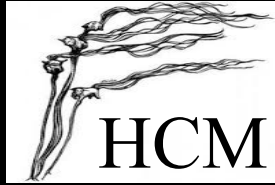




PUGET SOUND
RESTORATION FUND



Case Study: Developing a Seaweed Farm in North Hood Canal



Joth Davis
Hood Canal Mariculture

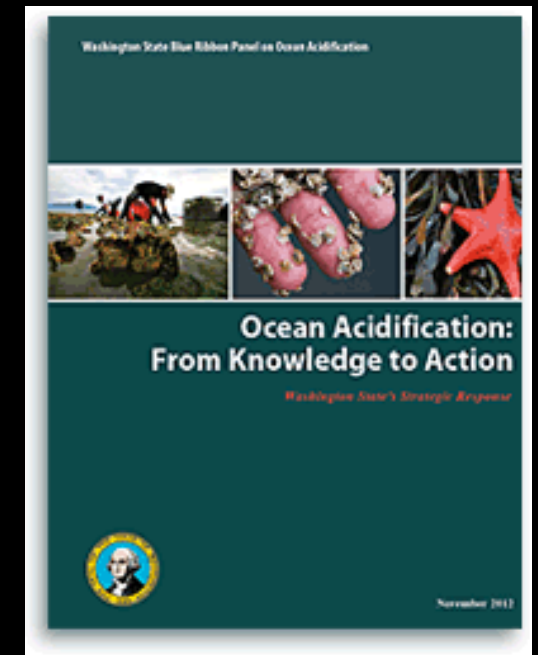


Betsy Peabody
Puget Sound Restoration Fund



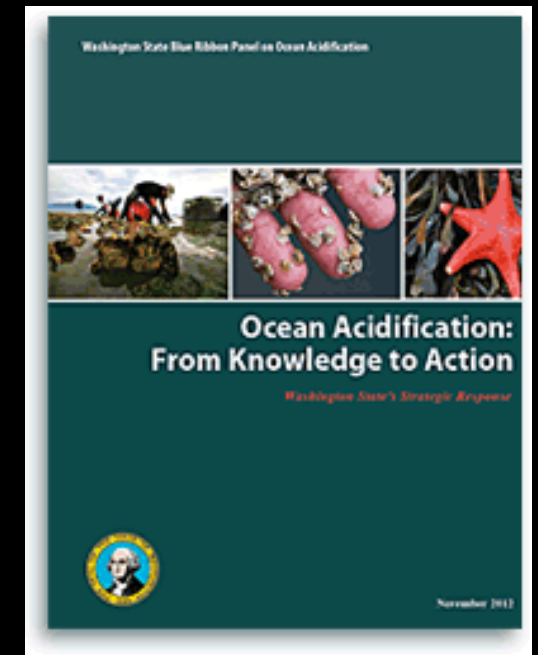
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- WA State Blue Ribbon Panel on Ocean Acidification recommended an adaptation strategy based on growing seaweeds for nutrient sequestration including carbon and nitrogen
- Paul J. Allen Foundation “Ocean Challenge” resulted in a proposal to consider how growing seaweeds might assist in creating a halo of improved water quality relative to dissolved carbon while sequestering other nutrients
- PSRF and Hood Canal Mariculture team to develop a project that would use an existing aquaculture site to develop a seaweed farm for a large field experiment



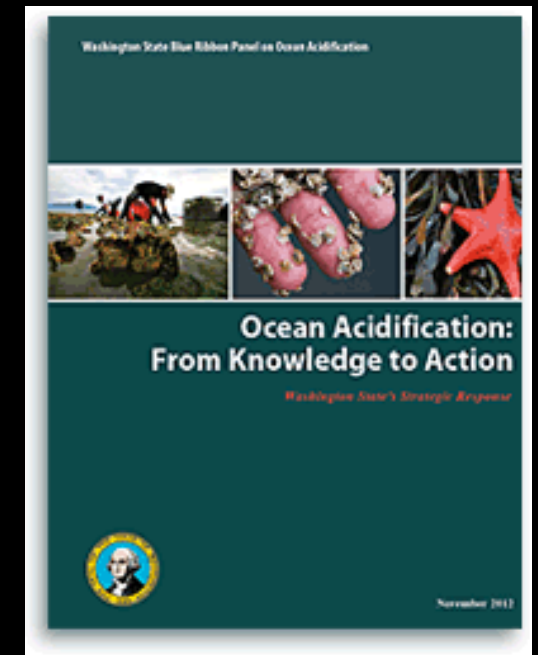
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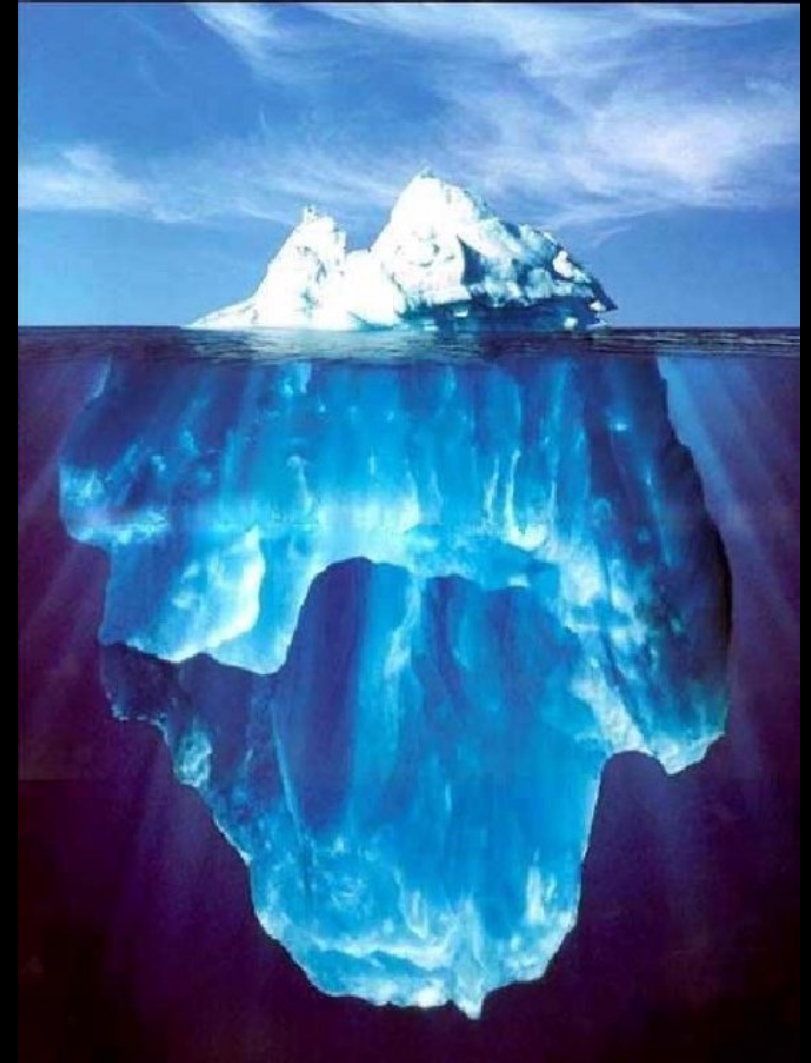
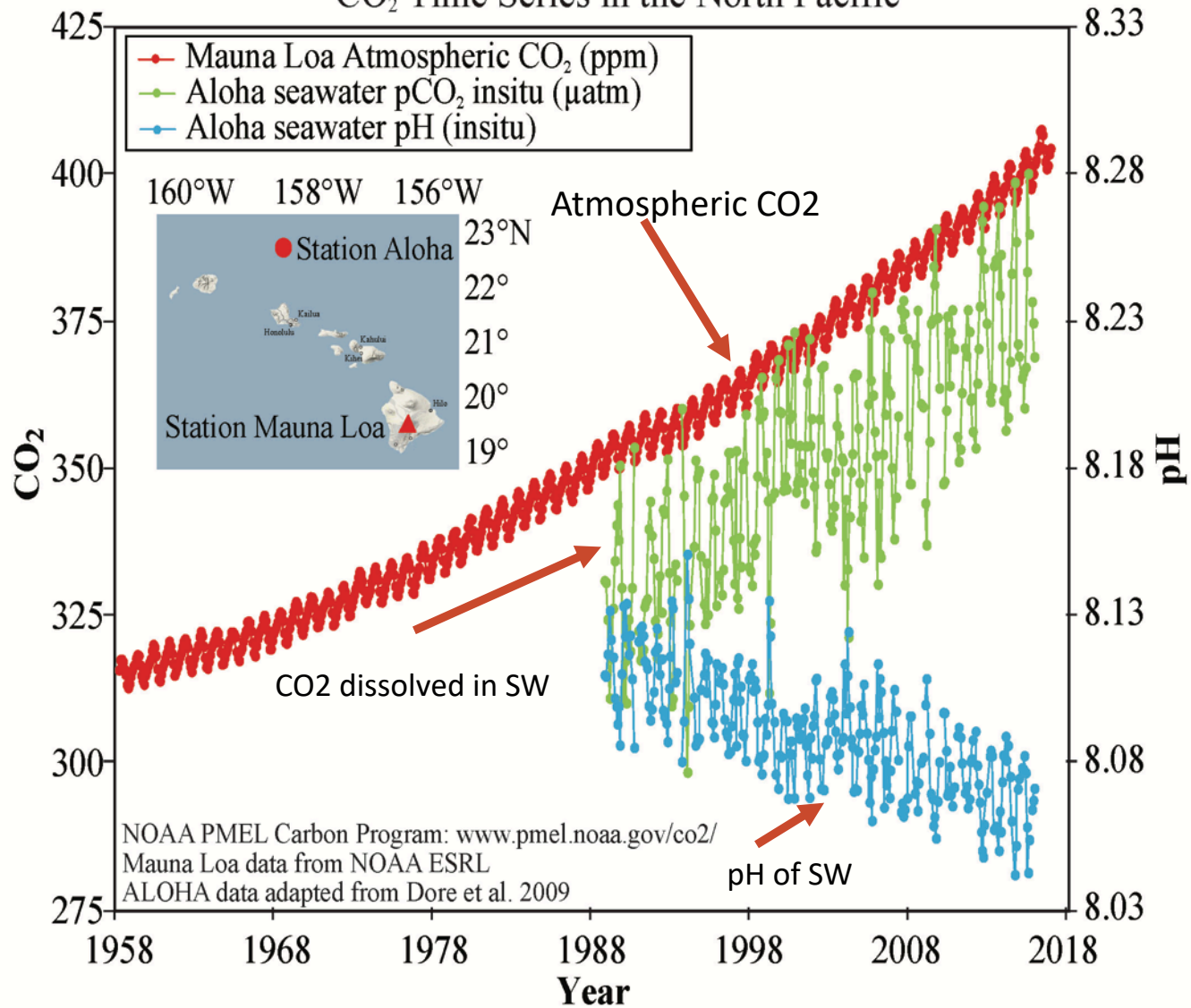


