Welcome to the C-CAN Ocean Acidification Roundtable!

We will begin at 1:00 pm PST using the free VOIP (Voice Over Internet Protocol).

If you need technical assistance, please type your questions into the Question box in in the control panel on the right hand side of your screen.
If you are unable to connect using VOIP, dial Toll: +1 (415) 655-0052
Access code: 357-930-756
You will be charged for this call.
To connect you MUST HAVE the audio pin number shown after joining the webinar

Today’s Webinar:

‘Kelping’ the sea – farming seaweeds for research and resources in the Pacific Northwest.

Hosted by: Meg Chadsey

Today's Moderator

Meg Chadsey

Ocean Acidification Specialist

Washington Sea Grant

Today's Facilitator

Shallin Busch

Ecologist

NOAA NWFSC & OA Program

Questions?

Please type questions into the Question box located in the control panel on the right side of your screen

Today's format

Presenters will cover:

1) The context and rationale for the experimental kelp farm in Puget Sound.
2) Opportunities and challenges of launching a commercial kelp aquaculture facility and developing new markets for kelp-based products.

Facilitated Q&A

Adjourn

Introducing our Featured Speakers

Joth Davis

A marine scientist with 30 years experience in the Pacific Northwest shellfish industry, as a consultant, researcher and farmer.

Joth has helped spearhead efforts to establish sugar kelp cultivation in Puget Sound, as a potential ocean acidification mitigation strategy.

Contact: jothpdavis@gmail.com

Introducing our Featured Speakers

Beth Wheat

Lecturer in the UW Program of the Environment, with expertise in Sustainability Studies and Regenerative Agriculture.

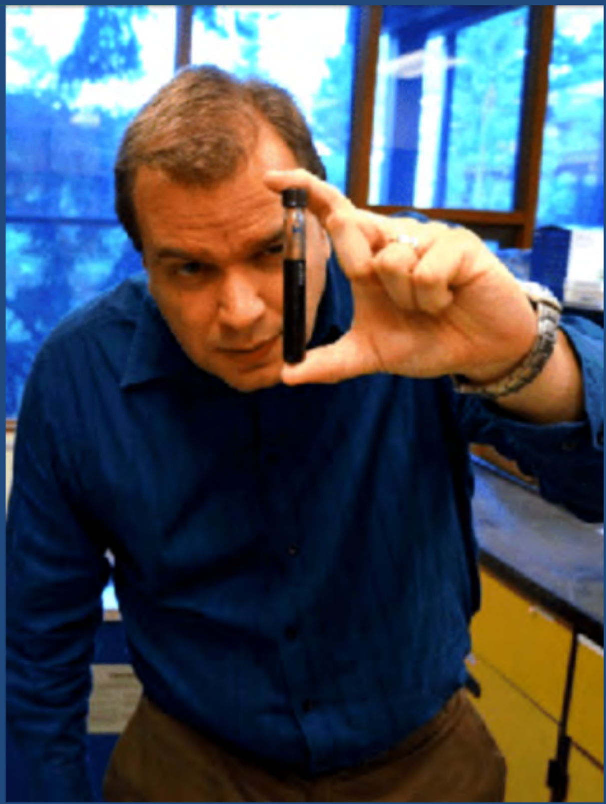
Beth engages students in hands-on training at both the UW Farm and her own 20-acre SkyRoot Farm on Whidbey Island in Puget Sound.

Contact: elizaw@u.washington.edu

Introducing our Featured Speakers

Fernando Resende

Assistant Professor at UW School of Environmental and Forest Sciences. Focus: turning plant biomass into renewable biofuels using high temperature processes.



Fernando is part of the Bioresource Science and Engineering program, which led a $40 million grant from the USDA to develop biofuels.

Contact: fresende@uw.edu

Kelping the Sea – farming seaweeds for research and resources in the Pacific Northwest

JOTH DAVIS

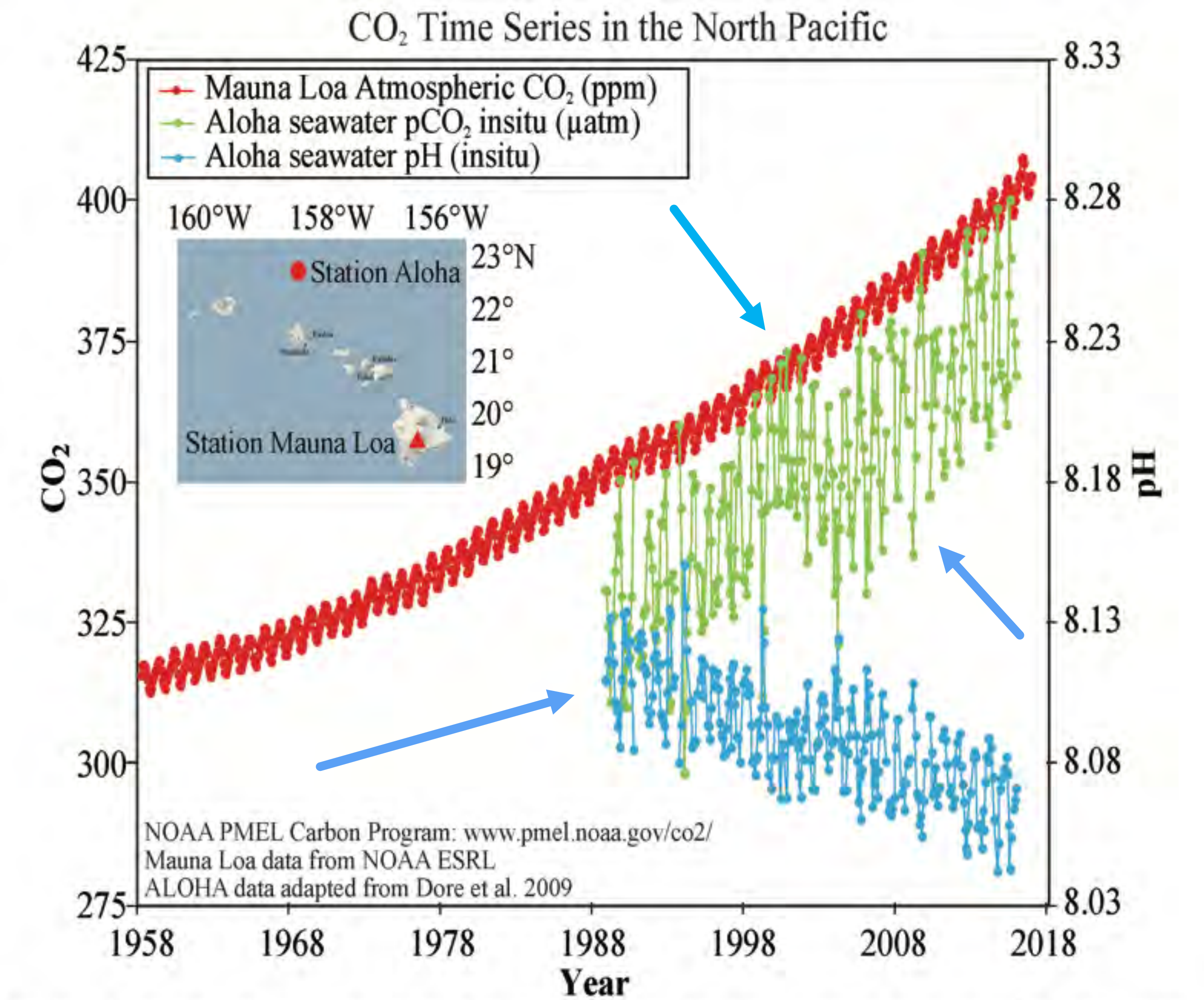
HOOD CANAL MARICULTURE AND PUGET SOUND RESTORATION FUND

Photo Credit – John Mickett APL-UW

Photo credit - PSRF

Seaweed Aquaculture and Carbon removal

- Key questions
  - Can kelp farms create a refuge from OA conditions that will protect organisms in or around them?
    - Phytoremediation – a WA State Blue Ribbon Priority Action to combat OA
  - How extensive is the halo effect?
  - Can growing seaweeds be scaled to provide meaningful nutrient and CO_2 removal on a local basis?
  - What do we do with all the seaweed?



Data: Mauna Loa (ftp://aftp.cmdl.noaa.gov/products/trends/co2/co2_mm_mlo.txt) ALOHA (http://hahana.soest.hawaii.edu/hot/products/HOT_surface_CO2.txt)
Ref: J.E. Dore et al, 2009. Physical and biogeochemical modulation of ocean acidification in the central North Pacific. *Proc Natl Acad Sci USA* **106**:12235-12240.

Credit: NOAA PMEL Carbon Program

2013 Ocean Challenge

- Paul Allen Family Foundation (Vulcan Philanthropy) competition to stimulate potential market-based solutions to help mitigate impacts associated with ocean acidification

Co-PI Betsy Peabody and staff of the PSRF and Hood Canal Mariculture together made a major commitment to seaweed culture

Proposal:

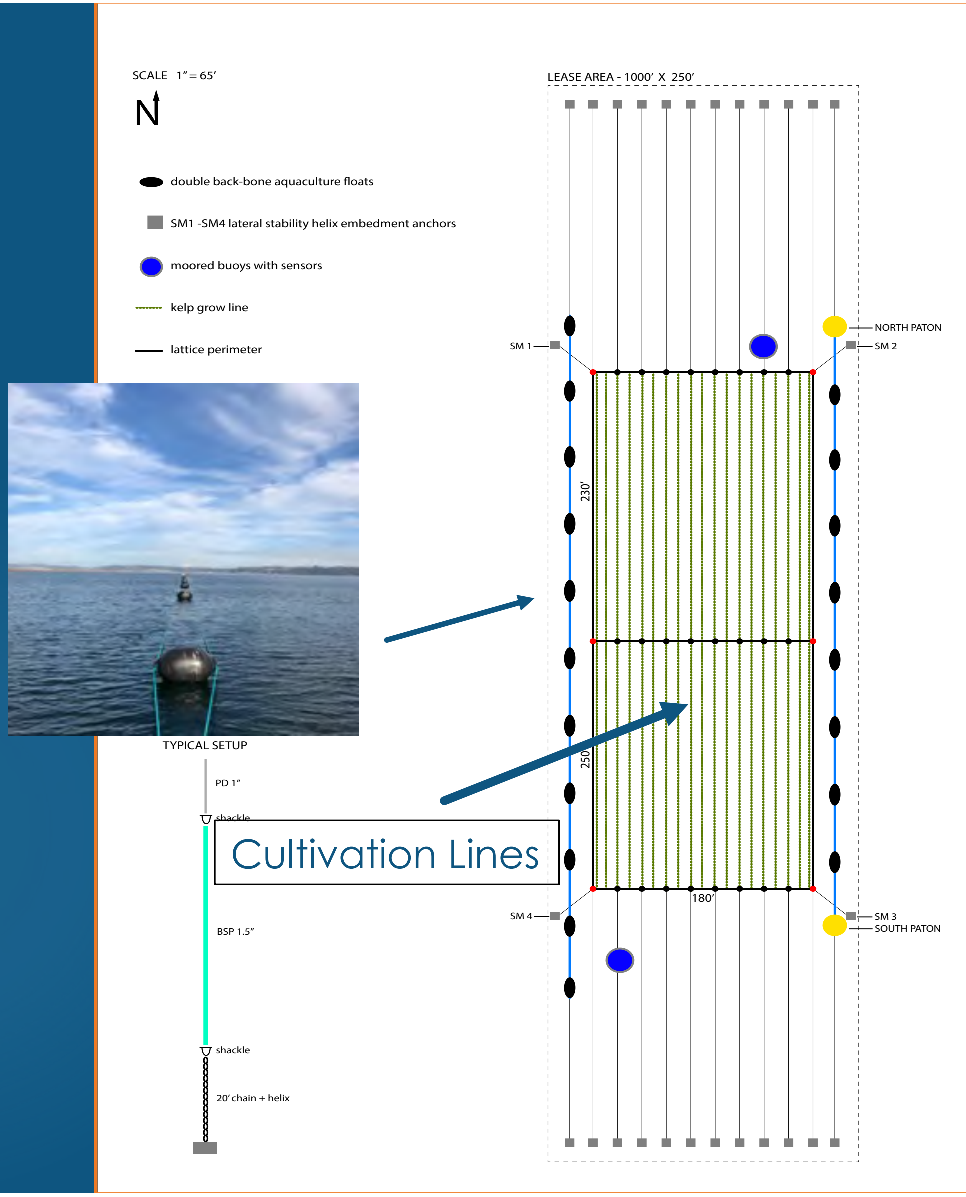
"Cultivating seaweed to mitigate ocean acidification, and generate habitat, fertilizer, food and fuel", focused on growing seaweeds coupled with the development of downstream industries utilizing seaweeds"

