Substrate test at Musholm 2016

Mussel growth in the western Baltic sea

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Introduction

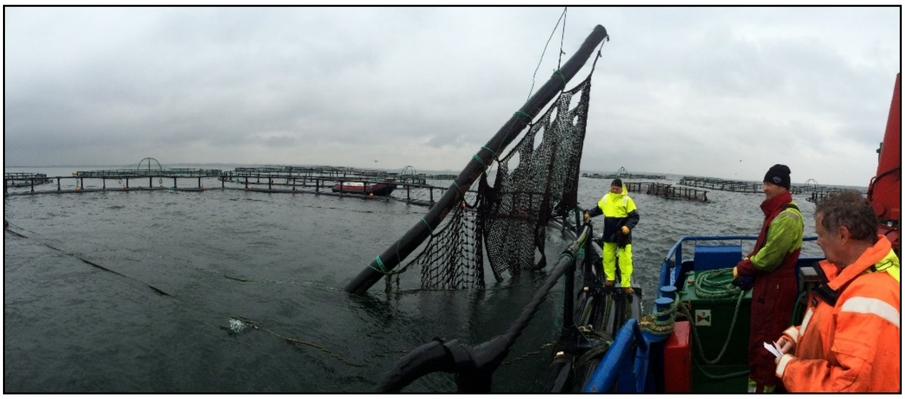
The Baltic Blue Growth interregional project aims at implementation of mussel farms at different regions of the Baltic Sea. To develop the best guidelines for doing so, six focus farms located in different areas of the Baltic have been chosen to compare growth and recruitment on different types of substrates. Two of the focus farms will test more than two different substrates (nets with different mesh size, Ø 50, 78, 80 and 150 mm, 300 mm respectively), longlines: traps, Fuzzy rope and Swedish bands.

Furthermore, analyses with respect to concentrations of nitrogen and phosphorous in the mussel meat are being carried out during different seasons of the year.

Focus will also be on predator control of eiders at two sites in the western and central part of the Baltic Sea. The activities will be coordinated to coincide with the growth and recruitment study coordinated by CAB Östergötland, that will be less detailed but performed at all 6 focus mussel farms in the project.

The outcome from these surveys will be valuable guidelines indicating the most optimal harvest times, optimization of mussel production including cost effective methods, best available techniques and equipment, most suitable areas for mussel production, processing lines and an evaluation of the market for small mussels.

This report describes the mussel growth at Musholm in the Western Baltic Sea during the first year according to the planned activities according to test different types of substrate for mussel production for this focus farm. Musholm has been using Smartfarm units to grow mussels, and we test the hypothesis, that the larger standard net mesh size (substrate) of these units is not necessarily the best possible mesh size for optimum production, i.e. mussel production may be improved by using nets with smaller mesh sizes. Preliminary tests in 2016 will be used to design large scale substrate tests in 2017 and 2018. Eider-predation of mussels may significantly impact the mussel production at Musholm. The Musholm Island close to the area with mussel production, is frequently visited by eider ducks from September to February of each year, and the mussels are an important part of their diet. We therefore review available data on eider densities at different seasons of the year in order to develop a strategy for mitigation.



Picture 1: The setup for the tests of substrates in 2017. The substrates were mounted on a floating pipe, and kept inside and empty fish cage to reduce predation from eider ducks.

Method and sampling

Setup for tests of different types of substrate

The 4 different Trawl test nets with mesh sizes of 50 mm, 80 mm, and 150 mm were placed inside an empty fish cage in an area of fish production (see picture. 1). The nets were held just below the surface by a floating PVC pipe, which was visible on the surface. The depth of each test net extended down to 3 m and the length of each test net was 4 m (see figure 1). The full length of floating PVC pipes, each with 2 test nets, was 10 m long and 30 cm in diameter. Additionally, a standard full length Smartfarm unit (120 m in length), holding the largest mesh size (mesh size: 300 mm) was placed next to the fish production area (figure 1).

Picture 2: The set up with two nets with different mesh sizes alongside each other on a 10 meter PVC tube.