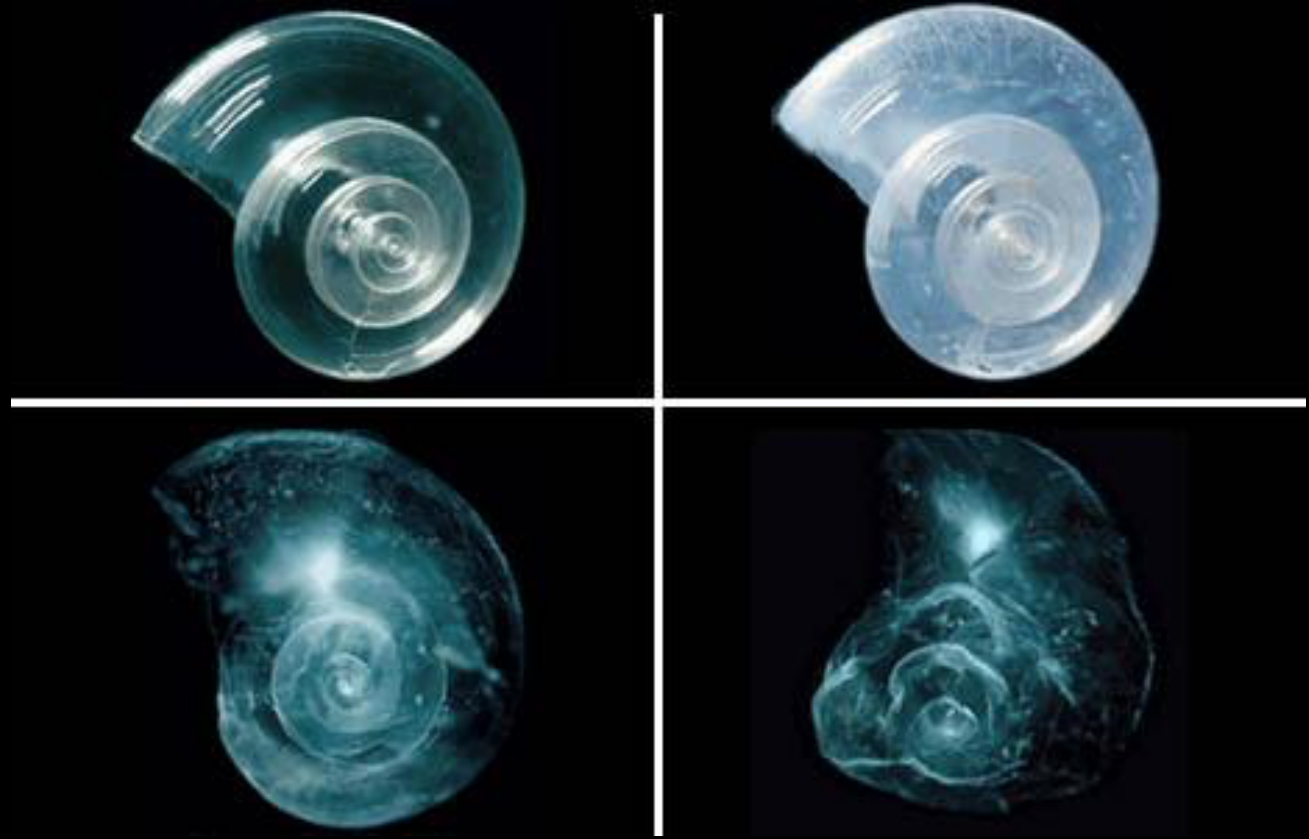
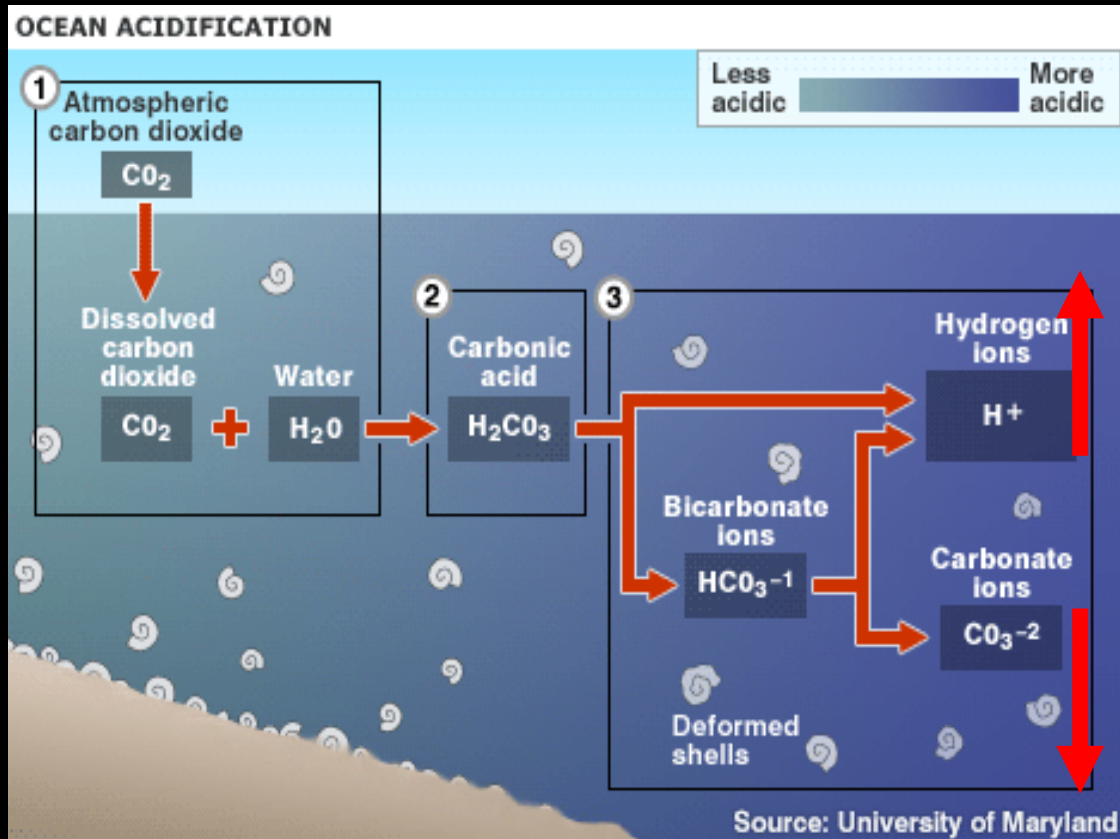
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CO₂ Time Series in the North Pacific





