ECOAST
ERA-net COFASP

IMPLEMENTED ECOLOGICAL FOOTPRINT ANALYSIS (EFA) FOR AQUACULTURE: CONCEPTUAL MODEL DEVELOPMENT AND CASE STUDY APPLICATION

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INTRODUCTION

The main goal of the co-funded COFASP / ERA-net ECOAST project is to identify, develop and test new methodologies for improved spatial and temporal management of aquaculture and other activities in coastal areas. ***The project aims to implement methodological criteria to assess the ecological footprint of the aquaculture industry, using a holistic approach which combines ecological, ecotoxicological, chemical analyses together with the LCA method, to evaluate the real carrying capacity of aquaculture activities in an increasing competition for space in marine and coastal areas.*** To quantify the fluxes nutrients and chemicals as well as their impact on the ecosystem, it is necessary to integrate several parameters such as the mass balance between supplied and uneaten food in a cage, the biotic analysis the organic and inorganic sediments chemistry, and the quantification of organic compounds and nutrients computed from supplemented food and excretion products (Fig. 1).
The project was initiated by implementing an integrated ecological-chemical and ecotoxicological biomonitoring to assess both the short and long term environmental impact of aquaculture farm site within different stages of the production located in Boknafjord (South-Western Norway; fig. 2).

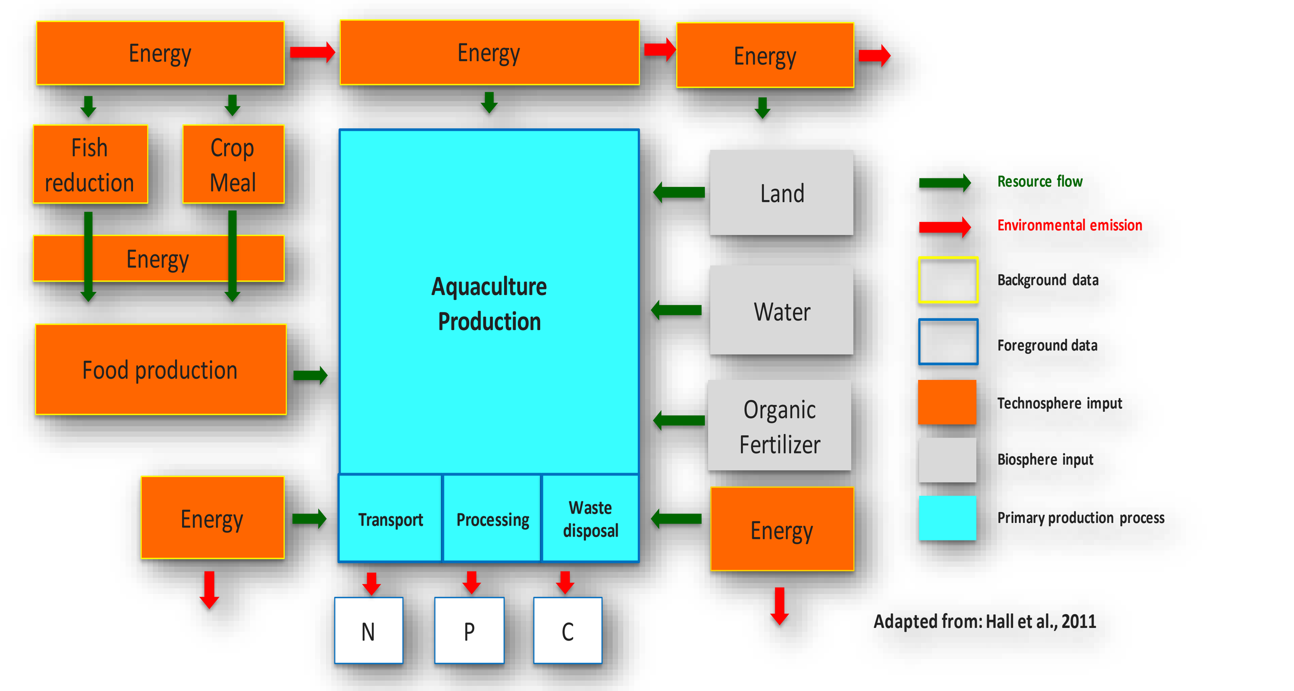

Fig. 1 - Scheme of the suggested boundaries in the Ecological Footprint Analysis.

