Learning by Doing – Advances in Seaweed Farm Design

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Outline

- **Experiences with conventional, multi-line, and catenary rigs**
- **Advantages and limitations**
- **To build an industry we need economy at scale**
- **SeaWheel introduction**

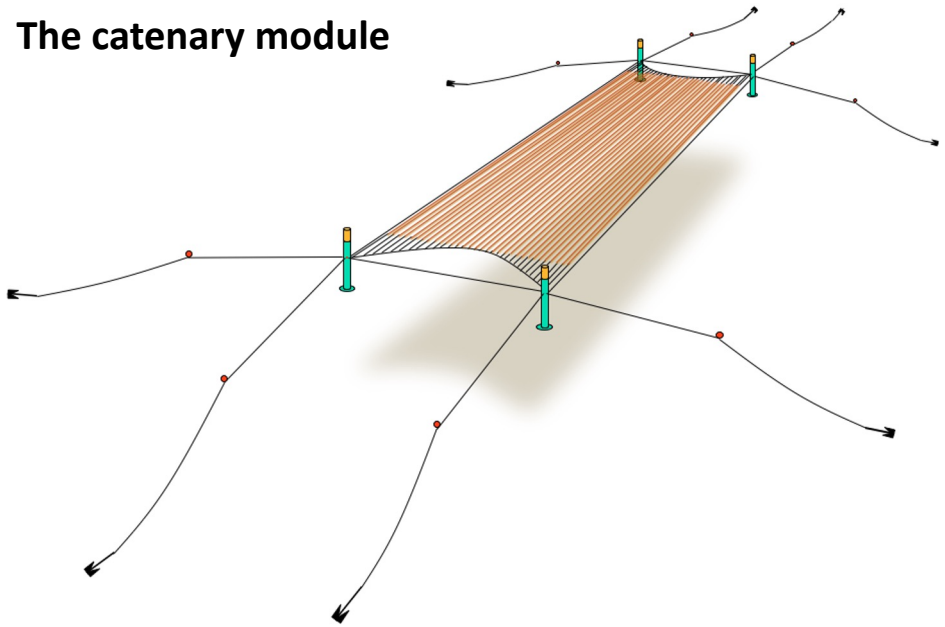
Is there an alternative to growlines? Netting? 2-D substrate?

Growlines turn a one-dimensional growth substrate into three-dimensions of crop. They are affordable and contribute to the integrity of the farm.

The challenges of growlines:

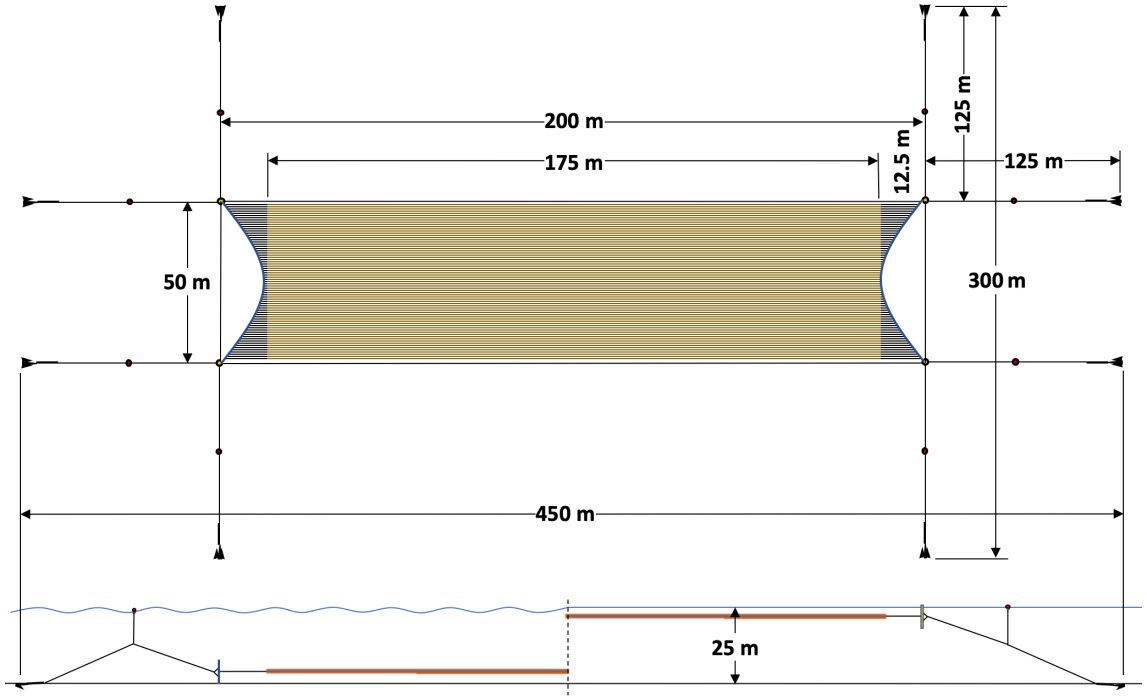
- **Efficient use of ocean space**
- **Preventing line tangles**
- **Maintaining proper depth**

The catenary module

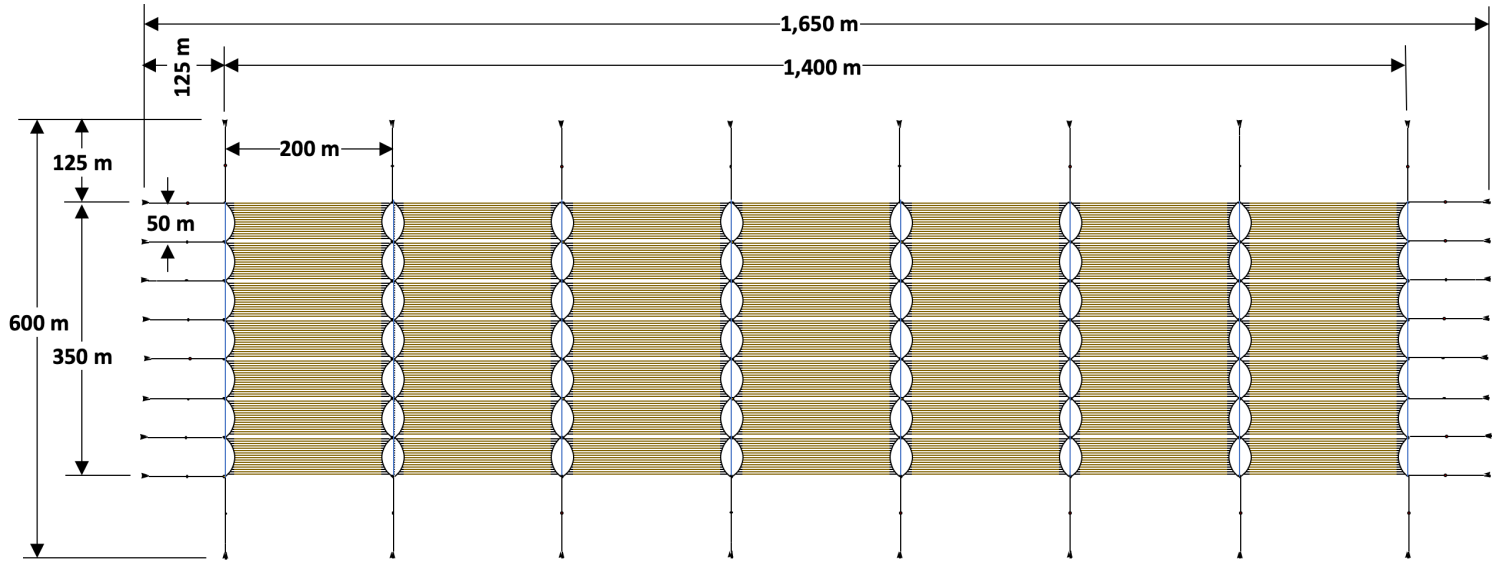


Catenary rigs at scale

- Uniform tension through precise growline measurements
- Consistent pretension allows close line spacing
- Close line spacing offers production density
- Uniform spacing enables efficient farm management
- Mechanized, multi-line harvests are possible
- Tight geometry has reduced user conflicts



Total growline: 8,750 m (28,700')
Module area: 1 Ha (2.47 acres)
Seabed footprint: 13.5 Ha (33 acres)
System: 8 anchors, 4 corner buoys



7 x 7 multi-module array

Total growline: 428,750 m (1,406,300')
Module area: 49 Ha (121 acres)
Seabed footprint: 99 Ha (245 acres)
System: 32 anchors, 64 corner buoys

There remain lingering questions regarding nutrient supply limitations.

Progress on farm depth control

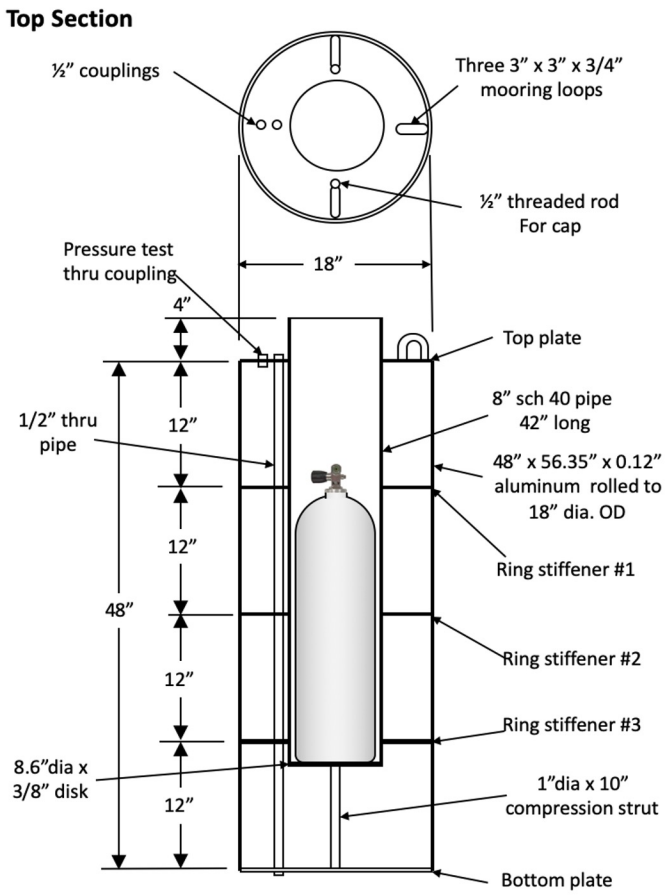
Our original Variable Displacement Spar Buoy (VDSB) was intended for occasional sinking, but required scuba support to return it to the surface.

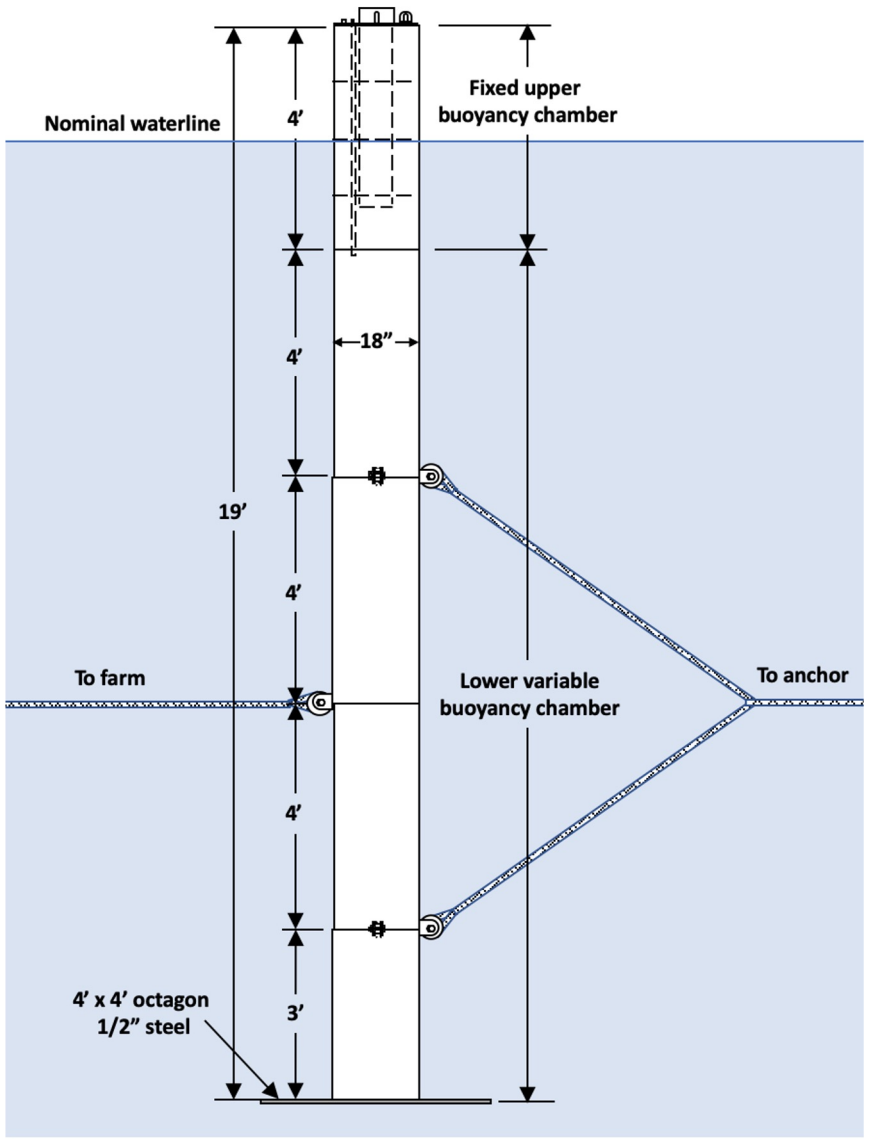
In the tropics, the high risk of hurricanes and of surface temperature anomalies demanded remote control.

Depth cycling has also emerged as a way to increase growth rates: sink for nutrients, return to the surface for sunlight.

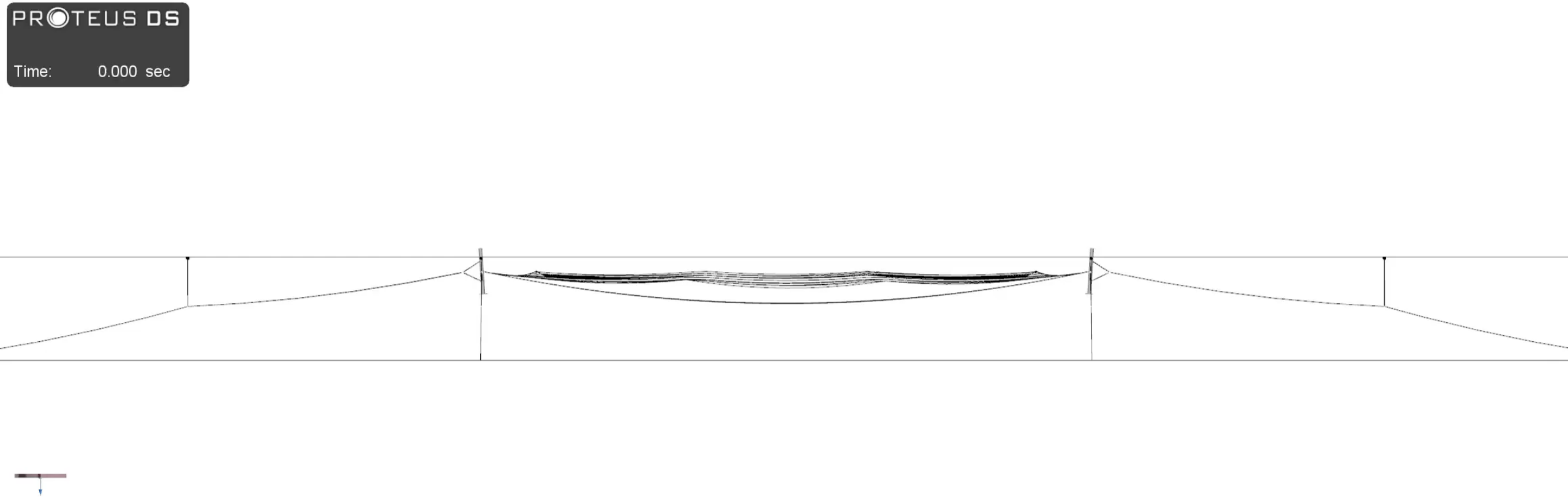
New 19’ x 18” VDSBs

Changes were confined to the top four feet of the buoy. The goal was remote control sinking and timed recovery.