Research on pteropod dissolution in open ocean. - Nina Bednarsek (NOAA PMEL)

Is this a harbinger of effects on biological resources due to future ocean conditions?

Site Selection Criteria

- What are key site characteristics to consider:
- Current and Temperature Profile
- Nutrient Availability including Nitrogen
- Temperature and Salinity
- Primary Productivity
- Approved Water Quality for growing shellfish

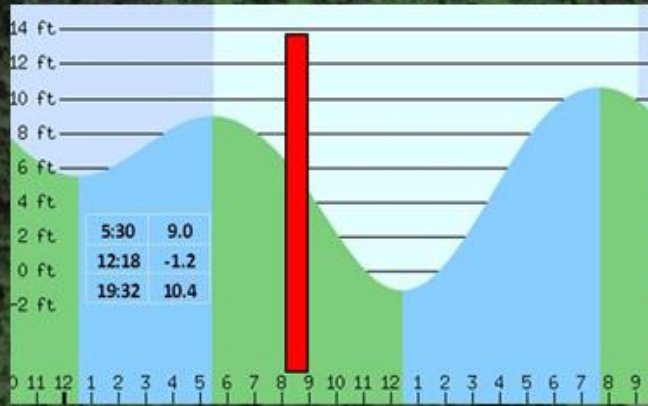




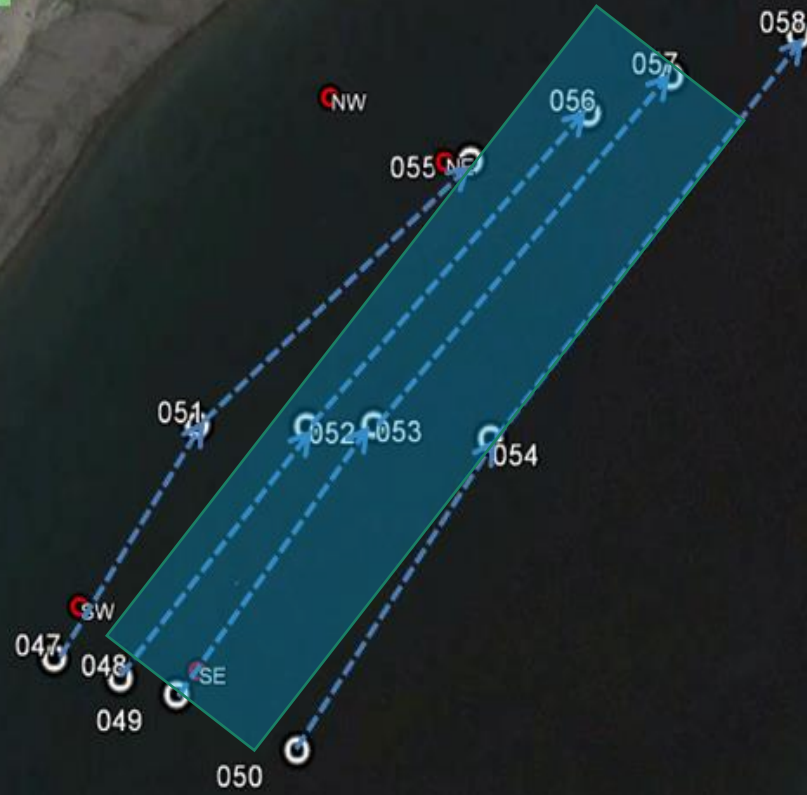
Hood Canal Bridge



Hood Head Tombolo



Hood Head



656 ft

© 2015 Google

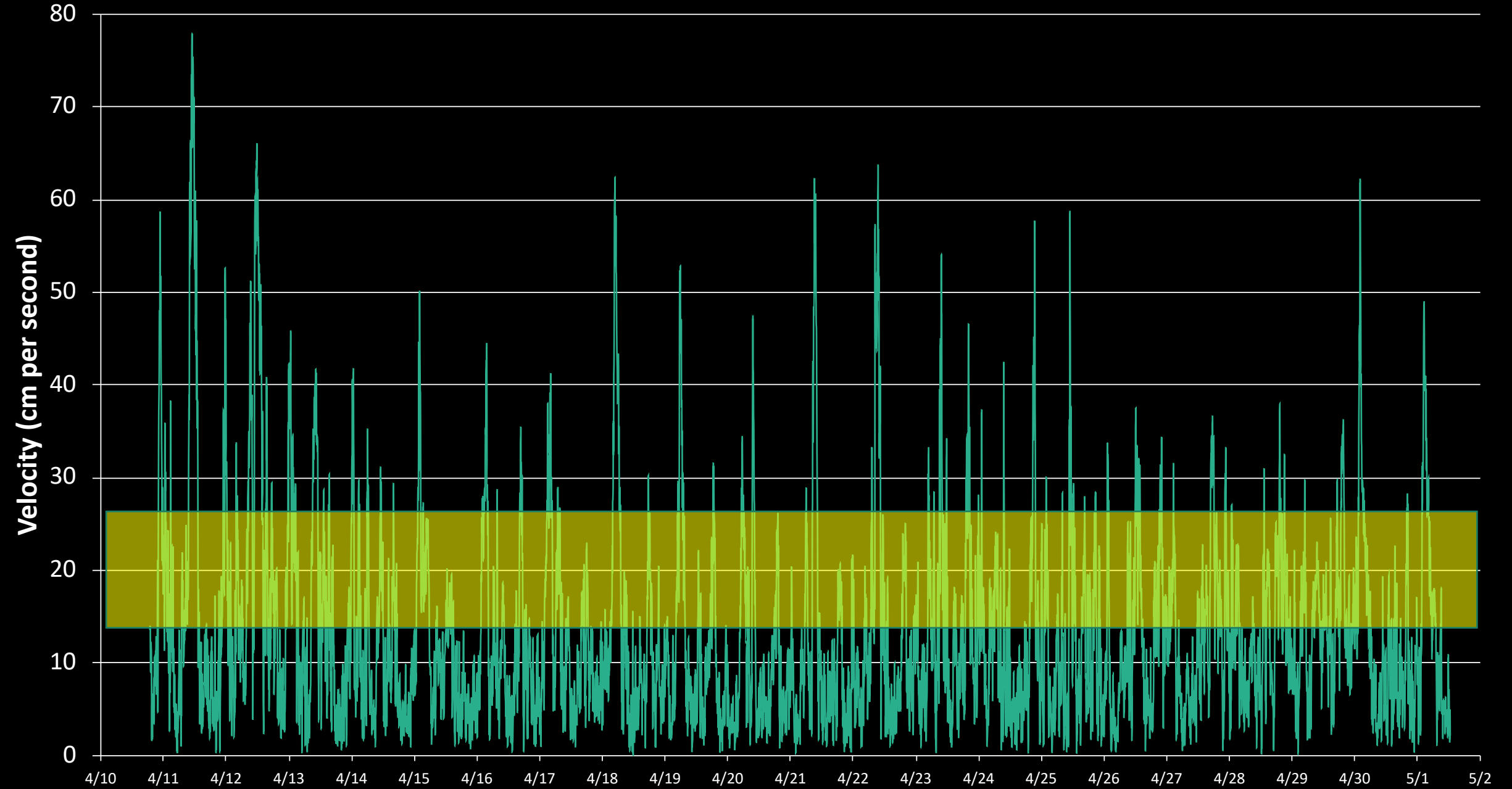
Google earth



Seawater Temperature at Hood Head, Hood Canal, Washington

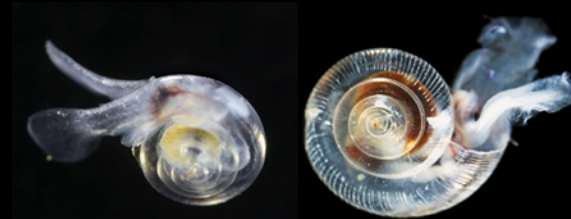


Hood Canal Current Velocity



Tool Building

- Building an OA toolkit was the driving idea behind the seaweed investigation
- What tools are at our disposal to mitigate OA locally?
- What actions can we take in the marine system to ameliorate conditions for sensitive species while OA in seawater worsens?
- Can marine vegetation play a role?



Pterapods, Nina Bednarsek



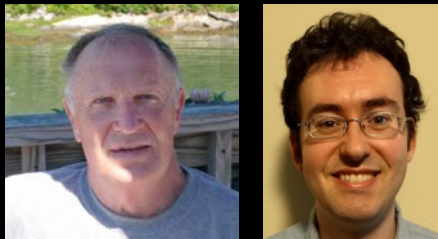
Enteromorpha on Samish Bay longlines

Team Building

Kelp Team (PSRF and HCM): cultivate sugar kelp and measured net production and change in biomass over season



Modeling Team (SSA) –Develop a kelp model that integrates kelp production, nutrient sequestration, and chemistry data to visually demonstrate the effect of kelp on seawater



