# ENHANCED AQUACULTURE PRODUCTION THROUGH REMOTE SENSING, FIELD STUDIES AND INDUSTRY PARTNERSHIPS

**Matthew W. Gray, Damian C. Brady, Jordan Snyder, Teiga Martin, Breanna Whittemore, and Kathy Miller**

School of Marine Sciences University of Marine, Orono Maine 04469

## Site Selection For Aquaculture

**A**quaculture production is increasing globally to meet the growing demand for seafood (**Fig. 1**).

The **S**ustainable **E**cological **A**quaculture **Net**work (**SEANET**) seeks to expand and enhance aquaculture production in Maine to meet domestic demand and bolster this emerging industry. With >3,000 miles of coastline, **identifying suitable habitat for aquaculture in Maine is a daunting but potentially lucrative and necessary task** to optimize production and profitability of farms.

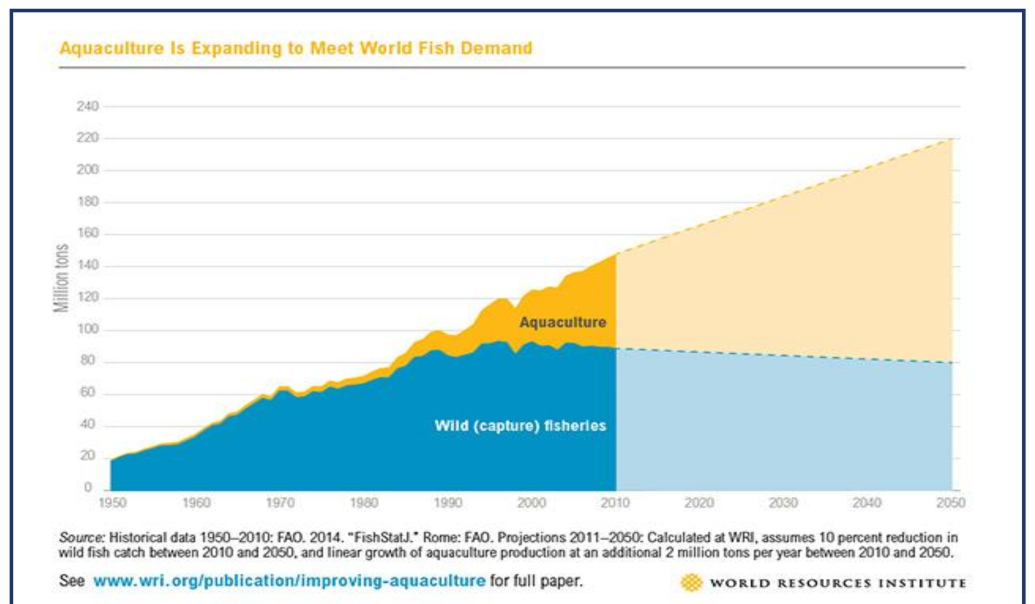


**Figure 1.** Aquaculture and wild fisheries production from 1950-2010 with production projections to 2050. It is projected that culturing species will become increasingly important as global population rises and wild fishery stocks decline (FAO 2016)

## Remote Sensing And Field Studies To Aid Aquaculture

The physiology of filter-feeding bivalves (mussels and oysters) respond to temperature, salinity, food quality and quantity and other environmental factors all of which vary spatially and temporally in estuaries. As a result, it is critical to capture a wide variety of physical, chemical, and biological data and pair it with animal/crop growth metrics. Using an array of tools and sampling efforts, SEANET collected data in the Damariscotta River in 2016 (**Table 1**).

These data are also relevant and useful for other aquaculturists and resource managers; for example, Land Ocean Biogeochemical Observatory (LOBO) buoys (**Fig. 2**) transmit real-time data (maine.loboviz.com) that is used by hatchery managers on the Damariscotta River Estuary (e.g. Mook Sea Farm) to decide when to transfers animals outdoors for field culture.

**Figure 2.** Land/Ocean Biogeochemical Observatory buoys collect a wide variety of environmental data.

**Figure 4.** Turner Designs C-Sense PCO2 sensor

**Table 1. Tools and parameters used to model oyster growth and map habitats aquaculture**

| Monitoring Tool | Parameters | | | Resolution | | Need Addressed |
|---|---|---|---|---|---|---|
| | Physical | Chemical | Biological/ Bio-Optical | Temporal | Spatial | |
| Land/Ocean Biogeochemical Observatory | Depth<br>Temperature<br>Current Speed<br>Current Direction | pH<br>Oxygen<br>Salinity<br>Nitrate | Chl-a<br>CDOM<br>Turbidity<br>Transmission | Hour | Single Point | Habitat Suitability |
| Oyster Growth | | | Shell Height<br>Total Wet Weight | Weekly | Single Point | Growth and Yield Potential |
| Oceanographic Cruises | Depth<br>Temperature | pH<br>Oxygen<br>Salinity | Chl-a<br>Secci<br>Zooplankton | Biweekly | Depth Profiles Throughout The Estuary | Habitat Suitability |
| C-Sense | | PCO2 | | Minute | Single Point | Carbonate Chemistry /Habitat Suitability |
| Satellite | Temperature | | Chl-a<br>Turbidity | 16 day | 60-100 m² | Habitat Suitability |