- Project evolved to focus on quantifying linkages between carbonate chemistry and seaweed production, including modeling these effects.
- US Navy Hood Canal Mitigation Funds being added in 2018 to carry project through a second year of production

PUGET SOUND RESTORATION FUND

Project Objectives

- Establish kelp cultivation at a suitable site in Hood Canal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SM1 -SM4 lateral stability helix embedment anchors
moored buoys with sensors
kelp grow line
lattice perimeter
LEASE AREA - 1000′ X 250′
SM 1
SM 2
NORTH PATON
230′
250′
180′
SM 3
SOUTH PATON
SM 4
TYPICAL SETUP
PD 1″
shackle
BSP 1.5″
shackle
20′ chain + helix
Cultivation Lines

14 ft
12 ft
10 ft
8 ft
6 ft
4 ft
2 ft
0 ft
-2 ft
5:30 9.0
12:18 -1.2
19:32 10.4
0 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9
Hood Head
NW
NE
SW
SE
047
048
049
050
051
052
053
054
055
056
057
058
656 ft
© 2015 Google
Google earth

Permitting for seaweed aquaculture in WA State

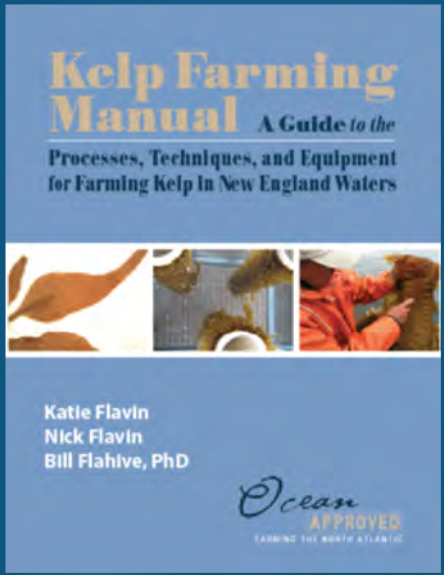
Steps we took;

1. Rewrote existing lease agreement with WA DNR to cover seaweed aquaculture combined with shellfish
2. Permitted with Jefferson County for SEPA and other local permits to make changes to an existing lease (Shoreline Development Permit)
3. Checked for compliance with WA DFW, DOE and DOH
4. Negotiated with Seattle District USACOE
    1. Agreed to release farm from Nationwide 48 permit
    2. Developed Individual Permit (IP) to conduct "mariculture" – required for seaweed
    3. Worked with local WA Tribes for support of project
    4. Worked with local WA NGO's for support of project
5. Initial contacts made with WSDA for HACCP development for seaweed harvest and processing for food

So let's build a sugar kelp farm.....

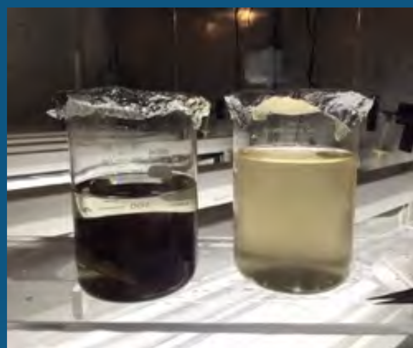
Steps

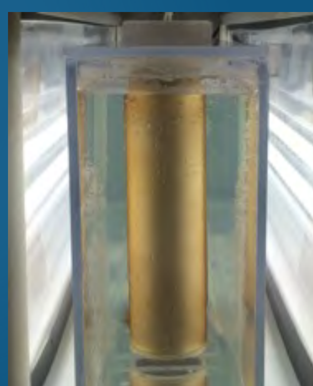
- Establish Mooring System to withstand expected drag from tidal and wind driven currents
  - information on storm wind direction, maximum fetch and wave height and period
- Install lattice and floatation system to support culture system
- Install grow lines just prior to seeding
- Plant out sporophytes seeded on twine
- Monitor early survivorship and growth rate
- Advance planning for HACCP, harvest, processing and marketing!
- Monitor biofouling and make plans for harvest
- Read and follow a good manual for all the above....!