Advisory Team

Funders:
Paul G. Allen Family Foundation
& U.S. Navy



Chemical Assessment Team (NOAA PMEL/UW/WDNR): measure upstream and downstream changes in carbonate chemistry of seawater passing through kelp



Biological Assessment Team (UW/PMEL/SCCWRP): measure rates of growth and shell dissolution in calcifiers within, upstream, and downstream of sugar kelp



Communications Team (WSG)

Permitting – Where Rubber Hits the Road

- Homework
- Tribes, U&As & Treaty Rights
- Local shoreline master plan
- Pre-application meetings
- Stakeholders
- Hood Head - an existing, fully permitted shellfish farm; NWP 48 suspended to obtain an IP for seaweeds & shellfish
- JARPA (Joint Aquatic Resource Permits App)
- USACE – Individual Permit
 - NMFS concurrence not likely to adversely affect
 - USFWS concurrence with USACE determination
 - Ecology – Coastal Zone Consistency
- US Coast Guard – lighting & navigation
- Local Shoreline Development Permit (Jefferson County)
 - No shoreline permit required for Hood Head (“existing aquaculture”)
- Conditional Use Permit (Jefferson Co)
 - Two oceanographic research buoys
- WA DNR Lease/Right-of-Entry
- Note: Other permits may be required, if starting from scratch
- Main messages:
 - Be realistic; it’s a long road.
 - Be honest about impacts.

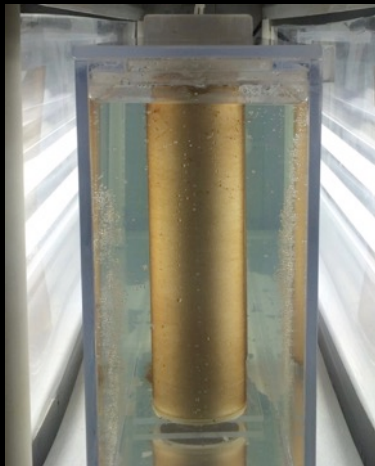
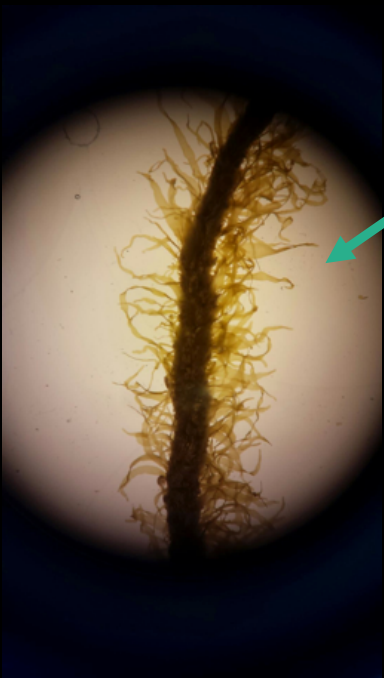
Building a Kelp Farm

