Composition and Morphometric Variations of Kelp Co-Cultivated with Atlantic Salmon in an Integrated Multi-Trophic Aquaculture System in Ireland

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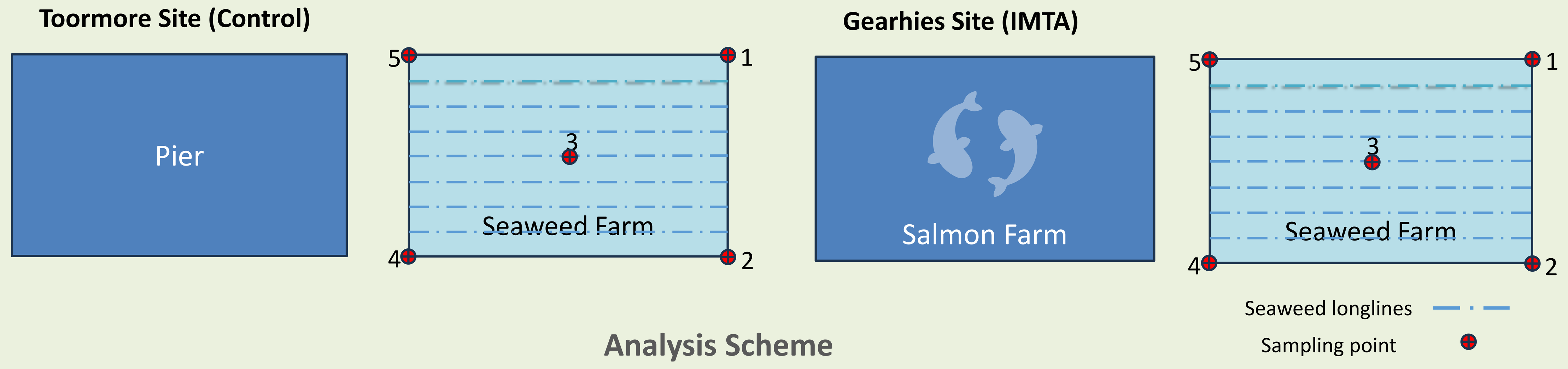
Introduction

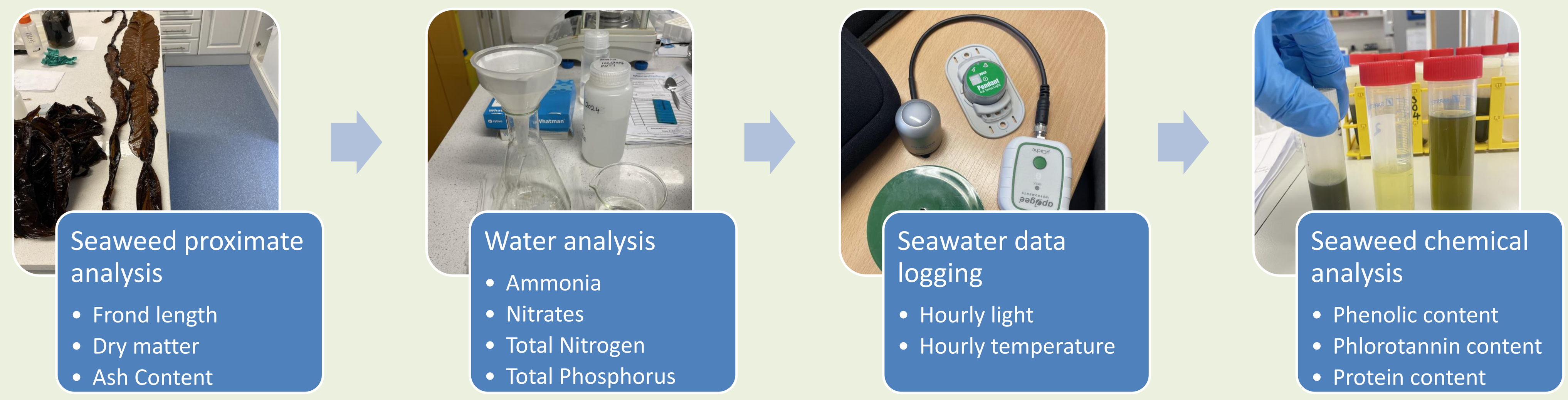
Alaria esculenta, commonly known as winged kelp, is a type of brown seaweed flourishing in cold waters. It contains various bioactive compounds with significant industrial potential (Blanco et al., 2023). Integrated Multi-Trophic Aquaculture (IMTA) synergizes the cultivation of species from different trophic levels, thereby improving environmental and economic sustainability (Fossberg et al., 2018). The present study investigates the effects of growth and quality of *A. esculenta* within an IMTA system, co-cultured with Atlantic salmon in Bantry Bay, West Cork, Ireland. This system is compared to a control site in Toormore Bay, where no salmon farming is present, but shares similar climatic conditions with Bantry Bay. *A. esculenta* is expected to act as an extractive species, absorbing nutrients released by the salmon (Sickander & Filgueira, 2022). Monthly growth assessments were performed at each site followed by analyses of bioactive compounds, such as phenolics, phlorotannin and proteins. Periodic water samples from both sites was analysed to assess nutrient abundance. Continuous logging of light and temperature data was done by probes attached to the cultivation lines, enabling the precise measurement of hourly light and water temperature. Upon harvesting, the kelp's final biomass was then evaluated. The findings aim to contribute to more sustainable aquaculture practices by optimizing nutrient cycling and enhancing the viability of seaweed cultivation in proximity to fish farms.