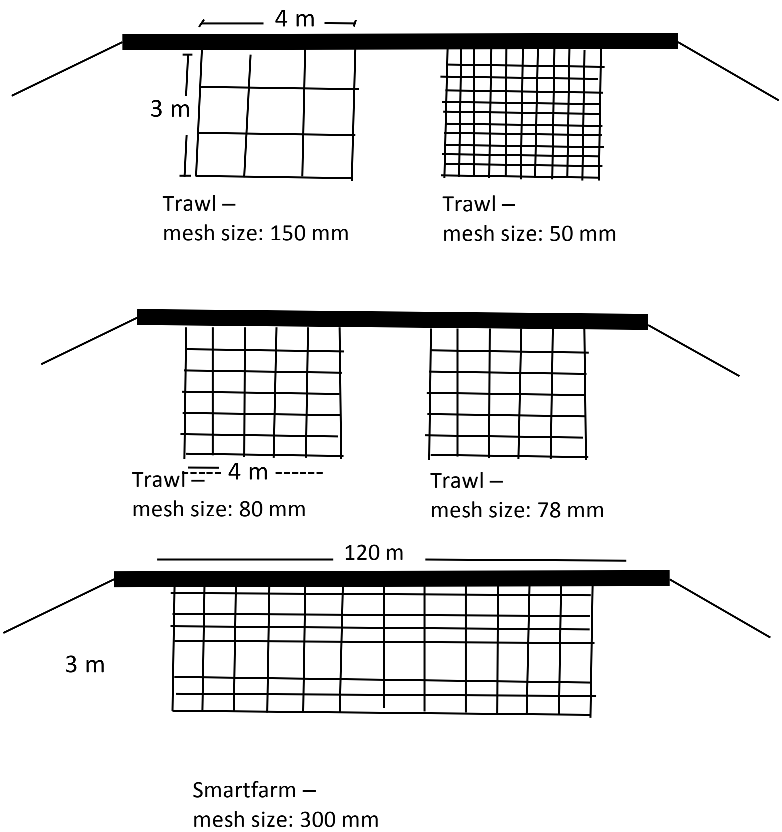


Figure 1: Schematic drawing of the test setup with Trawls (mesh size: 50, 78, 80 and 150 mm) and Smartfarm units (mesh size: 300 mm) at Musholm. Each net is in replicates.

Picture 3: A 10 meter test tube placed inside an empty fish cage.

Sampling of mussel production

The sampling followed a BBG sampling instruction manual developed by Orbicon. The aim of the sampling instructions is to standardize methodology of measuring the growth and production of mussels, so the production among focus farms can be compared. The production data is therefore presented as weight (biomass) per meter rope from each Trawl test net and from the Smartfarm Units.

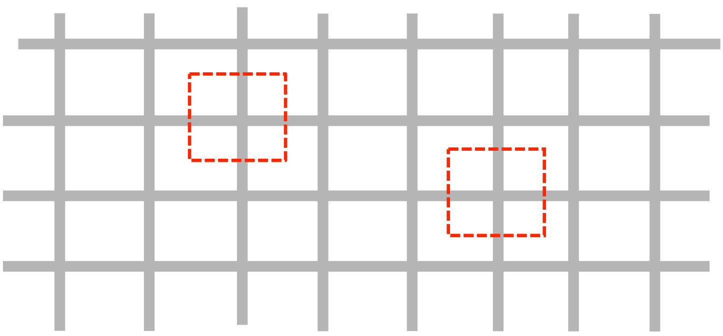


Figure 2: Schematic drawing of how the samples are removed (cut out) of the test nets. The squares measure 300 x 300 mm.

Sampling on Smartfarm nets: Mussels were collected in separate samples from squares (quadrants) of 300x300 mm from near the top and bottom of the substrate net. Four squares, two in the top and two in the bottom, were cut out of each substrate net and the mussels were collected and analysed in the laboratory. The same procedure was carried out for the trawl nets with 4 samples per test type, two in the top and two in the bottom.

Procedures in the Laboratory

The study covers the time period running from September to December, 2016, where a total number of 45 samples was cut out of the test nets and analyzed in the lab.

The mussel lengths were measured on subsamples of 100 mussels using an electronic sliding caliper, which was necessary due to very small sizes. The time spent on each sample with 100 mussels, when the procedures was up and running was approx. 0.5 hours.

Because mussels loose water over time after sampling, the collected mussels were weighed just after sampling and again after being frozen to estimate the loss of water during the freezing process. This amounted to approx. 30 %. If the water is not included in the weight, then loss of water from mussels during the freezing process will lead to an underestimation of the wet weight when thawed. The weight of the mussels before sampling, the frozen weight, the drained weight of the mussels, and eventually the weight of the substrate is noted. The wet weight (WW) of the mussels is calculated as:

$$WW = WW_D + (WW_{FS} - WW_D - W_S)$$

where WW_D is the drained weight of mussels, WW_{FS} is weight of frozen sample including the substrate, and W_S is the weight of substrate.

Exactly 100 individuals of mussels were randomly subsampled from each type of substrate from both the surface and the bottom samples. The shell length of each mussel was measured and recorded with an electronic caliper (0.1 mm precision). The shell length was measured as the maximum length from the umbo (see Figure 3).

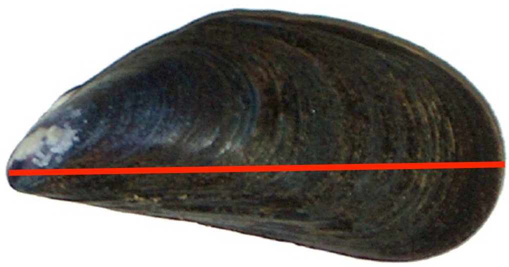


Figure 3: showing the maximum length from the umbo.