- Once permitting and social license was acquired, Hood Canal Mariculture initiated plans to rebuild an existing shellfish farm to include a one-hectare (2.47 acre) area devoted entirely to sugar kelp production
- A cultivation lab space was necessary to provide sugar kelp sporophytes for the project.
- Existing Hood Head farm needed a retrofit to accommodate sugar kelp production

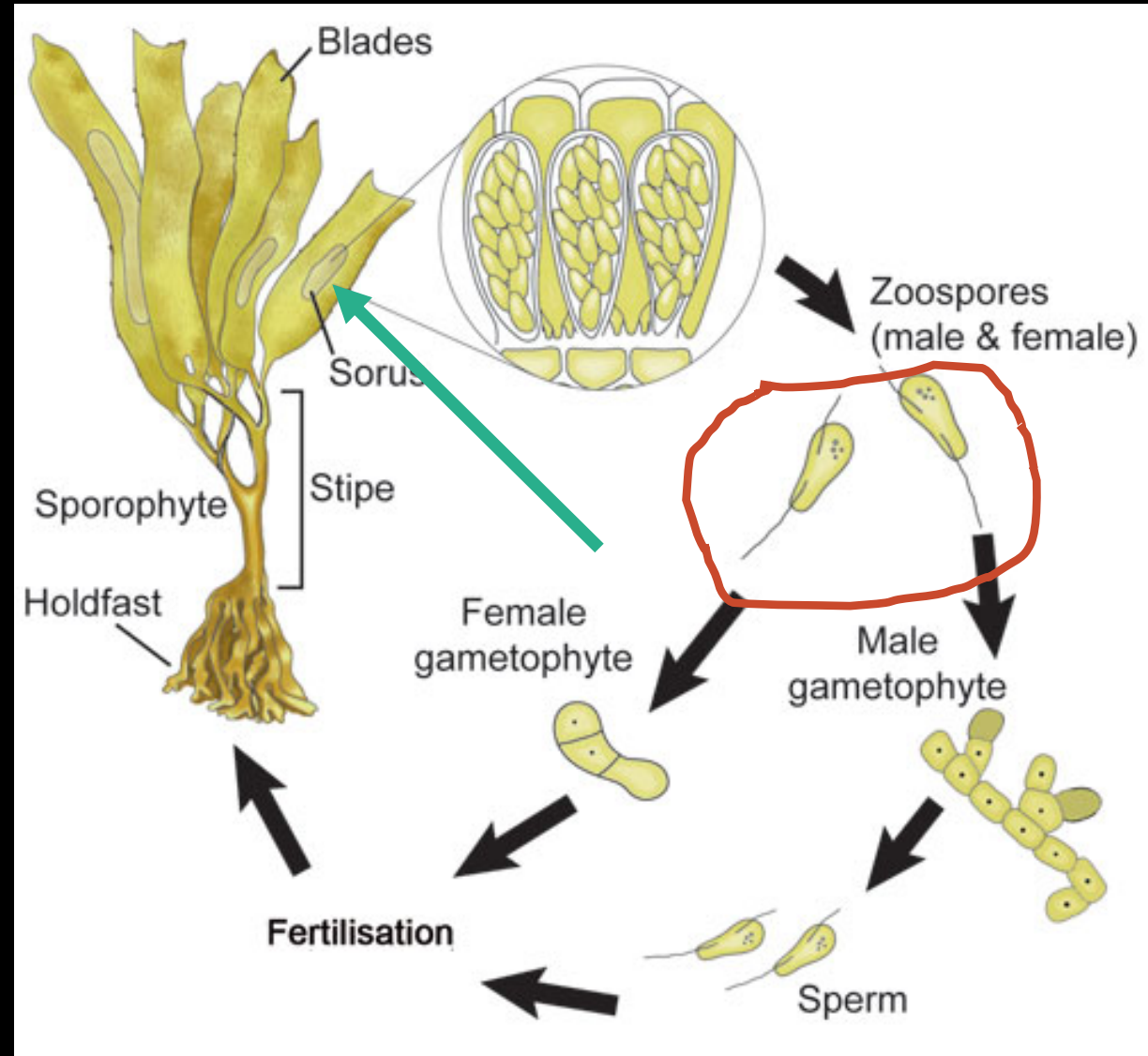
- Production of seeded twine from mature sorus



Young sporophytes on twine

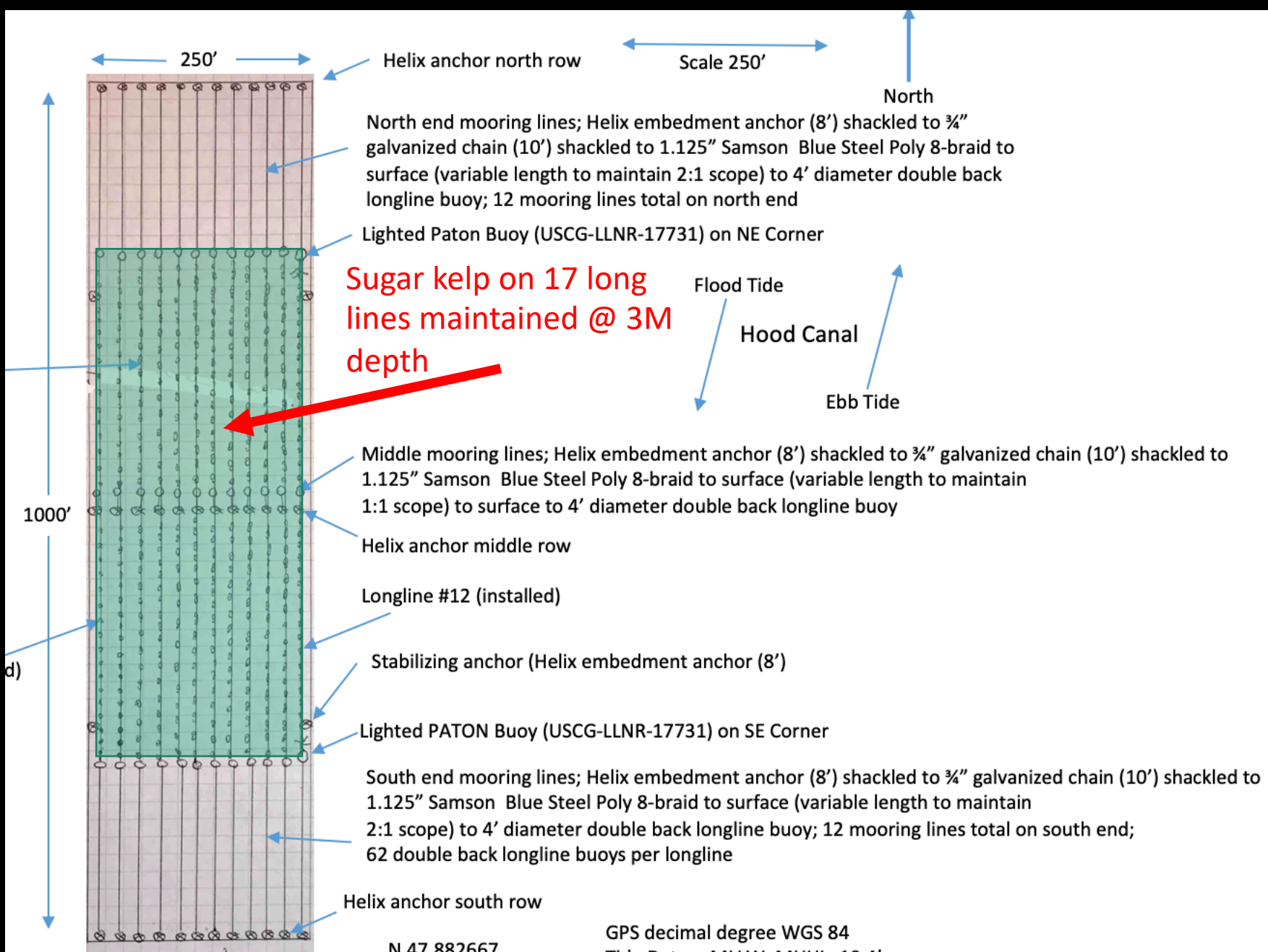


Sporophyte Cultivation





Meanwhile out on the Farm.....