## Current SEANET Sampling Array

Oceanographic and sampling occur throughout the Damariscotta River (**Fig. 3**). **LOBOs** were deployed throughout the estuary to characterize biogeochemical cycles of the system. **Caged oysters** were deployed under LOBO buoys and monitored for growth from July to Nov 2016. **Oceanographic cruises** profiled physical, chemical, and biological data at 5 stations throughout the estuary to increase spatial coverage of the monitoring program. PCO2 was monitored using a **C-Sense (Turner Designs®) (Fig. 4)**, which when paired with pH sensors on the LOBOs, constrained the carbonate chemistry within the estuary. CaCO3 saturation state is an important metric to track for hatchery and field production of oysters.

This sampling scheme will be moved to other bioregions throughout Maine's coastline between 2017-2019 to characterize and map aquaculture suitability throughout the state.

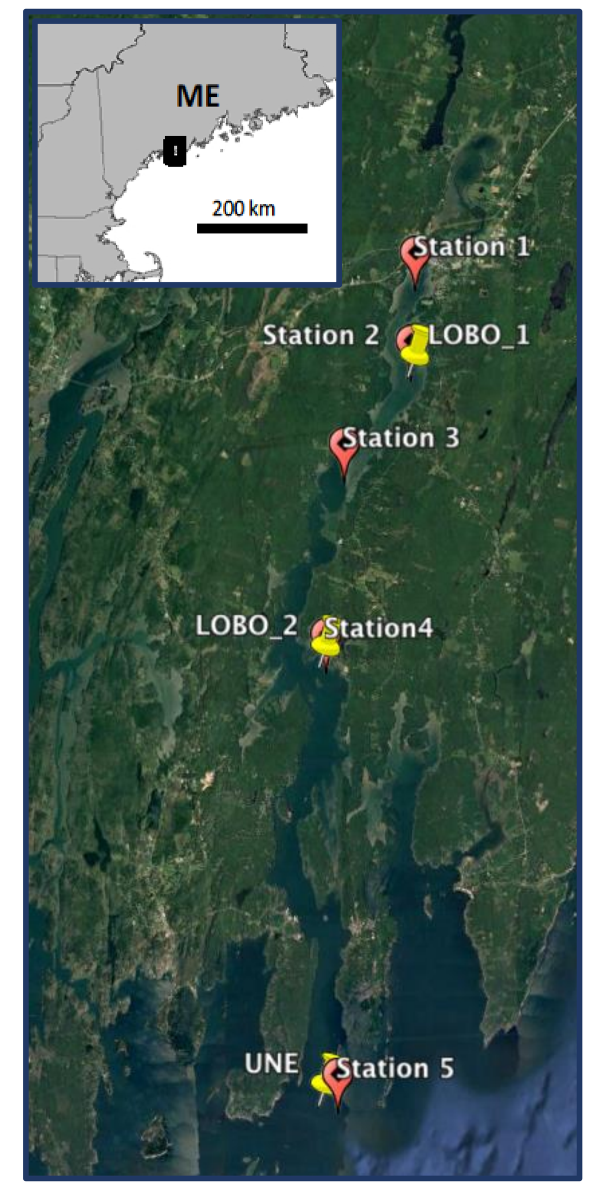


**Figure 3.** Buoy deployment location and sampling stations in the Damariscotta River Estuary

## Developing Oyster Growth Models And Habitat Maps

Environmental data and oyster growth data is being incorporated into statistical models to determine drivers of oyster growth (**Fig. 5**). Secondly, these same data will be used in ShellSIM, which is specifically designed to estimate production rates, profitability, and environmental impacts of shellfish aquaculture.

