Scalable Aquaculture Monitoring System (SAMS)

Dr. David Siegel, UC Santa Barbara

Project Vision

We will design, validate, and deploy an autonomous monitoring system that delivers key, actionable products to kelp aquaculture managers, using optical and acoustic sensors

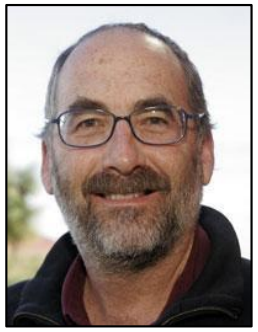
Project Impact

Leverage rapidly evolving autonomous technologies to monitor all dimensions of a kelp farm and provide a suite of data products

SAMS

Scalable Aquaculture Monitoring System

Project Team



David Siegel - PI
Lead optical sensor development and construction of SAMS

Tom Bell - Co-PI
Manage overall project and hyperspectral algorithm development and analysis

Kyle Cavanaugh - Co-PI
Development of UAV assets and imagery analysis

Robert Miller - Co-PI
Kelp ecology and analysis of underwater imagery

Norman Nelson - Co-PI
Optical properties of kelp condition and macromolecular content

Nick Nidzieko - Co-PI
Development and implementation of UUV assets

Dan Reed - Co-PI
Giant kelp ecology and life history expert

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CHANGING WHAT'S POSSIBLE

Innovation & Objectives

Innovation

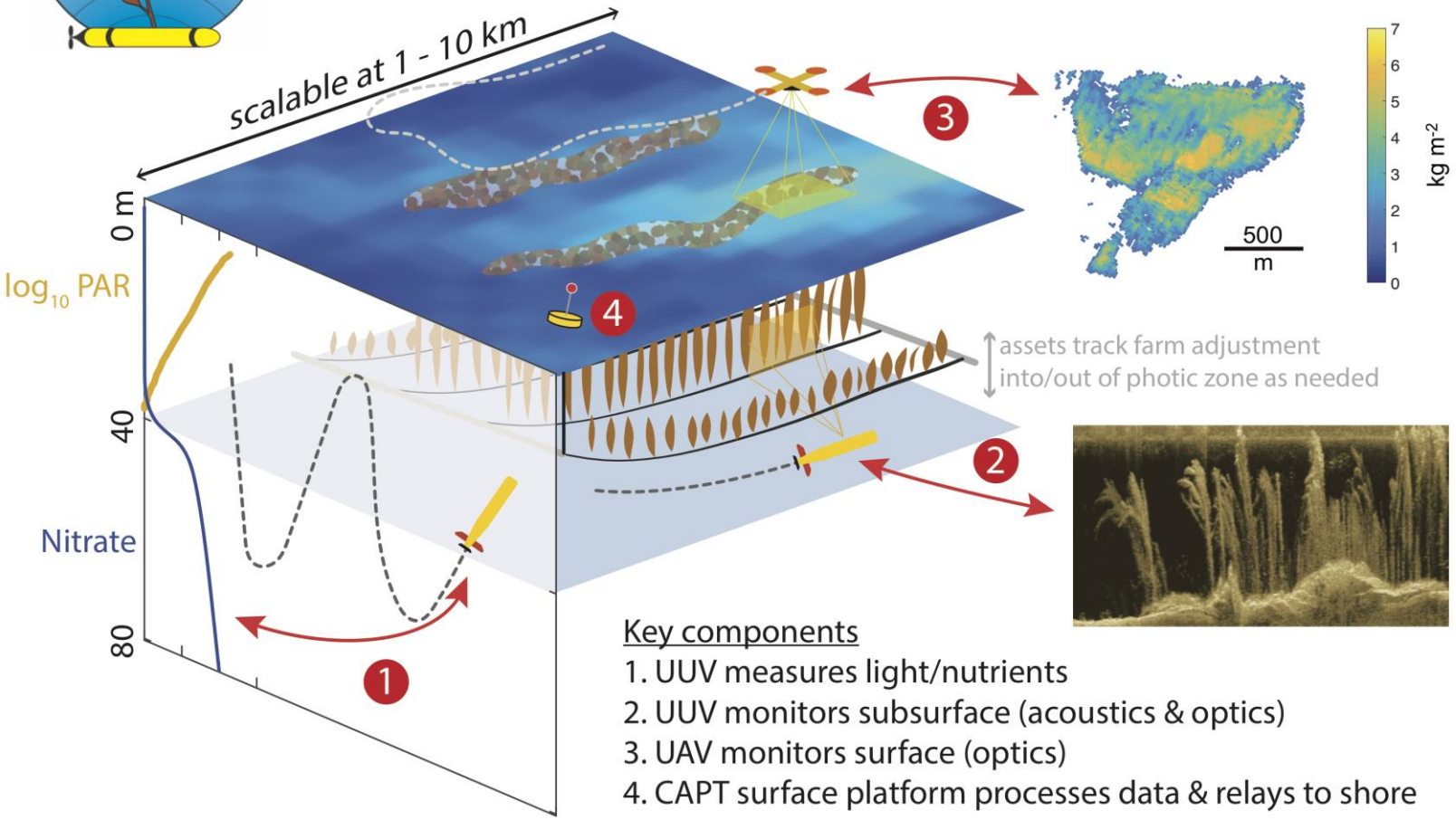
Autonomously collect imagery and derive relevant metrics