Sugar kelp on 17 long lines maintained @ 3M depth

Helix anchor north row

Scale 250'

North

North end mooring lines; Helix embedment anchor (8') shackled to 3/4" galvanized chain (10') shackled to 1.125" Samson Blue Steel Poly 8-braid to surface (variable length to maintain 2:1 scope) to 4' diameter double back longline buoy; 12 mooring lines total on north end

Lighted Paton Buoy (USCG-LLNR-17731) on NE Corner

Flood Tide

Hood Canal

Ebb Tide

Middle mooring lines; Helix embedment anchor (8') shackled to 3/4" galvanized chain (10') shackled to 1.125" Samson Blue Steel Poly 8-braid to surface (variable length to maintain 1:1 scope) to surface to 4' diameter double back longline buoy

Helix anchor middle row

Longline #12 (installed)

Stabilizing anchor (Helix embedment anchor (8'))

Lighted PATON Buoy (USCG-LLNR-17731) on SE Corner

South end mooring lines; Helix embedment anchor (8') shackled to 3/4" galvanized chain (10') shackled to 1.125" Samson Blue Steel Poly 8-braid to surface (variable length to maintain 2:1 scope) to 4' diameter double back longline buoy; 12 mooring lines total on south end; 62 double back longline buoys per longline

Helix anchor south row

1000'

d)

N 47.882667
W 122.614167

GPS decimal degree WGS 84
Tide Datum MLLW; MHH: 10.4'
Seattle, Elliot Bay (NOAA)
Station ID:1033

Mooring details...

Helix Screw Anchors
(10') position the kelp
lattice to the seafloor

Screw anchors are
connected to the
surface via 20'
 $\frac{3}{4}$ " diameter long-link
chain to 1.12" diameter
8-braid blue steel poly
line with 2:1 scope to
surface buoys

36 moorings position
the rectangular kelp
lattice in the middle of
the lease area to
accommodate seaweed
grow lines (17 @ 460'
each).

Total grow out capacity
is 7800 lineal feet
(2377 meters)