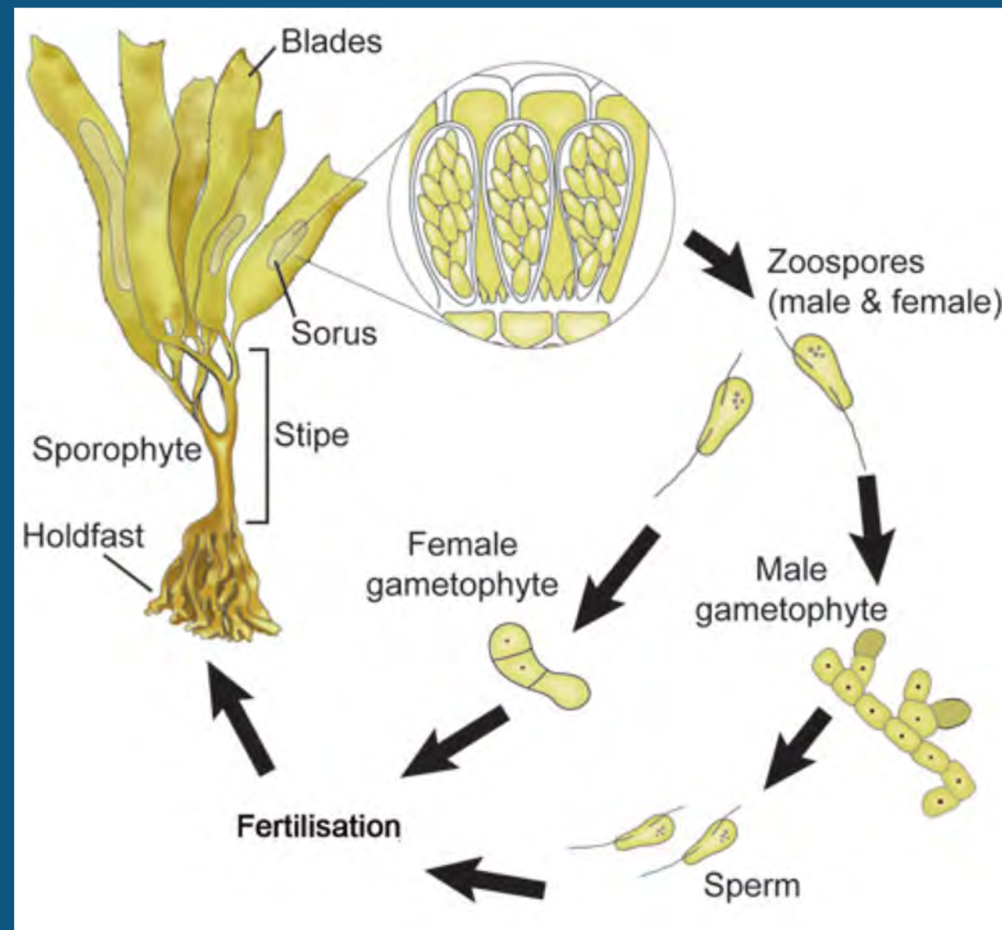


Project Objectives

- Production of seeded twine from mature sorus





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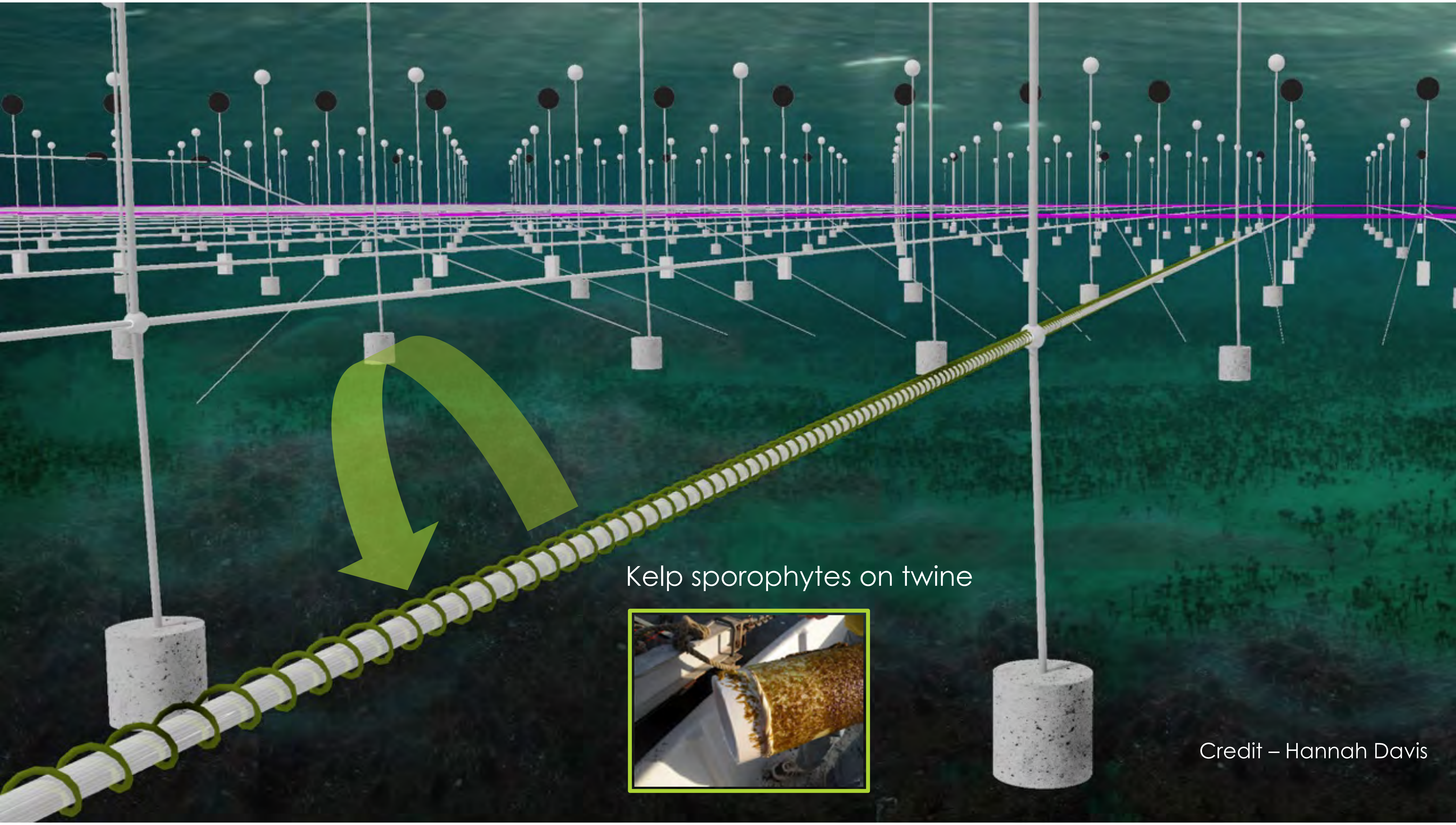
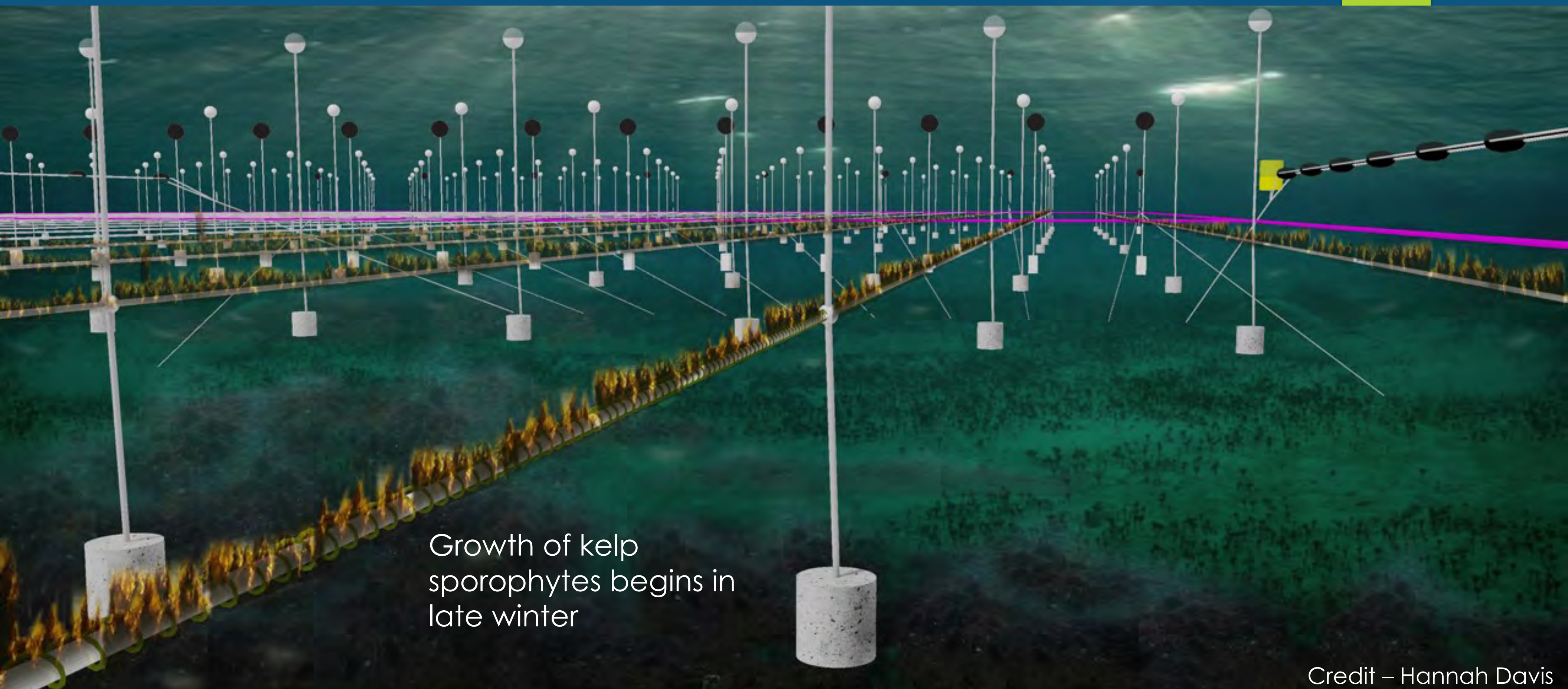
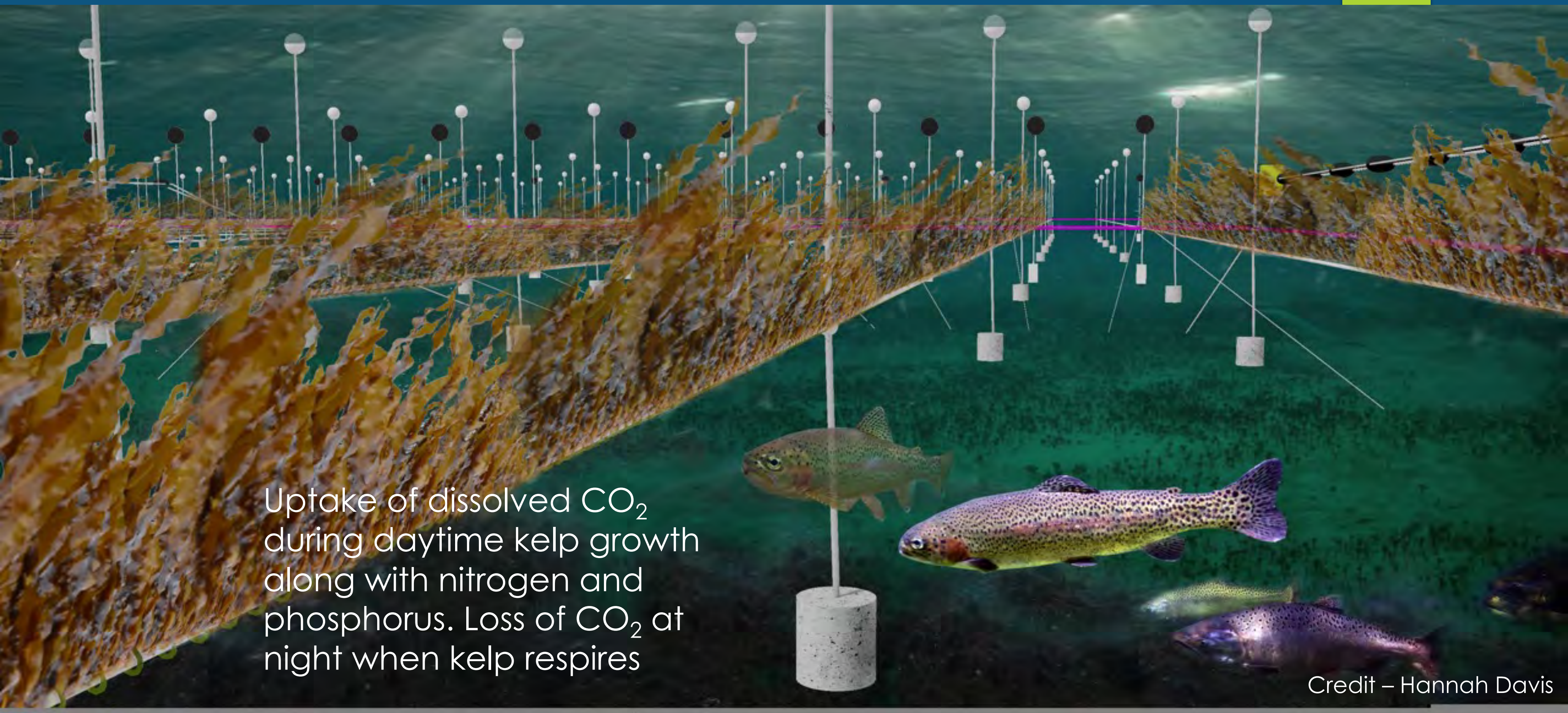
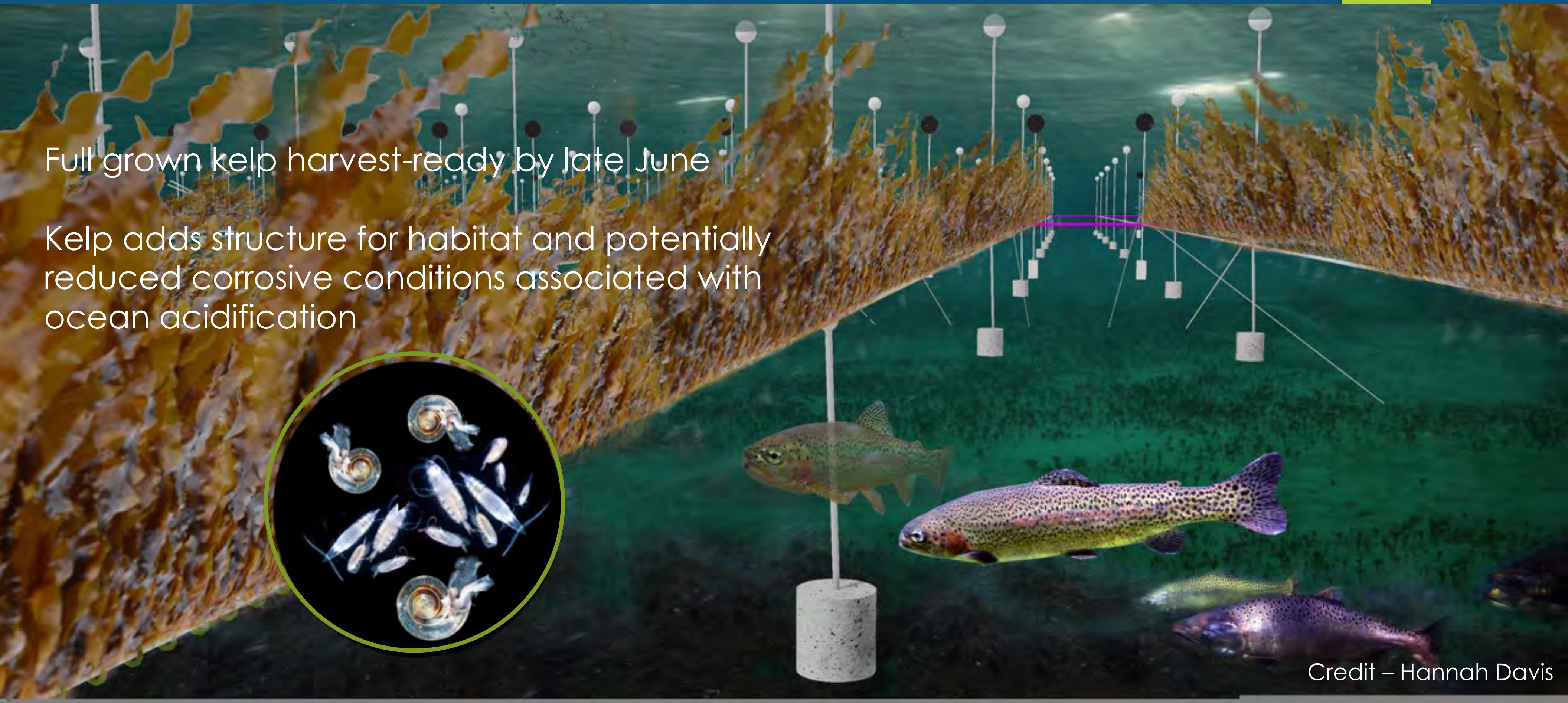
Seeding Sugar Kelp sporophytes on twine onto grow lines

