How to Determine the Best Anchor Size for Your Kelp Array

There are different ways to determine the minimum size of anchors that you will need to hold your kelp farm in place. We have adapted an equation for kelp drag described in the 2019 paper *Current Induced Drag Forces on Cultivated Sugar Kelp* by Endresen, Norvik, Kristiansen, Birkevold, and Volent,[1] and have used that to estimate holding power needs and anchor sizes in different scenarios.

Here is a summary of how we calculate drag forces and, subsequently, holding power and anchor size.

Drag = the force on your growline x the length of your growline x the biomass per foot of growline

You need to know Drag to determine the best anchor size and holding power for your kelp arrays

To calculate ***Drag*** **(N)**, in Newtons, you need to know:

- the ***Current Velocity*** **(V),** in meters/second
- the ***Length of your Growline*** **(L)**, in meters
- the ***Biomass*** (i.e. weight) of the kelp along the growline **(B)**, in kilograms/meter

N = Force x Length x Biomass
N = F x L x B

In this equation, **F** is the ***Force*** affected by the ***Current Velocity*** **(V)**, and is represented in Newtons/kilogram

F = au^b = (16.82 x (V^1.43)
(in this equation ***a*** and ***b*** are constants; and ***u*** = **V**)

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[1] Endresen, Per Christian, Norvik, Carina, Kristiansen, David, Birkevold, Jens, Volent, Zsolt (2019) *Current Induced Drag Forces on Cultivated Sugar Kelp*. Proceedings of the ASME 2019 38th International Conference on Ocean, Offshore, and Arctic Engineering. OMAE2019. June 9-14, 2019. Glasgow, Scotland, UK.

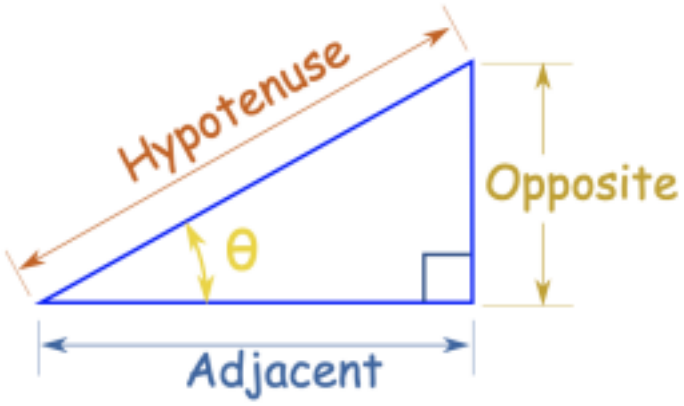
Once you have calculated **N**, a simple conversion will yield ***Drag* (D)**, in pounds, on your growline:

D = N x 0.2238090795

Now that you have estimated the ***Drag*** on your growline, you can do some trigonometry to determine approximately how much ***Holding Power* (H)** you will need per anchor. For this equation, you'll need the recommended ***Anchor Scope* (S)** of your preferred anchor type (i.e. if the ***Anchor Scope Ratio*** is 3:1 the depth of water at Mean High Water (MHW), then ***Anchor Scope*** = 3; if the ***Anchor Scope Ratio*** is 5:1, ***Anchor Scope*** = 5 and so forth). A scientific calculator or Excel spreadsheet will come in handy.

H = D / Cosine x (Tangent x (1 / S))

The **Cosine** is the trigonometric function that is equal to the ratio of the side Adjacent to an acute angle (in a right-angled triangle) to the Hypotenuse. And the **Tangent** is the trigonometric function that is the ratio of the Opposite side to the Adjacent side. See the diagram below.[2]



To determine the size anchor you will need to hold each end of your growline in place, simply divide the **H** by the ***Holding Power: Weight Ratio*** of your preferred anchor. *Make sure that the ***Anchor Scope* (S)** you used to calculate **H** is the proper scope for your preferred anchor. Similar to scope, when ***Anchor Holding Power* (A)** is represented as a ratio (i.e. 25:1) then **A** = 25, and so forth.

Minimum Anchor Size (per Anchor) = H / Anchor Holding Power

[2] Diagram Source: Math Is Fun: https://www.mathsisfun.com/sine-cosine-tangent.html. February 24, 2021