Kelp Farm Design: The Basics
PWS EDD Mariculture in Prince William Sound Webinar Series

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GreenWave trains and supports regenerative ocean farmers in the era of climate change.
Farm Design Considerations

Though some concepts are transferrable, designs are site specific

Influenced by bio-physical and social conditions

And available equipment and infrastructure

Your level of experience

As well as end-use and buyers (What’s your business plan?)

Among other things...
Horizontal longline wrapped with seedstring or direct seeded with kelp spores (together, called the growline)

Submerged ~1-2 meters below the water surface

Secured in place by anchors

Kept at depth through the use of buoys and (sometimes) weights

Pretensioned and under tension

This longline system is referred to as an array
We are going to focus on 3 common kelp array types:

- Single-Line (Beginner)
- 5-Line (Intermediate)
- Multi-Line Catenary (Advanced)

Generally speaking, a farm is comprised of multiple arrays.
Single-Line Array

Photo Credit: GreenWave
Beginner

Single-Line Array
Single-Line Array

- **Beginner**
- **Growline (or Longline)**
- **Retrieval Buoy**
- **Anchor Line Buoy**
- **Growline Buoy**
- **Anchor**
- **Tag Line**
- **Anchor Line +/- Chain**
Beginner

Single-Line Array

Growline Length + Anchor Scope + Anchor Length

X:1 MHW

200'

MLLW

MHW
Single-Line Array
5-Line Array

Photo Credit: Dave Bailey, Woods Hole Oceanographic Institution
5-Line Array: Designed by Cliff Goudey & Associates

Credit: Adapted from design by Cliff Goudey & Associates
Intermediate

5-Line Array

Growline Length + Anchor Scope + Anchor Length

5:1 MHW

100’

Credit: Adapted from design by Cliff Goudey & Associates
5-Line Array

Photo Credit: Kendall Barbery
5-Line System
Catenary Array
Advanced: Multi-Line Catenary Array

- Longlines/Growlines
- Catenary Framing Lines
- Buoy
- Retrieval Buoy
- Tag Line
- Anchor Line +/- Chain
- Anchor

Credit: Adapted from design by Cliff Goudey & Associates
Farm Design

What Type of Line Should I Use?
Farm Design

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Farm Design

What Type of Line Should I Use?
There is no one-size fits all solution. The best anchor type and size is site specific.

But here are some things that will influence the type of anchor that is best for your site:

- **Bottom type** (i.e. gravel, sand, silt, mud, clay, bedrock)
- Exposure to wind, waves, weather
- Peak current velocity
- Potential biomass (i.e. how many pounds of kelp per foot of line)
- The size of your lease
- Your budget
Common Anchor Types for Seaweed Farming

- Helical
- Fluke
- Pyramid
- Mushroom
- Concrete

See last slide for image credits
Anchors

Bottom Type Impacts Anchor Performance

Helical
- Sand
- Mud
- Clay

Fluke
- Gravel
- Sand
- Mud

Pyramid
- Unpacked Sand
- Soft Mud
- Silt

Mushroom
- Unpacked Sand
- Soft Mud
- Silt

Concrete
- Most Bottom Types

See last slide for image credits
Anchor Holding Power Impacts Anchor Size and Cost

See last slide for image credits
Scope impacts your farm footprint (and lease costs)

Scope = L : D

8:1  5:1  4:1  3:1  2:1  1:1
Anchor Line Scope

Scope impacts your farm footprint (and lease costs)

Scope = L : D

Fluke, Wing/Plow, Claw
Mushroom, Pyramid, Concrete, Deadweight
Helical, Manta Ray
What Should I Choose?

• Get to know your **site conditions** and evaluate the **types of anchors that will work** in those conditions

• Determine **the size you need to meet holding power requirements**

• Compare the requirements for setting and retrieving anchors of this size (**do you need a barge or other infrastructure?**)

• You may have to make some tradeoffs...
There are a lot of other decisions you’ll need to make as you design your farm

- Like choosing **buoys**
- Deciding whether or not to use **chain**, and whether or not to use other types of **hardware**, like shackles, swivels, links and the like

This can be confusing for a first time farmer and experienced farmer alike.
**Marine Factors**

**BATHYMETRY**

- Flat

This tool currently only supports farm designs with consistent (flat) bathymetry.

**BOTTOM TYPE**

- Sand

If you have a site in mind, find the bottom type in the local NOAA nautical chart.

**CURRENT VELOCITY**

- 18 knots

The average speed of the peak daily current.

We recommend checking out these websites to make educated guesses about your current velocity: [NOAA National Ocean](https://www.nos.noaa.gov/nauticalchart)

**SALINITY**

- 32 ppt

The level of salt in your waterbody determines which species can be grown there.

For more information about how salinity affects multi-species aquaculture, see: [Multi-Discipline Metrics](https://www.greenwave.com/)

**WATER CLARITY**

- 6 ft.

**WATER DEPTH**

- 30 ft
- 16 ft

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**Cross-Sectional Diagram**

- Anchor Line Buoy
- Retention Buoy
- Torsion Buoy
- Growline Flotation Base
- Growline Flotation Body Line

**5-Line Array Plan View**

- Growline Footprint 200 ft
- Growline Flotation Body Sizing 100 ft
- Growline Length 200 ft
Farm Design

What’s Next?

Cross-Sectional Diagram

Farm Plan View

Gear List

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<thead>
<tr>
<th>ITEM</th>
<th>QUANTITY</th>
<th>COST PER UNIT</th>
<th>TOTAL COST</th>
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<tbody>
<tr>
<td>Seedstring</td>
<td>6000 ft.</td>
<td>$120</td>
<td>$7200.00</td>
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<td>3/8 inch, 3 strand neutrally buoyant; Hydropro</td>
<td>644 ft.</td>
<td>$0.12</td>
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<td>979.63 ft.</td>
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<td>$434.14</td>
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<tr>
<td>5/8 inch, 3 strand neutrally buoyant; Hydropro</td>
<td>86.4 ft.</td>
<td>$0.</td>
<td>$0.00</td>
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<tr>
<td>1 inch, 8-plait nylon line</td>
<td>86.4 ft.</td>
<td>$3.18</td>
<td>$271.04</td>
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<tr>
<td>1/2 inch, hot dipped, galvanized, steel chain</td>
<td>9.6 ft.</td>
<td>$7.7</td>
<td>$73.44</td>
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<tr>
<td>1/4 inch permaflex cable</td>
<td>144 ft.</td>
<td>$0</td>
<td>$0.00</td>
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</tbody>
</table>
Questions?

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Anchor Image Credits:


