COASTAL & MARINE

Aquaculture in the Baltic Sea Region

EUC Coastal & Marine

EUCC-D

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Editorial

Dear reader,

The future development of fisheries and the fishing sector is unthinkable without aquaculture. There are three essential reasons for this: the overfishing of the seas, the pollution of the environment through transport from overseas as well as the aspect of freshness, and the quality and regionality of the products.

Next to aquaculture's role as an economic element, aquaculture research also plays a prominent role in Mecklenburg-Western Pomerania. Leading on this topic is the State Research Institute for Agriculture and Fisheries. Under the European Fisheries Fund EFF 2007-2013, diverse research projects are carried out. These include, among others, projects on the following species: eel, Baltic sturgeon, pike-perch, and crayfish. The Fisheries Institute in Rostock at the State Research Institute for Agriculture and Fisheries developed a method for commercially raising pike-perch at the in 2011 constructed pilot plant "Hohen Wangelin." This method is particularly suited for basin plants in which the breeding occurs under controlled conditions. The water will be continually reused, being mechanically and biologically cleaned in between. In this manner, water can be saved and the fish can grow over the entire year. A further advantage of aquaculture over wild catches is the guaranteed sustainable and traceable form of the production and a consistently high quality product.

It is vital that the development of aquaculture for more fish species will be driven forward. It is our goal to build and develop a competitive, animal and environmentally friendly aquaculture in Mecklenburg-Western Pomerania.

Dr. Till Backhaus
Minister for Agriculture, Environment and Consumer Protection, Mecklenburg-Western Pomerania, Germany

Translated by Christopher Pavia

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Content

Colophon

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Whitefish in a recirculation system in Russia, © Silke Krüger

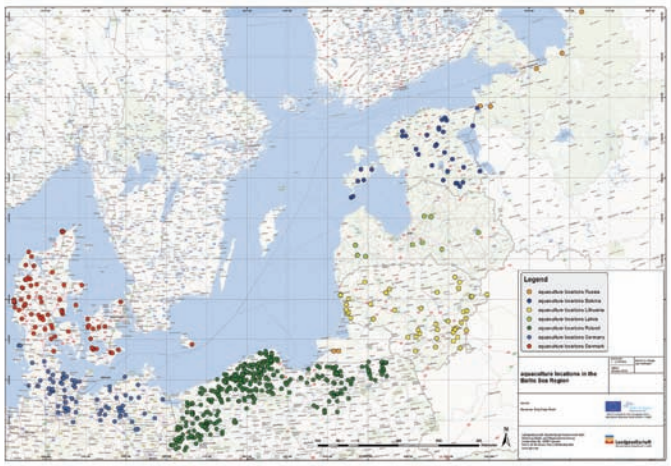
Introduction to the AQUAFIMA project

The aim of AQUAFIMA (Integrating Aquaculture and Fisheries Management towards a sustainable regional development in the Baltic Sea Region) is to determine the state of the art in stocking, restocking, and stock enhancement, for instance by the release of reared fish into the marine environment, in the Baltic Sea Region (BSR) and to assess in which areas, with which species, and under which conditions such measures can be feasible, profitable, and advisable. The focus is on small-scale and recreational fisheries and species of regional importance. The project concentrates on four stocked fish species – salmon, sea trout, sturgeon, and whitefish. However, elements such as economic potential, regional development, qualification, and education apply to the entire aquaculture sector.

Aquaculture is the controlled breeding of water living organisms including fish, crustaceans, molluscs, and aquatic plants. The aquaculture sector in the BSR is committed to applying the highest standards for the environment, nature, climate, and animal welfare, but is stagnating or even decreasing over the last 20 - 30 years. Today fish from aquaculture contributes nearly the half of the world´s human fish consumption and it is expected that it will be 65 % by 2030.