Deliver essential products in near real-time

Objectives

Rapid, high-frequency observation

Optimize tissue content depending on application



Key components
1. UUV measures light/nutrients
2. UUV monitors subsurface (acoustics & optics)
3. UAV monitors surface (optics)
4. CAPT surface platform processes data & relays to shore

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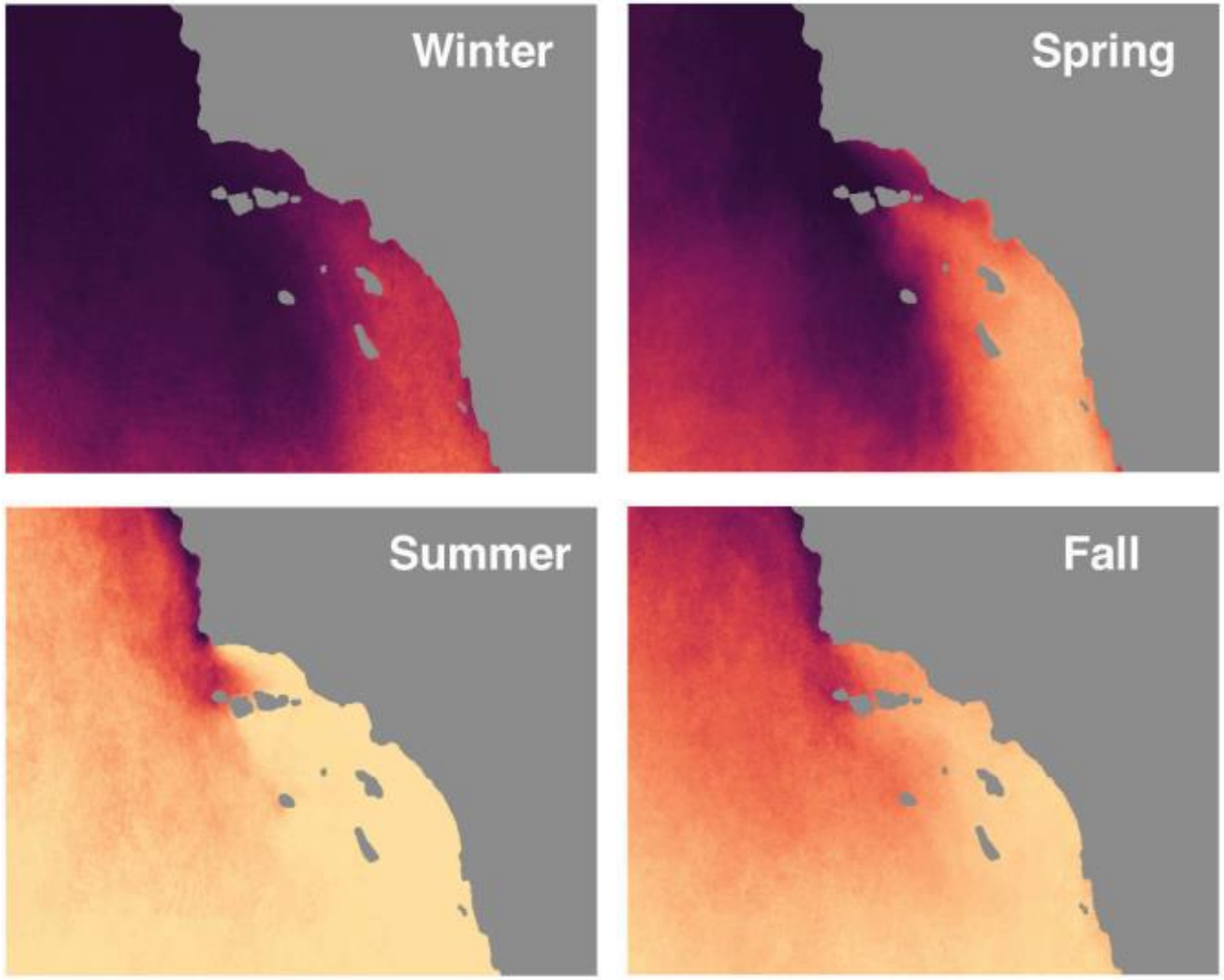
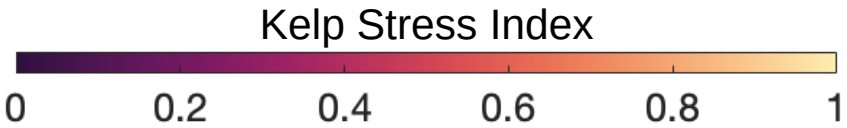
Siting offshore farms in Southern California

