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Blue Oceans with Blue Mussels

Management and planning of mussel farming in coastal ecosystems

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Abstract

Eutrophication is one of the largest and most serious global threats to the marine environment. The effect of eutrophication has become increasingly clear during recent time, and major economic and political efforts are being made to tackle its causes and consequences in Sweden and its surrounding seas. Mainly, it is the dramatic increase in the supply of nitrogen and phosphorus that has several undesirable effects on marine ecosystems. More and more emphasis is placed on how to utilize the natural processes in restoration measures of eutrophic coastal areas. One such proposition is to use mussel-farms with substantial capacity for filter-feeding to "clean" coastal waters by assimilation of particulate material and removal of potentially large amounts of nutrients from coastal areas at harvest.

In this thesis, several aspects of mussel farming have been studied in a series of experiments as a step in the process to develop and evaluate the concept of mussel farming as restoration measurement in eutrophic coastal areas. The experiments were designed and attempts made to evaluate three major issues 1) effects of mussel farming on water quality, 2) spatial patterns of growth and 3) mitigation of negative effects in sediments beneath mussel farms. The first issue was attempted to evaluate using a before-after control-impact design with two mussel farms and two reference locations. Transplanted mussels were used to investigate spatial and temporal variability and thus the predictability of mussel growth. Predictive models were then developed and evaluated with the best model implemented into GIS, producing a map of predicted growth. In a series of field and laboratory experiments the survival and growth of a bioturbating polychaete on mussel faeces and the impacts on nutrient and oxygen fluxes across sediment-water interface of its activities were evaluated.

Due to loss of mussels, presumably because of predation, the planned evaluation of local effects of mussel farming and its potential as a mitigation tool was not possible. This shows that the use of mussel farming in mitigation efforts is quite unpredictable and development of techniques used are needed. However, the extensive data collected can be used to evaluate spatial and temporal variability of the sampled parameters and provide important information for future attempts to evaluate effects of action programs. The studies show that growth is highly variable both between sites and times, both between and within years. Despite the variability there is some predictability in terms of growth in soft tissue, while for growth in shell length it is more difficult. Prediction of growth indicates that about 15 % of the investigated area belongs to the highest growth class. The highest growth rates were generally observed in the innermost areas, in fjords and other protected areas. These are also the areas that are in most need of restoration activities. This fact, from the perspective of utilizing mussel farming in mitigation efforts, is positive. The studies also point on the importance of understanding the complex systems in coastal areas. One environmental variable does not always influence the growth in the same manner. The influence may vary between both levels of growth and levels of the variable itself but also depends on other environmental factors within the system. Further improvement of growth prediction requires refinements of predictors with regard to both the nature and quality. As perhaps the greatest negative impact of mussel farming, it is important to minimize the effect of biodeposition on the sediment. The results indicate that the use of natural processes such as bioturbation may be a possibility. The polychaete *Hediste diversicolor* showed improved growth while a positive effect on the decomposition of organic matter was obtained with an improved sediment environment as a result. The effect was mainly indirect presumably through increased microbial activity due to the mechanical impact on the sediment by the polychaetes.

In summary, this thesis provides important insights into several aspects of the potential and sustainability of mussel farming as a mitigation tool and the results provide a base for scientifically based planning of aquaculture. Under the right conditions, mussel farming has the potential to be a useful and sustainable mitigation method but due to the complexity of the system it can be quite unpredictable and further studies are needed. The use of bioturbation by polychaetes, and possibly other organisms, has the potential to mitigate sediments negatively impacted by mussel farms and thus has the potential to be an important component in future mitigation measure using mussel farming. However, technical developments are needed before the approach can be used in practice.

Key words: Coastal management, *Mytilus edulis*, Modelling, Growth, Predict, Eutrophication, Mitigation, Nutrient fluxes, Biogeochemistry, Aquaculture, Bioturbation