APPROACH

Surface sediment samples from two orthogonal transects were collected by a Van Veen grab according a sampling grid (fig. 2). Toxicity of the sediment was assessed using marine protozoan as biological model (Gomiero *et al*. 2013) as well as and the inhibition growth of *Dunaliella* sp. according to ASTM E 1218 (2004). A simple and robust battery of tests, including mortality, replication rate, lysosomal membrane stability and endocytosis aimed at providing a snapshot of protozoan community health status following exposure to sediment collected along the transect. Biological response are compared with chemical analyses to correlate chemicals occurrence, potential bioavailability and adverse effects. Impact on ecological functioning was documented through documenting the impact of aquaculture derived matter on sediment organic matter content and reactivity (examined through sediment oxygen consumption rates).

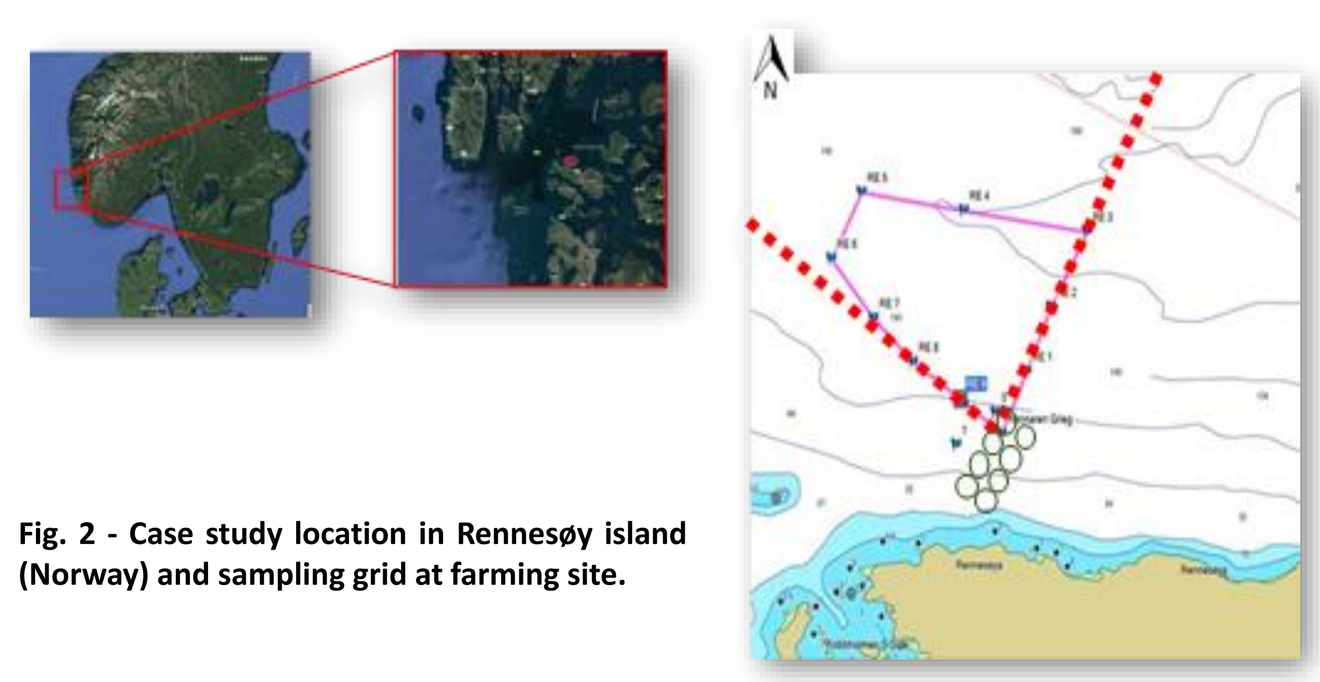

Fig. 2 - Case study location in Rennesøy island (Norway) and sampling grid at farming site.

RESULTS & DISCUSSION

The spatial distribution of some monitored chemicals has have been used to track the cumulative-long term (trace elements) versus short term (polyaromatic molecules; fig. 3) impact of the aquaculture in the surrounding environment. Results of geostatistical analyses point out a space distribution with moderate accumulation of PAHs as well as inorganic elements like Zn, Pb and Cu in the sites far from the aquaculture site. Such distribution may be explained by the combination of the strong ESE–WNW main coastal current and the seafloor topography dominated by a combination of plains and slopes which tend to collect sedimented matter in the central and deeper part of the fjord. Results of chemical analyses are in good agreement with biological responses. A strong hormetic effect shown by the microalgae test was positively correlated to the total content of phosphorus in sites close to the aquaculture production facility (fig.4). On the other hand, reduction in the protozoa fitness in sites far from the aquaculture facility were correlated to the occurrence of trace elements like Cu and Zn (fig.5).