One subsample of mussels pooled from each type of substrate was frozen (which in this case was 4 samples) for further analysis to determine the parameters relevant for animal feed and to assess the effect of nutrient extraction from the environment.

Picture 4: An example of a subsample of 100 small mussels.

Picture 5: Working process with an electronic caliper, measuring very small mussel lengths.

Calculation procedures

To assess whether the higher biomass observed on the trawl nets placed within a fish cage were due to their smaller mesh size, or other factors such as better protection from eider duck predation, we calculated the full length of the sampled substrate, as if the mesh sizes was stretched into one long line. Then the biomass per unit length of the substrate could be calculated using the units g/cm.

Results: growth of mussels from May to December 2016

The following changes in relation to the original sampling plan for 2016 has been carried out: The sampling program started in September and ended in December. Due to very little biomass on substrates, the harvest planned for November was cancelled and all the Smartfarm nets and trawl nets were left in the water until spring 2017. One of the PVC test pipes with 2 test nets (mesh size: 78 mm and 80 mm) was lost between November and December, and therefore the sample measurements for December only include trawl nets with mesh sizes 50 mm and 150 mm. Because the mesh sizes 78 mm and 80 mm were so close to each other, they were both treated as mesh size: 80 mm in the laboratory. By mid-February 2017, there were no more mussels on any of the trawl or Smartfarm nets and it is assumed that they have been eaten by Eider ducks.

In September, the size of the mussels ranged from 1-8 mm, and means lengths (approx. 3 mm) were similar on all tested nets (Figure 4). Overall, there was an increase in length from September to November, however, the largest increase in length was between November and December (Figure 4). The average size of the mussels grown on Smartfarm nets only increased slightly from September to December, whereas the mussels grown on trawl nets with different mesh sizes increased their length by nearly a factor of two (on mesh size = 150 mm) between November and December.

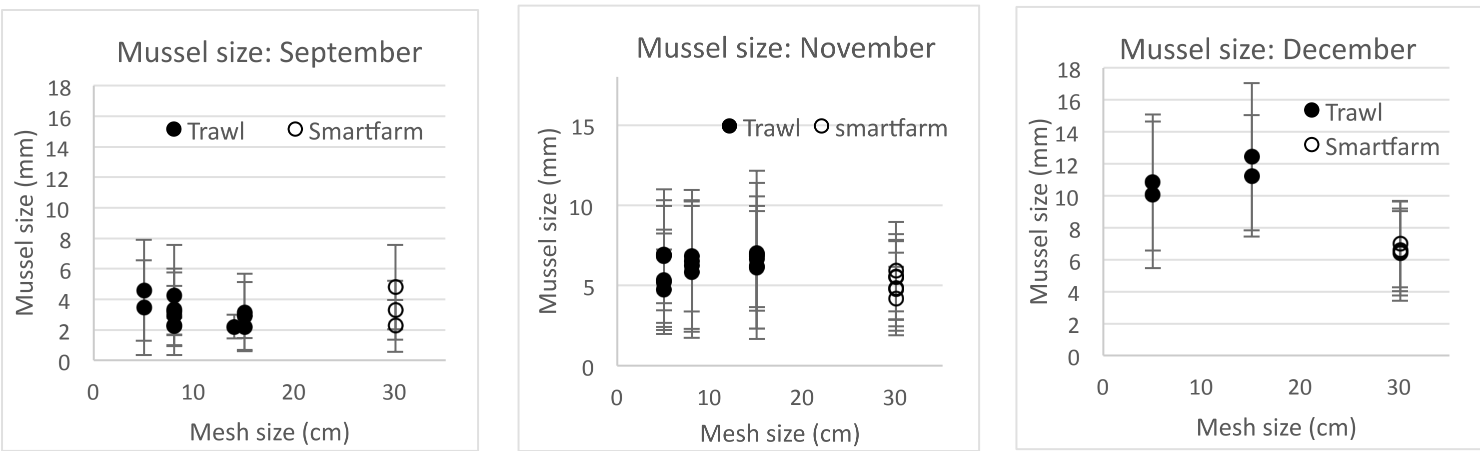
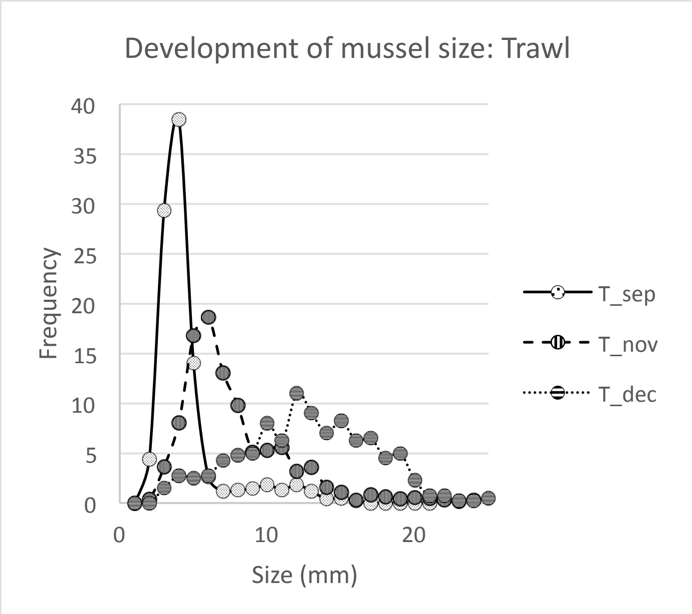


