

Work package activities

WP1 Extraction culture: A farm unit was established in Skive Fjord in May 2010 (milestone 1.1), larvae settled in May and June and at the end of October the biomass had reached approx. 1000 tons of blue mussels. Development in biomass was followed with one-month intervals except for the months where an ice-cover prevented biomass sampling. Mussels have been harvested in November-December 2010 (milestone 1.4) as planned, however in limited amount due to bad weather and increasing ice coverage.

A monitoring program consisting of 2 moorings, a meteorological station and regular sampling at 5 stations was established (milestone 1.3) and carried out from June 2010, except during ice-cover from December-February.

WP2 Environmental impact: Coordination of field campaigns was carried out on the first MUMIHUS meeting in March 2010 (milestone 2.1). During the first field campaign (23. Aug. – 3. Sep. 2010) a number of measurements and experiments were carried out. Benthic studies consisted of sediment traps that were deployed at five different stations three inside the mussel farm and two outside they were analysed for dry weight, organic material, nutrients (C, N and P) and chlorophyll *a*. Furthermore sediments cores were collected at the same stations and analysed for loss of ignition, nutrients (C, N and P), chlorophyll *a*, sulphide and grain size of the top sediment layer. Fauna samples were collected inside and outside the farm unit.

Samples in the pelagic consisted of both physical and biological measurements. To identify the physics around and inside the farm, current velocity, turbulence and stratification were measured (CTD profiles, SCAMP turbulence data and ADCP profiles) during the field campaign. The results will be used in a box model that includes both vertical and horizontal fluxes. The spatial resolution of suspended particle removal by a suspended mussel farm was investigated using a rapid 3-D mapping approach. Detailed synoptic surveys of suspended particulate concentrations (total particulate matter and chlorophyll *a*) were conducted using the BIO-Acrobat towed undulating vehicle, which contained fluorometer, transmissometer and CTD sensors. The surveys were conducted in parallel with ADCP measurements collected from the same moving vessel. Reference chlorophyll *a* concentrations, measured to the south and west of the farm, were used to map the reduction (depletion) of phytoplankton by the suspended mussels. An example of the distribution of chlorophyll *a* around the experimental farm on 1 September 2010 is shown in Figure 1. Measurements of the fluxes between mussel lines and the water column were performed using in situ incubations and siphon mimics.

