Towards an improved assessment of biogeochemical impact of low-trophic aquaculture in coastal ecosystems: a stoichiometric geometry approach at the longline scale

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Low-trophic aquaculture, including mussel farming, represents an important resource for coastal communities and involves multiple interactions with biogeochemical processes in coastal ecosystems. Most of these interactions occur at the scale of mussel aggregates (ropes and longlines) and are increasingly affected by climate-driven environmental changes. Yet, the biogeochemical functioning remains understudied at the scale of the farming unit. Most of the existing studies focus on individual mussel physiology or large-scale ecosystem effects, leaving a gap in our understanding of how food quality and quantity drive faecal fluxes at the aggregation scale.

Here we propose a conceptual framework that treats the mussel rope as a functional unit and applies a stoichiometric geometry model to link food composition to tissue biochemistry and faecal fluxes. The main objective of this contribution is defining a scheme for the integration of the modelling and observational components, which can support the design of field experiments.

The stoichiometric geometry approach, implemented in R using available packages, provides a mechanistic tool to predict how changes in seston composition, in terms of organic content, carbon-to-nitrogen ratios, and biochemical quality, propagate through mussel metabolism and modify the quantity and quality of faeces produced and exported to the water column. The proposed framework would integrate two complementary activities. First, continuous sensors deployed inside mussel nets at multiple positions within the farm (edge vs. center) monitor dissolved oxygen and pH dynamics, allowing detection of hypoxic or anoxic events. Second, an active sampling campaign simultaneously characterizes seston composition, mussel tissue biochemistry, and faecal production rates at the rope scale, providing the empirical data needed to parameterize and validate the stoichiometric geometry model.

Once implemented, this approach would improve our capacity to understand what occurs within the mussel aggregation, moving beyond single-individual physiology toward a more realistic representation of rope functioning in dynamic coastal environments.