- Developed algorithms to estimate seawater nitrate concentration from sea surface temperature imagery and validated with four decades of *in situ* measurements
- Combined with physiological traits of giant kelp to develop the Kelp Stress Index
- Can be used to identify the best sites for offshore kelp aquaculture when considering seasonal and interannual variability





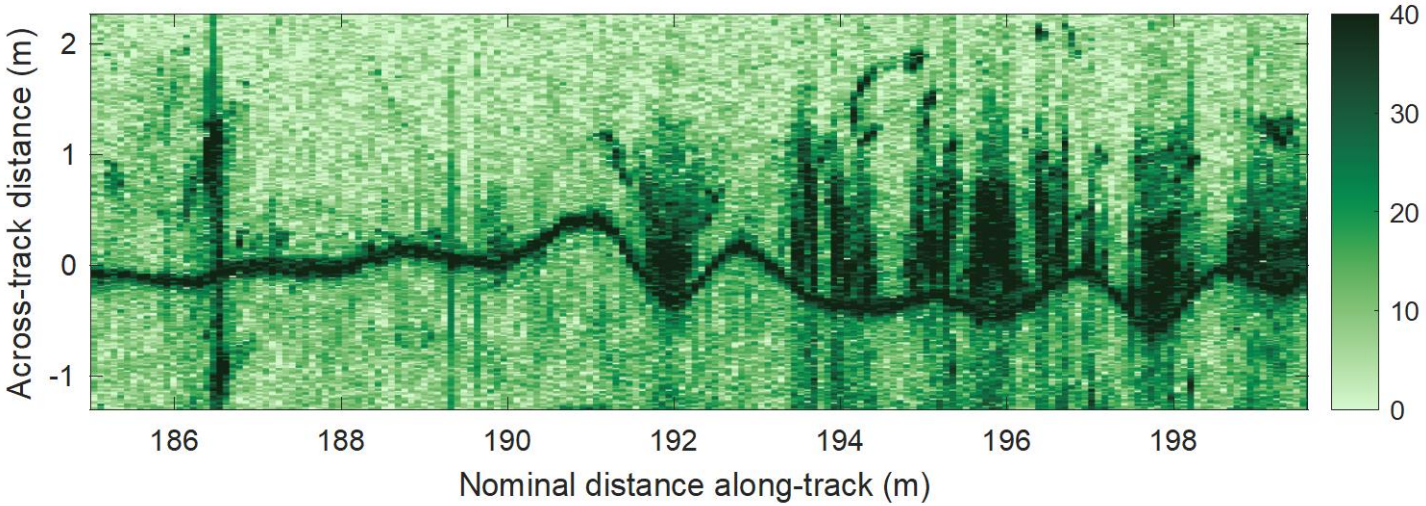
Snyder et al. 2020

Monitoring Subsurface Outplant Success & Growth

- Developed deep learning image classifier to identify and size kelp outplants using subsurface color imagery collected with an ROV
- Using sidescan sonar to track the growth of kelp throughout the water column
- The formation of pneumatocysts provides acoustic targets to assess subsurface growth and development

Underwater Color Image

Deep Learning Classification

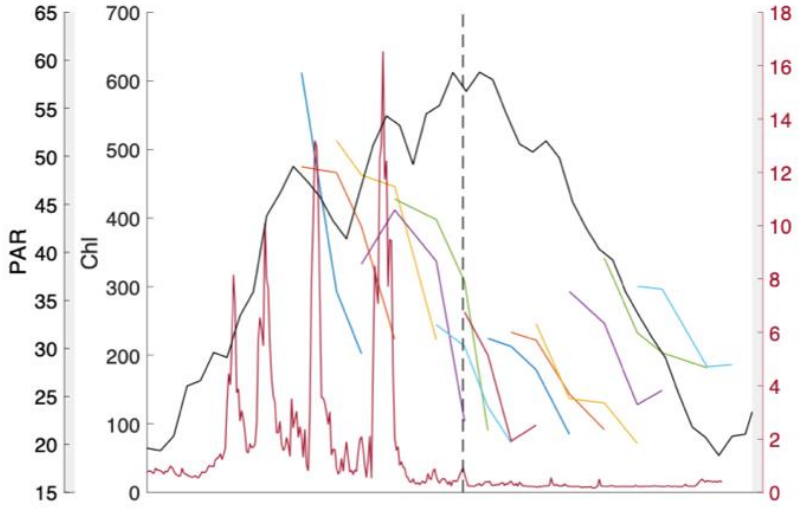


Bell et al. 2020

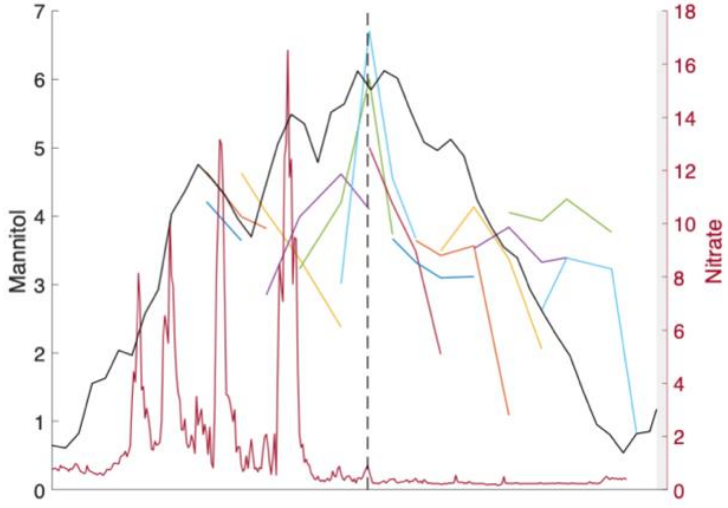
Physiological dynamics w/ *in situ* sampling

