Development of a Wave-Powered Integrated Multi-Trophic Aquaculture Farm

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Introduction

Integrated Multi-Trophic Aquaculture (IMTA) is an ecologically balanced practice that farms aquaculture species from different trophic levels. It allows one species byproducts to be converted into fertilizer, feed, and energy [3].

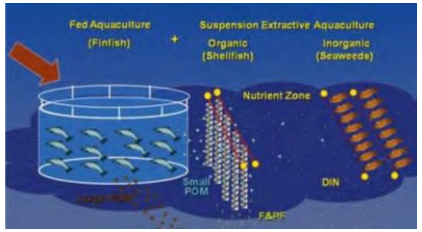


Figure 1: Example of nutrient transfer in IMTA system

There has been a limited number of studies done on this concept and none on an IMTA system powered by a wave energy converter (WEC).

This study focuses on the design of an optimal offshore IMTA system powered by wave energy converter (WEC) through a comprehensive literature review and interviews with stakeholders.

Methods

Atlantic salmon, sugar kelp, and blue mussels

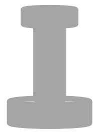
Table 1: Species Constraints and Harvesting

Species	Hatchery Time Frame	Net-pen time Frame	Optimal Harvest Time	Harvesting Process	Temperature (°C)	Dissolved Oxygen (mg/L)	Salinity (PSU)	Current Speed (m/s)	Wave Height (m)
Atlantic Salmon	18 months	24 months	spawning occurs between mid-November and December in hatcheries and smolts transferred to net pens btw mid-April and mid-May	3 year cycle of production	2 - 20	min: 4.41	30 - 35	0.1 - 2	-
Blue Mussel	Spawning to settlement: ~20 days; settlements to out-planting: 30-40 days	12-15 months	reccomended to be harvested in winter, when mussels are highest quality	harvesting machine used to collect/process	-10 - 29	min: 2	5 - 34 (25 optimal)	0.51 - 1.5	0 - 4
Sugar Kelp	spores are attached to ropes	4-6 months	growing season can vary, but average from October to May	use cranes to lift, manually harvest	10 - 18	-	18 - 35 (27-33 optimal)	0.08 - 1.52	0 - 6.4

Species Selection → Species constraints and harvesting → Determine parameters for IMTA Farm → Optimal structure(s) for IMTA system

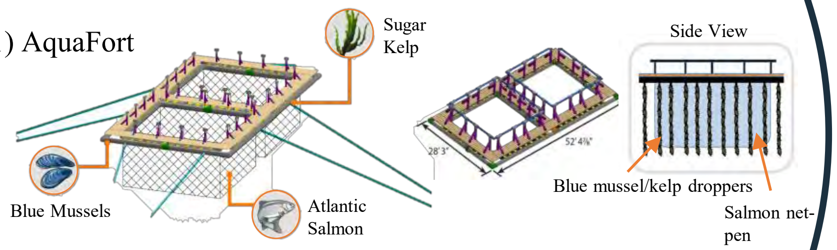
Wave-Powered IMTA

Wave Energy Converter
Point absorber RM3

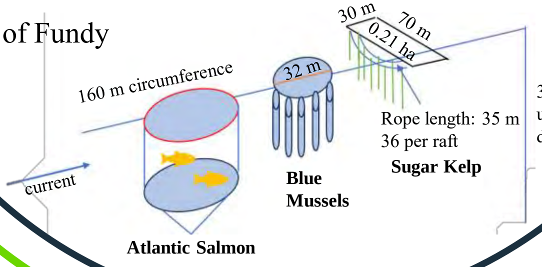


Two choices found for IMTA farm:

1) AquaFort



2) Bay of Fundy



Results

Summary of Parameters for IMTA Farm:

1. **Current and Wave Dynamics:** the flow of nutrients from salmon to Kelp/mussels; seaweed blade entanglements; mussel detachment and influence on growth; structures must withstand force from current; can influence flushing rates; minimum forces needed for WEC
2. **Energy Consumption**: only salmon require energy input from feeding and transforming data
3. **Nutrients:** 3:1 ratio of mussels/kelp to salmon for oxygen/nitrogen levels to be maintained; concentrations vary over seasons and distance from shore; minimum concentration of nutrients needed for growth of kelp and mussels
4. **Light:** appropriate light penetration necessary for kelp growth
5. **Temperature:** 6 to 9 °C suggested optimal range
6. **Salinity:** heavily influences kelp and mussel growth
7. **Position of IMTA components**: influences nutrient uptake of extractive species; position of culture system influences water flow, flushing of wastes, oxygen concentration
8. **Fouling and Predators**: avoid fouling through cleaning of net pen; nets needed to deter predators (e.g. eider ducks)
9. **Disease, parasites**: integration of mussels reduces disease/parasite infestation

Discussion/Conclusion

Through analysis of the necessary parameters determined for an IMTA farm including species constraints, the **AquaFort net-pen structure and the Bay of Fundy model, found through a literature review, were determined to meet the requirements and be the potentially suitable structures to use for our IMTA system.**

The **next steps** of this project are to finalize the cost model, which will influence final selection between these two structures and any necessary altercations.

References:

[1] Chambers, M., & Bradt, G. AquaFort Info Sheet. University of New Hampshire. [2] Buck, B. H., Troell, M. F., Krause, G., Angel, D. L., Grote, B., & Chopin, T. (2018). State of the art and challenges for offshore integrated multi-trophic aquaculture (IMTA). *Frontiers in Marine Science*, 5. [3] Chopin, Thierry & Cooper, John & Reid, G.K. & Cross, Stephen & Moore, Christine. (2012). Open-water Integrated Multi-Trophic Aquaculture: environmental biomitigation and economic diversification of fed aquaculture by extractive aquaculture.. Reviews in Aquaculture. 4. 209-220. 10.1111/j.1753-5131.2012.01074.x.