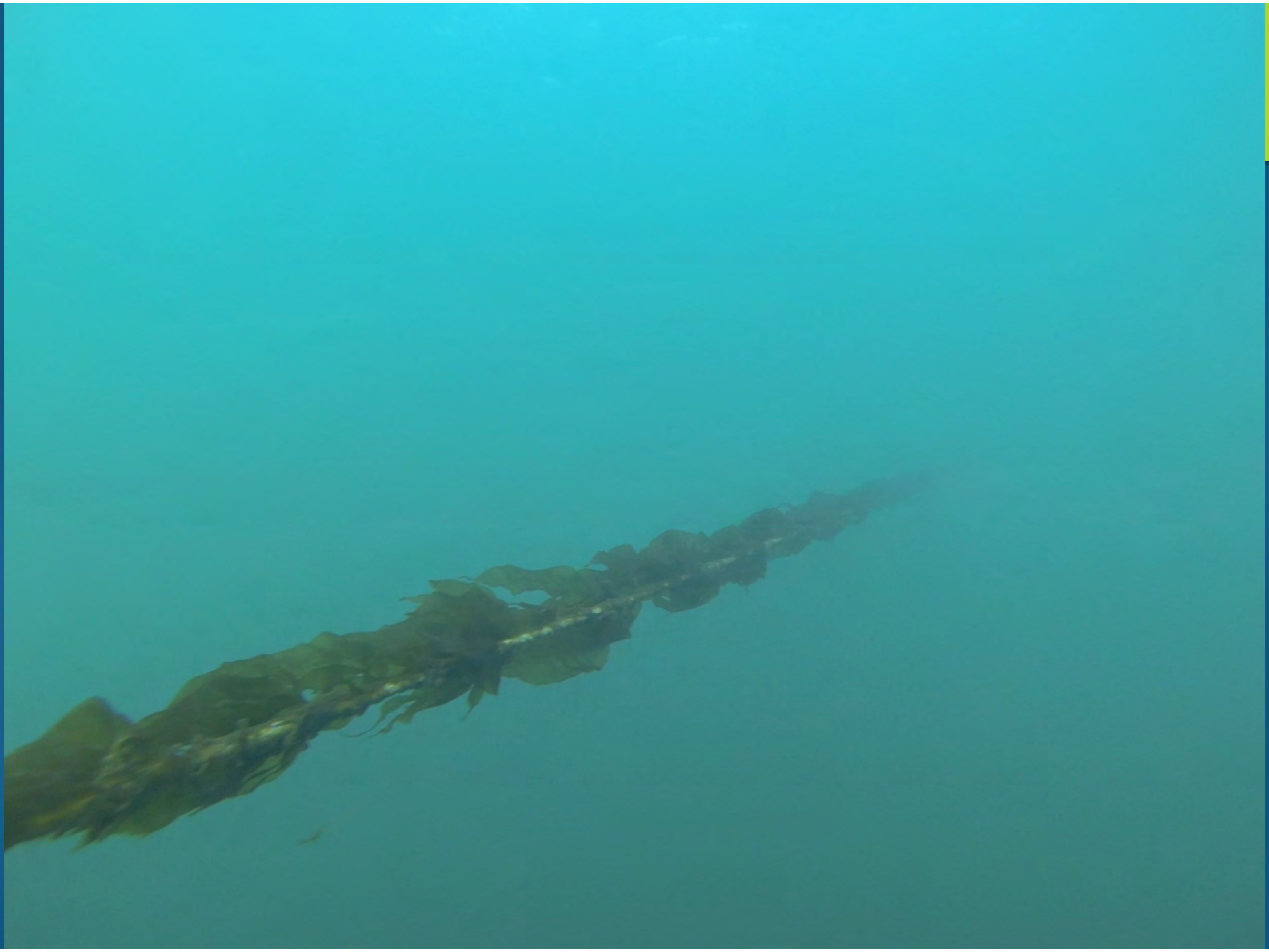

Kelp sporophytes on twine
Credit – Hannah Davis

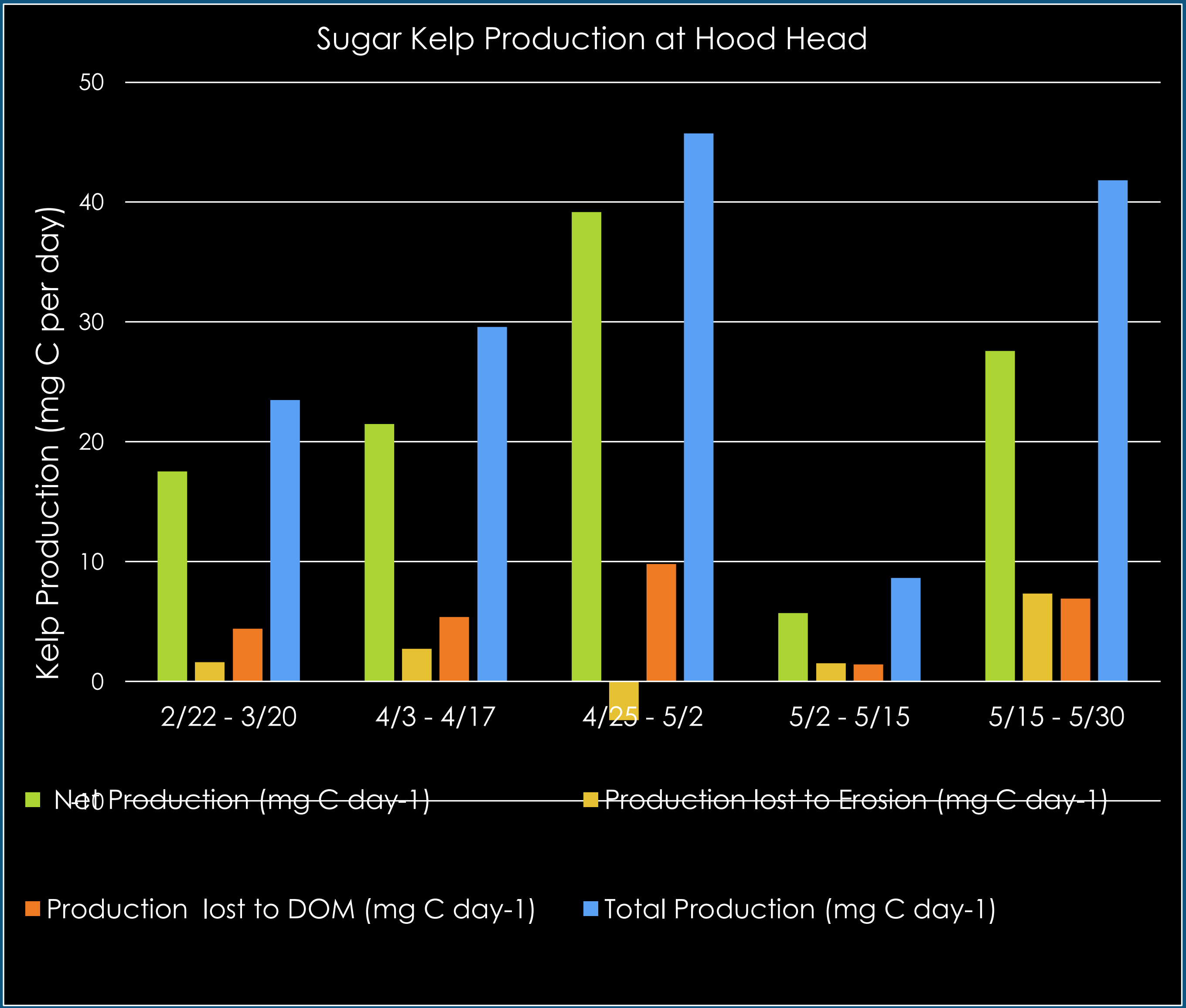

Growth of kelp sporophytes begins in late winter
Credit – Hannah Davis


Uptake of dissolved CO_2 during daytime kelp growth along with nitrogen and phosphorus. Loss of CO_2 at night when kelp respires
Credit – Hannah Davis


Full grown kelp harvest-ready by late June
Kelp adds structure for habitat and potentially reduced corrosive conditions associated with ocean acidification
Credit – Hannah Davis

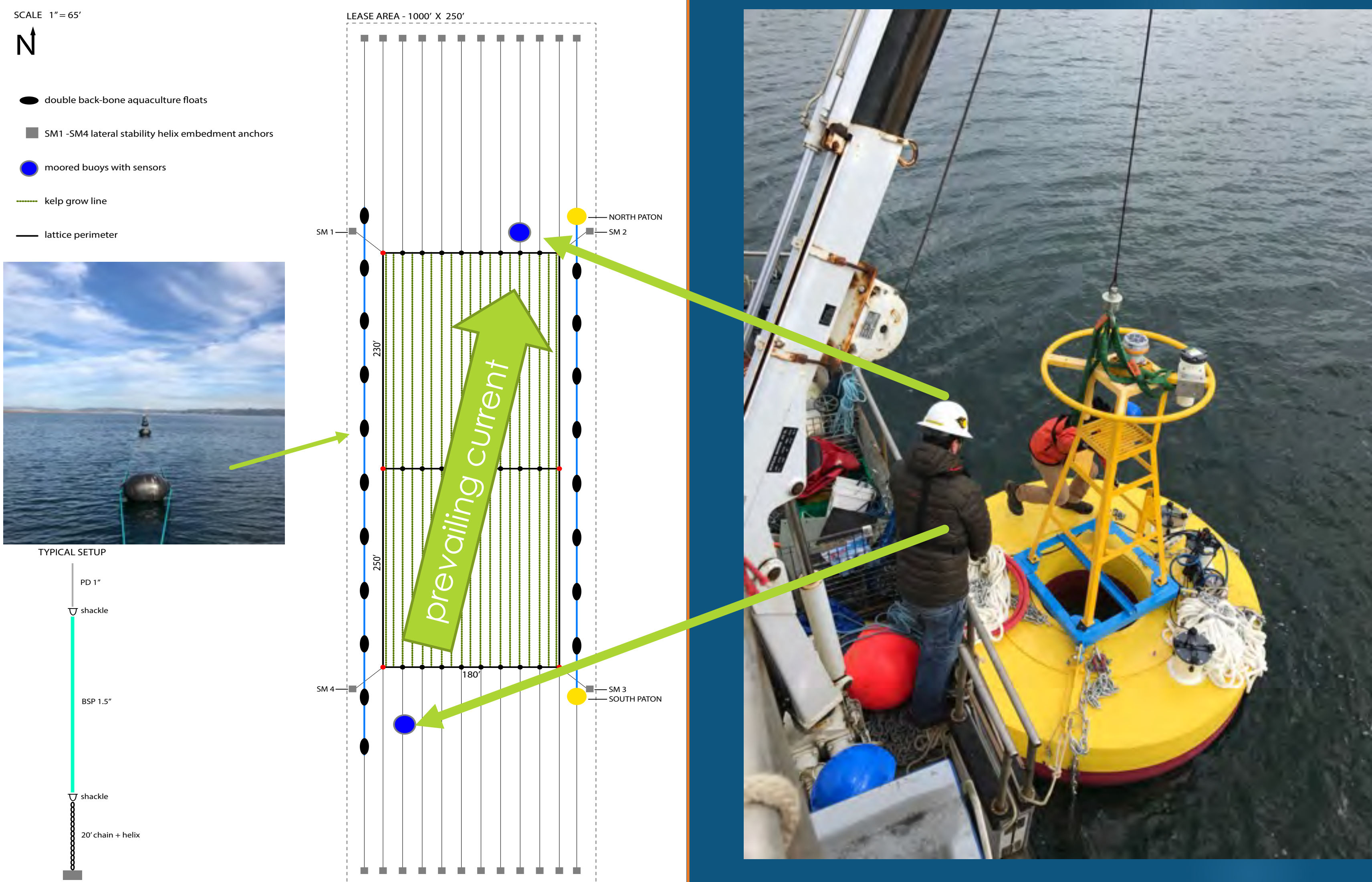

2018/03/29





Sugar Kelp Production at Hood Head
Kelp Production (mg C per day)
50
40
30
20
10
0
-10
2/22 - 3/20
4/3 - 4/17
4/25 - 5/2
5/2 - 5/15
5/15 - 5/30
Net Production (mg C day-1)
Production lost to Erosion (mg C day-1)
Production lost to DOM (mg C day-1)
Total Production (mg C day-1)

Harvest Day!