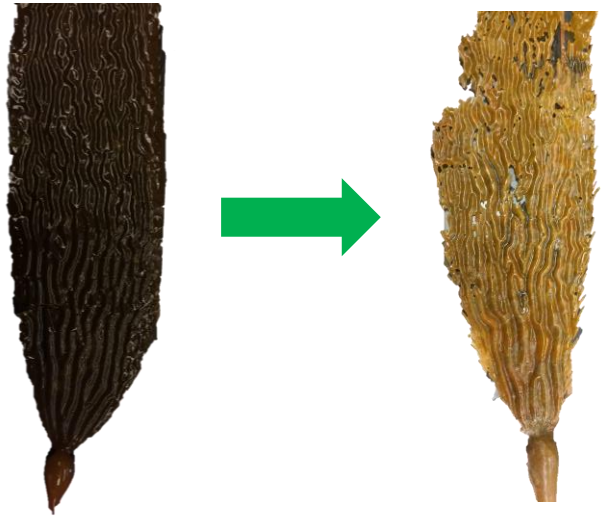
- Followed frond cohorts over a year at Mohawk kelp forest
- Physiological condition (Chl content) increases with elevated seawater nitrate concentration and decreases with elevated light and age
- Mannitol content spikes 6 weeks after the termination of nutrient upwelling during high light periods, just before photosynthetic stress occurs