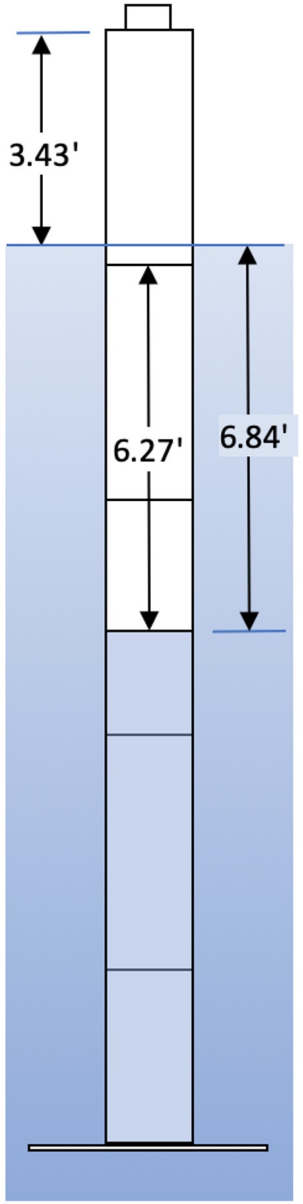
Video of sinking simulation from DSA Ocean



Air consumption and cycling capabilities

- The air consumption needed for a return to the surface depends on:
  - Depth
  - Net weight/buoyancy
  - Desired final freeboard
- For our 19’ buoy in 60’ of water:
  - Buoy alone, 0.7’ freeboard > 48 cycles
  - Voided buoy plus 300 lbs to 8.1’ freeboard > 6 cycles
  - Min. venting plus 300 lbs to 3.4’ freeboard > 10 cycles

Conclusion: For a catenary system with four or more VDSBs, the idea of remote-controlled sinking and recovery is achievable but the cost and complexity is high.



Other challenges

1. Maintaining crop depth – flotation (or weights) are costly, time consuming, and interfere with seeding and harvesting.
2. Seed string residue complicates mechanized harvesting.
3. Off-season growline storage and preparation.

Seaweed-based twine as a candidate for seed string

Viable Gear – Portland Maine
https://www.viablegearco.com/

Might this also be a fiber source for growlines where stripping is unnecessary and the rope gets processed with the crop?

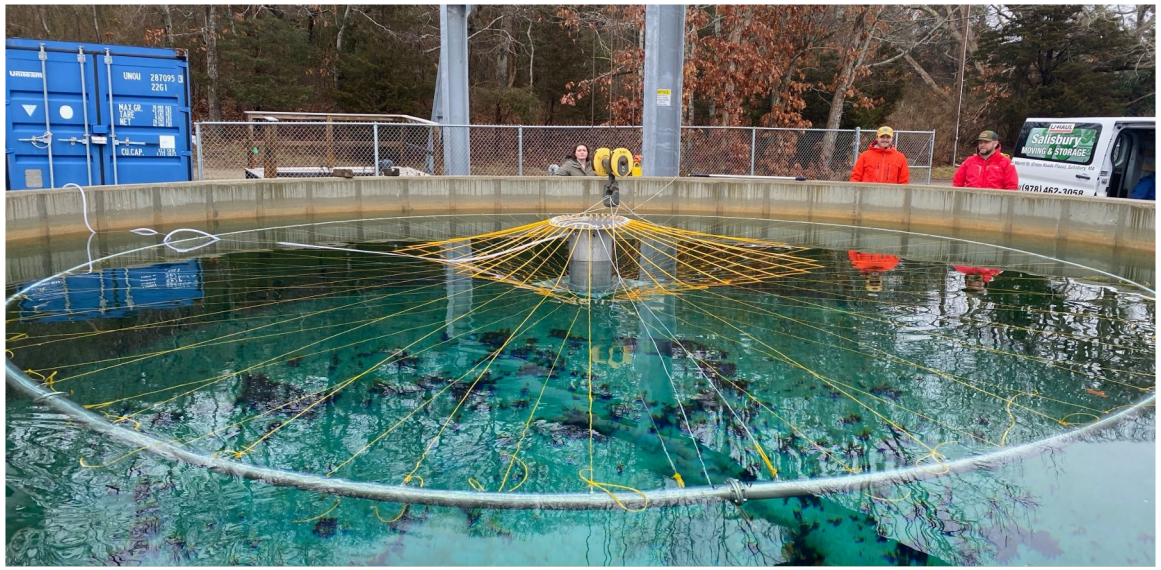
Guilt-free, single-season growlines!