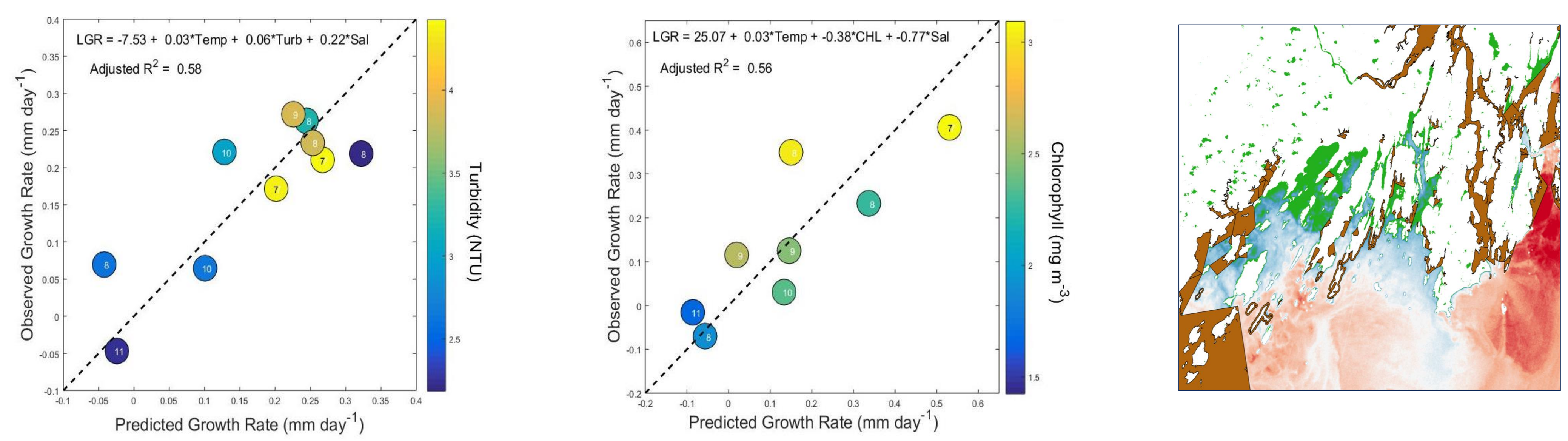


**Figure 5.** Best Fit Model Uses Temperature, Turbidity, Salinity at LOBO 1 (**LEFT**) while Temperature, Chlorophyll-α and salinity were found to the drivers oyster growth at LOBO 2 (**MIDDLE**). Data points represent weekly growth rates. Numbers within points are month numbers the data were collected. These data will be incorporated into first generation of habitat models created through ShellSIM (**RIGHT**). Within this map, green, blue and red areas represent sites with high, moderate and low growth potential areas for aquaculture, respectively. Brown areas are closures.

## Extrapolation Of Results To Maine Coast

SEANET is busy mapping the Maines coastal environment using images from the Landsat 8 Satellite. These images are novel for their spatial resolution and that they are groundtruthed with LOBO data (**Fig. 6**). Once growth models are finalized, satellite images will be used to construct habitat suitability maps composed of multiple image layers (e.g. SST, turbidity, salinity, etc.), once growth mode' ... finalized.

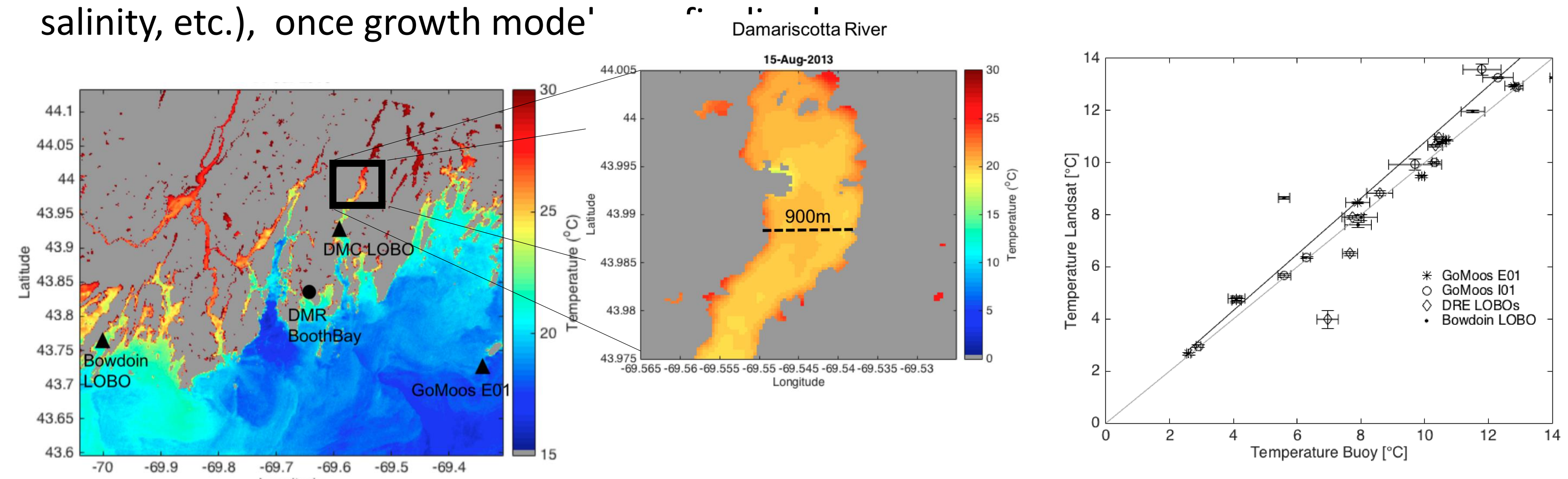


**Figure 6.** Landsat 8 images of temperature in Gulf of Maine and the Damariscotta River Estuary (left) and groundtruthed comparison between satellite and LOBO *in situ* measurements (right).