Physiological Condition

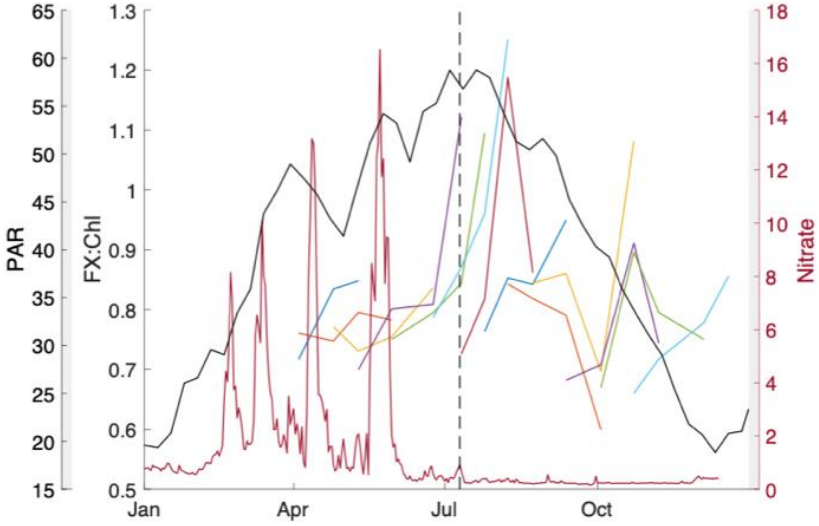


Mannitol Content





Photosynthetic Stress



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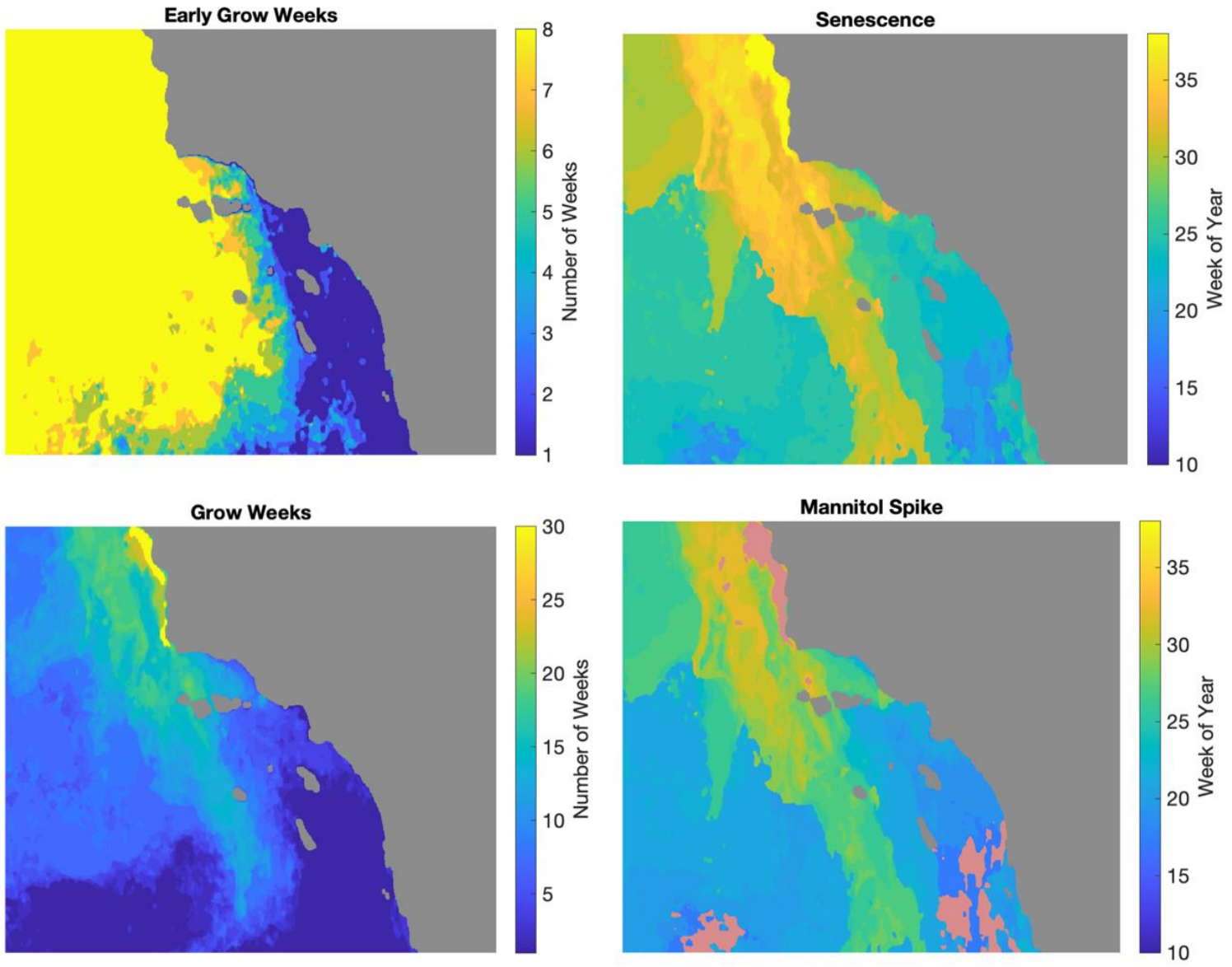
Transferring *in situ* observations to spatial data

- We have transferred the knowledge derived from the *in situ* sampling to develop maps of growth, risk of crop loss due to senescence, and timing of mannitol spike
- Used satellite estimates of seawater nitrate and irradiance to drive these models
- These maps can aid in harvest planning and, when combined with sensors on the farm structures, can provide near-real time information about physiological processes over large areas



