

Student projects at the Kristineberg center 2020



Our study organisms — Pacific oysters (*Magallana gigas*), European oyster (*Ostrea edulis*) and blue mussel (*Mutilus edulis*)

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Aquaculture projects run by IVL

- 1. Culture of Pacific oysters and evaluation of submerged culture systems – can new species and new production techniques contribute to the diversification and expansion of the Swedish mariculture sector?**

This project is funded by the EMFF. In this project we will test and evaluate culture methods that can allow cultivation of the Pacific oysters in Swedish waters and facilitate expansion of the existing bivalve culture industry. More specifically we will: 1) Develop a model for evaluation of maturation of cultured Pacific oysters in relation to temperature, and test different techniques to prevent reproduction of the cultivated oysters, 2) Evaluate the biological culture potential of native bivalves (blue mussels and flat oysters) in submerged culture systems, and determine whether the technology can contribute to reduced fouling on the cultured organisms and equipment, and 3) create a knowledge platform regarding different types of submerged culture systems and highlight appropriate model systems based on Swedish conditions. The proposed student projects related to this project are:

- 1a) Effects of temperature on reproductive success of Pacific oysters**
- 1b) Effects of salinity on reproductive success of Pacific oysters**

Since 2006, the non-native Pacific oyster has established large populations along the Swedish west coast. Although the species is now a permanent part of the Swedish marine fauna, government authorities have a responsibility to control activities that may enhance dispersal of non-native species in Swedish waters, and as a consequence, are reluctant to allow culture due to the possibility of cultured oysters contributing to the expansion of wild populations through incidental spatfall. Moreover, import of sterile triploid oyster spat is not allowed due to the risk of transmission of pathogens and parasites to native species as neither *Martelia*, nor *Bonamia*, exist in the country. Thus, development of protocols that will enable culture of the species without associated reproduction is crucial for obtaining culture permissions of Pacific oysters in Sweden.

A first step towards meeting government requirements is to control the reproductive cycle of the farmed Pacific oysters. To date, the most frequently used method for predicting maturation is Mann's constant which describes gamete maturation in relation to number of days and temperature (degree-days) required for spawning. We have evaluated this model in field conditions and adjusted it to the prevailing conditions at the Swedish west coast. The next step, and the focus of this specific study, is to prevent spawning of the cultured oysters. Different modes of relaying (transferring) the oysters to environments sustaining survival and growth, but not reproduction, can be used to hinder gonadal development and subsequent spawning. This can be done for example by lowering the oysters to greater depths with lower temperatures, or movement of the oysters to low salinity areas.

For this reason, two different sub-projects are offered in this study. To evaluate the possibility to control maturation and spawning using temperature manipulation (relaying in deeper waters), oysters will be transferred to different depths for varying periods of time according to a pre-determined protocol. Treatments to be evaluated will be selected based on simulated scenarios using previously collected temperature data from various depths. Maturation will be monitored at regular intervals using histology and subsequent sample analysis. Oysters maintained in surface water will serve as a control treatment.

To evaluate the possibility to control maturation and spawning using salinity manipulation (culture in low salinity areas), oysters will be kept in flow through, land based, tanks in which salinity can be controlled. Three different salinities (approximately 10, 20 and 28 ppt, corresponding to salinities observed at the southern part of the Swedish west coast, Gothenburg area and Northern west coast) will be used, and maturation will be monitored regularly throughout the reproductive season.

Both projects will run from April to September 2020, but the exact times for student involvement can be discussed. The temperature study will be performed at the Kristineberg center (located approximately 80 km north of Gothenburg) where a suspended culture system is available adjacent to the research station. The salinity study will be performed at the Tjärnö research station (located approximately 160 km north of Gothenburg).

1c) Production potential and food availability of Pacific oysters, flat oysters and/or blue mussels in deep water culture

The Swedish aquaculture industry faces a range of challenges. The main challenge is related to the social licence of suspended aquaculture systems, that are often perceived as "visual pollution" by tourists and residents at the Swedish west coast. Submerged culture systems

constitute a solution to these problems. The benefits of the systems are many, including being visually unobtrusive, thus avoiding conflicts with inshore land owners and boat traffic, being less exposed to fouling, thereby increasing product value and decreasing costs for cleaning and processing and increasing shellfish quality by reducing reproduction in the lower temperatures available in deeper water. Such technology therefore offer great promise to alleviate many potential conflicts in the Swedish maritime arena, where competing nearshore uses have typically led to tight regulatory constraints (and in some cases prohibitions) against surface based aquaculture activities, and may have several additional beneficial effects on production.

Although submerged culture systems are used worldwide for bivalve culture, information on bivalve performance in the systems are scarce and mainly available as “industry know-how”, posing constraints on the transfer of the method to new regions. Moreover, as production success of bivalves in submerged systems vary between areas and with environmental conditions, and as the reported species specific optimal depth for submerged culture presents contradictory results, evaluation of local growth performance of target species using submerged culture is a prerequisite before commercialization.

