Changes in the **ebb and flow**

Ocean engineering helps ensure a productive estuary

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AT 6 in the morning, beneath the pastel hues of dawn's first light, the 26-foot University of Maine research vessel *Nucella* pushes through the calm waters of the Damariscotta River as the full moon sinks slowly beyond the western horizon.

Onboard, Kimberly Huguenard and a team of researchers, armed with a suite of high-resolution sensors, prepare to collect data that will help build a baseline understanding of the hydrodynamic properties of the Damariscotta River estuary system.

Huguenard, an assistant professor of ocean and marine engineering who joined the Department of Civil and Environmental Engineering in 2015, is conducting research to help understand the impacts of a changing climate and the potential expansion of aquaculture on the Damariscotta River.

"We know that aquaculture activity will continue to increase in the future, and the information we are gathering is important to help inform sustainable growth," says Huguenard, "particularly within a changing climate."

In 2014, the economic impact of Maine's aquaculture industry totaled just over $137 million, and the Damariscotta River has become largely synonymous with high-quality sea-farmed oysters, mussels and seaweed. The river has sustained successful aquaculture farms for decades — 80 percent of Maine's oysters are grown within the highly productive estuary.

An estuary is a tidal interface between river and ocean where freshwater and marine ecosystems meet, and due to the Damariscotta's unique bathymetry, water temperature and current velocities can vary widely throughout. This creates prime opportunities for farmers to grow multiple species, each best

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Kim Huguenard and her research team are beginning to understand the complex processes at work in the Damariscotta. Exploring and understanding those present-day conditions will allow them to be accurately modeled in the future using projected climate change scenarios.

suited for specific environmental conditions, all within the same estuary system.

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However, climate change will influence the region's sea level, precipitation rates and tidal flow, each of which will have a direct impact on the flow of water and materials through the estuary system, says Huguenard.

ESTUARINE CIRCULATION is the process that governs long-term material transport in an estuary system. This transport can significantly vary spatially throughout the estuary and during different forcing conditions; for example, during spring and neap tides, and seasonal precipitation increases and decreases. Huguenard and her crew are beginning to understand these complex processes so they can be accurately modeled in the future using projected climate change scenarios.

Throughout the 13-hour cruise, the researchers collect detailed measurements along a lateral transect of the river using an Acoustic Doppler Current Profiler (ADCP), an Acoustic Doppler Velocimeter (ADV) and a Vertical Microstructure Profiler (VMP). These instruments record a variety of parameters, including current speed, turbulence, temperature and density, as well as turbidity and fluorescence throughout the water column.

In the cramped deckhouse on the boat, two laptops collect data as the vessel tracks slowly, back and forth, across the width of the Damariscotta River. Combined, the varied data build a comprehensive profile of the underlying physics of the river as it changes throughout a complete tidal cycle.

Huguenard and her team will conduct other data collection cruises throughout the year and in different locations in the estuary to reflect a variety of environmental conditions.

She also is investigating the physics of tidal and subtidal variability, and how these might change with an increase in sea level. Tidal flow and subtidal water level can vary greatly throughout an estuary system. The physical nature of these variations is important to understand because the flows are directly connected to material transport, Huguenard says.

Sixteen pressure and temperature sensors at different locations throughout the estuary collected data throughout the summer and fall to build a baseline understanding of the tidal and subtidal dynamics of the Damariscotta River. Huguenard is planning to scale up the project to include volunteer citizen scientists and aquaculture stakeholders in this and other estuary systems along the coast. She hopes to capture data on future storm surge events and their effects through the networks of sensors.

> “I'm applying my research to an industry that **matters to the people of Maine.** It affects where they live and where they work.” Kim Huguenard

MUCH OF the data from these studies will be used to help develop and enrich predictive and analytical models of the Damariscotta River estuary. The models will be capable of simulating a number of different variables, including current velocity, temperature, salinity and material transport throughout the estuary system.

Researchers also will be able to model how systems critical to estuary health and aquaculture productivity will respond to a variety of changes.

In addition, Huguenard will model the hydrodynamic changes that aquaculture infrastructure — farm size, placement or equipment design — induce on the circulation in the Damariscotta estuary. She asks an important question: How much can aquaculture activities be expanded before they unfavorably change the natural characteristics of the system?

"The impact of larger and more prevalent aquaculture farms can be modeled so that expansion activities can be conducted in a sustainable manner, for both the industry and the environment," says Huguenard.

Previous studies have shown that aquaculture farms can reduce flow up to 40 percent. Understanding the impact of aquaculture infrastructure on the flow of the estuary system is important. Flow influences water quality, material transport and nutrient supply to farms.

Not considering these effects can result in the overestimation of the supply of nutrients essential for some aquaculture species like bivalves, and by extension, overestimation of the carrying capacity of the system itself, says Huguenard.

She hopes the study will help aquaculture farmers make informed decisions about farm location, size, design and sustainable growth strategies, and shed light on how the carrying capacity of the Damariscotta River might change with expansion of the rapidly growing industry.

Huguenard's research is supported by UMaine's Sustainable Ecological Aquaculture Network (SEANET) project. Funded by a five-year, $20 million research grant from the National Science Foundation, the SEANET project is the largest award NSF has granted in aquaculture research.

Interdisciplinary researchers from UMaine and 10 other institutions — are working collaboratively throughout the coast of Maine to determine the social, economic and ecological potential and impacts of aquaculture expansion in Maine.

"I'm applying my research to an industry that matters to the people of Maine," says Huguenard. "It affects where they live and where they work. It affects their livelihood." ■

MAINE SIGNATURE AREA

Marine Sciences

The University of Maine Signature Area of Excellence in Marine Sciences includes a multidisciplinary Marine Research Solutions initiative to improve understanding of the physical, biological and socioeconomic processes that shape the ocean. Goals include being a reliable, deeply engaged partner with policymakers, fisheries stakeholders, marine industries and coastal communities, helping to develop solutions for the broad array of issues associated with Maine's marine resources; and providing high-quality, interdisciplinary undergraduate and graduate education, outreach and research for the Gulf of Maine.