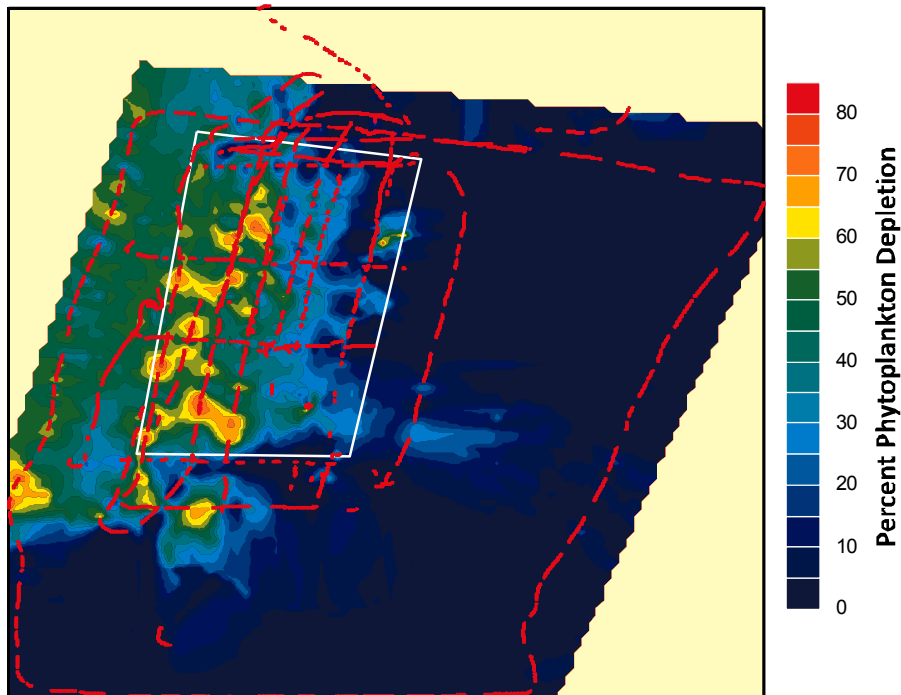


Figure 1. Percentage reduction in chlorophyll *a* concentrations, relative to boundary conditions, measured between 1 and 3 m depth at the experimental mussel farm (white box) on 1 September 2010. The red dots are locations sampled by the Acrobat sensors.

WP3 Modelling: It has been decided to use the newly developed Framework for Aquatic Biogeochemical Models (FABM) as the interface between the physical, mussel DEB model and biogeochemical model (milestone 3.4). The FABM has been implemented on a Linux server at NERI and is ready to use for the Skive Fjord ecological model. The DEB modelling is postponed to start later this year (milestone 3.3.) because the input from WP4 has been delayed due to snow and ice conditions. Furthermore the numerical modelling of Skive Fjord is based on a high-resolution bathymetry for the Limfjord (25x25m) two-model bathymetries with horizontal resolutions of 100m and 200m and has been created. Using both resolutions two Limfjorden model setups with the same meteorological- and boundary-forcing have been set up for year 2003 covering the whole Limfjorden from Thyborøn to Hals. The Limfjorden model agrees well with the observations but simulations applying some further adjustments of the bathymetry (channels, drying and flooding, coastlines) and barotropic flow are planned.

A comparison of both Limfjorden model setups (100m, 200m) has revealed no significant difference in the spatial and temporal development in salinity and temperature. Hence the model setup with lower horizontal resolution is used to provide open boundary conditions (salinity, temperature and vertically integrated velocity) for the high resolution model setup of the Skive Fjord. This Skive Fjord setup has a horizontal resolution of 25x25m and 10 vertical sigma layers. The open boundary of the Skive Fjord model setup is south of Hvalpsund. Currently the Hjarbæk Fjord is included in the Skive Fjord model but it will be removed in future simulations as the connection to the Hjarbæk Fjord is irregularly opened and closed depending on the biological conditions in the strongly separated Hjarbæk Fjord which hence makes no sense to include the corresponding dynamics. The Skive Fjord model has not further been validated yet.

WP4 Growth limitations: DTU Aqua has deployed test farm in three Danish fjords (Nørrefjord (14‰), Karrebækfjord (7‰), Præstøfjord (10 ‰)) with varying salinity during May to October 2010. Three fjords were chosen instead of five as the workload of sampling and working up the samples was too extensive compared to the time and economy of this package and therefore mussel farms will not be deployed for a second year. The mussel farms were sampled six times (May- October) for mussel biomass, mussel growth, phytoplankton composition, chl a, mussel larvae abundance, secchi depth, CTD-profiles of salinity, temperature, and fluorescence.

Besides the field experiments, laboratory experiment on filtration and growth as function of salinity and food composition was performed. Two different experiments were conducted during the field campaign (August/September 2010). The aim of the first experiment was to trace mussel growth as a function of food conditions. Mussels were positioned at different places in- and outside the farm in nylon nets and recovered in November 2010 – measurements and analysis are still pending. In the second laboratory experiment filtration as a function of food composition was investigated. The experiment was conducted with water collected from three positions two inside the mussel farm and one outside. Furthermore experiments of addition of *Isochrysis galbana* were performed.

WP 5: Management of extraction culture: The analysis of the cost-effectiveness of extraction culture mussel production compared to other nutrient abatement measures in agriculture and point sources is ongoing, The costs of producing mussels are estimated using data from the extraction mussel production in Skive Fjord, and a cost-minimisation model for the area is under development to compare this measure with other abatement measures. The model will be finalised in 2011, and scenarios run and presented. The costs have been presented to the Ministry of Foods in February 2011.