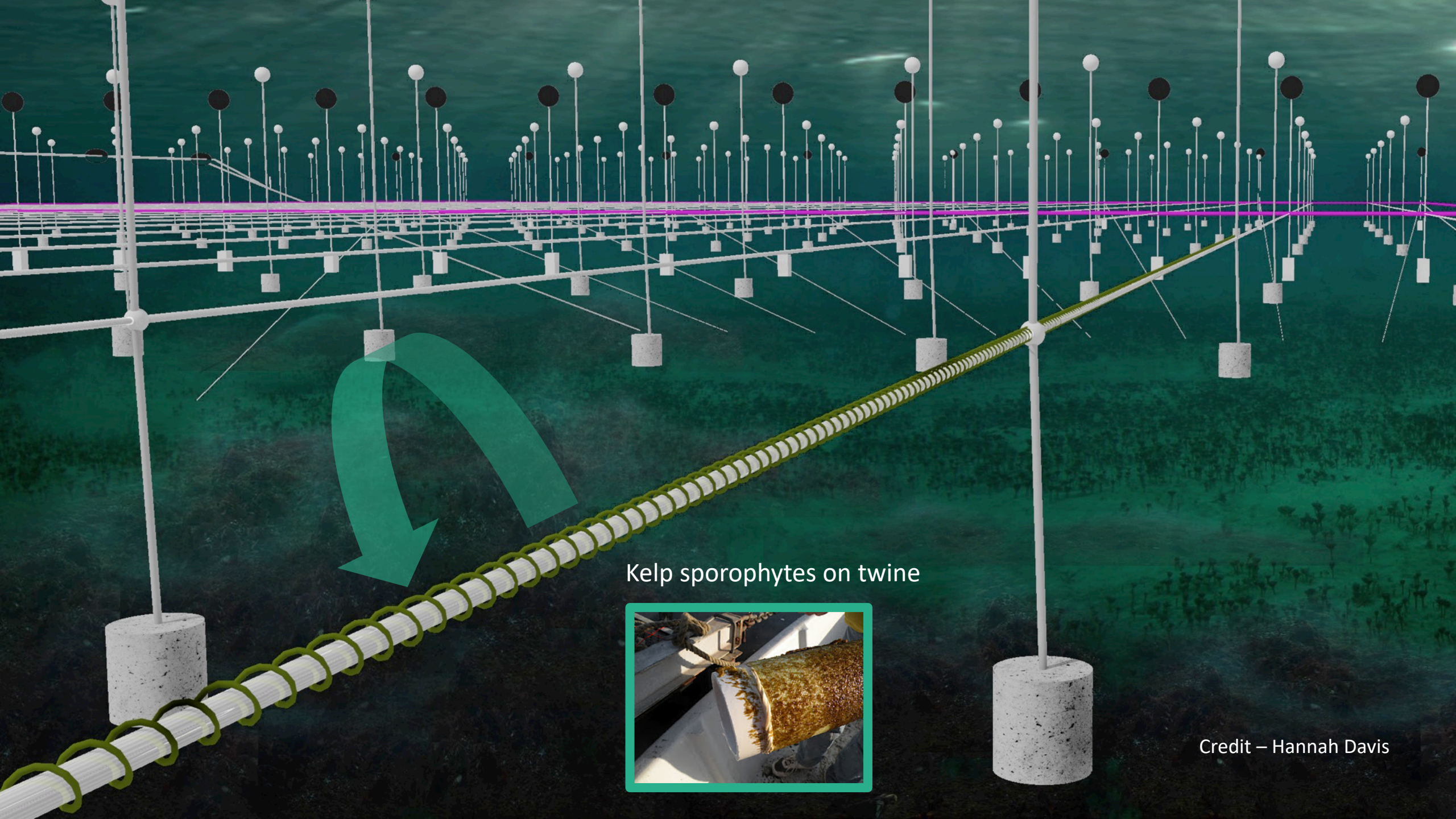




Seeding Sugar Kelp sporophytes on
twine onto grow lines

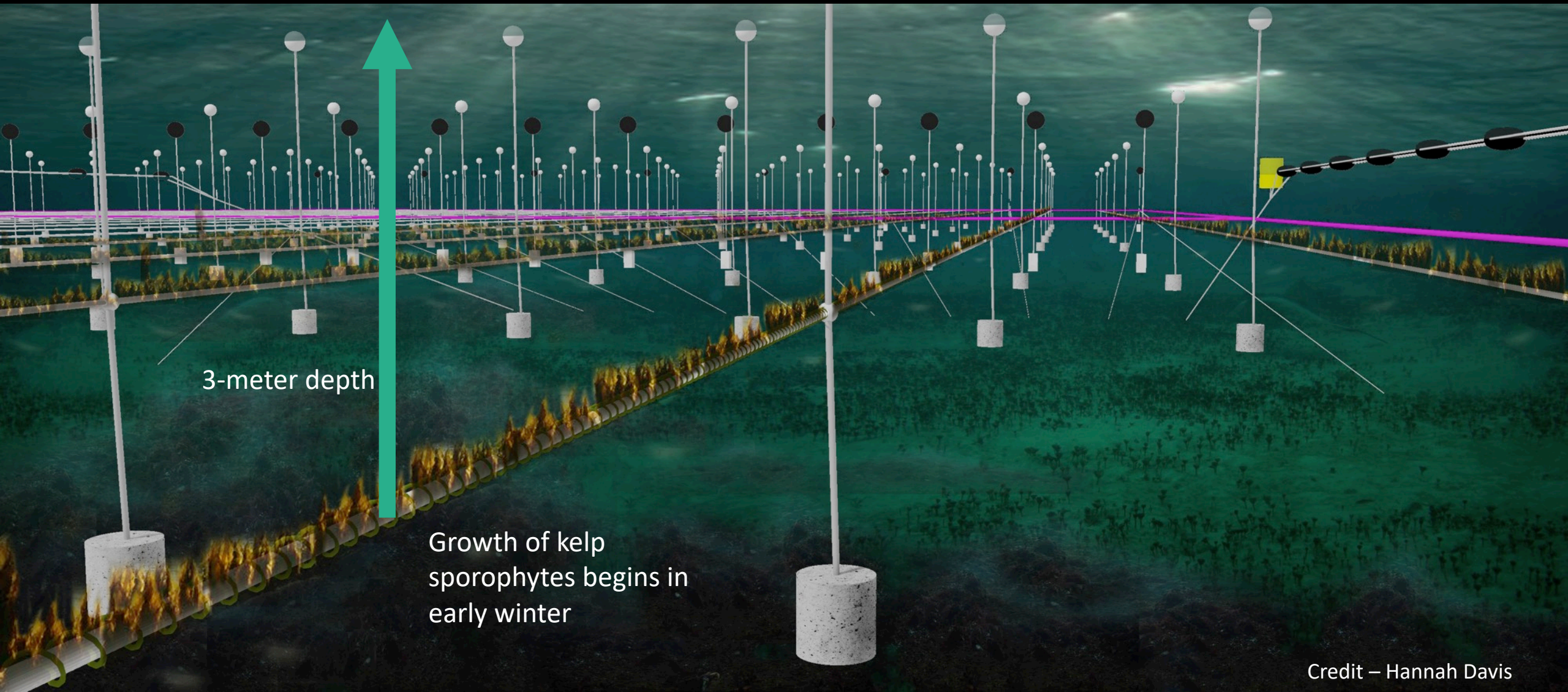






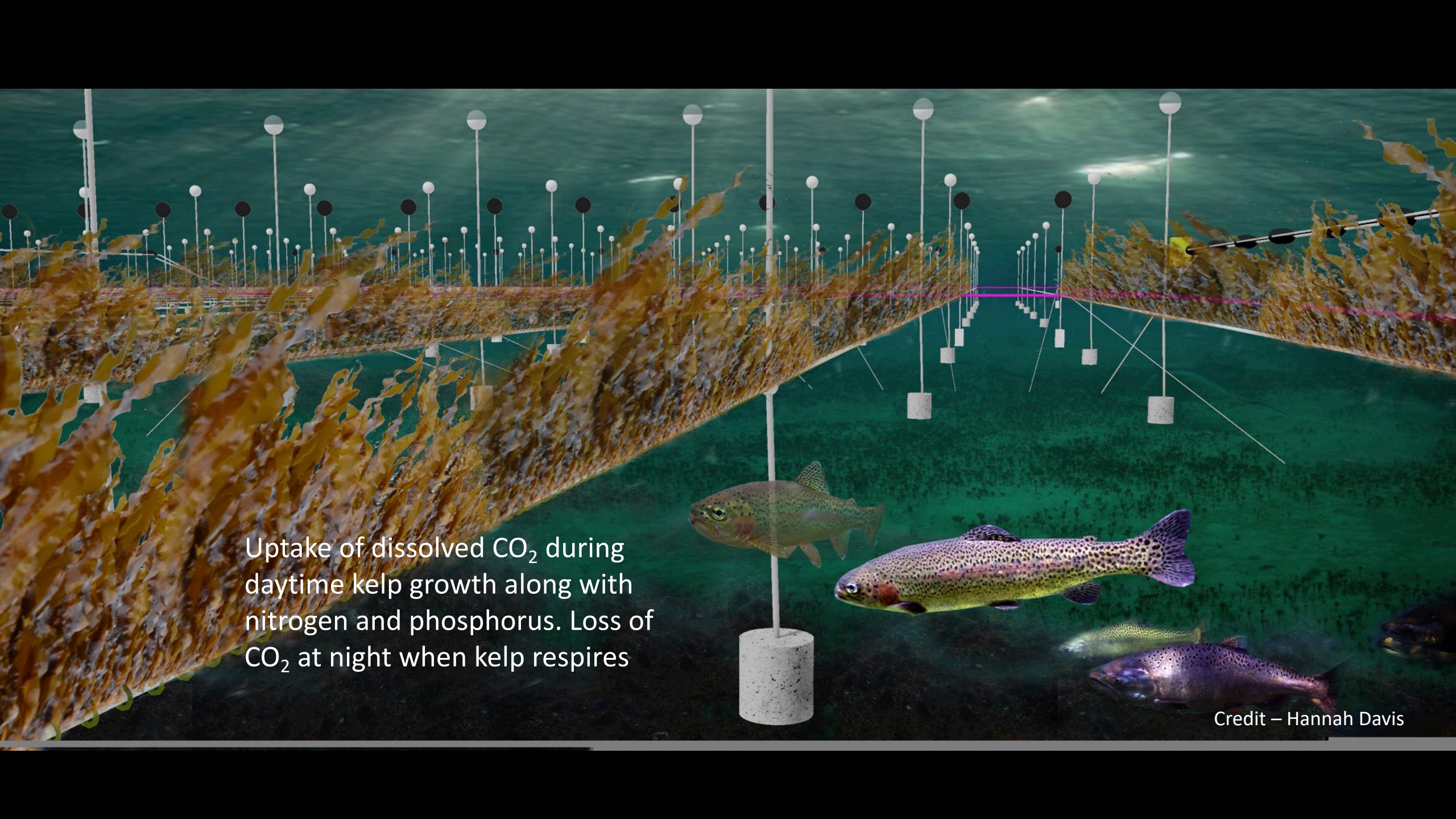
Kelp sporophytes on twine





3-meter depth

Growth of kelp sporophytes begins in early winter



Uptake of dissolved CO₂ during daytime kelp growth along with nitrogen and phosphorus. Loss of CO₂ at night when kelp respire