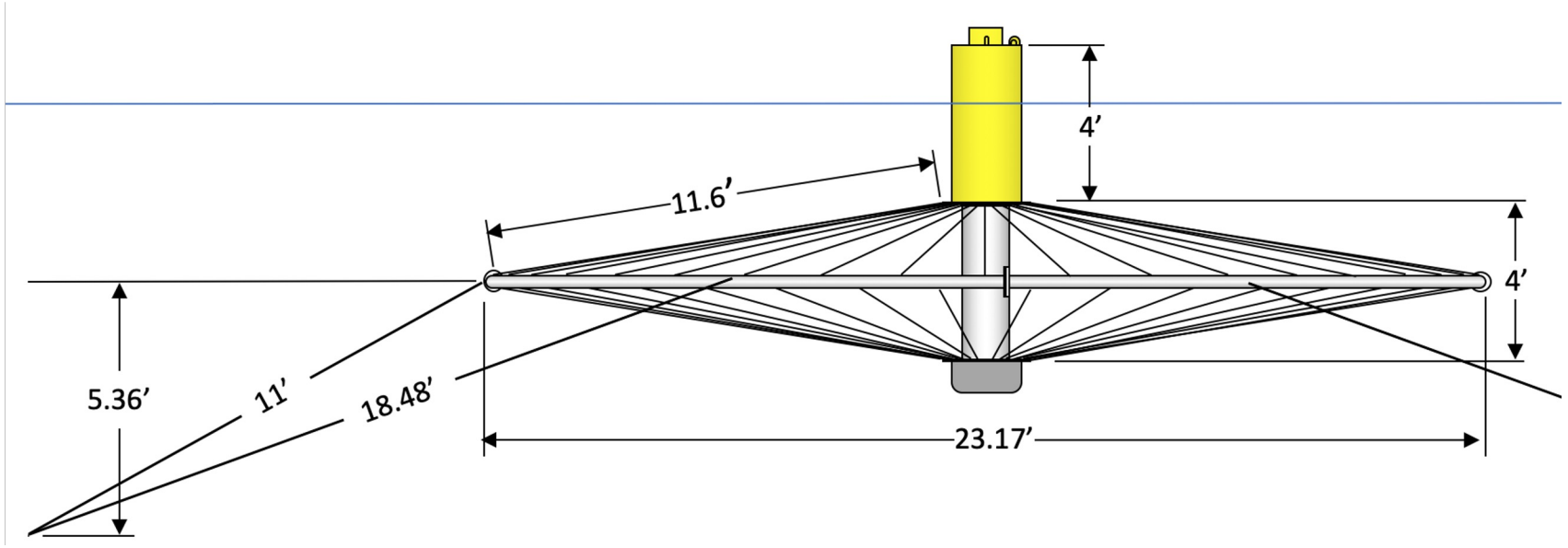
An anchorless, inflatable-hose set line

SeaWheel

To simplify the approach to farm depth control at the Marine Biological Laboratory farm in Parguera, P.R., the *SeaWheel* circular farming system was developed that uses a single VDSB surrounded by a circular rim.

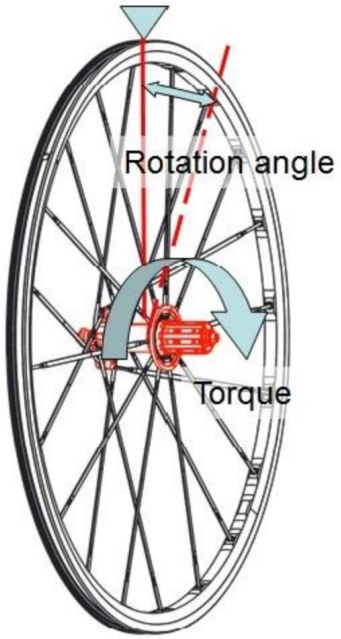
This farm supports 72 planted radial lines and can be remote controlled for storm avoidance and depth cycling. It can be supported by a pair of opposing anchors or can pivot on a single-point mooring.

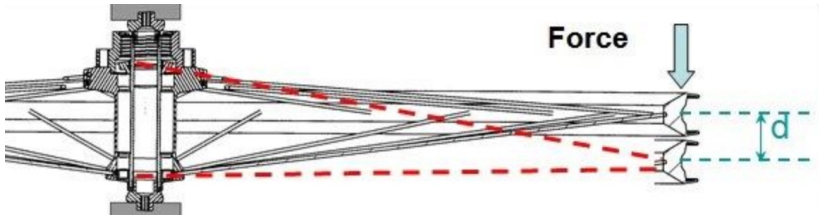


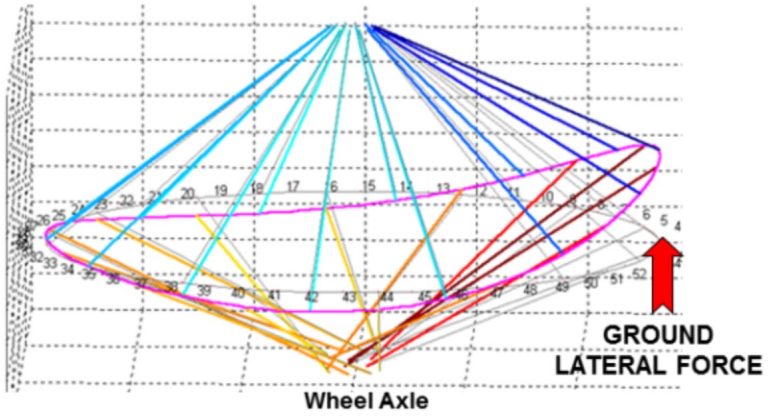


The Compelling Properties of the Spoked Wheel

The bicycle wheel is one of the most efficient structures having been engineered to near exhaustion.