The AQUAFIMA project is analysing the prospects for an increased integration of stocking and restocking into regional fisheries management in the BSR under the reformed Common Fisheries Policy. The partners are providing an overview of aquaculture technologies and stocking strategies which are currently in use in their countries. The project is analysing the technical and economic feasibility of stocking measures for different species and regions, thus determining viable paths of action for regional actors and making concrete proposals for the future development of restocking activities in the BSR.

The role of aquaculture in regional development is being analysed in terms of planning needs, supply chains, employment potential, and the promotion of regional fish products, as well as fishery-related tourism. An exhibition was developed to inform consumers about the importance of aquaculture, with a special focus on regional aquaculture production, fish as a healthy food, and certification and labels for aquaculture products. The exhibition was presented at different events in Germany and Lithuania and welcomed about 26,500 visitors.



Aquaculture locations in the Baltic Sea Region, © Silke Krüger

The results of the named development activities will be incorporated into higher education programs with a particular focus on international exchange in order to foster the development of professional training opportunities for aquaculture.

Until now marine aquaculture in the BSR exists only at a very low level, due to the administrative burden, time-consuming licensing systems, strict environmental protection regulations, an overall lack of sites with suitable hydrological conditions and low salinity. The development of marine aquaculture in the Baltic Sea Region needs the coordinated action of all relevant authorities and stakeholders.

Silke Krüger
Landgesellschaft Mecklenburg-Vorpommern
Germany

Exhibition "Regional fish by aquaculture" © Silke Krüger

Fish stocking and restocking activities in the Baltic Sea Region

Fish stocking is a practice commonly used to mitigate the loss of commercial stocks, to enhance recreational or commercial catches and to restore or create new fisheries. In natural habitats fish stocking is generally carried out in response to the degradation of wild fish populations, which is a result of habitat change or stock overexploitation. Fish stocking is practised in many countries around the Baltic Sea. Data about stocking measures were collected within AQUAFIMA:

Denmark has no current or planned restocking activities. However, as recently as 2010, the most released fish species was turbot (*Scophthalmus maximus*). Denmark is now focusing on integrated multi-trophic aquaculture (IMTA) facilities in coastal areas of the Baltic Sea.

Germany releases sea trout (*Salmo trutta*) in areas with rivers that flow into the Baltic Sea, Baltic whitefish (*Coregonus maraena*) in inner-coastal waters and Baltic sturgeon (*Acipenser oxyrinchus*) in rivers and lagoons. These measures are taken to support both small-scale and recreational fisheries and to re-establish sturgeon as part of the native Baltic Sea fish community.

In **Poland** stocking and restocking issues are regulated by the stocking commission of the Ministry of Agriculture and Rural Development. The fish species mainly released comprise salmon (*Salmo salar*), sea trout, Baltic whitefish, Baltic sturgeon and eel (*Anguilla anguilla*).

In **Lithuania** the stocking measures in inland and coastal waters are regulated by the national fishing law. The species most stocked include perch (*Perca fluviatilis*), Crucian carp (*Carassius carassius*), carp (*Cyprinus carpio*), freshwater bream (*Abramis brama*), roach (*Rutilus rutilus*), pike (*Esox lucius*), tench (*Tinca tinca*), vendace (*Coregonus albula*), pike-perch (*Sander lucioperca*) and smelt (*Osmerus eperlanus*).

Latvia releases Baltic whitefish, salmon, sea trout, burbot (*Lota lota*), pike-perch and brown trout (*Salmo trutta f. fario*) in the Daugava river basin, which is connected to the Baltic Sea. The Institute of Food Safety, Animal Health and Environment is responsible for the implementation of the national fish resources restocking programme. The programme was established to ensure the release of fish fry in order to compensate for the damage to fish resources caused by hydropower stations. It was also started to restore the fish stocks in public water bodies that were damaged or lost due to different human activities.