Credit – Hannah Davis

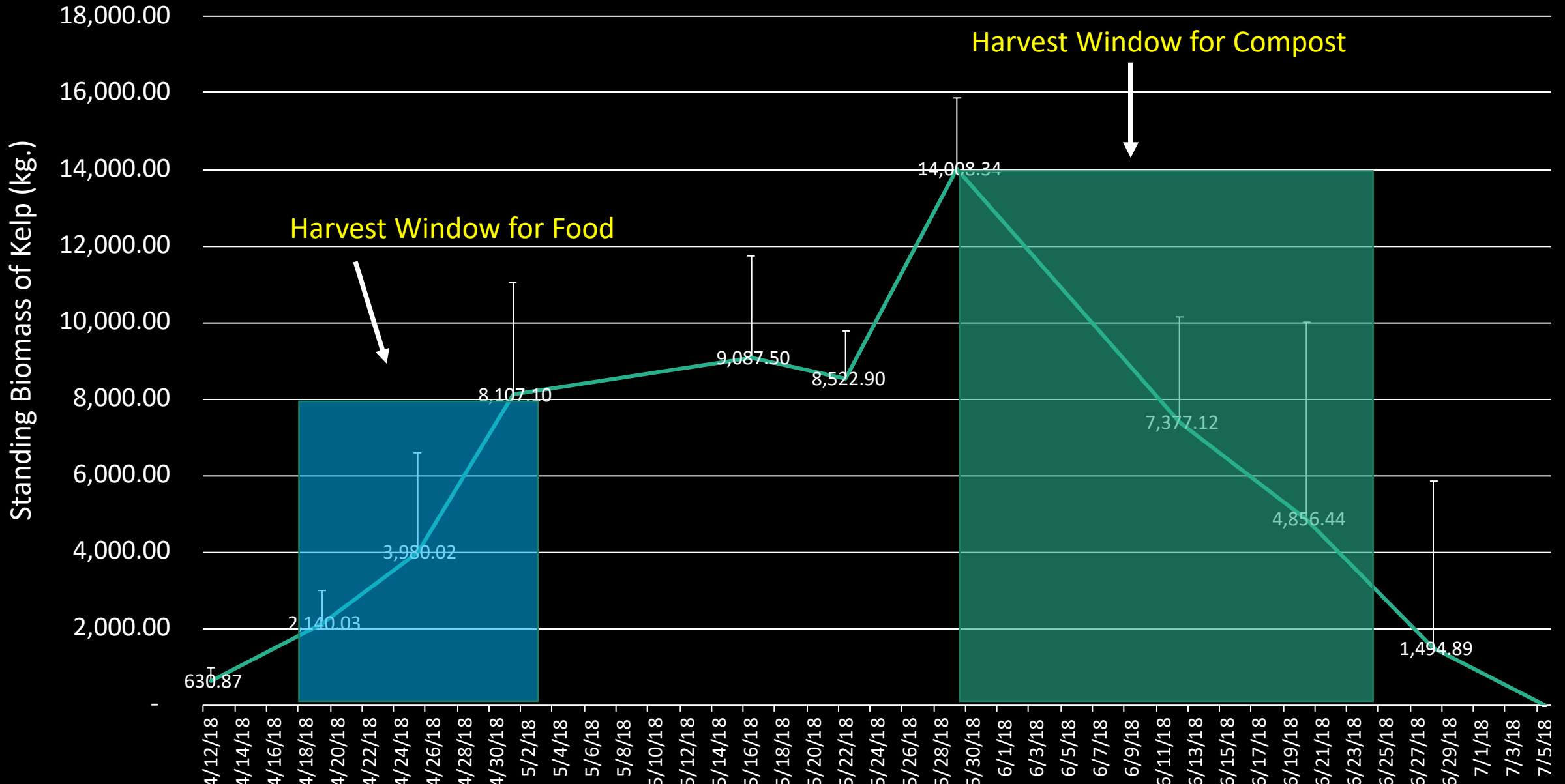
Full grown kelp harvest-ready by late March

Kelp adds structure for habitat and potentially reduced corrosive conditions associated with ocean acidification



Credit – Hannah Davis

Standing Biomass of Kelp on Cultivation Lines - A Spectrum of Uses



2018 Production – approx. 14,000 kg/ha wet weight; 1400 kg dry weight



Production metrics...

5.9 kg kelp per meter

280 kg carbon
removed from Hood
Canal

28 kg nitrogen
removed from Hood
Canal



License to harvest food-grade kelp



- Washington Department of Agriculture
- Complete food safety program
- Training through HACCP (Hazardous Analysis & Critical Control Points)
- Sanitation Standard Operating Procedures (SSOP)

What to do with all the kelp?

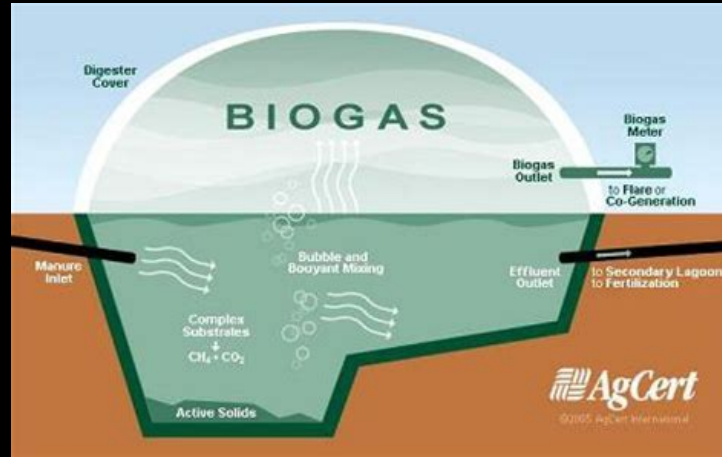


- In 2017, carbon captured by kelp at Hood Head was used to enrich soils at SkyRoot Farm on Whidbey Island to simulate a virtuous cycle from land to sea to land.

Building relationships with downstream uses

Opportunities

- Food
- Compost
- Bioenergy



Continuing Research

- Hood Canal Mariculture continues to operate under an Individual Permit (IP) with the USACE
 - An IP enables the company to continue research on seaweeds and nutrient uptake
 - New research beginning in 2020 with the Pacific Northwest National Laboratory will address nitrogen uptake over an annual growing cycle of sugar kelp to better evaluate the potential for sugar kelp to provide nutrient sequestration services for local water bodies

Site Conditions are Paramount

- Conditions at a particular site (currents, nutrient availability), together with the density of cultivation, will determine the benefits that can be gained.
- “Puget Sound Seaweed Site Evaluator” is a modeling tool developed by System Science Applications (SSA) to assess the suitability of other sites in Puget Sound for siting kelp farms and predicting the kelp effect.
- Other great tools in WA, such as Live Ocean, could also be applied.

Building a Community of Seaweed Growers

- There is so much to learn about seaweed farming on the west coast
 - Public education needed about both impacts and benefits of growing seaweeds in Washington
 - Critical focus on downstream uses of seaweeds necessary for anyone contemplating getting into seaweed cultivation
 - Necessary to better integrate seaweed with shellfish culture to capture the synergy between seaweeds (improved water quality) and shellfish (provision of nutrients) to benefit both at the right spatial scale.
 - Community building needed to provide growers, Tribes, regulators and educators/researchers for regular information exchange
 - Blue Carbon Initiatives - help through kelp and other seaweeds