The objective of this study is therefore to evaluate growth, survival and product quality of bivalves cultured at different depths. Presently we have initiated the experiment using oyster spat (both flat oysters and Pacific oysters) collected on sea based collectors during summer 2018. The spat was maintained in surface conditions until April 2019, and was thereafter relayed at different depths (surface, 7, 15 and 25 m) to monitor growth and survival until market size. The oysters are expected to reach market size summer 2020, at which point differences in condition and product quality will be evaluated. Growth trials using blue mussels will be initiated summer 2020. Food availability (POM and Chl a) as well as temperature and salinity are monitored on regular intervals. This monitoring could be extended to a student project relating to food intake of bivalves at different depths. The study will be performed at the Kristineberg center (located approximately 80 km north of Gothenburg) where a suspended culture system is available adjacent to the research station. Student projects of different length can be accommodated within the project and the studies can be performed using Pacific oysters, flat oysters and/or blue mussels.

2. AquaVitae

AquaVitae is a H2020 project with the aim to increase aquaculture production in and around the Atlantic Ocean by developing new species, processes and products. The focus of the project is on low trophic species (e.g. algae, echinoderms, shellfish), contributing to the circular economy and the Belém Statement. AquaVitae will offer new opportunities to enhance the environmental, societal and economical wealth of aquacultures communities. The project will implement 11 case studies (CS) across the Atlantic basin (Europe, Africa, South America) taking into account several cross-cutting issues: biosensors, Internet of Things, market potential, sustainability, business and socio-economic analysis, policy framework and training. The target organisms of CS8 and 9 are oysters and mussels, respectively.

The ambitions of CS8 are to 1) increase availability of spat of native and underutilised oyster species in Brazil and Scandinavia by developing and optimizing protocols for hatchery and sea based production of oyster spat and 2) improve economic sustainability of oyster culture in these regions by enhancing and optimizing existing grow-out protocols and techniques for both native and non-native oyster species to local conditions. This will be done through the following tasks:

- 1) Improve availability of underutilized oyster species spat through:
 - a) tech-transfer and optimization of hatchery production of native oysters and techniques for local production of tetraploid and triploid selectively breed Pacific oysters in areas where oysters are an underutilized resource.
 - b) evaluation of alternative techniques and development of new protocols for collection of wild settled oyster spat targeting native oyster species in Scandinavia and Brazil.
 - c) supplying data for cost-benefit analysis of hatchery production of oyster spat and collection of wild spat to identify the most economically valid technique in regions with emerging oyster production.
- 2) Enhance production and consumption of underutilized oyster species by:
 - a) developing new, and adjusting existing, culture techniques to native oyster species and local culture conditions.
 - b) testing and implementing methods for improving product quality through management of fouling epibiont species such as barnacles (*Balanus* sp.) and calcifying worms (*Pomatoceros triqueter*).
 - c) supplying data for cost-benefit analysis of improved anti-fouling treatments.
 - d) supplying data for analysis of consumer acceptance and market potential of new oyster species and products.

CS9 will result in increased production of blue mussels. Specific tasks will include:

- 1) Utilisation of new production areas offshore based on known offshore technologies adapted to local conditions
- 2) Development of seeding and stocking methods to ensure stable and cost-effective supply of recruitments of blue mussel larvae/spat for offshore production
- 3) Developing methods to use the main by-product of blue mussel culture, namely the CaCO_3 in shells, in applications that contribute to the long-term storage of this product to valorise the potential of mussel shells as an anthropogenic carbon sink (zero waste).

The proposed student projects related to this project are:

2a) Pond based production of flat oysters and blue mussels

A protocol for pond production of native oyster seed (*Ostrea edulis*) has been developed based on review of previous projects and literature and collation of industry know-how. The protocol was tested and evaluated by research and industry partners in Ireland during summer 2019, and will be refined during winter 2019. The proposed student project aims to implement and evaluate the developed protocol either in a sea-based pilot scale system, in a small scale land based system or potentially in both. The work will be performed in collaboration with local industry partners and will include monitoring of water quality parameters and recruitment success as described in the developed protocol. Moreover, for oysters, low tech solutions for nursery systems will be developed and evaluated using the produced spat.

The land based study will be performed at the Kristineberg center (located approximately 80 km north of Gothenburg). The sea-based study will be performed at Stigfjorden where the industry

partners are located. A drivers license is required for participation in the sea based study but not in the land based study. The exact times for student involvement can be discussed.

2b) Optimizing sea based spat collection of flat oysters – the importance of substrate and depth

The production of native oysters in Sweden is based on sea-based spat collection, but since the establishment of the Pacific oyster, a mixture of oyster spat is obtained on the collectors. The spat must then be separated by species, which is difficult, labor demanding and costly due to the small size and similarity of the spat. Hence, current production of native oysters is limited. One of the most important challenges to increase oyster culture in Sweden is thus to secure a supply of native oyster spat. In this project, different types of sea based seed collectors will be evaluated to enhance capture of native oyster spat instead of spat of Pacific oysters. The collector types will also be deployed at different depths to evaluate settlement success of the different species at various depth.