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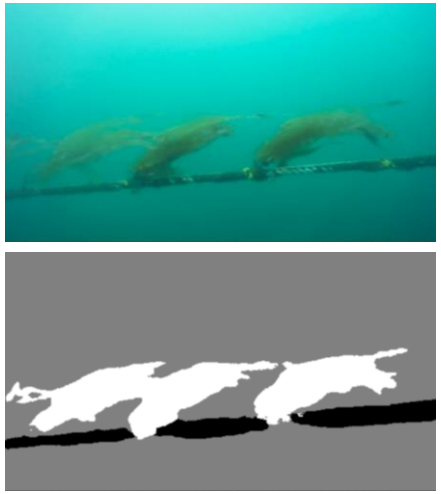
Future Vision – Subsurface Monitoring with UUV's

- We are currently transferring our subsurface methods to unoccupied underwater vehicles (UUV's)
- We will combine the spatial positioning from the UUV's along with color imagery and derived products
- We are developing a web-based mapping product so that farm managers can visualize the subsurface condition of kelp outplants on demand

Color/Classified Imagery



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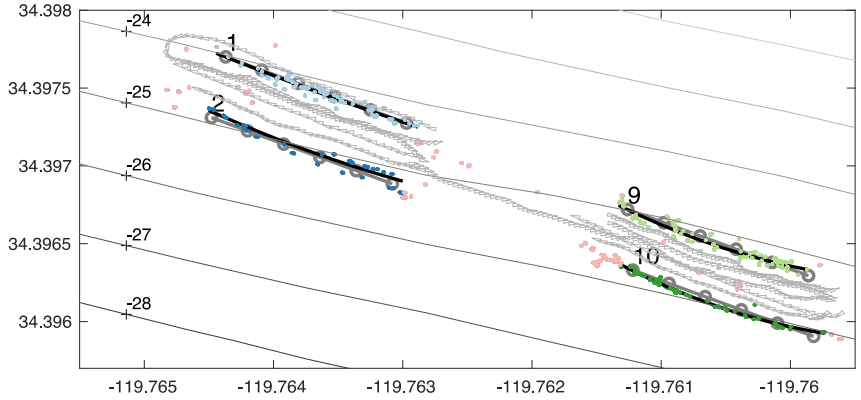
Spatial Position of Vehicle