The flux of energy is being monitored, parametrized in terms of characterization and quantification and linked with the recorded mass production. Identifying novel tools to monitor anthropogenic changes is one of the goals of the project. Although conventional parameters documenting environmental impact are informative, early results show that a direct measure of sediment organic matter reactivity represents a superior discriminator of fish-farm derived organic matter. Larger amounts of reactive carbon are encountered close to cage (Fig. 6b) and the impact from aquaculture does not extend more than 400 m. This was not evident in bulk organic carbon content and the Reference station was a sink for refractory organic matter (Fig. 6a). To verify these results, the sediment organic matter reactivity and the analysis of surface sediment molecular based biodiversity, will be conducted at selected sites of the project's partners, and applied to sites of contrasting trophic status.

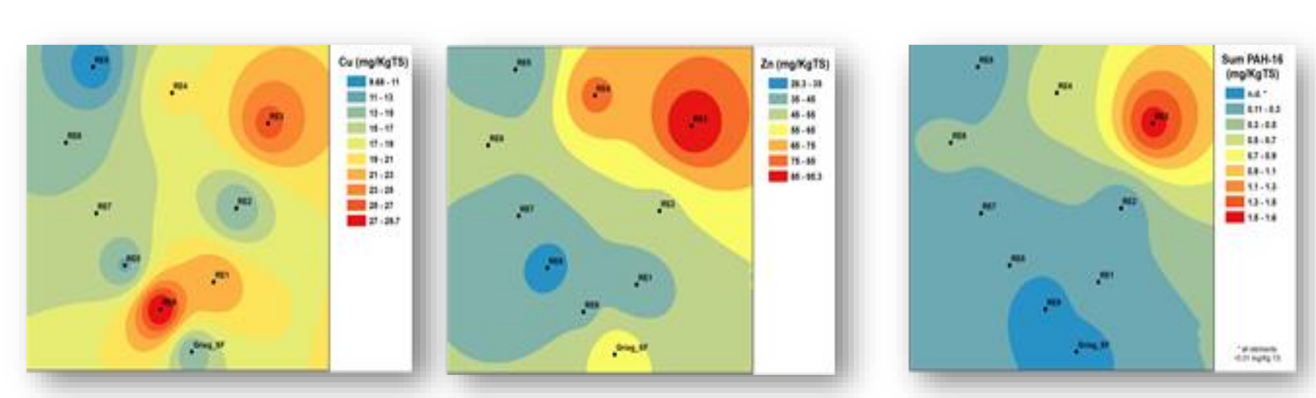

Fig. 3 - Spatial distribution of some selected organic and inorganic chemicals among all those investigated.

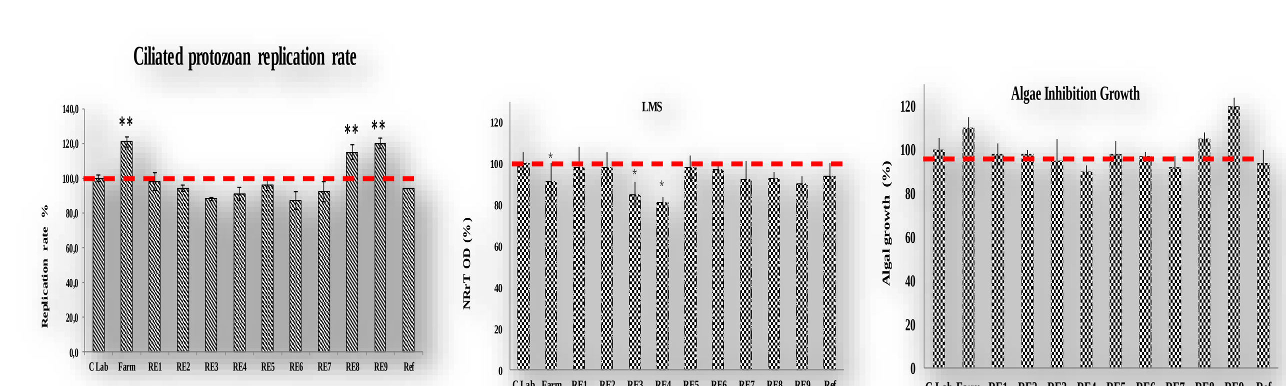

Fig. 4 - Results of ecotoxicity assessment with marine protozoan and green algae (C) in collected sediments (0-2 cm layer).

