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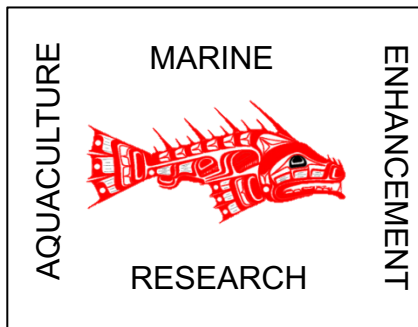
**Northwest
Fisheries
Science Center**

LAND-BASED MACROALGAE BASED PRODUCTION SYSTEMS

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Seaweed Farming in Washington State
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Types of Macroalgae Production Systems

Ocean-based Agricultural Systems

Land-based Agricultural Systems

Ocean-based, intertidal, and beach harvest (wild harvest or resource-based)

Focus of my talk:

- I am going to talk about land-based production systems (or “tumble culture”).
- This is an introduction to the topic. Additional information on design, performance, selected references, and YouTube videos are included in this PowerPoint but will not be discussed at this time.

Macroalgae in Pacific Northwest

Turkish Towel (*Chondracanthus exasperatus*)



Macroalgae in Pacific Northwest

Pacific Dulse

(*Palmaria palmata*, now *Devaleraea mollis*)

Summer growth

Starter algae



Macroalgae in Pacific Northwest

Sea Lettuce (*Ulva rigida*)



Annual Production

Macroalgae/Crops	Wet weight (tonne/ha year)	Dry weight (tonne/ha year)
Ulva species ^a	340	50
Dulse ^a	640	60
Turkish towel ^a	510	72
Wheat ^b		2.93
Corn ^b		10.57
Soybean ^b		3.23



24 Tank Array – Manchester WA



1200 gal Production Tanks –side view



1200 gal Production Tank– Center Diffuser



Video - PC



600 gal Research Tanks



3 ft Circular Tank



Capilano Troughs



Research Kelp Troughs



Research Pot System



Design/Construction Advantages

- Tanks of various sizes and for multiple species or cultivars can be sited together.
- Replicated small-scale units for nutrient, stress, and genetic selection can be easily developed.
- Small quantities of new products can be produced at reasonable costs without the need for large ocean-based farms.

Operational Advantages

- Boats or specialized equipment are not required to access the site.
- The land-based systems are largely removed from tides, waves, and wind impacts
- Plant density and light can be accurately controlled.
- Shading and nutrient levels can be adjusted to favor production of specific functional compounds.
- Reduced regulatory constraints and user conflicts
- Hatcheries are not need for macroalgae that vegetatively reproduce.

Product Quality Advantages

- Macro & micro nutrients can be efficiently controlled. {Pulse fed at night to reduce diatom growth.}
- For some species, protein content doesn't vary over the year.
- Daily or weekly harvest is possible
- Control of invertebrate pests and epiphytes are possible.
- For some kelp species, the harvest season is significantly extended.
- Traceability, sustainability, secure supply is superior to ocean-based systems.

What would we like to know about macroalgae production systems?

- Yield (lb/day ft²)
- % solids
- N and C
- Protein (6.25 x N or a macroalgae specific number)
- Lipids
- Hydrocolloids (agar, alginate, carrageenan)
- Bioactive compounds (prebiotics, phenolics, oligosaccharides)
- Functional foods components
- **\$/lb for fresh product**
- **\$/lb for processed or dried product**

Important things that we don't have time to discuss – Engineering Design

- Depth (m), surface area (m^2), volume (m^3), surface area/volume (m^2/m^3)
- Shape (especially the corners)
- Q_{water} (Lpm)
- Q_{air} (Lpm/m)
- Hydraulic detention time ($Q_{\text{water}}/\text{Volume}$)
- Rotational speed of macroalgae (rpm)
- T_{light} (s), t_{dark} (s), $t_{\text{light}}/t_{\text{dark}}$
- Plant Density (kg/m^2)
- PAR (mole/day m^2)
- Specific Light Density (mol/g day)

Important things that we don't have time to discuss – Inputs, Outputs, Performance

- Power and Resource Inputs
 - Electrical power for pumps and blowers
 - Nutrients (N, P, and trace metals)
 - Harvest requirements
 - Rinsing, Drying, and Processing
 - Transportation
- Outputs
 - Kg/week wet weight
 - kg/week of processed product
- Environmental Performance (LCA or other methods)
 - Greenhouse gas emissions
 - Energy use
 - Nutrient discharges

Important things that we don't have time to discuss – Greenhouse gas emissions

- CO₂ Discharges to Atmosphere
 - Discharges from electrical generation for pumps and blowers
 - Discharge from automobiles and trucks
 - Discharges from N, P, and metals mining and processing
- Carbon Removed from the Ocean
 - Yearly Production x % dry x % C

References (for your night-time reading!)

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Titlyanov, E.A., Titlyanova, T.V. 2010. Seaweed cultivation: Methods and problems. *Russian Journal of Marine Biology*, 36, 227-242.

YouTube Videos

https://youtu.be/uUQLU_VwTMs

<https://youtu.be/Hw11nnBDXT8>



Land-based Macroalgae Facilities

- | | | |
|------------------------|------------------|---------------------|
| • Sol-Sea LTD | Turkish towel | Manchester, WA |
| • Duks Energy | Pacific dulse | Bandon, OR |
| • Monterey Bay Seaweed | dulse, ogo, Ulva | Moss Landing, CA |
| • The Abalone Farm | Pacific dulse | Cayucos, CA |
| • Big Island Abalone | Pacific dulse | Kona, Hawaii |
| • Acadian SeaPlants | <i>Chondrus</i> | Nova Scotia, Canada |
| • Blue Evolution | Ulva spp. | Erendira, Mexico |

{These are private sector farms; general public access may be limited!}

Questions?

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