The work with the quota model has started. The estimated costs are disseminated to the Ministry of Foods, and the outline of the economic analyses and the anticipated results were presented at a meeting at DSC in the autumn 2010 (see below).

Milestone 5.1 is 4-6 months delayed, but work in WP5 is otherwise proceeding according to plan.

WP 6 Output: Samples for heavy metals have been collected throughout the monitoring program of the test unit and during the field campaigns to accommodate for modelling of uptake using the DEB-model. The different sample types include free heavy metals in the water (passive samplers), particle bound metals in the water phase and sediment traps, heavy metals in mussels, fractionated as gills, soft parts and gonads. Collection of gonads will take place in spring 2011 once the reproductive period has started. Analyses of heavy metals are on-going and sampling and analyses will continue until the test system is concluded in order to cover temporal variation, as well as different growth stages of the mussels. At the different harvest occasions mussels will be analysed for heavy metals and dioxins before and after the production of mussel meal.

Meeting activities

Two project meetings have been held, in March and May 2010. Next meeting has been scheduled to May 2011. The steering group has kept regular meetings in the first year, either as meeting at NERI in Roskilde or as telephone meetings.

Dissemination activities

MUMIHUS has performed various dissemination activities. A stakeholder meeting was held March 8th 2011 with participation of the mussel fishermen's association, the shellfish farmers association and regional and local environmental authorities. At the meeting, the MUMIHUS project was presented and discussed and especially it was discussed which model scenarios is needed by stakeholders. Minutes from the meeting outline decisions made by stakeholders. A second stakeholder meeting aimed at primarily environmental authorities – both national, regional and local – was held November 23rd with focus on development of management tools in relation to using mussels for mitigation purposes. Furthermore in February 2011 The Danish Shellfish Centre (DSC) was invited to the Ministry of Food, Agriculture and Fisheries to inform the Minister of the concept of mussels as a tool for mitigation of effects of eutrophication in Danish coastal waters. Subsequently DSC was asked to present a note to the Ministry of how production of "environmental mussels" can be implemented and what unsolved challenges we are facing.

During the first year, the outreach of MUMIHUS in the media has been very successful and the project has been mentioned in TV, radio, newspapers and magazines covering national, regional, local and trade specific media.

Scientific presentations:

- D. Plew 2010. Aquaculture and Physics. Presentation at the *NIWA Seminar Series*, Christchurch, New Zealand, September 2010.
- P. J. Cranford, Ø. Strand, T. Strohmeier, P. Kamermans, K. Troost, M. J. Fernández-Reiriz, U. Labarta, P. Duarte and J.K. Petersen 2010. Phytoplankton depletion criteria for assessing the ecological carrying capacity for suspended mussel aquaculture. Poster at the *Aquaculture Europe Conference*, Porto, November 2010.
- J.K. Petersen 2010. Mussels – Mitigation and feed for Husbandry. Presentation at the Euroshell session at the *Aquaculture Europe Conference*, Porto, November 2010.
- P. Dolmer 2010. En fattig natur i et rigt samfund, Biodiversitet - fra ord til handling. Presentation at the *Wilhelmkonferencen*, Copenhagen, November 2010.
- J. K. Petersen, P. Nielsen, D. Tørring, M. Maar, M. Holmer og M. Carlsson 2011. Muslinger som virkemiddel 1: Overvejelser og første resultater om miljøeffekter. Presentation at *Det 16. Danske Havforsker møde*, Ebeltoft, January 2011.
- P. Nielsen, J. K. Petersen og D. Tørring 2011. Muslinger som virkemiddel 2: Overvejelser og første resultater om produktion af biomasse og fjernelse af næringsalte. Presentation at *Det 16. Danske Havforsker møde*, Ebeltoft, January 2011.
- D. Tørring 2011. Miljømuslinger – muslinger som virkemiddel. Præsentation for Fødevarerministeriet, Copenhagen, February 2011.