Pacific Northwest
NATIONAL LABORATORY

Quantifying Nitrogen Bioextraction by Seaweed Farms

THE PROBLEM

Anthropogenic nitrogen (N) input is the leading cause of marine eutrophication, which manifests as increased algal blooms and hypoxia. In addition to continued practices in reducing land-derived N loadings, efforts that provide direct “onsite remediation” solutions by removing existing N stock from marine systems are especially attractive. Cultivating seaweeds at large scales in eutrophic coastal waters provides a potentially viable solution, especially when N extraction is achieved as an added environmental benefit of seaweed cultivation for bioenergy and food production. As the first step to promoting and implementing this technology, it is critical to quantify and assess the effectiveness of N removal by existing seaweed farms.

OUR APPROACH

We propose to address this problem by leveraging our existing capabilities in kelp farming, field monitoring, and computational modeling. Specifically, we are using a coupled computational modeling and field monitoring approach to dynamically simulate and measure N uptake by an operational sugar kelp (*Saccharina latissimi*) farm in Hood Canal, Washington (Fig. 1). To simulate kelp growth and N uptake at high spatial (~meters) and temporal (~seconds) resolutions around the farm, we are using a farm-scale hydrodynamics-macroalgal growth modeling framework developed through a Cat 3 MARINER project (Fig. 2). Field data collection are conducted using the combination of high-frequency, automatic *in situ* data sensors deployed inside and surrounding the kelp farm and spatially intensive discrete “grab samples” for key parameters (e.g., nitrogen, chlorophyll) related to kelp growth and N uptake.

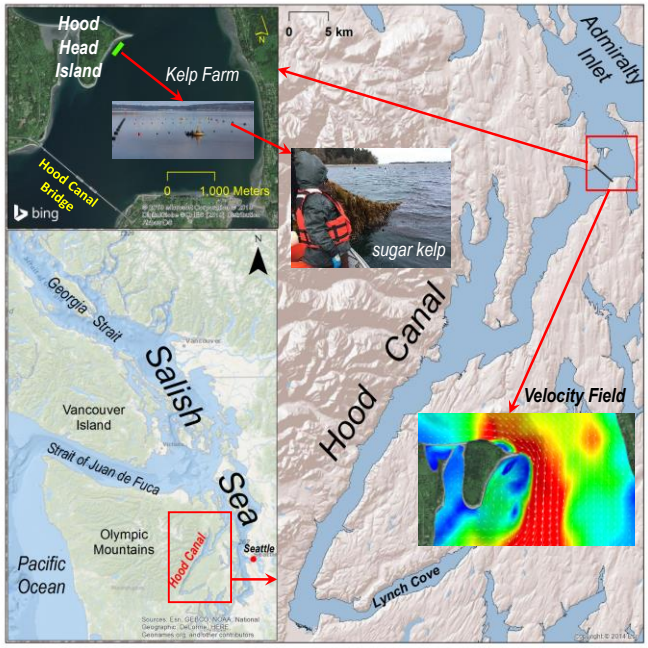

Fig 1. Maps indicating the location of Hood Canal Kelp Farm in Hood Canal, Washington. The insets are sugar kelp farm site photos and snapshot of the surface velocity field predicted by the hydrodynamic model.

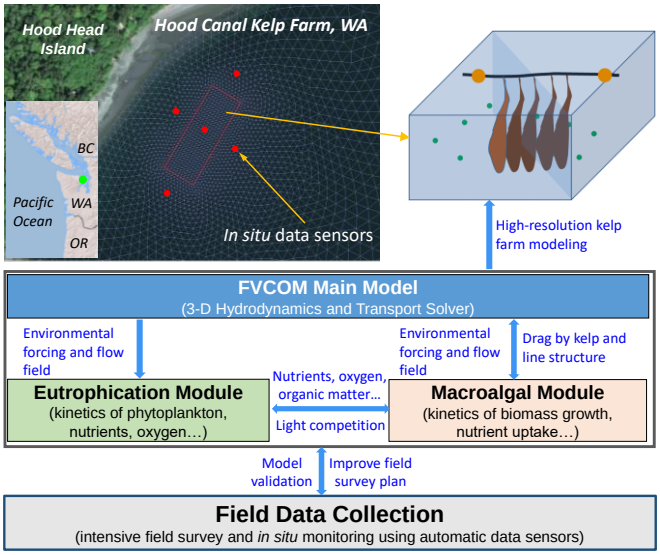

Fig 2. Conceptual diagram depicting the integrated computational modeling-field monitoring approach for real-time assessment and validation of N bioextraction by Hood Canal Kelp Farm, WA.