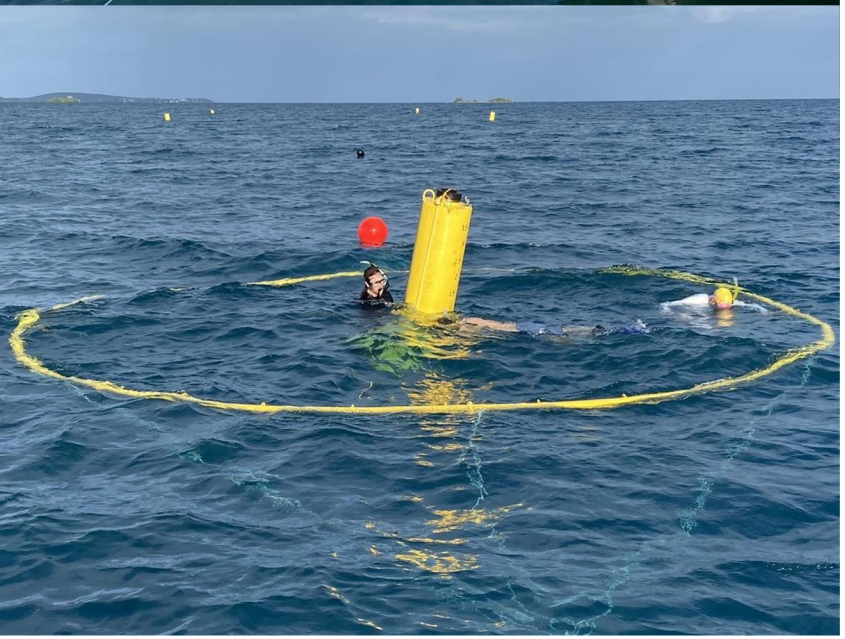


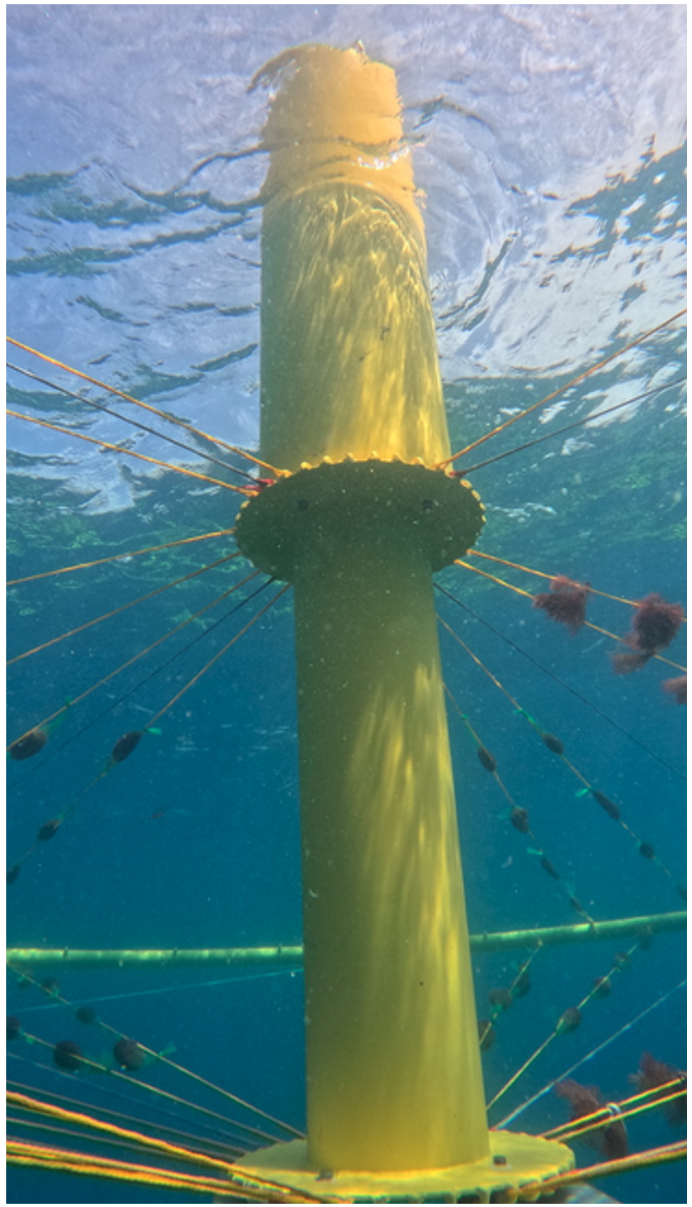


Its use as an ocean farming structure can bring some surprising advantages.