Figure 4: The graph shows average mussel length measured on 100 mussels from each sample. The overall number of mussels measured in September was 1500 mussels, November 2400 mussels and December 800. The errorbars show ± standard deviations from average values.

The distribution of mussel length from September to December changed from a narrow peak with high frequency of mussels from 1-8 mm on both Trawl nets (smaller mesh sizes) and Smartfarm nets in September, to a broader size distribution in December peaking in the range of 12–19 mm for mussels grown on trawl nets, and 6-9 mm for mussels grown on Smartfarm nets. The size of mussels on both the trawl and Smartfarm substrates showed a greater increase in size from November to December than from September to November (see Figure 5).

To compare the average length of mussels grown on trawl nets with mussels grown on Smartfarm nets a T-test was carried out on average length values from the trawl nets and from SmartFarm nets. Results showed there was statistical difference between mean values for each group in September.

(T-test, p < 0.05, N=200), November (T-test: p<0,001, N=200) and December (T-test: p<0,001, N=200).



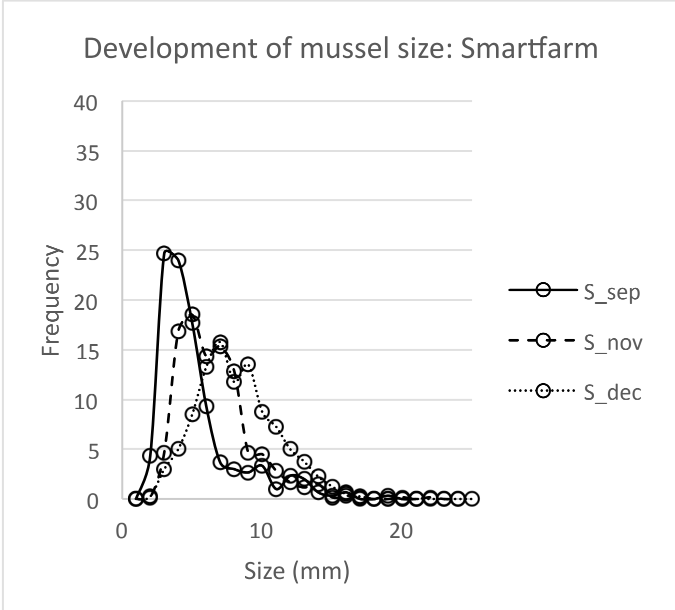


Figure 5: The graphs show the development and distribution of mussel size from September to December for mussels grown on Trawl nets (left graph) and for mussels grown on Smartfarm nets (right graph).

Overall, the average weight of the mussels on the Trawl and Smartfarm nets, measured by weighing a subsample of 100 mussels from each substrate, increased from September to December, and most markedly during the last month (Figure 4). Mussels grown on trawl nets increased their average weight per month by a factor of 3, whereas the mussels grown on Smartfarm nets only increased their average weight per month by approx. 60 % (see Figure 6). Overall, the total weight (biomass) of mussels on Smartfarm nets decreased from September to December (see Figure 7), whereas the overall biomass on trawl nets continued to increase during the study period (September-December) (see Figure 7).

Picture 6: Example of homogeneity in mussel size. The picture is taken in December 2016.