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SM 2
NORTH PATON
230'
250'
180'
SM 4
SM 3
SOUTH PATON
prevailing current

FIELD RESEARCH PROGRAM

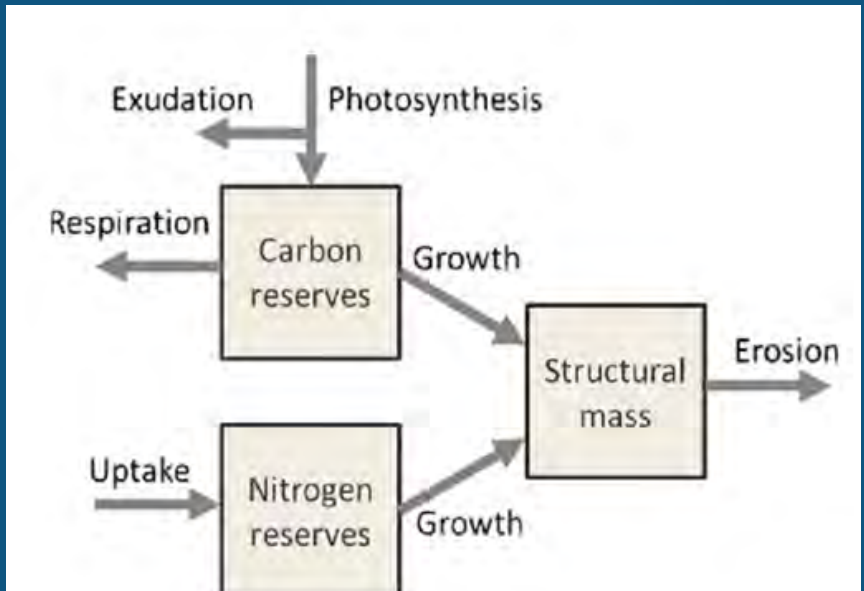
- Changes in Carbonate Chemistry - assess changes in chemistry and hydrographic parameters of seawater passing through kelp biomass to assess daily net changes in dissolved $C0_2$ and other carbonate chemistry variables?
  - Employ discrete, semi and continuous measurements of pCO_2, pH, DOC, DIN, TA, DO_2, salinity over kelp grow out season

Project Partners: Jan Newton & John Mickett (UW APL), Richard Feely & Simone Alin (NOAA PMEL), Micah Horwith (WDNR)

- Modeling Kelp Production - nutrient flux vs uptake, net and total production and effects on carbonate chemistry

Project partners: Dale Kiefer and Zach Siegrist (SSA)

“Upstream downstream measurements”



Credit – D. Kiefer & Z. Siegrist

Biological Studies to Assess Halo Effect and Habitat Use

NOAA Pacific Marine Env. Laboratory
Pteropod survivorship and dissolution assays placed into mesocosms during kelp grow out

Project partner – Nina Bednarsek
UW Contractor

WA DNR, NOAA and PSRF
Habitat Use by fish and invertebrates
Hydrophones to detect salmon implanted with acoustic tags passing through kelp

Credit – David Liittschwager

Seaweed, Aquaculture and Carbon removal

- Key questions
  - Can kelp farms create a refuge from OA conditions that will protect organisms in or around them?
  - How extensive is the halo effect?
  - Can growing seaweeds be scaled to provide meaningful nutrient and CO_2 removal on a local basis?
  - What do we do with all the seaweed?

Downstream Uses of Seaweeds...

Opportunities

- Food
- Compost
- Bioenergy

We are seeing only the very beginning of seaweed utilization here in North America

SO MUCH POTENTIAL!

Credit – Betsy Peabody

The Kelp Team

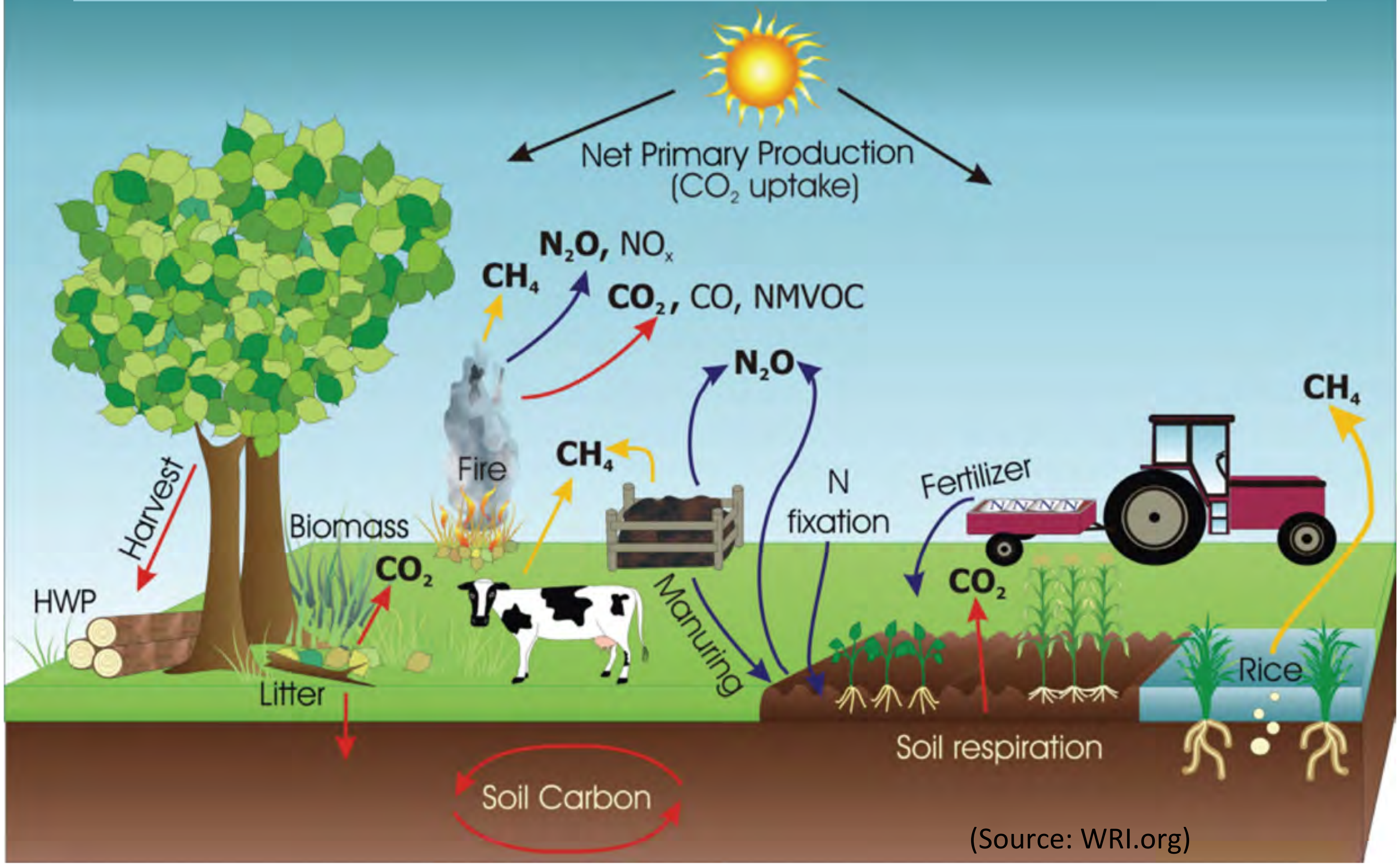
Assessment, Modeling & Lab Study

- Dick Feely, NOAA PMEL
- Simone Alin, NOAA PMEL
- Jan Newton, UW APL, WOAC
- John Mickett, UW APL
- Nina Bednarsek, UW Contractor
- Dale Kiefer, SSA
- Zach Siegrist, SSA
- Cinde Donoghue & Micah Horwith, WA DNR
- John Colt, NMFS
- Ron Johnson, NMFS

Kelp Cultivation, Sampling & Outreach

- Walt Dickhoff, NMFS - retired
- Mike Rust, NOAA Aquaculture
- Tom Mumford, Marine Agronomics
- Louie Druehl, CKR
- Terrie Klinger, UW SMEA, WOAC
- John Forster, Forster Consulting
- Connie Mahnken, WA F&W - retired
- Meg Chadsey, WA Sea Grant
- Brian Allen and Stephen Schreck (PSRF)

How do farms interact with the Carbon Cycle…?



(Source: WRI.org)