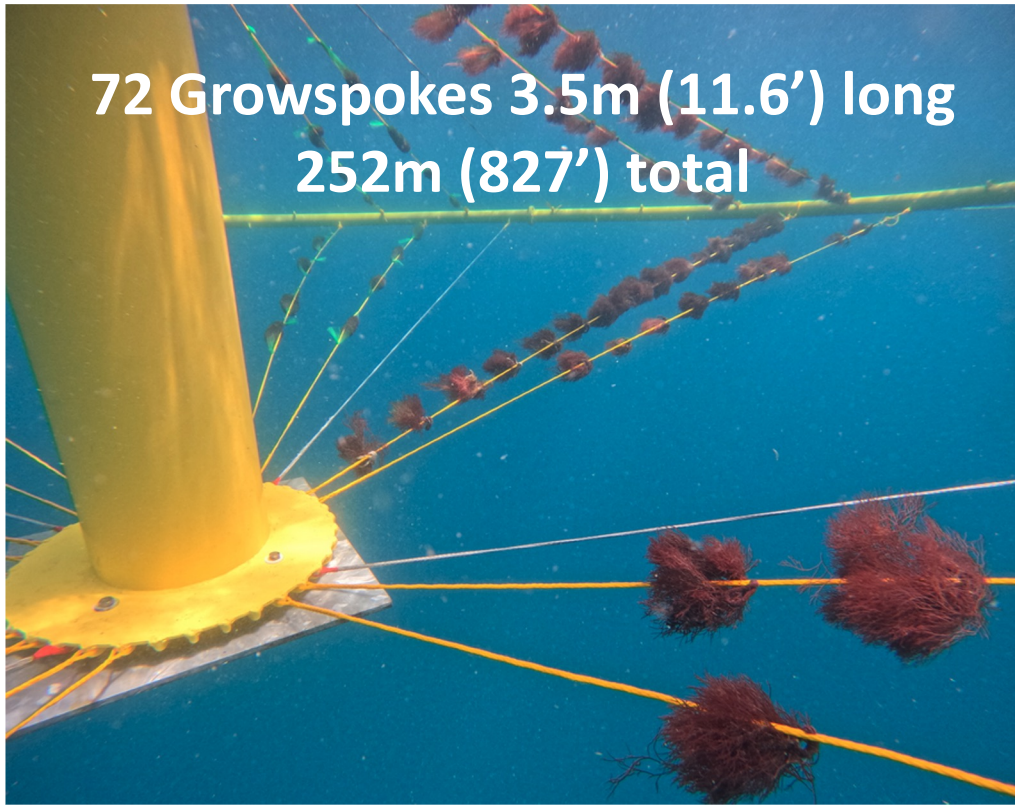
1. **The more spokes the merrier.**
2. **An extremely light rim is possible.**
3. **Spoke axial angle is essential to prevent potato shipping.**
4. **It's use in offshore farming has been well documented.**

Innovasea's Sea Station





***SeaWheel* has been deployed in Parguera, Puerto Rico and planted with *Gracilaria* and *Solieria*.**

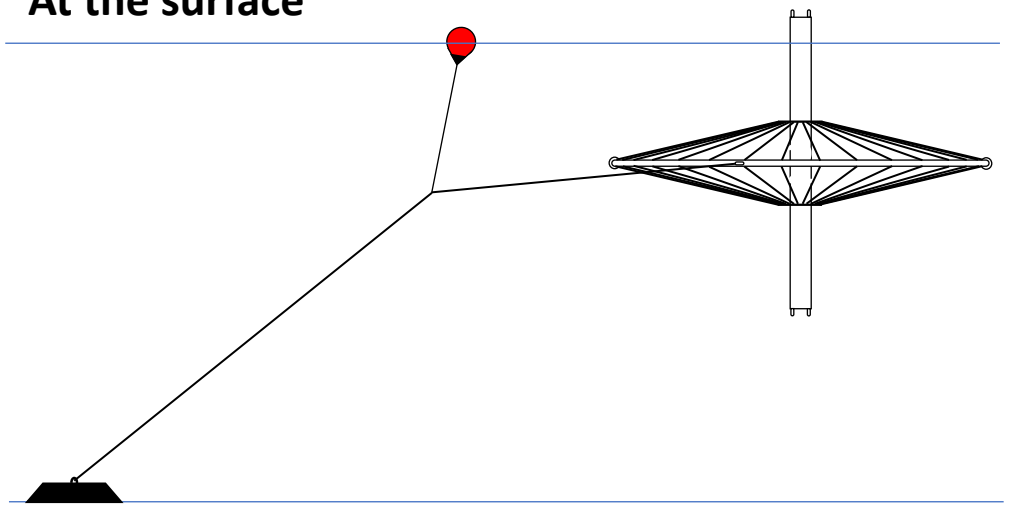


SeaWheel design for Souto Ocean, Sweden

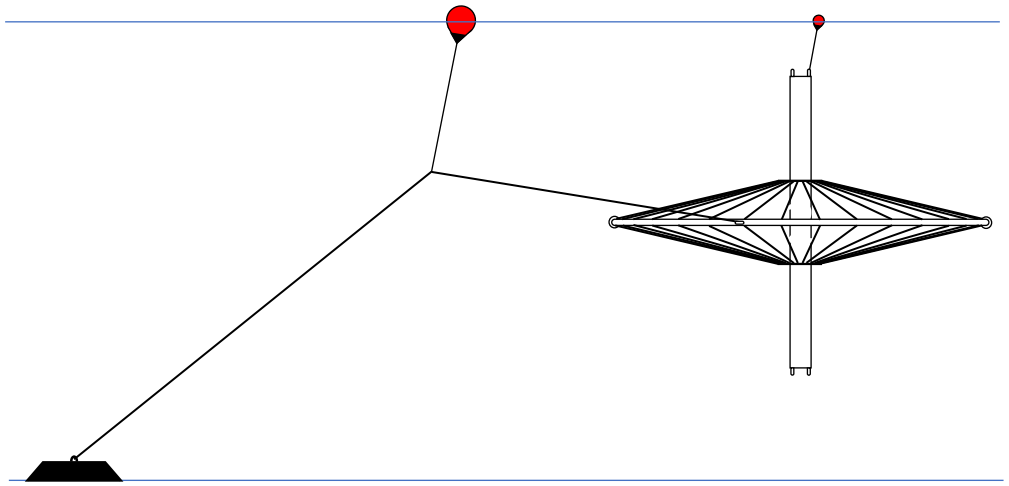
This 4m (13’) diameter SeaWheel is for research purposes testing Ulva growth in the Baltic Sea where the system can be lifted aboard for planting, monitoring, and harvesting.

