC State University

![](_page_28_Picture_5.jpeg)

North Carolina Renewable Ocean Energy Program

## New approach for oceanic energy harvesting

![](_page_29_Picture_1.jpeg)

![](_page_29_Figure_2.jpeg)

![](_page_29_Picture_3.jpeg)

✓ Renewable

- No carbon emissions
- ✓ Inexpensive
- Easy to integrate with existing technology
- Friendly to marine life No rotating blades or noise unlike turbines
- Not prone to corrosion Not only tolerates salt water, the device requires it

Vallem, V., Roosa, E., Ledinh, T., Jung, W., Kim, T.-i., Rashid-Nadimi, S., Kiani, A., Dickey, M. D., A Soft Variable-Area Electrical-Double-Layer Energy Harvester. Adv. Mater. 2021, 2103142.

# **Quantifying Changing Precipitation in a Warmer Climate for Resilient Design**

# Jared H. Bowden

jhbowden@ncsu.edu

10 year

### **Quantifying Changing Precipitation in a Warmer Climate for Resilient Design**

Jared H. Bowden (jhbowden@ncsu.edu), Senior Research Scholar / SECASC / Applied Ecology

![](_page_31_Figure_3.jpeg)

----- 100 years ----- 1000 years

North Carolina Highway Patrol drone image of I-40 after Florence, September 14<sup>th</sup>, 2018

### Climate Change Projections & Quantifying Future Rainfall Uncertainty Downscaling of Global Climate Models (GCMs) required

### Need studies comparing various downscaling methods (data available)

Design Rainfall Approach Change in maximum daily rainfall (50yr storm) applied to Hurricane Matthew (end-century RCP8.5) <u>Using Dynamically Downscaled Rainfall Data</u>

![](_page_32_Figure_4.jpeg)

Change in maximum daily rainfall (50yr storm Neuse River; end-century RCP8.5) <u>Statistically Downscaled Rainfall Projections</u> (multiple GCMs for different statistical methods)

![](_page_32_Figure_6.jpeg)

# Forested coastal wetland resilience

![](_page_33_Picture_1.jpeg)

Marcelo Ardón Associate professor Forestry and Environmental Resources <u>mlardons@ncsu.edu</u>, Twitter @Ardonlab

![](_page_34_Figure_0.jpeg)

![](_page_34_Picture_1.jpeg)

Hurricanes 2006-2018

![](_page_34_Picture_3.jpeg)

![](_page_35_Picture_0.jpeg)

![](_page_35_Figure_1.jpeg)

![](_page_35_Picture_2.jpeg)

![](_page_35_Figure_3.jpeg)

![](_page_35_Picture_4.jpeg)

![](_page_35_Figure_5.jpeg)

# **Phytotoxins in North Carolina Waters**

## **Astrid Schnetzer**

aschnet@ncsu.edu

![](_page_37_Picture_0.jpeg)

## **Phytotoxins in North Carolina Waters**

**The Problem:** "....global increase in the frequency, magnitude, and geographic extent of HABs events over the preceding two decades"

![](_page_37_Picture_3.jpeg)

**<u>Plankton Ecology Lab</u>** Marine, Earth and Atmospheric Sciences

Schnetzer Astrid: aschnet@ncsu.edu

### **Cyanotoxins, Domoic Acid** hepato-, cyto-, endo-, neuro-, and dermatoxin

adapted Song et al. 2015 Aerosolization **Cellular** Toxin Food Web **Dissolved Toxin** Transfer Drinking Water **Pathways of toxin** exposure 20 micrometer

![](_page_38_Figure_0.jpeg)

### **Consequences:**

- Water quality issues (clarity)
- Safe drinking water
- Safe recreation
- Ecosystem regime shifts
- Fish kills (anoxia)
- Pet deaths
- Human health risks
- Socioeconomic impacts
- Property values

. . . . . . . . .

![](_page_38_Picture_11.jpeg)

- Mixture of toxins detectable year-round - chronic exposure risks?
- Record levels of microcystin during summer of 2019 in the Chowan River/Albemarle region
- Varying fish, blue crab and clams test positive in the western Albemarle Sound
- Freshwater and marine toxins merge in marine sounds and are detectable in shellfish (Collaboration with Dr. Ben-Horin at CMAST)

TENER COLOR CONTRACTOR CONTRACTON

NC STATE

Center for Human Health and the Environment

# Towards Real-Time Fecal Indicator Bacteria Monitoring in Nearshore Waters

Natalie Nelson (BAE Dept.) Angela Harris (CCEE Dept.) Chris Osburn (MEAS)

**RISF Funded** 

![](_page_40_Picture_1.jpeg)

- Monitoring fecal indicator bacteria involves tests that require 18-24h before you get results
- Water quality varies over short time scales
- Often postings aren't reflective of current water quality
- Can we predict FIB real-time using a multi-parameter sonde?