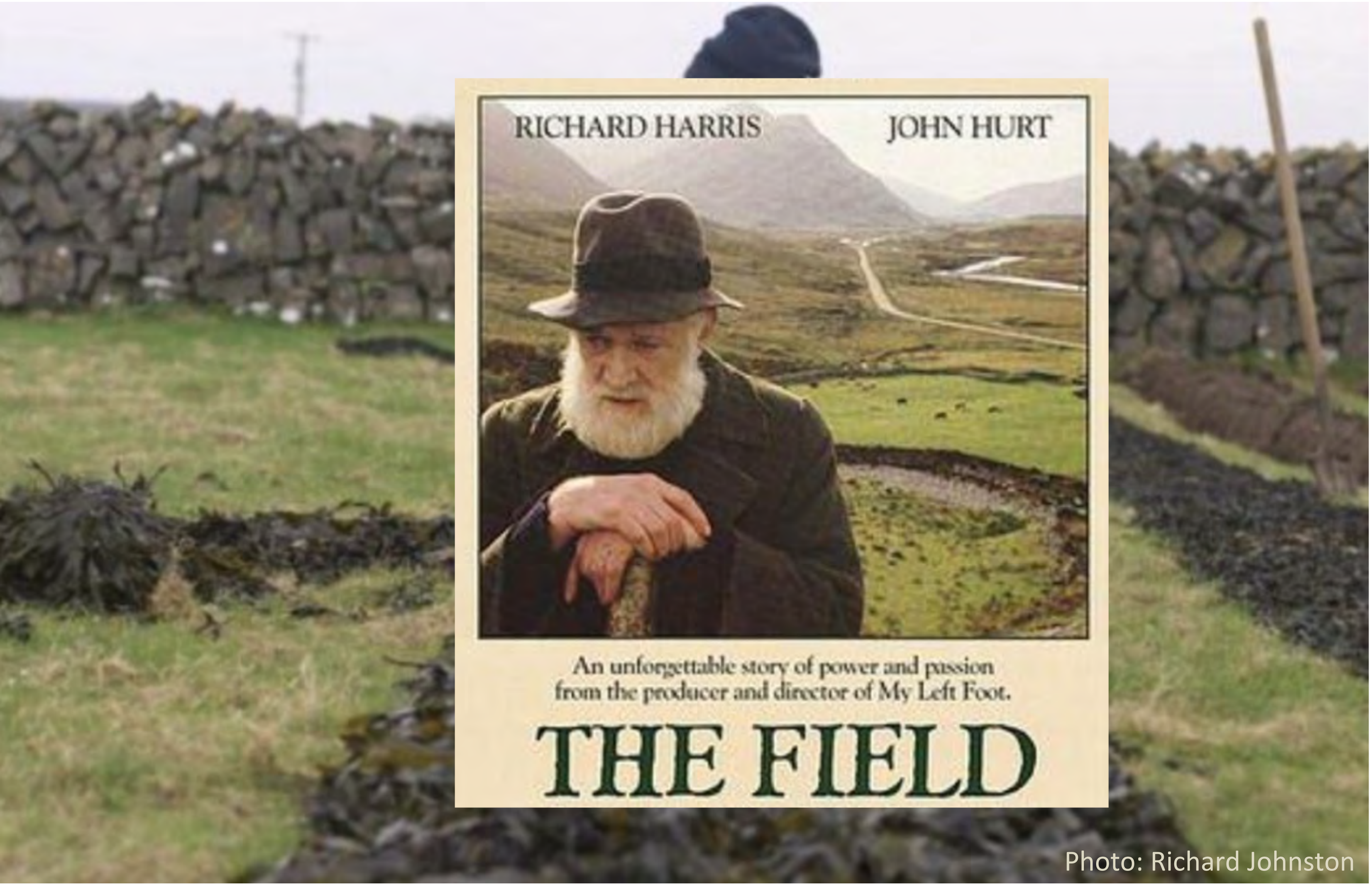


Photo: Richard Johnston

Kelp Production in the Salish Sea!

Experimentation

Kelp/Carbon Research

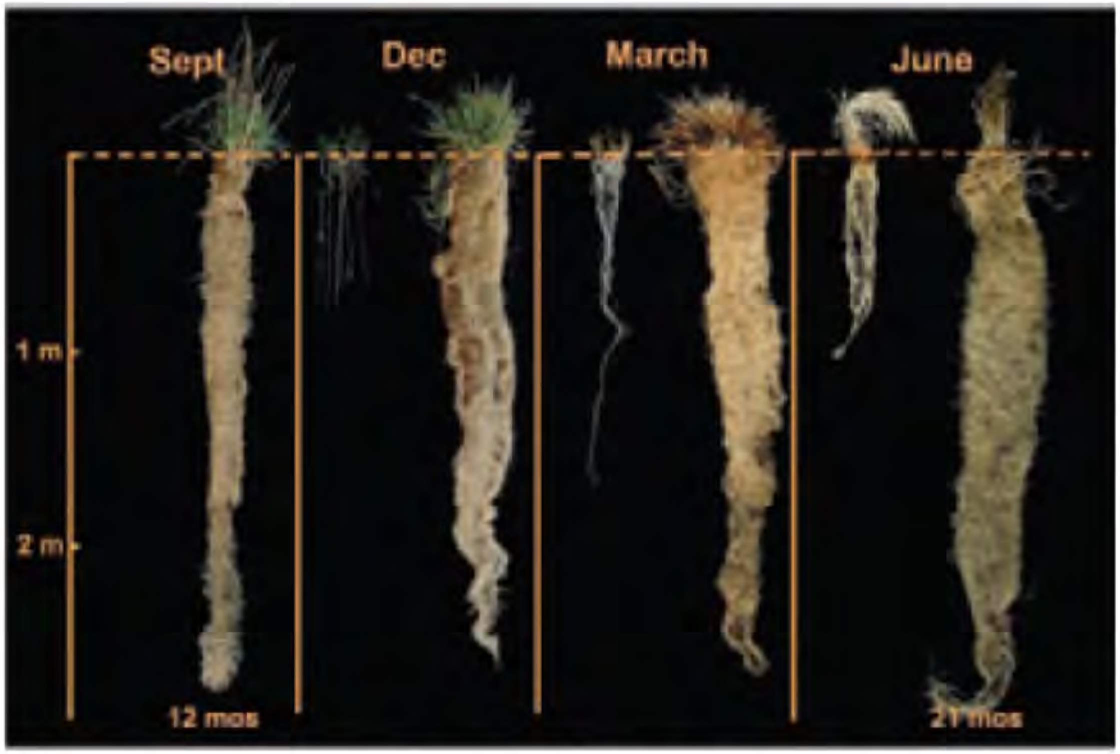


Figure 3.2. Root systems of annual wheat (at left in each panel) and wheatgrass, a perennial, at four times of the year. Approximately 25% to 40% of the wheatgrass root system dies back each year, adding considerable amounts of organic matter, and then grows back again. Compared to annual wheat, it has a longer growing season and has much more growth both above ground and below ground. Wheatgrass was 12 and 21 months old when the first and last photos were taken. Photo by the Land Institute.

Organic Matter!

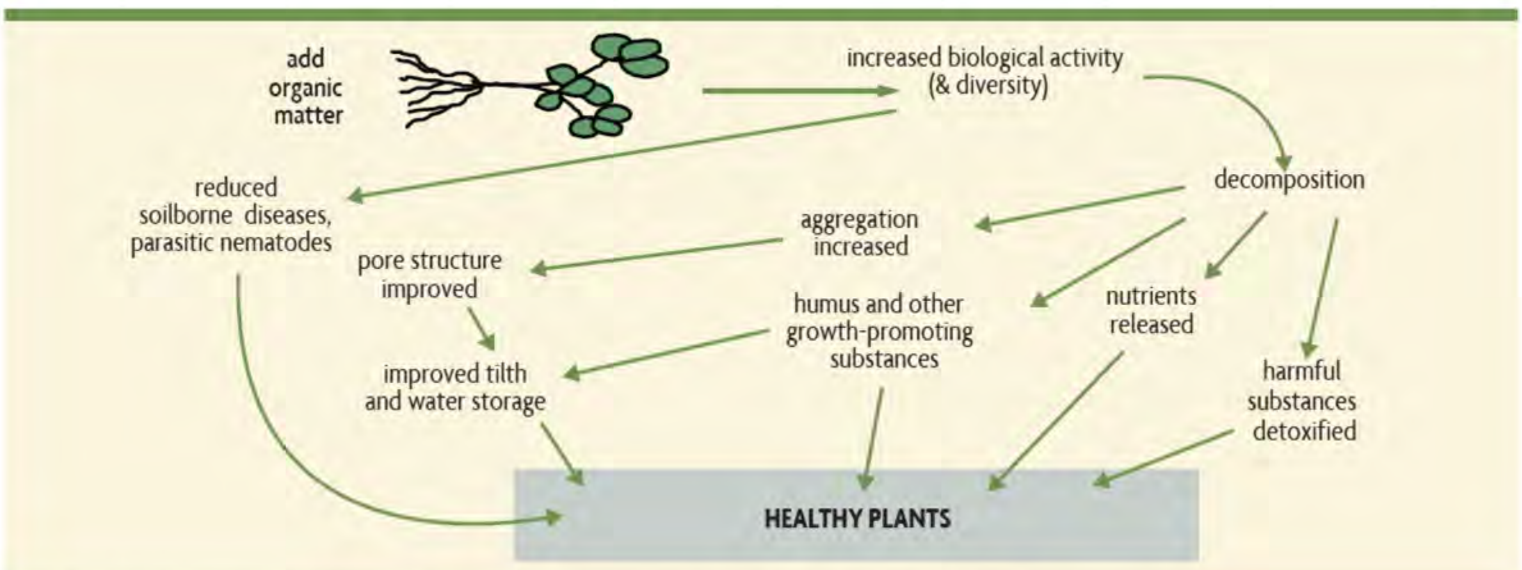


Figure 2.3. Adding organic matter results in many changes. Modified from Oshins and Drinkwater (1999).

Re-Generative Agriculture:

- Conservation Tillage
- Crop Rotation
- Short Term Pasture Rotations
  - Increase pasture biomass
- Compost Production
- On Farm Habitat Restoration/improve on site water capture/retention
- Incorporation of animals

Habitat Restoration

Pasture Management




Animal Integration

Cover Crops

Orchards

Soil Building

Perennial Production

Vegetables

Reduced Tillage Trials

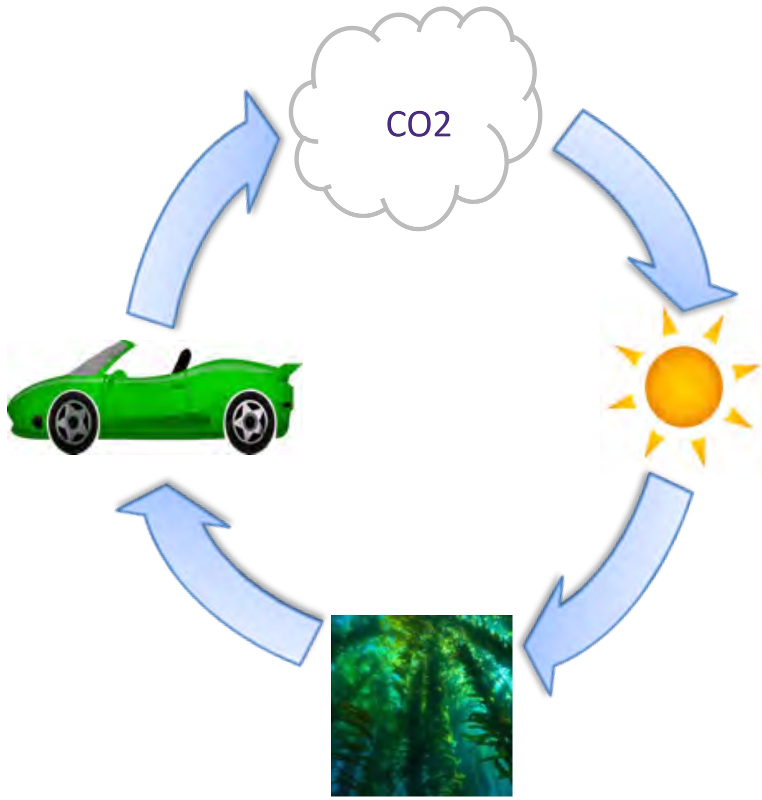
Hydrothermal Conversion of Sugar Kelp into Hydrocarbons

Fernando Resende

SCHOOL OF ENVIRONMENTAL AND FOREST SCIENCES
UNIVERSITY *of* WASHINGTON
College of the Environment

Why biofuels?

- Renewable
- Carbon neutral
- Large availability
- Alternative in case of oil price fluctuations



Why kelp?