Sixty 1.8m (6’) growspokes
110m (360’) total substrate
Can be inverted if D < depth
Low cost and durable

At the surface



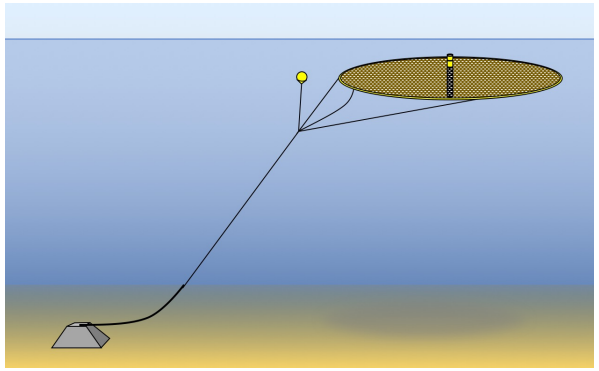
Submerged

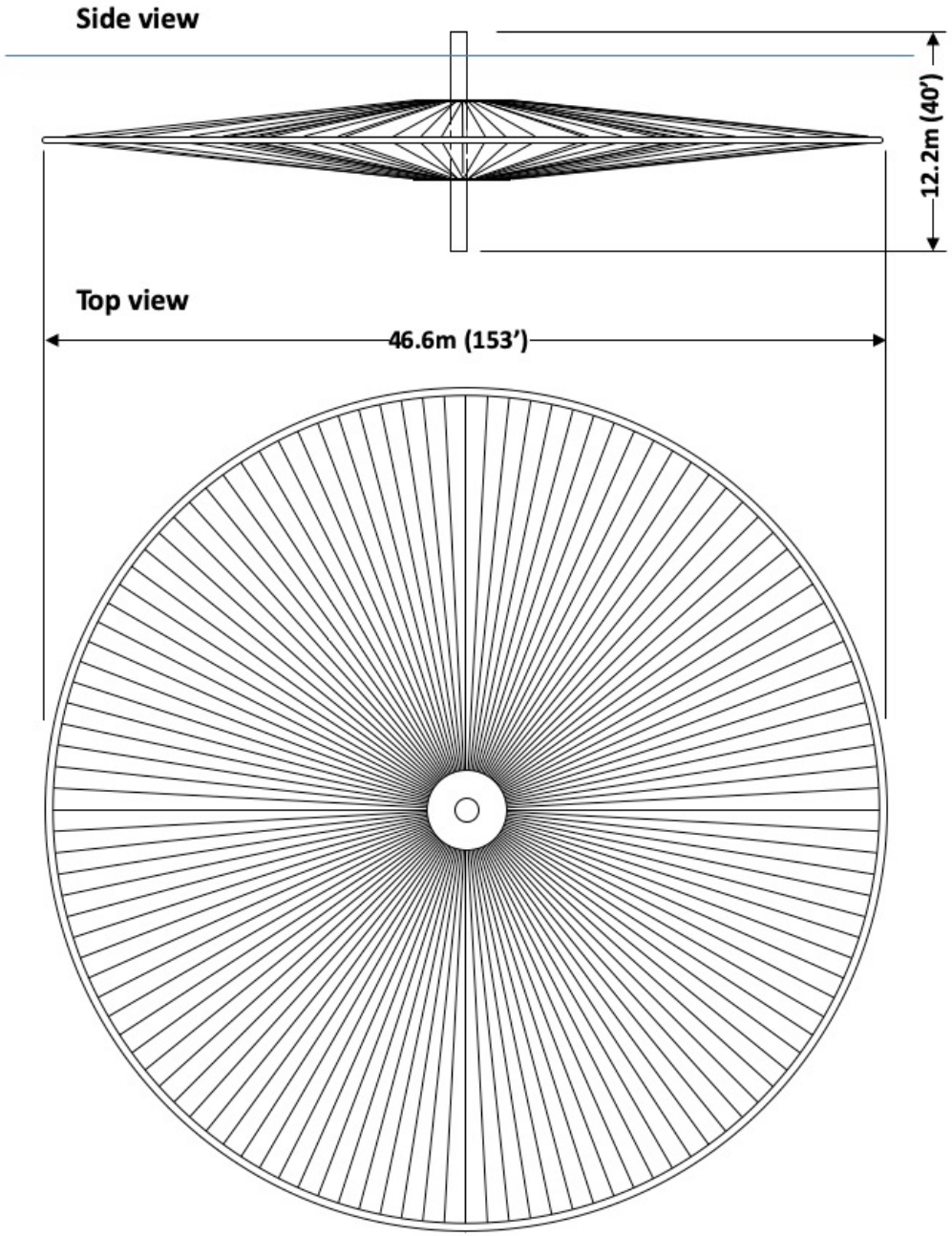


Conceptual commercial-scale SeaWheel

This system is designed to swing on a single-point mooring, eliminating the requirement of opposing anchors to provide pretension. The inherently high spoke tension means sag and no growline floats or weights.

Two hundred and forty 22m (72’) growspokes
1.22m (4’) line spacing at rim
5280m (17,280’) total substrate
Can be inverted if D < depth





Thanks for listening

Questions?