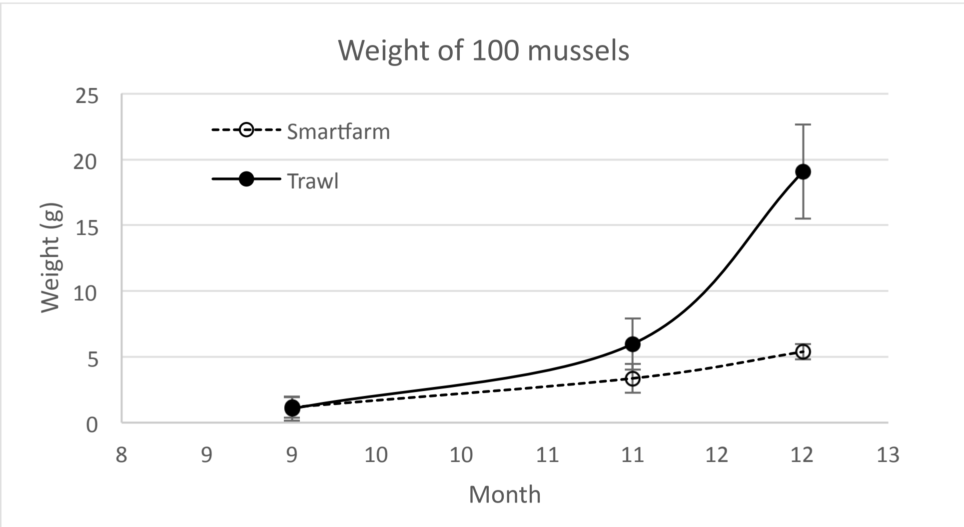


Figure 6: The graph shows the development of the average weight of 100 mussels on Trawl nets and Smartfarm nets from September to December. The vertical bars show ± standard deviations from average values.

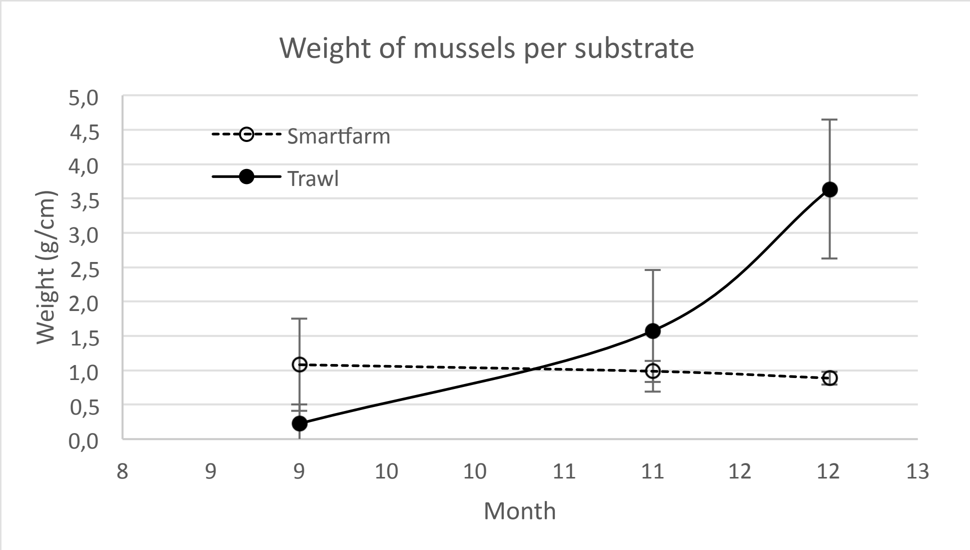


Figure 7: The graph shows the weight of mussels (g) standardized to weight of mussels per cm substrate line for mussels grown on Smartfarm nets and for mussels grown on trawl nets. The vertical bars represents the ± standard deviations from average values.