# Research Aims

- Use multi-parameter sonde to measure multiple water quality covariates (e.g., pH)
- Collect *E. coli* and enterococci measurements at high temporal and spatial resolution
- Develop FIB predictive models using machine learning algorithms

![](_page_41_Picture_5.jpeg)

# Resource Economic Policy and Governance: Coastal Economies

Dr. Eric C. Edwards

Department of Ag and Resource Economics

Assoc. Dir., Center for Environmental and Resource Economic Policy (CEnREP)

E: Eric.Edwards@ncsu.edu

T: @NCWaterEcon

W: ericcedwards.com

Climate Change and Onsite Wastewater Treatment Systems in the Coastal Carolinas

- Assess relative effectiveness of onsite technologies under various climate conditions
- Estimate economic return on onsite climate adaptation technologies
- Expand legal analysis of regulatory barriers and solutions to barriers
- Share with planners and officials

### Website

ncseagrant.ncsu.edu/programareas/sustainable-communities/climatechange-and-onsite-wastewater-treatmentsystems-in-the-coastal-carolinas/

![](_page_43_Picture_7.jpeg)

# The Economic Impact of N.C. Fisheries

![](_page_44_Picture_1.jpeg)

### North Carolina's Wild-Caught Commercial Seafood Industry

MAKING A SPLASH ON THE COAST AND ACROSS THE STATE

North Carolina's wild-caught commercial seafood industry provides nearly \$300 million in economic impact and 5,500 jobs in the state. While the largest impacts occur in the harvesting sector along the coast, the industry also includes the seafood preparation and wholesaling, retail, and restaurant sectors. Growing inland consumer demand for local seafood is increasing the economic impact of the industry across the state via restaurant and retail sales. This project was funded through the N.C. Division of Marine Fisheries Commercial Fishing Resource Fund Grant Program.

### Total Income

Commercial Fishing economic impact employment

Seafood Preparation and Processing economic impact employment

Fish Markets and Retailers economic impact employment

Seafood Restaurants economic impact employment

Total economic impact employment

![](_page_44_Picture_11.jpeg)

\$65.8N Seafood Preparation and Processing \$5.4M \$5.3M Fish Markets and Retailers Seafood Restaurants \$2.1M North Coast Total \$78.6M

![](_page_44_Picture_13.jpeg)

Commercial Fishing \$48.6M Seafood Preparation and Processing \$3.2M \$0.6M Fish Markets and Retailers Seafood Restaurants \$5.0M \$57.5M Central Coast Total

![](_page_44_Picture_15.jpeg)

Commercial Fishing \$21.6M Seafood Preparation and Processing \$1.8M Fish Markets and Retailers \$1 0M Seafood Restaurants \$6.0M South Coast Total \$30.3M

### VALUE ADDED INCOME

All figures are value-added income for 2019. For commercial fishing value-added is total sales. At the \$80.3M seafood processing restaurant and retail levels value-added is sales minus the cost of non-labor inputs. Value-added does not include non-North \$47.3M Carolina inputs, and avoids double counting product 1.043 used several times in the production chain, Economists view value-added as the most accurate \$297.3 measure of economic impact

Methodology and addition details for the estimates included in this factsheet are available by emailing eric edwards@ncsu.edu

Prepared by Dr. Eric Edwards, NC State' Department of Agricultural and Resource Economics February 2021

\$155.3M

2.660

\$14.4M

210

![](_page_44_Picture_21.jpeg)

### The Economic Impact of North Carolina's Shellfish Mariculture Industry

OYSTER FARMING HAS EMERGED AS A KEY COASTAL INDUSTRY

North Carolina's shellfish industry provides over \$27 million in economic impact and 532 jobs in the state. Until 2016, this sector's impact was primarily due to the harvest of wild clams and oysters. More recently, wild harvests have declined and cultivated ovsters now represent over half of the total economic impact of shellfish in the state

Our estimates suggest farmed oysters contribute over \$14 million to state GDP and 271 jobs. Growing inland consumer demand for oysters, especially from restaurants, is increasing the economic impact of the industry across the state.