Methodology

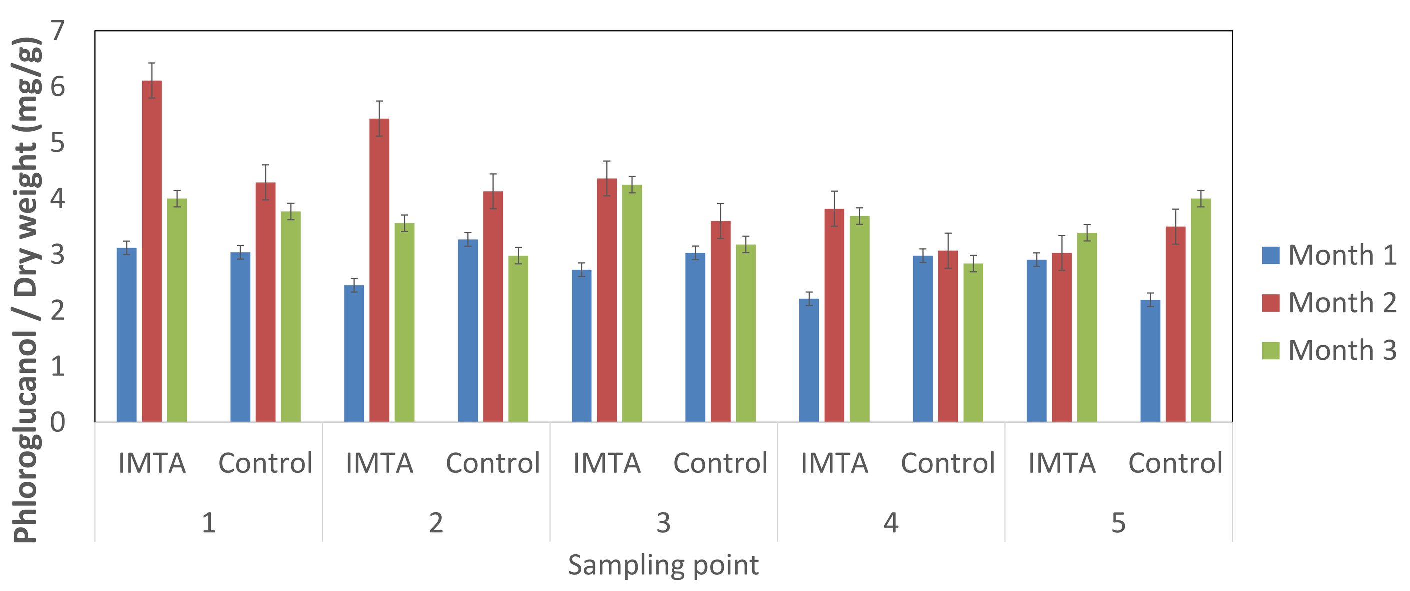
Site Sampling Selection

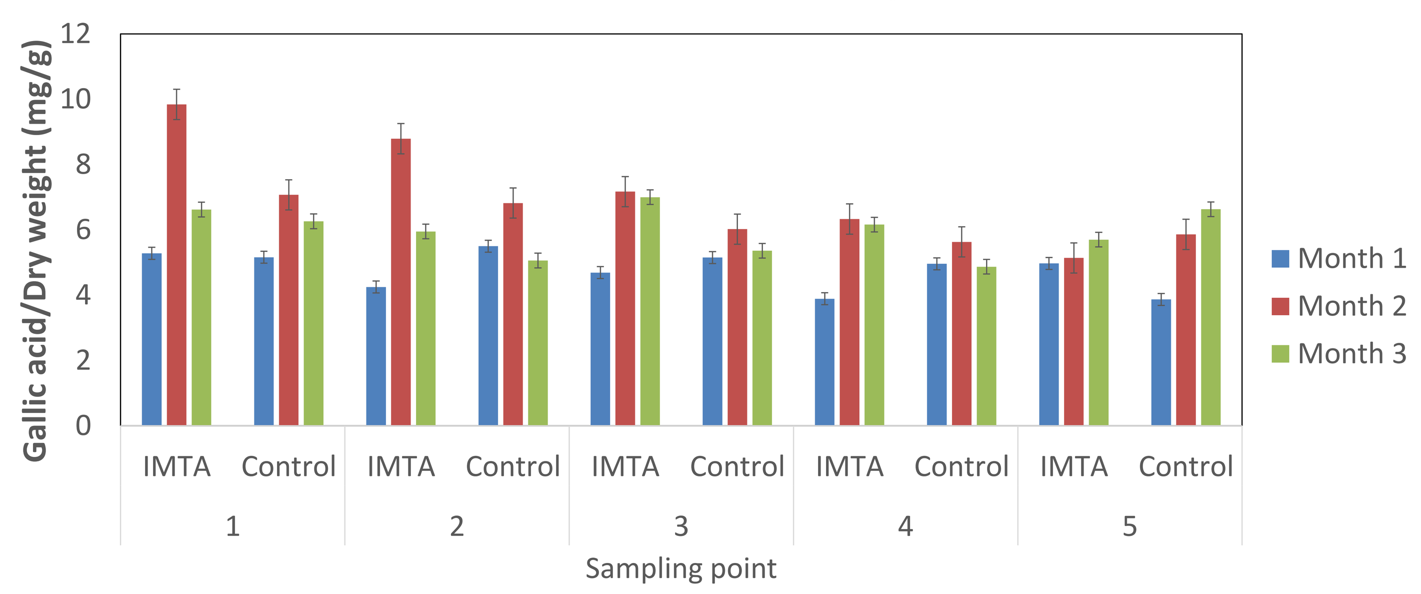


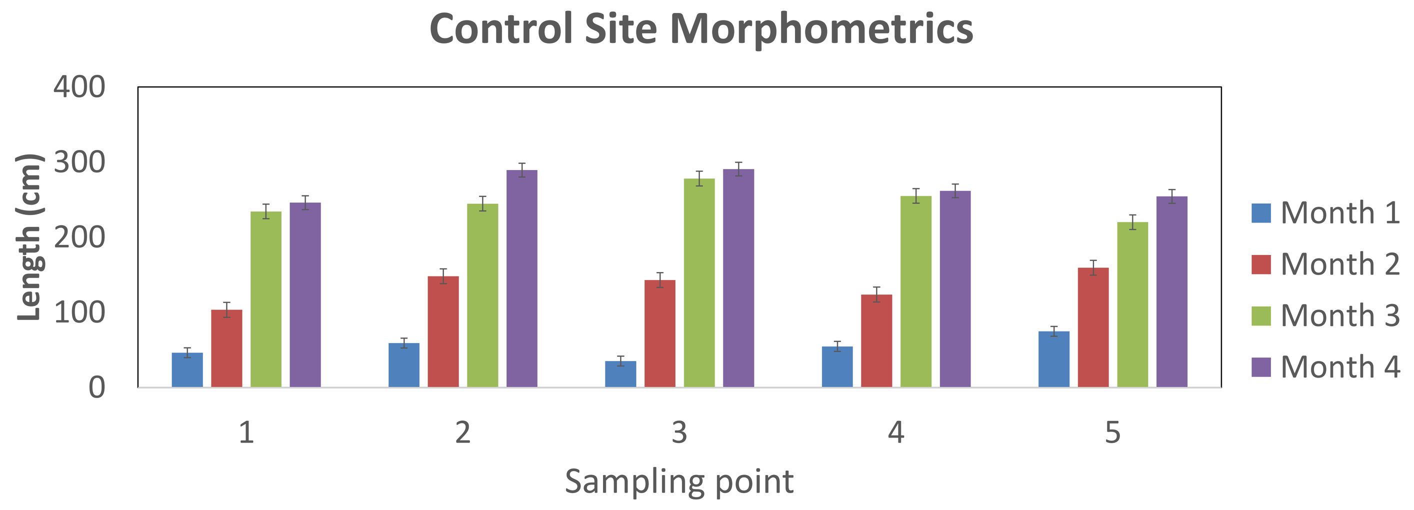
Analysis Scheme

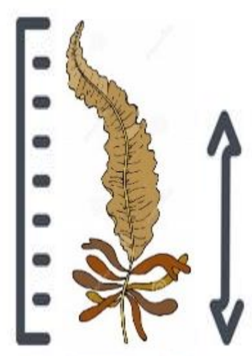


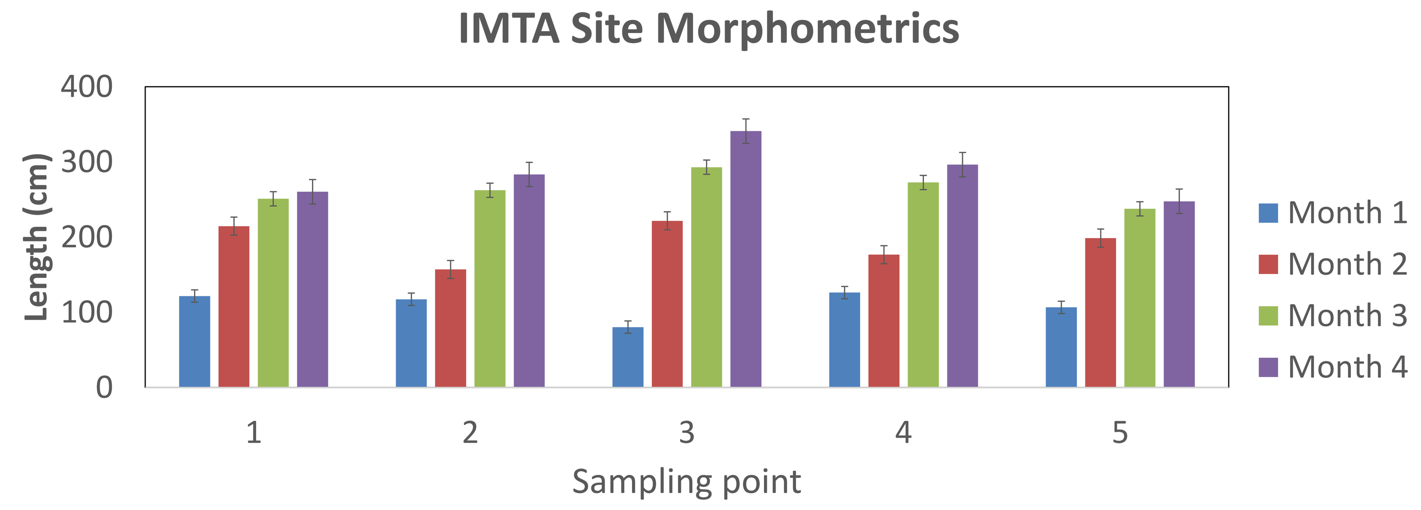
Results











Proximate Analysis

Sampling Point	1		2		3		4		5	
Site	IMTA	Control	IMTA	Control	IMTA	Control	IMTA	Control	IMTA	Control
Dry Matter, % ↓	8.72 ± 0.19 7.98 ± 0.60 7.83 ± 0.76	11.90 ± 0.23 12.13 ± 0.31 6.50 ± 0.27	11.52 ± 0.31 10.41 ± 0.39 15.97 ± 0.50	11.88 ± 0.46 11.45 ± 0.52 8.52 ± 0.23	11.62 ± 0.41 20.81 ± 0.55 8.81 ± 0.83	10.98 ± 0.39 13.22 ± 0.15 12.68 ± 0.13	14.84 ± 5.76 14.97 ± 1.23 17.36 ± 0.43	13.88 ± 0.55 11.03 ± 0.36 8.46 ± 0.18	10.65 ± 0.11 17.61 ± 0.19 7.13 ± 0.52	15.17 ± 0.48 14.19 ± 0.92 7.28 ± 0.12