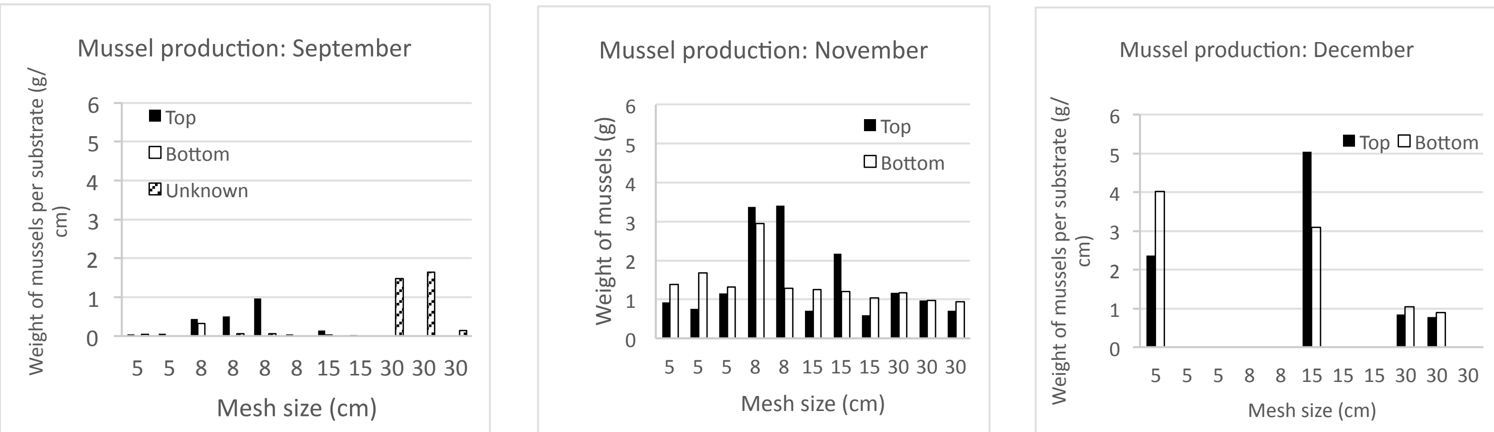


Figure 8: The graphs show production measured as weight of mussels per length (cm) of substrate from trawl nets with mesh sizes: 50, 80, 150 mm and the Smartfarm net with mesh size: 300 mm. Filled bars indicate samples taken from the top of nets and open bars indicate samples taken from the bottom of nets. Samples noted "unknown" means that it is unknown if samples are from the top or bottom. There is no statistical difference between the weight per length of substrate in samples taken from the top and bottom of the nets; T-test (P > 0.05, n=22) from November.

The highest biomass per length of substrate varied between different mesh sizes in different months. For September, Smartfarm nets (mesh size 300 mm) had the highest biomass indicating the largest settlement of mussel spat. In November the highest biomass was found on Trawl nets with mesh size 80 mm, (see Figure 8). In December, Trawl nets with mesh size 150 mm showed the highest biomass, results from the mesh size 80 mm were, however, not available and may have showed even higher biomass if earlier tendencies in biomass growth on this substrate continued.

Full scale estimates of the production (biomass) of mussels on all the substrates (mesh size 50 mm, 150 mm and 300 mm) in December, upscaled to production units that are 100 m long with 3 meter deep vertical panels, would result in a mussel production of approximately 3.7 tonnes (trawl - mesh size 150 mm), 1.95 tonnes (trawl - mesh size 50 mm), and 216 kg (Smartfarm – mesh size 300 mm) (Table 1).

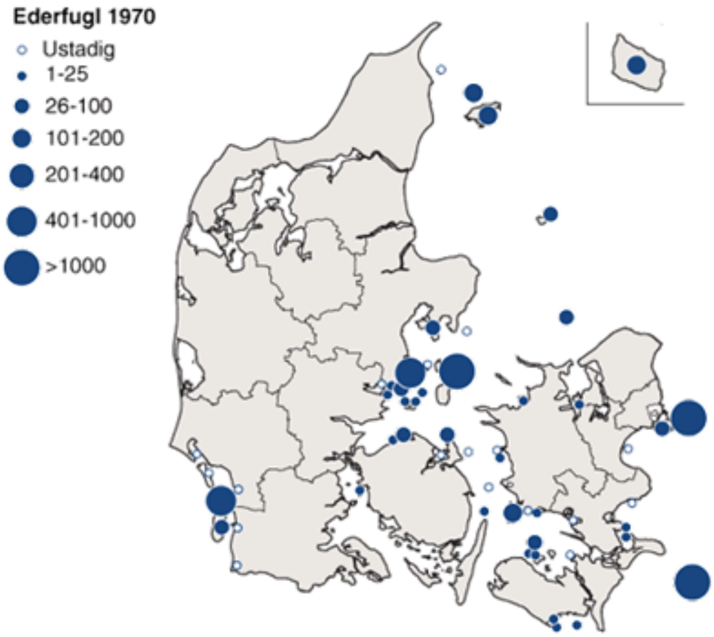
Table 1: Full scale estimates of the production (biomass) of mussels on all the substrates (mesh size 50 mm, 150 mm and 300 mm) in December 2016.

Estimates of the production (biomass) of mussels on all the substrates (mesh size 50 mm, 150 mm and 300 mm) in December upscaled to 100 m long nets with 3 meter deep vertical panels	
Mesh size	December
50 mm - trawl	1.95 t
80 mm - trawl	No data – damaged production units
150 mm - trawl	3.7 t
300 mm - Smartfarm	0.22 t

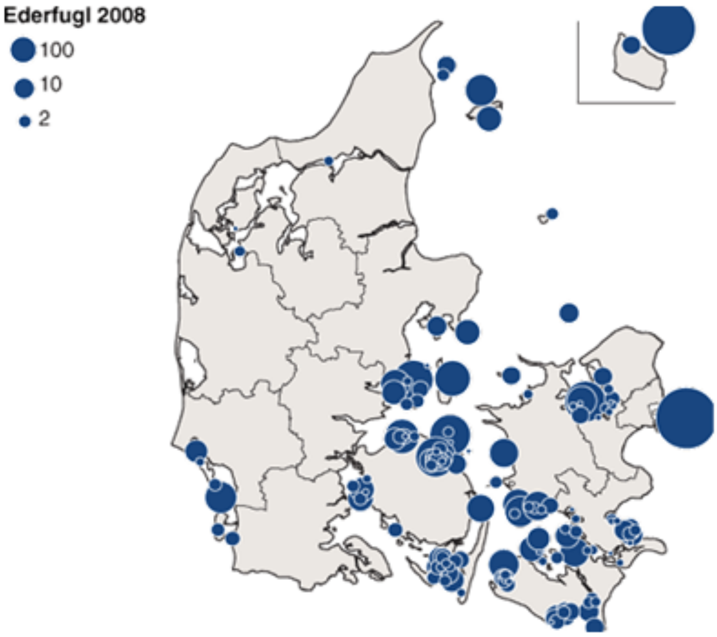
Predation from Eider ducks

In general, the population development of eider ducks from 1973 to 2008 has increased in several areas in Denmark (Figure 9).