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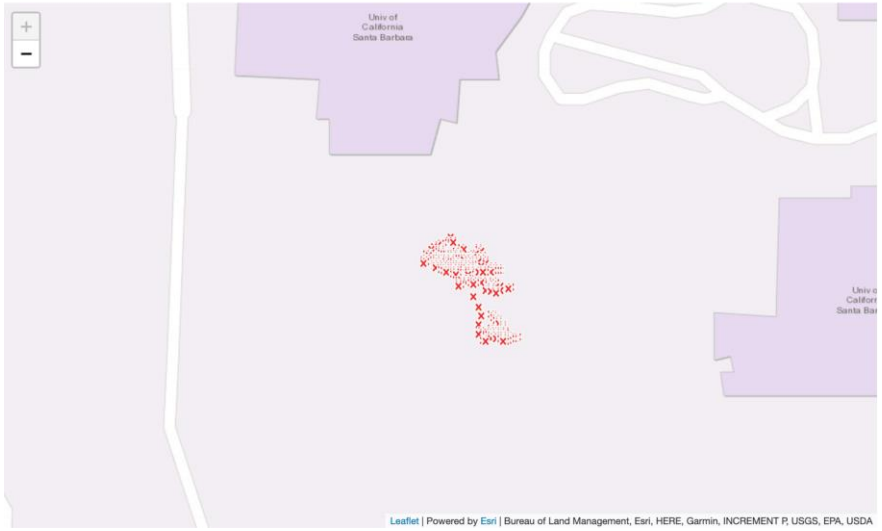
Web-based Mapping Product

Log file data points:



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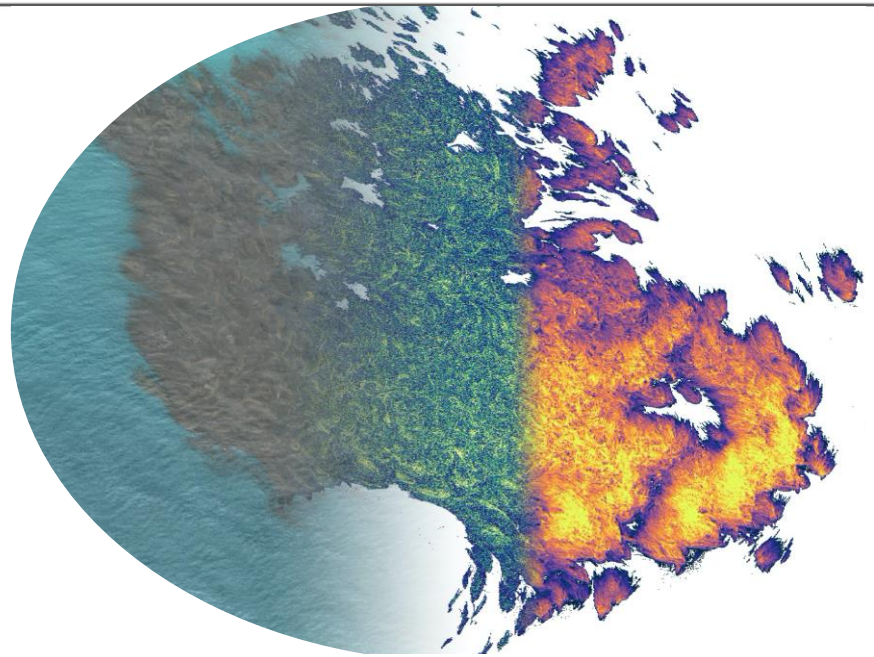
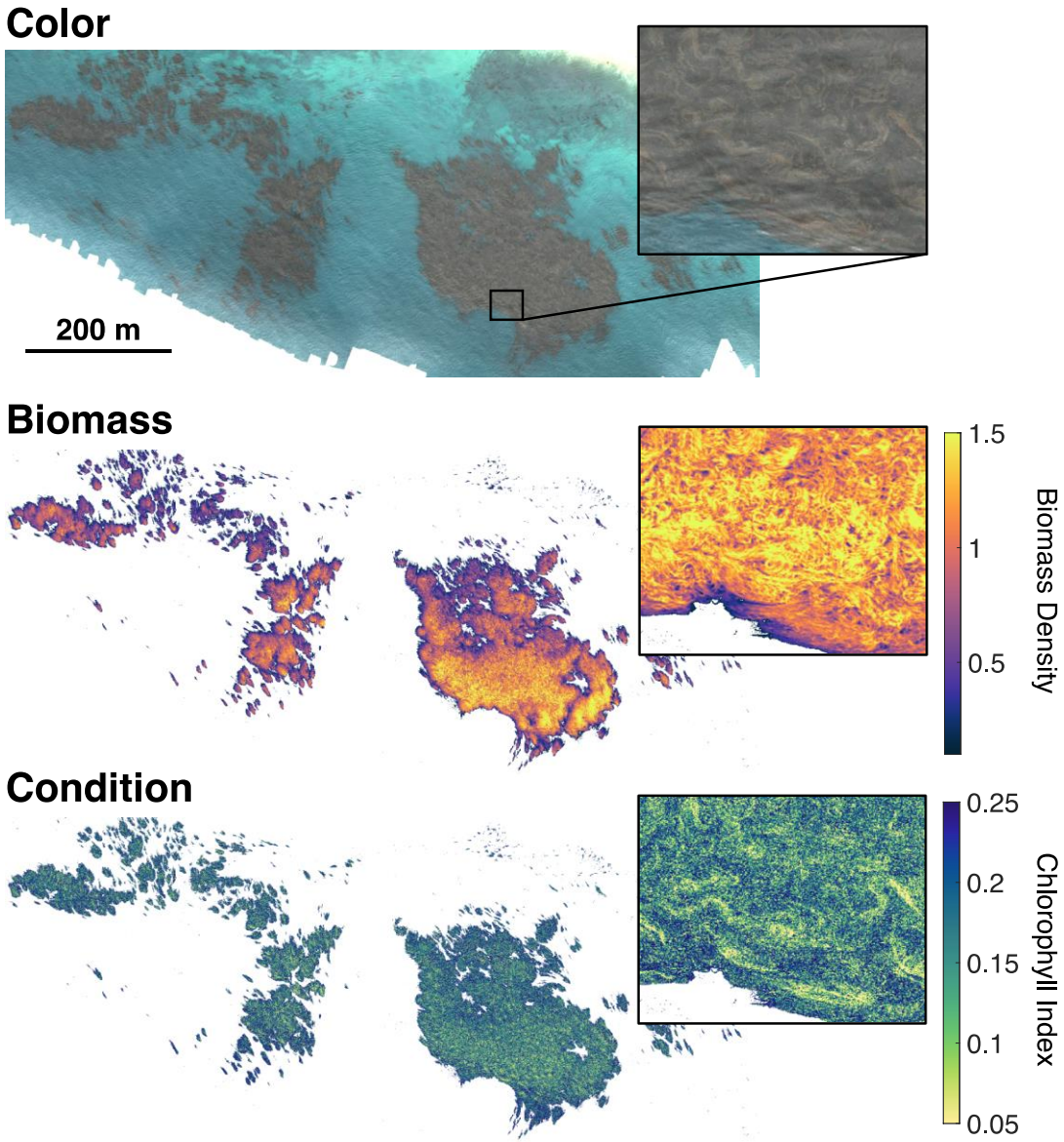
Commercial Opportunities/T2M - SAMS Drone Sensor





- Used the commercially available MicaSense Dual Sensor 10-band multispectral sensor system
- Developed algorithms to produce color imagery, maps of canopy biomass, and canopy condition of the surface canopy from drone imagery

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