The study will be initiated in June 2020 and collectors will be deployed in July during the major settlement period. The project will be executed in collaboration with several industry partners. Harvest of collectors and spat identification will be performed in October/November to allow the spat to reach a size large enough for species identification. We are currently developing a deep-learning algorithm using machine learning for spat identification, and depending on the success of that project, the algorithm may be used to identify spat by species.

2c) Developing protocols for efficient treatment of tube worm fouling on blue mussels

Biofouling can have significant economic impacts on aquaculture operations, including increased processing and production costs. Biofouling can consist of many different types of organisms, some more problematic than others (e.g. tubeworms forming calcareous shells are more problematic than mussel spat that are more easily removed from shells and cages). The timing of settlement of biofouling organisms can vary during the season and with environmental conditions making it difficult to predict. The main method for handling biofouling used today is to clean the cages and equipment regularly, which is both time and labor intensive. Soft bodied fouling organisms such as seaweeds and tunicates can be treated using fresh water baths or desiccation. These techniques are, however, not efficient against organisms with calcareous shells. An alternative technique to handle such organisms is heat treatment.

In this project, heat treatment as a means to reduce fouling of calcareous organisms on mussels and oysters will be evaluated using lab trials. A range of different temperatures and exposure times will be tested to determine the most efficient method in terms of fouling management and mussel/oyster survival. The most promising treatments will then be evaluated in field conditions at industry scale.

The lab study will be performed at the Kristineberg center (located approximately 80 km north of Gothenburg). The sea-based study will be performed at Stigfjorden where the industry partners are located. A drivers license is required for participation in the sea based study but not in the land based study. The exact times for student involvement can be discussed.

2d) Evaluation of different culture systems for production of flat oysters in Sweden

Presently, the aquaculture industry in Sweden is, with one exception, using suspended longline systems for mussel and oyster production. Oysters can, however, be produced using alternative systems of which many are submerged, hence reducing the visual impact of oyster farming. The performance of such systems are yet to be evaluated in Sweden. The objective of this study is therefore to evaluate growth, survival and product quality of oysters cultured in different types of systems (surface based and bottom based systems). Production in suspended systems will be used as a control. The evaluation of alternative grow-out systems will be based on existing systems used in other regions around the Atlantic with similar climatic conditions (e.g. Maine, US). Knowledge of system alternatives and of pros and cons with each system will be provided by US partners and from experiences of the IVL staff. New systems will also be developed and evaluated. The study will be performed in collaboration with several industry partners. A driver license is therefore required. The exact times for student involvement can be discussed.

3. Knowledge base for unified management of OSPAR-listed bivalve beds (“The bivalve project”). Collaborative project between IVL and UiA (Norway)

Over the past years, an increasing number of reports about declining blue mussel (*Mytilus edulis*) and oyster (*Ostrea edulis*) beds have been received by Swedish researchers and by the Swedish agency for marine and water management. In accordance, populations of blue mussels and oysters are known to be declining in many parts of Europe. However, as there is no monitoring of these species in Sweden, and as the knowledge of past and present distribution is fragmented, the validity of these observations is hard to confirm. Moreover, little is known about the pressures affecting the bivalve beds in Sweden. In contrast to many parts of Europe, exploitation of wild bivalve beds, especially blue mussel beds, is very low in Sweden, and pathogens affecting bivalves in Europe are less frequent or absent. The effects of other factors may thus be more pronounced on bivalves in Sweden compared to in Europe, e.g. interactions with the Pacific oyster (*Magallana/Crassostrea gigas*). There is also a lack of knowledge relevant for formation of informed management strategies related to native bivalves, such as genetic structures and dispersal patterns in the Swedish archipelago, which offers a multitude of islands and fragmented habitats.

In this project we will address these challenges by 1) quantifying population development of both blue mussels and native oysters, 2) reviewing current knowledge of relevant pressures that may affect population development negatively, 3) producing knowledge related to population genetics and larval dispersal, and 4) evaluating different methods to favor development of native bivalve populations. In these sub-tasks, a range of projects of varying scope can be offered. Methods include field surveys, controlled field experiments, lab experiments and modelling approaches.

Possible topics (non-exhaustive list)

- 3.1 Population control and management of Pacific oysters through commercial activities such as harvest of wild populations and population modeling
 - 3.2 Efficiency of efforts to remove Pacific oysters from popular beaches
 - 3.3 Effects of Pacific oysters on population development, demographics and condition of native bivalve populations
 - 3.4 Restoration trials to enhance native bivalve populations
 - 3.5 Literature studies to determine the baselines for determining conservation status and future management actions to protect native blue mussels and European oysters
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Med vänlig hälsning,

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