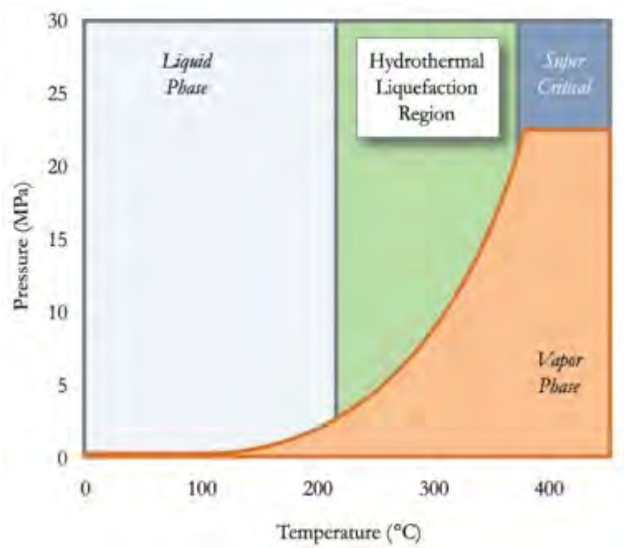
- Does not require land
- Does not require freshwater (halophyte)
- Does not require fertilizers / pesticides
- One of world's fastest growing plants: up to half a meter/day, reaching 30 – 80 m
- Harvesting and collection may benefit US coastal communities

Current limitations for biofuels production from kelp

Fermentation to ethanol

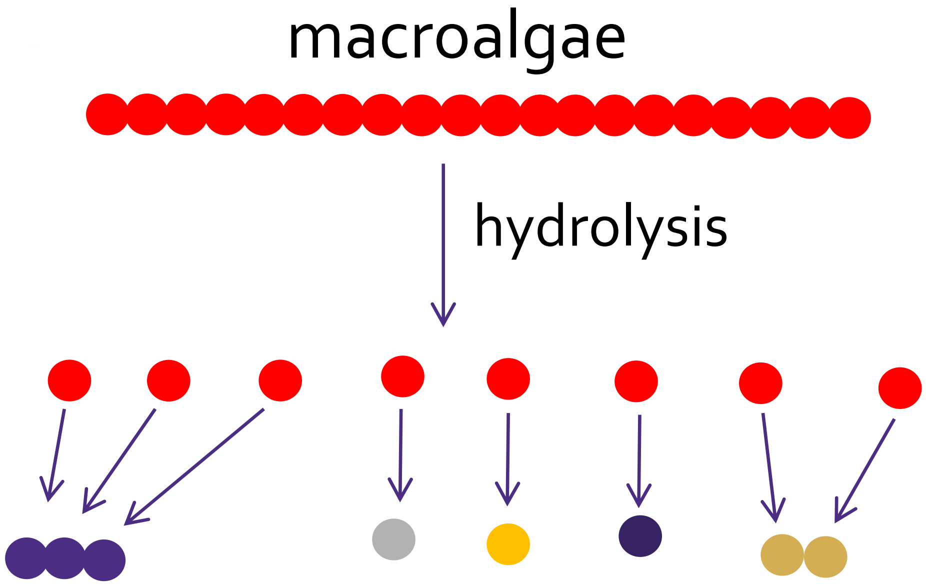
- Kelp has at least 60-70 wt % moisture
- Huge dewatering effort

Our contribution
Use the water as a solvent: Hydrothermal liquefaction



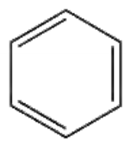
- Dewatering is unnecessary
- Takes place at 200-350°C and 10-20 MPa

Hydrothermal Liquefaction

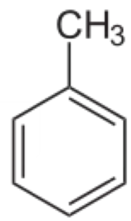


Products are typically a mixture of many compounds

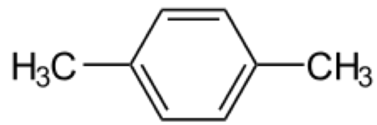
Target products – liquid hydrocarbons for transportation fuels



benzene

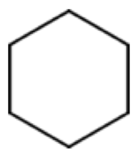


toluene

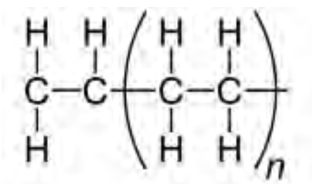


P-xylene

- Known as "BTX"
- Additives for gasoline



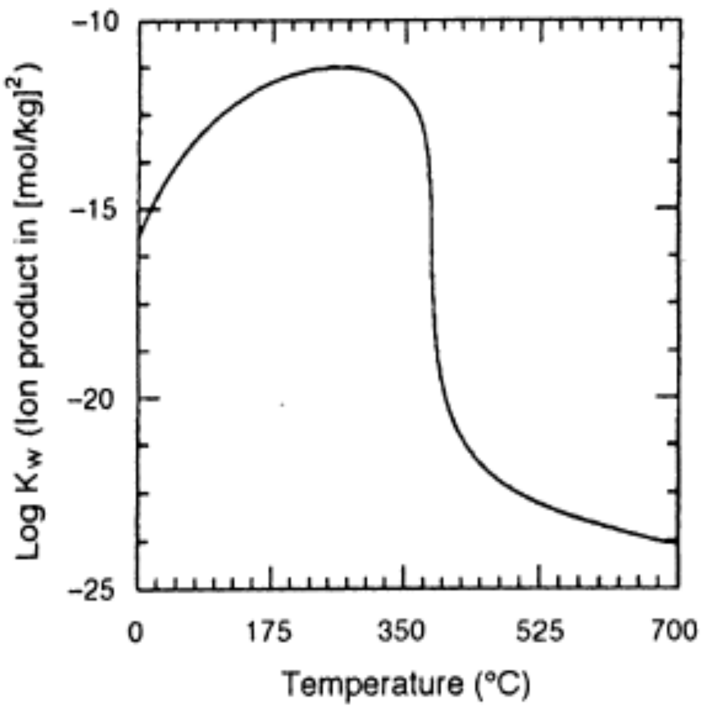
Cyclohexane



Alkanes

- Components of jet-fuel molecules

Hydrocarbons from hydrothermal liquefaction

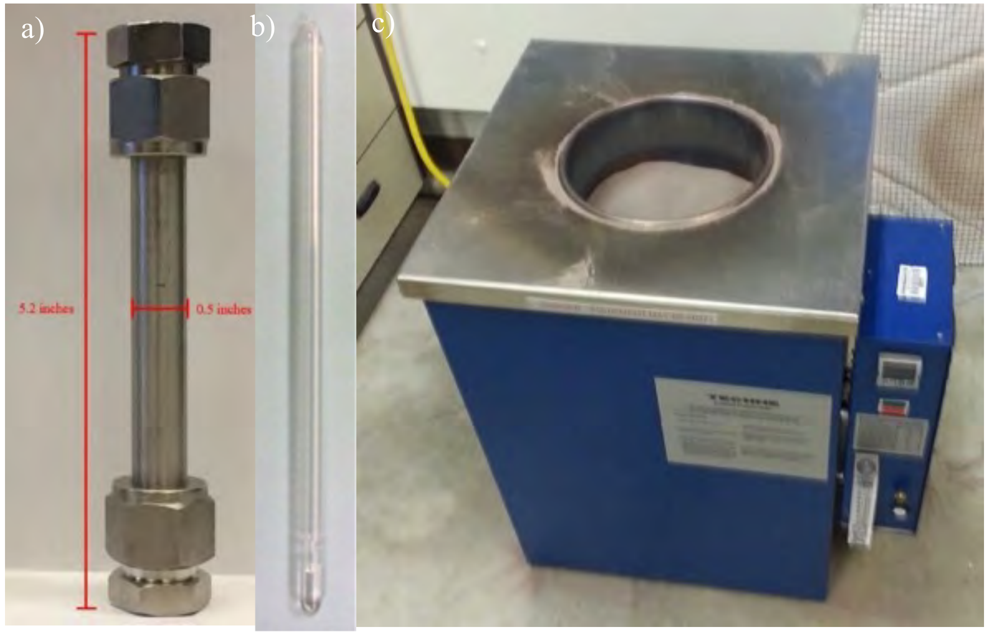


Algae is composed of carbohydrates: significant oxygen content

In HTL, water becomes a source of hydrogen atoms:

$$H_2O \longrightarrow H^+ + OH^-$$

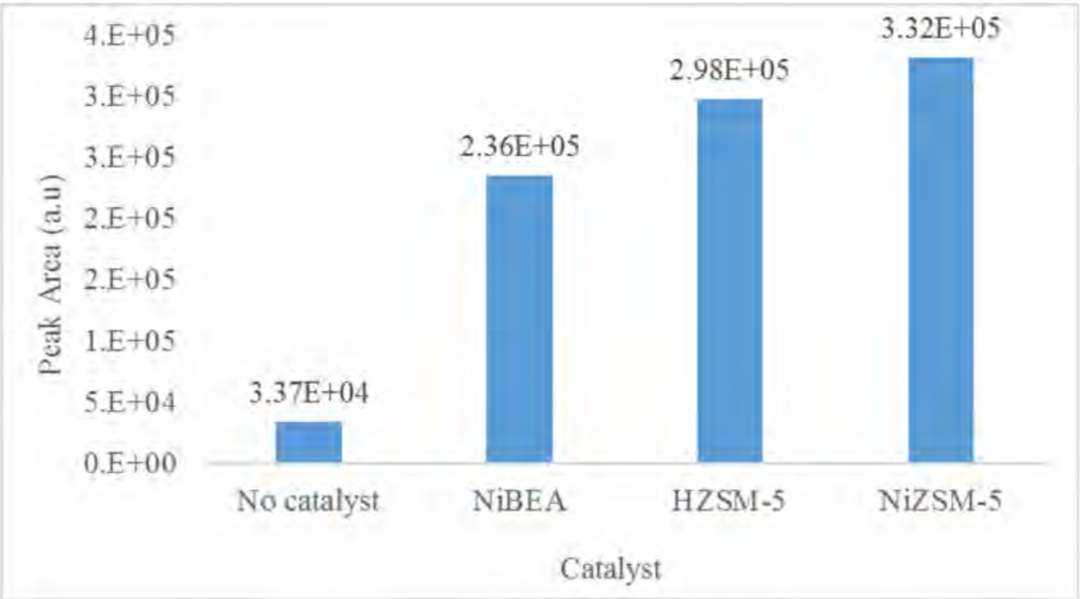
Experimental set up



(a) Swagelok/ (b) quartz reactor immersed in a (C) fluidized sand bath

Preliminary runs
T = 360°C, P = 30 Mpa

Hydrocarbon yields



The catalyst is the key for hydrocarbons production

Summary

- The use of kelp addresses several of the current issues with biofuels production
- The proposed hydrothermal liquefaction takes advantage of the water from kelp to generate liquid transportation fuels

Hydrothermal Conversion of Sugar Kelp into Hydrocarbons

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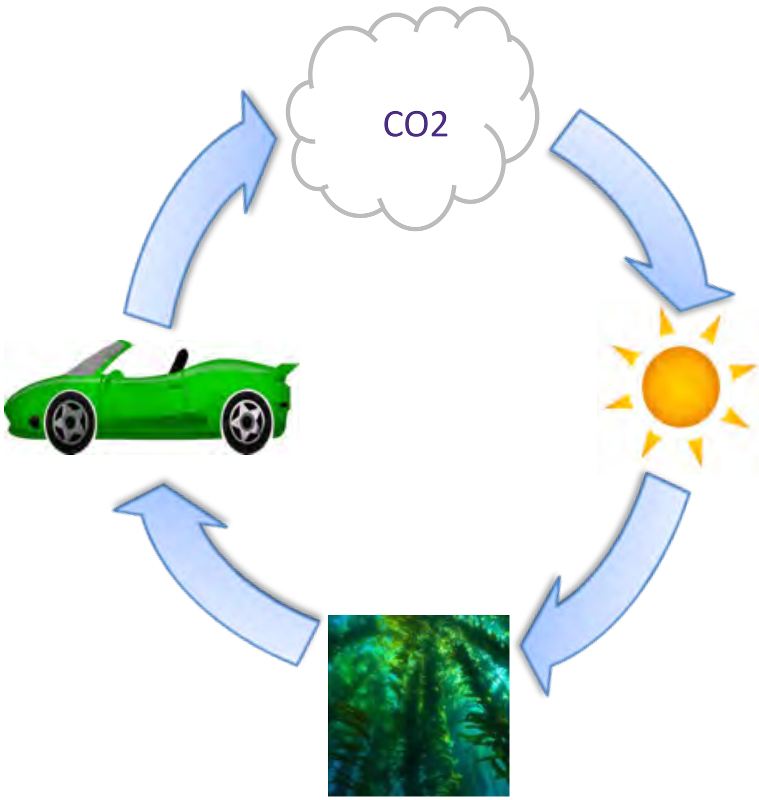

