

# Environmental impact from large salmon farms at wave exposed coast

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*We can trace waste up to a thousand meters from large salmon farms. That's one of the preliminary results from the research project ERA so far.*

In Sør-Trøndelag and Møre og Romsdal counties, most of the salmon production takes place on wave exposed coast. The farms are often large and can contain 10 000–14 000 tonnes of fish. Farms are generally located in shallow coastal areas where kelp forest and coarse sand are the main habitats.

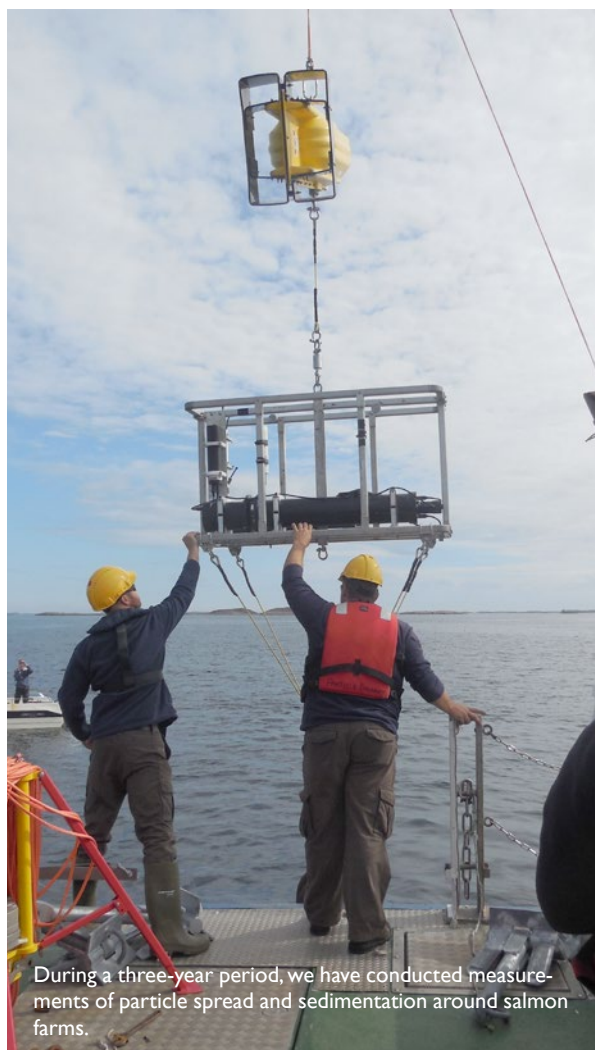
The ERA project has studied dispersal and impact of waste from such farms through the production cycle and during fallowing at Frøya and Smøla since 2014. We here present some preliminary results from this project.

## DISPERSAL AND TRACING OF ORGANIC WASTE

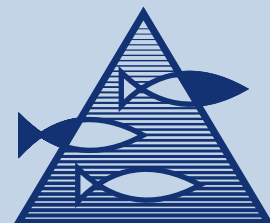
During a three-year period, we have conducted measurements of particle spread and sedimentation around farms using advanced instruments in cooperation with Canadian researchers. Analysis of these measurements are in progress and will contribute to novel numerical models for particle dispersal and response in the benthic communities.

Fin-fish diets are comprised of large quantities of terrestrial ingredients. These ingredients occur at low levels in the marine environment, providing ideal tracers properties. To determine the spread of organic matter into the marine environment, we use stable isotope and fatty acids to detect increases of these ingredients.

By using seston trap and sediments surrounding farms at Frøya, we found organic waste outflow along transects into the marine environments up to 400 m from the cage, and in some cases reaching 1000 m residing in deeper depressions. In addition, we have analysed fauna in the area and found that brittle stars, sea urchins and crabs are



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consuming high amounts of organic waste from fin-fish farms. We can detect terrestrial components of aquaculture diets in these species up to one km from the farm.

### IMPACT IN MARINE ENVIRONMENT

#### *Benthic fauna*

Despite minimal visual impacts on the near-field sediments, the results revealed very strong chemical and biological responses out to 600 m from the farms.

Microbial processes and a prolific and responsive macrofauna appear to be metabolizing a large proportion of the farm waste, however a lot is also being exported through resuspension.

There were some signs of low-level enrichment in far-field locations. Interesting ecological responses were observed with some epibiota on mixed bottom habitats, and large lugworms (*Arenicola marina*), were identified as key ecosystem engineers in farm sediments, oxygenating sediments and facilitating colonization by the opportunistic polychaetes and microbes that help metabolise organic waste.

#### *Kelp forest*

An important habitat around farms at Frøya and Smøla is kelp forests (*Laminaria hyperborea*) harbouring a vast number of associated species. Video inspections shows that kelp is growing rather close to farms (50–100 m) with little visual impact on kelp plants. We have studied the impacts from nutrients and organic particles on sea weed and fauna communities associated with the kelp forest.

Collected material is still being processed, but preliminary results show that seaweed diversity on kelp stipes and biomass of bryozoans are higher close to farms during high production.

#### *Sea urchins*

Our understanding of the impact on individual and population level in species feeding on a vast amount of terrestrial material being released into the marine environment, is fairly limited.

Various species of sea urchins are demonstrated to be feeding on aquaculture waste in fjords and coastal environment. Experimental studies show that this feed subsidy can have a large impact on individual reproduction success.

Sea urchins fed with novel salmon feed developed larger gonads, but survival of sea urchin larvae were significantly reduced. This indicates that large emissions of waste with terrestrial origin may have unexpected consequences for marine life.