PROGRESS

We have finished field data collection for the two past growing seasons (2019-2020 and 2020-2021). Field data collected include weekly nutrient water samples and high-frequency environmental variables (e.g., temperature, salinity, oxygen, chlorophyll) inside and surrounding the kelp farm during the peak growing months (February-March). The kelp biomass growth and tissue nutrient content was also monitored over time. Extensive field data analysis and model-data comparison are being conducted to validate model predictions (Figs. 3 and 4). The validated model will be used to quantify the rate and amount of N extracted by the kelp farm in time and space in conjunction with field data.

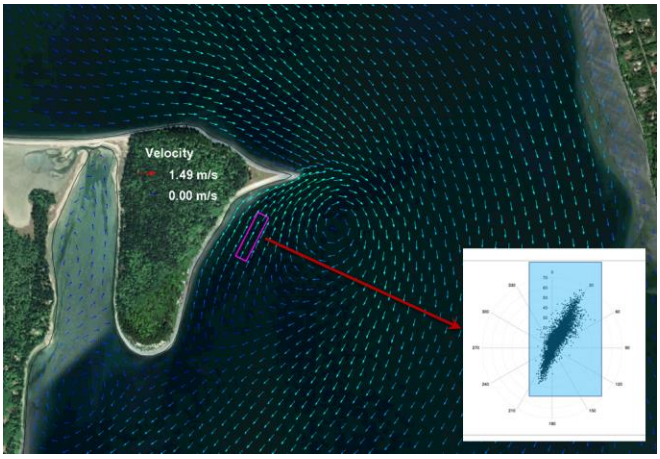

Fig 3. Model predicted current field inside the kelp farm vs. field data collected by the Acoustic Doppler Velocimeter.

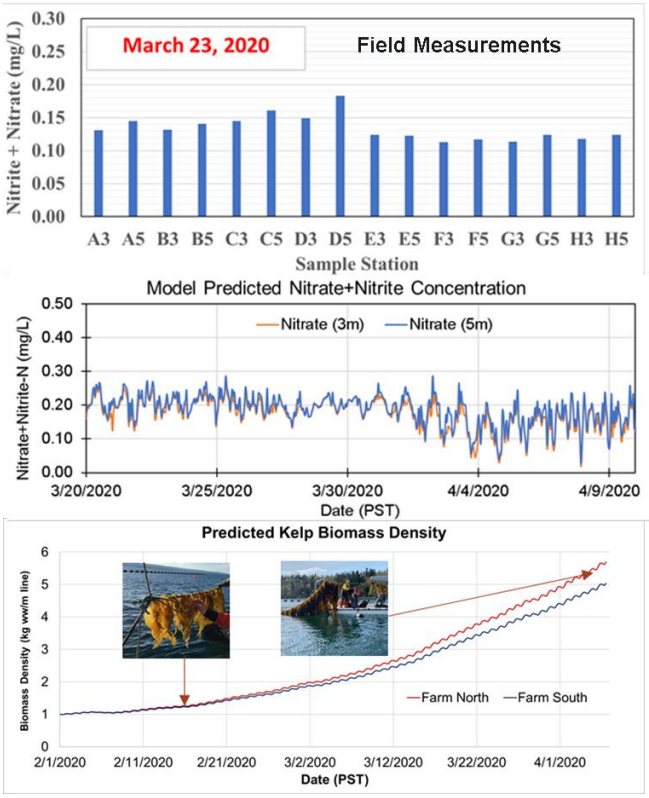

Fig 4. Top panel – N concentrations measured inside and around the kelp farm; Middle panel – model predicted N concentration time series inside the kelp farm; Bottom panel – model predicted kelp biomass density time series (kg wet weight per meter growing line).

IMPACT

- This study will provide a quantitative assessment of the rate and effectiveness of nitrogen bioextraction by seaweed farms.
- The approach can be transferable to other seaweed growing sites with less granularity as a practical tool to support seaweed farming and eutrophication remediation research.

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