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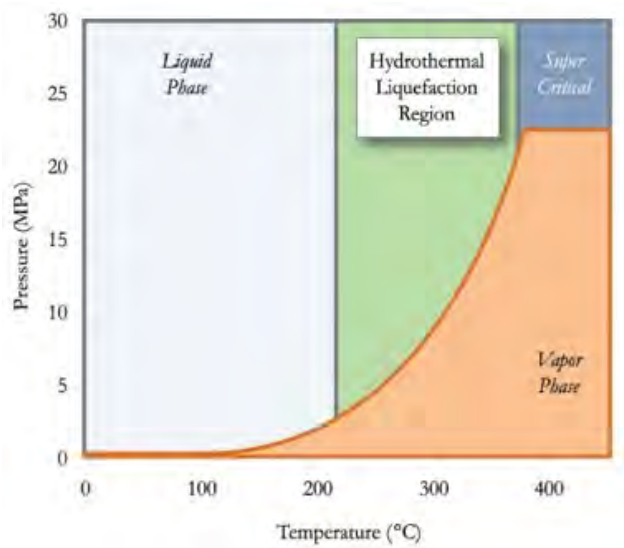

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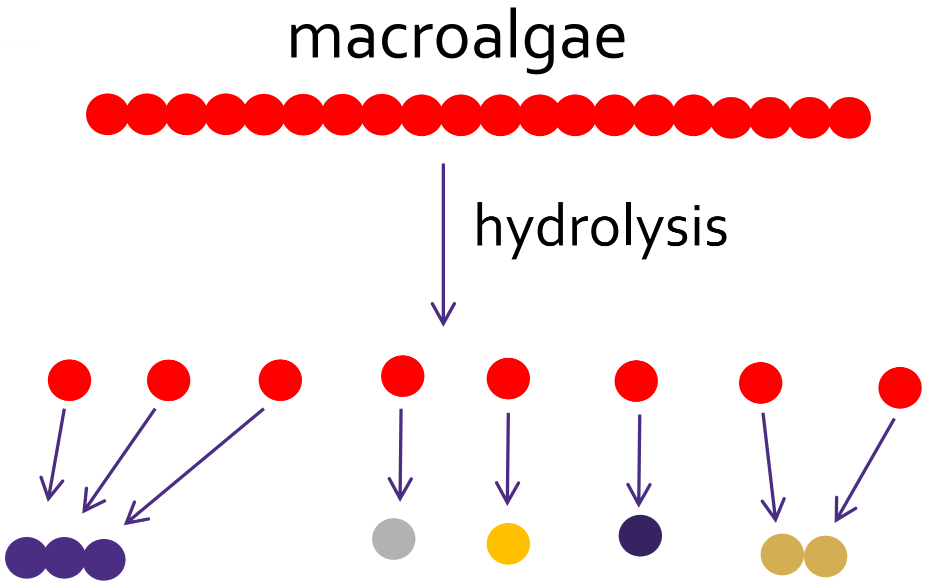

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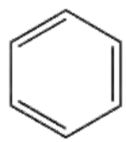
hydrocarbons for transportation fuels



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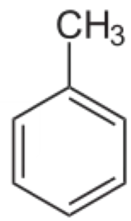

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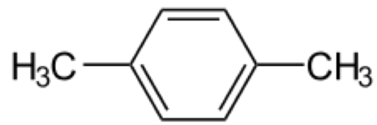

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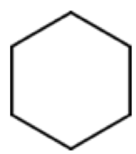

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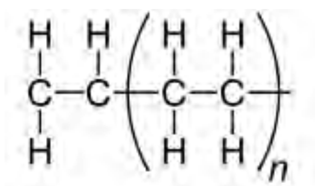

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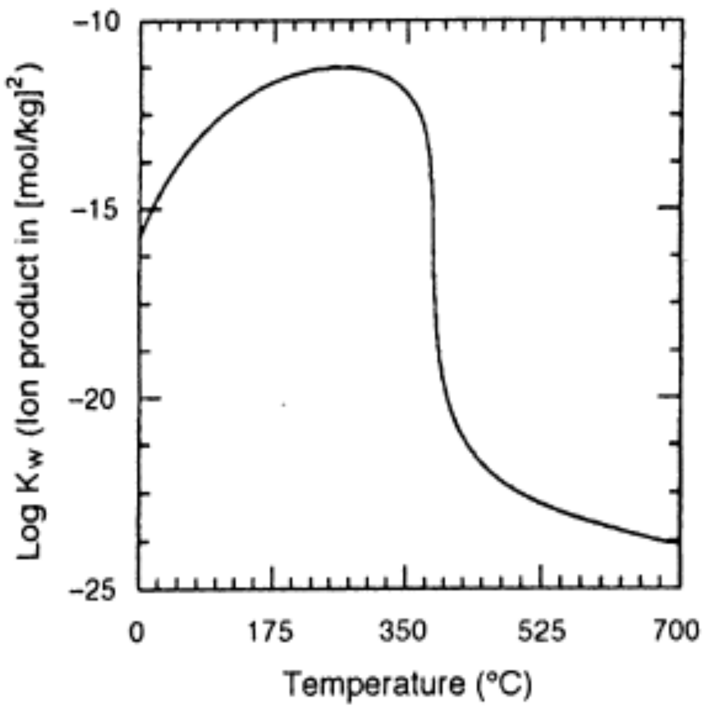

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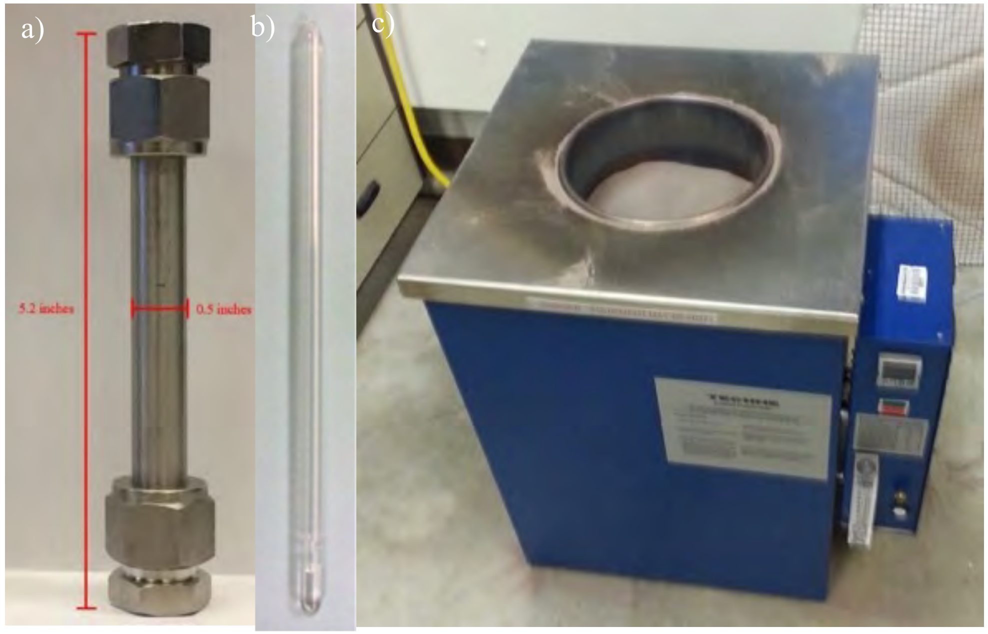
$$H_2O \longrightarrow H^+ + OH^-$$

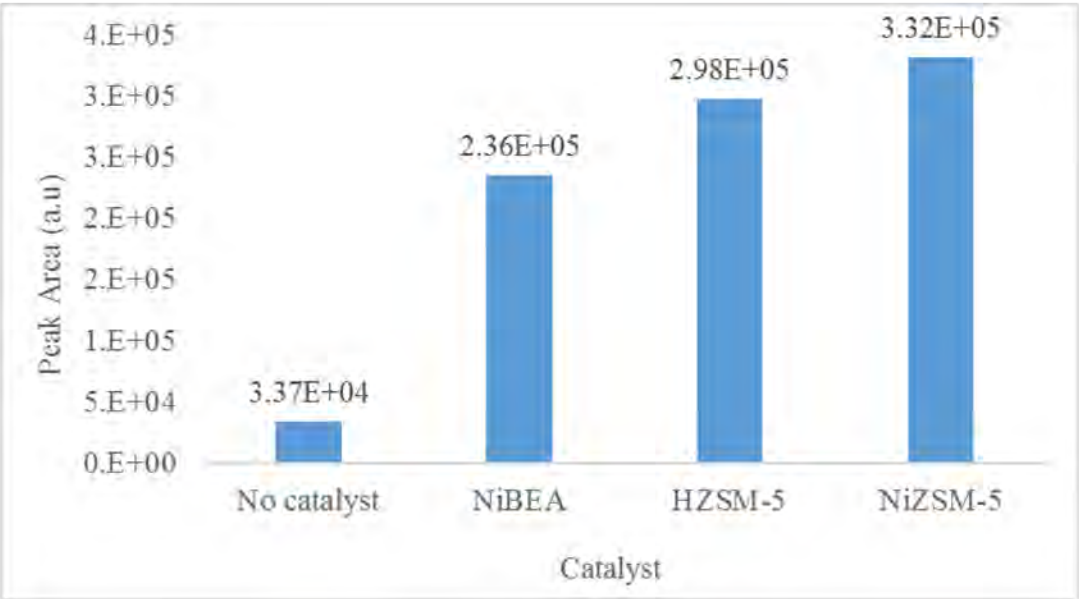
Experimental set up



(a) Swagelok/ (b) quartz reactor immersed in a (C) fluidized sand bath

Preliminary runs
T = 360°C, P = 30 Mpa

Hydrocarbon yields



The catalyst is the key for hydrocarbons production

Summary

- The use of kelp addresses several of the current issues with biofuels production
- The proposed hydrothermal liquefaction takes advantage of the water from kelp to generate liquid transportation fuels

A video archive of this webinar will available on the C-CAN website on the "workshop/webinars" page

http://c-can.info/workshopswebinars/

Please contact Teri King at wsgcanal@uw.edu with any questions about C-CAN

Next Roundtable Discussion!

Wednesday, June 20 at 1 PM PDT (4 PM EDT)

A state-level policy, management and science approach to build support to address ocean acidification: lessons learned after 5+ years of stakeholder collaboration in Washington State.

Presented by:
Martha Kongsgaard, Bill Dewey, Kristen Feifel, Terrie Klinger, Jan Newton and Richard Feely. Moderator, Jan Newton

Registration and more info will be distributed via the C-CAN listserv. You can sign up by visiting the C-CAN News page

http://c-can.info/category/news/