Specific data on the population development of Eider ducks in the area of the mussel production test site of Musholm from 1995-2016, indicates that the population fluctuates considerably from year to year, but overall the number of eiders in the area has increased, and in some years by more than a factor of five during this period (Figure 10).



Figur 4.5.16a Udbredelsen af ederfugl i Danmark i 1970 (efter Joensen (1973).



Figur 4.5.16b. Udbredelsen af ederfugl i Danmark i 2008 efter Lyngs (2008).

Figure 9: The development of the number of Eider ducks in Denmark from 1970-2008. Maps taken from Joensen (1973) and Lyngs (2008).

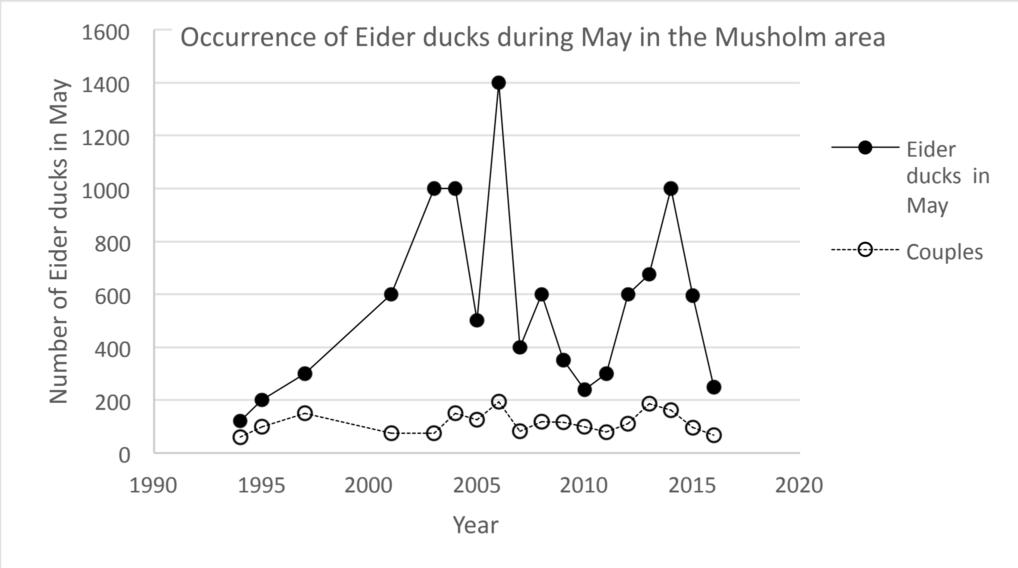


Figure 10: The results of observations of Eider ducks on the Musholm Island during the month of May from 1995 to 2016. The blue data points indicate the total number of eiders and the grey data points indicate the number of eider couples. Both time series represent a minimum number of observed eiders, since many of the observers were not able to count every single individual.

Eider ducks feed on a number of food items, with mussels being their preferred prey (Ross & Furness, 2000). Normally, eiders forage on mussels at depths from 0-6 meters, but they are capable of diving for prey down to 40 meters of depth (Guillemette, 1993). Because the prey items of eiders can be characterized as being relatively low in energy content and eiders swallow mussels whole, they consume a large amount of food each day. It is estimated, that Eider ducks consume approximately 2-3 kg of mussels each day (Guillemette et al., 1992). Eiders eat mussels from a few millimeters to several centimeters in length (Nehs, 2001). Studies from other areas in Denmark (Ringebjerg Sand and the Island of Tunø) indicate that eiders prefer consuming mussels less than 40 mm in length (Larsen & Guillemette, 2000).

Discussion and Conclusions

Comparisons of recruitment and growth on different substrate mesh sizes (50, 80, 150 and 300 mm) and different units (Trawls and Smartfarm units) at Musholm test site showed that initially (September measurements) Smartfarm units (large mesh size) had a slightly greater recruitment of small mussels (spat) than Trawl units with smaller mesh sizes. Results over time, however, indicated that both the average size of mussels and the biomass (weight per unit length of rope) on the nets with smaller mesh sizes (Trawl units) increased at a considerably better rate than the average size of mussels and biomass on the large mesh size on Smartfarm units. In fact, the total biomass of mussels on the Smartfarm units with the largest mesh size (300 mm) remained more or less the same from September to December despite a five-fold increase in average mussel size, indicating a large decrease in the overall abundance (number) of mussels on the Smartfarm units. Comparisons of results between the different smaller mesh sizes on trawl nets indicated that initial biomass was consistently best on the nets with mesh sizes of 80 mm (September and November measurements) in comparison to the trawl nets with mesh sizes of 50 and 150 mm. Estimated production (biomass) of mussels on the different mesh sizes upscaled to gear that represent complete production units showed that between 0.22 – 3.7 tons could be harvested, with the greatest amount of mussels on the trawl units with mesh size of 150 mm. The results from test nets with mesh size 80 mm, does however indicate that the biomass on this net could have been higher, had the test unit not been lost.