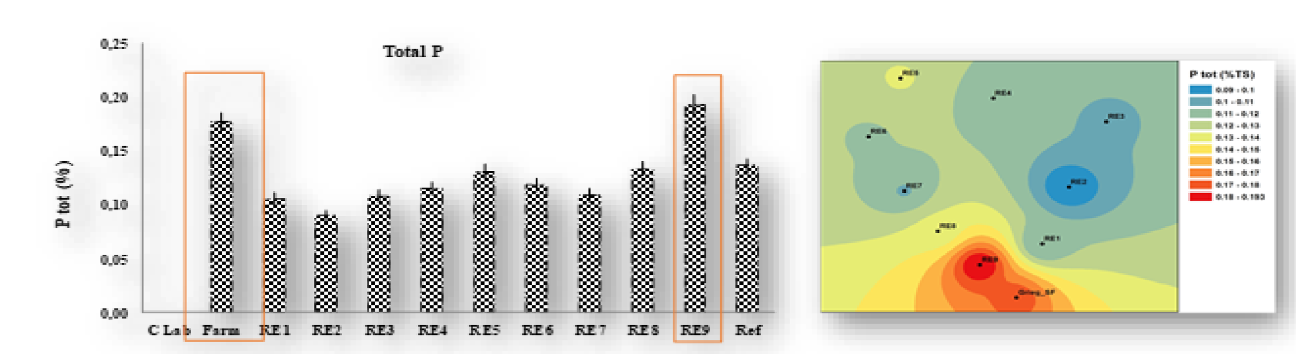

Fig. 5 – Distribution of P in the investigated sites

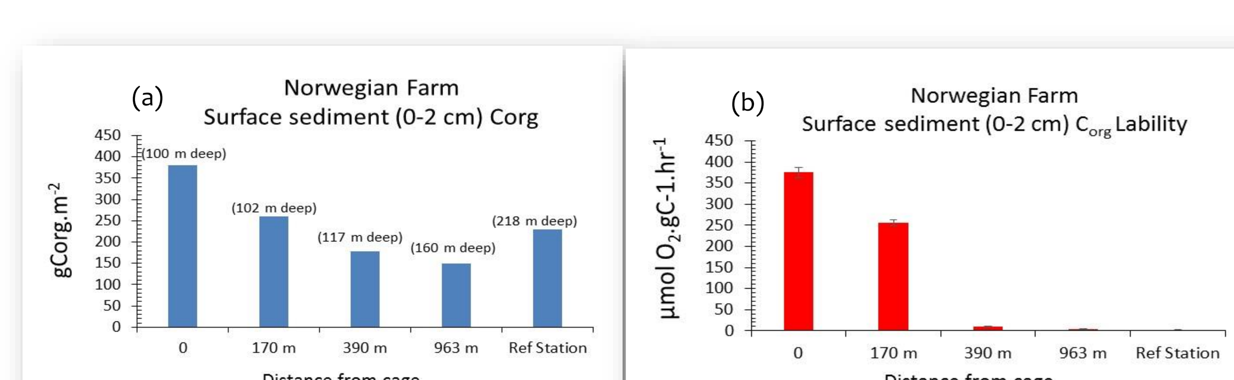

Fig. 6 – Different measures of impact of aquaculture derived matter on sediment organic carbon content.

CONCLUSIONS

- ✓ **The suggested multiple-endpoint approach based on two high-level tests (mortality and replication rate) and a sensitive and sub-lethal tests (lysosomal membrane stability) in combination with a chemical characterization of the sediments successfully identified a stress gradient in the study area.**
- ✓ **Chemicals - induced changes in both the abundance and composition of microbial communities can be reflected at higher ecosystem levels because the disruption of the flow of both energy and substances from one trophic level to the next can significantly alter the food web and the trophic net.**
- ✓ **Direct measure of sediment organic matter reactivity represents a superior discriminator of fish-farm derived organic matter, even more so in combination with sediment organic carbon stable carbon isotope signatures (data not shown)**

Forskningsrådet

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