Ash, % ↓	34.16 42.95 41.20	39.38 39.53 30.35	32.01 37.56 36.44	37.31 33.19 26.16	33.54 37.31 35.98	40.69 36.13 34.38	31.32 49.67 31.32	32.14 38.19 30.74	39.49 35.29 39.81	37.17 37.12 39.34
Protein, % ↓	11.24 11.93 13.95	11.87 9.39 12.50	12.39 11.34 12.24	13.32 12.47 13.85	12.31 10.04 11.03	14.14 10.12 11.62	11.02 9.84 12.16	13.46 11.77 12.24	12.41 8.92 12.46	11.02 12.50 11.19

Water Analysis

Sampling Point	1		2		3		4		5	
Site	IMTA	Control	IMTA	Control	IMTA	Control	IMTA	Control	IMTA	Control
Total Phosphorus , mg/L ↓	0.011 0.012 0.014	0.011 0.015 0.007	0.012 0.010 0.015	- 0.011 0.010	0.010 0.009 0.013	0.008 0.019 0.007	0.013 0.015 0.013	0.013 0.011 0.009	0.180 0.008 0.015	- 0.015 0.011
Total Nitrogen , mg/L ↓	0.617 0.691 0.504	0.627 0.524 0.462	0.475 0.658 0.507	- 0.430 0.536	0.623 0.594 0.545	0.590 0.497 0.474	0.595 0.558 0.503	0.742 0.447 0.430	0.680 0.595 0.486	- 0.518 0.511
Final Ammonia , mg/L ↓	0.185 0.274 0.177	0.202 0.193 0.206	0.193 0.235 0.193	- 0.231 0.177	0.355 0.218 0.220	0.191 0.200 0.181	0.191 0.177 0.206	0.183 0.254 0.160	0.187 0.206 0.202	- 0.187 0.189
Final Nitrite , mg/L ↓	0.002 0.003 0.002	0.002 0.003 <0.001	0.002 0.003 0.002	- 0.002 <0.001	0.002 0.004 0.002	0.002 0.001 <0.001	0.002 0.003 0.002	0.003 0.001 0.004	0.130 0.002 0.002	- 0.002 <0.001

Discussion & Conclusion

The results of this study indicate that Alaria esculenta, when integrated into an IMTA system with Atlantic salmon, exhibits enhanced growth of about 20% and increased concentration of bioactive compounds compared to the control site without salmon farming. The elevated levels of phenolics and phlorotannin in the IMTA system of up to 9.84 mg/g and 6.11 mg/g, respectively, suggest that nutrient uptake from salmon effluents may boost the nutritional profile and industrial value of the kelp. The successful co-cultivation of kelp with salmon demonstrates a viable strategy for sustainable aquaculture, promoting efficient nutrient use and potentially reducing environmental impacts. Further research should explore long-term impacts and scalability of IMTA systems to optimize their implementation in various aquaculture settings.

References & Contact information:

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