There are several factors that have undoubtedly affected the production of mussels on the different units (Trawl net units and Smartfarm units) of this study, and which should be taken into consideration when interpreting the results. First, production of mussels have been attempted at the Musholm test site on Smartfarm units for several years without success. This has been primarily due to predation by Eider ducks. In this study, all the Trawl net units with the smaller mesh sizes were within a fish cage at the test site and probably more protected from Eider duck predation due to the enclosure and the daily disturbance from human activity. In contrast, the Smartfarm unit was placed in open water nearby. Initially, mussel recruitment on the larger mesh size substrate (300 mm) of the Smartfarm units was higher than the trawl units with smaller mesh sizes. However, both a lower number of larger mussels and the poor development biomass on the Smartfarm units over time in comparison to the test units with trawl nets suggests size-selective predation by Eider ducks (ducks choosing the largest mussels first) on the Smartfarm unit. If this is the case, then general comparisons between the development of mussel production on the different mesh sizes of the potentially more protected Trawl net units with the large mesh size of the Smartfarm units is difficult due to the biases created by Eider predation.

Results of the mussel production on different mesh sizes within the fish cage and thus on units with comparable conditions, indicated that the highest initial recruitment and biomass per length of substrate was clearly on the units with a mesh size of 80 mm. This could indicate that nets with 80 mm mesh size could be more optimal for recruitment and initial production, in comparison to nets with mesh sizes of 50 mm and 150 mm. Unfortunately the trawl units with mesh sizes of 80 mm were lost in the final sampling in December, and thus final production measurements from mesh size 80 mm were not available for comparisons.

The total estimated biomass on the different production units upscaled in size to represent full sized production units was only between 0.2 – 3.7 tons. This production can be considered very low in comparison to, for example, Smartfarm units in other areas such as Horsens Fjord, where biomass estimates of up to 20-25 tons of mussels in October/November have been recorded. There is almost no doubt that predation by Eider ducks has probably effected the low production outcomes on all the units and mesh sizes in this study, and in particular on the more exposed Smartfarm units. This knowledge and the length of the study makes it difficult to make definitive conclusions on what net mesh sizes would be best for optimal mussel production.

It is worth noting that the small average size and that there were almost no mussels >10 mm in length on all the test production units in September indicate that the biomass on all these units was primarily represented by mussel recruitment from late summer early Autumn mussel spat. All test production units were put out in the late spring (month of May) and thus recruitment of mussel spat from the often more prominent spring spawning of mussels would be expected on the test units. Because this does not appear to be the case, it can be assumed that there is a potential for a greater overall production of mussel biomass on each production unit if early season mussel recruitment was more successful and under more optimum conditions i.e. with no/less predation by Eider ducks.

Picture 7: Torben Wallach from Musholm holding up a sample of trawl net. The picture is taken in November 2016.

About

Baltic Blue Growth is a three-year project financed by the European Regional Development Fund. The objective of the project is to remove nutrients from the Baltic Sea by farming and harvesting blue mussels. The farmed mussels will be used for the production of mussel meal, to be used in the feed industry. 18 partners from 7 countries are participating, with representatives from regional and national authorities, research institutions and private companies. The project is coordinated by Region Östergötland (Sweden) and has a total budget of 4,7 M€.

Partners

- *Region Östergötland (SE)*
- *County Administrative Board of Kalmar County (SE)*
- *East regional Aquaculture Centre VCO (SE)*
- *Kalmar municipality (SE)*
- *Kurzeme Planning Region (LV)*
- *Latvian Institute of Aquatic Ecology (LV)*
- *Maritime Institute in Gdańsk (PL)*
- *Ministry of Energy, Agriculture, Environment and Rural Areas (DE)*
- *Municipality of Borgholm (DK)*
- *SUBMARINER Network for Blue Growth EEIG (DE)*
- *Swedish University of Agricultural Sciences (SE)*
- *County Administrative Board of Östergötland (SE)*
- *University of Tartu Tartu (EE)*
- *Coastal Research and Management (DE)*
- *Orbicon Ltd. (DK)*
- *Musholm Inc (DK)*
- *Coastal Union Germany EUCC (DE)*
- *RISE Research Institues of Sweden (SE)*