![](_page_44_Picture_26.jpeg)

![](_page_44_Picture_27.jpeg)

![](_page_44_Picture_28.jpeg)

Southern District Farmed Oyster Harvest: \$0.83M Wild Oyster Harvest:

Methodology and additional details for the estimates included in this factsheet are available by emailing eric edwards@ncsu.edu.

\$0.55M

\$0.07M

\$1.53M

\$0.41M

Prepared by Dr. Eric Edwards, N.C. State Department of Agricultural and Resource Economics

### N.C. Shellfish Landings

![](_page_44_Picture_33.jpeg)

2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 Wild Oysters Wild Clams Farmed Oysters Farmed Clams

### Farmed Shellfish Economic Impact

economic impact employment	\$6.77M 118
Preparation and Processing economic impact employment	\$0.84M 12
Fish Markets and Retailers economic impact employment	\$0.57M 11
Seafood Restaurants economic impact employment	\$5.89M 130
Total economic impact employment	\$14.06M 271

### **Central District** VALUE ADDED INCOME

All impact figures are value-added income for 2019. For the harvesting sector value-added is total sales. At the processing, restaurant, and retail levels, value-added is sales minus the cost of non-labor inputs. Value-added does not include non-North Carolina inputs, and avoids double counting product used several times in the production chain. Economists view value-added as the most accurate measure of economic impact.

May 2021

### Website: go.ncsu.edu/NCSeafoodDemand

\$1,49M

![](_page_44_Picture_42.jpeg)

![](_page_45_Picture_1.jpeg)

## Academic Acceleration: Can We Meet the Grand Challenge?

### **Coastal Resilience and Sustainability (CRS)**

Julie Swann, PhD Allison Distinguished Professor and Department Head ISE, North Carolina State University Affiliate, UNC-Chapel Hill Oct 2021

jlswann@ncsu.edu or ise@ncsu.edu

![](_page_46_Picture_0.jpeg)

## Industrial and Systems Engineering (ISE)

### What is industrial and systems engineering? (IISE official definition)

Industrial and systems engineering is concerned with the design, improvement and installation of integrated systems of people, materials, information, equipment and energy. It draws upon specialized knowledge and skill in the mathematical, physical, and social sciences together with the principles and methods of engineering analysis and design, to specify, predict, and evaluate the results to be obtained from such systems.

- ISE makes "things" or systems more
  - Efficient, Effective, or Equitable
- The People Engineering
- NC State ISE Strengths
  - Health & Humanitarian, Human-Systems (& Technology)
    Manufacturing, Supply Chain & Logistics,
    System Analytics & Optimization
- Ex: Pandemic modeling, prediction, intervention, response

![](_page_46_Picture_11.jpeg)

Complex System Long Time Horizon Uncertainty Limited Resources Multiple decision-makers

> Agriculture Energy & Power Health Infrastructure Manufacturing Supply Chains Transportation

![](_page_47_Picture_0.jpeg)

## **Opportunities**

- Breed multi-discipline educational innovation
  - Stakeholder-centered, problem-based learning (PBL) for multi-disciplinary student teams to tackle challenging environmental and sustainability challenges affecting society
- Build it, and expand
  - Leverage broadly across NC State
  - Template for expansion to other universities
  - Accelerate capabilities of students, faculty, practitioners
- Germinate research collaborations that lead to impact (short, medium, and long-term)
- Ex: Center for Health & Humanitarian Systems in 2007

(GT)

jlswann@ncsu.edu or ise@ncsu.edu

External Partners (companies, utilities, non-profits, government)

Engineering Physical sciences Social sciences Policy

![](_page_47_Picture_15.jpeg)

# Rewilding Architecture: Building as Ecosystem Enhancement

## George Elvin gelvin@ncsu.edu

# Florence, Floods, Forests and Wastewater Treatment

## **Elizabeth Nichols**

egnichol@ncsu.edu

# **Evaluating the Potential of Natural Infrastructure for Flood Mitigation**

# **Barbara Doll**

bdoll@ncsu.edu

## Questions about today's presentations? Contact individual presenters for questions about their work.

## Questions about the Coastal Resilience and Sustainability Initiative? Contact Mary Watzin <u>mwatzin@ncsu.edu</u> or Amanda Jueller <u>ammuell2@ncsu.edu</u>