Estonia's most-stocked species are salmon, sea trout, brown trout, Baltic whitefish, pike, eel, pike-perch, tench and carp. In 2002, a state programme for restocking activities was introduced by the Ministry of Environment. The activities recommended focusing on the conservation of rare and endangered species rather than the enhancement of commercially exploited fish stocks, except for eel.

The **Russian Federation** in the BSR releases salmon, sea trout, Baltic whitefish, and lamprey (*Lampetra fluviatilis*) in the Saint Petersburg region, and Baltic whitefish in the Kaliningrad region. The artificial reproduction of aquatic resources in Russia is determined by the federal law "On fisheries and protection of water-bioresources". Reproduction is carried out with the aim to increase the number of commercial fish species and to preserve biological diversity.

In **Finland** the most important species for restocking are salmon, sea trout, Baltic whitefish and vendace. The Finnish state produces and stocks fish to maintain the genetic diversity of several threatened fish stocks and species in their natural habitats (mainly salmonids) and to maintain coastal salmon fisheries in the Gulf of Finland and in the Bothnian Sea by stocking salmon smolts ("sea-ranching") in these areas that have totally lost their indigenous salmon stocks.

Fish hatchery, © Franziska Göttsche

The success of any concept for a stocking-based fisheries management can only be realised when intelligent strategies for the release of cultured juveniles are developed. Studies with the following objectives are required:

- Investigations on the habitat structure and habitat requirements of juvenile fish,
- Model studies (in experimental units and in-situ) on aspects of habitat restoration and on the effectiveness of stocking with released juvenile fishes,
- Release strategies ("time-size release window") and
- Monitoring and assessment of release programmes.

A stocking-based fisheries management should focus on the support of natural stocks through release measures. This requires a good management of breeding stocks in order to ensure genetic equivalence between wild and cultured stocks. The primary goal is to maintain the genetic variability and prevent inbreeding which could trigger a population collapse.
Besides considering the technical and biological research aspects, there is a need to describe the socio-economic benefits of such release measures. Moreover, aspects of the economics of the proposed research projects will have to be included as well. It is indispensable to demonstrate the added value of projects that can be attained in this focal area. This added value relates to both the boosted attractiveness for tourism (e.g. recreational fishery) and the increased availability of aquatic products on local markets and across country borders.

Taking into account the framework provided by the EU under the reformed Common Fisheries Policy, European Maritime and Fisheries Fund, and the Blue Growth Strategy, the AQUAFIMA partners have worked out concrete proposals for restocking activities in the Baltic Sea Region. Based on AQUAFIMA's analysis of current fisheries and aquaculture management, available aquaculture technologies, and the preferences of the Member States, we argue that such restocking activities should focus on regionally important fish species such as sea trout, Baltic whitefish, salmon, and Baltic sturgeon.
Stocking of Baltic whitefish would enhance commercial catches, stocking of sea trout would benefit the recreational activity of rod and trolling anglers, but also enhance the catch by commercial fishermen, and stocking of Baltic sturgeon would reintroduce an extinct species to its former range.

Norbert Schulz
Association Fish and Environment Mecklenburg-Western Pomerania e.V.
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Young sea trout in an aquaculture facility in Rutki, Poland © Franziska Stoll

Cod, © Thomas Bjørkan

Producing marine juveniles for aquaculture with special focus on cod

The tradition of fisheries in Norway led to experiments with hatching cod eggs and startfeeding larvae to enhance the wild stocks a century ago. Since cod spawn easily in captivity, scientists at the Institute of Marine Research in Bergen (IMR) started trials on startfeeding cod larvae for aquaculture in the 1980s. These experiments raised the commercial interest for cod and a number of other marine juveniles like halibut, turbot, wolffish, and hake. More recently, the production of cleanerfish for the salmon industry like wrasse and lumpfish has expanded.

Domestication of wild marine fish requires knowledge of diet, feeding habits, and light conditions. Whether wild broodstock will spawn in captivity and how easily they will do so is the first challenge in the process of obtaining eggs. In contrast to cod, turbot and halibut have to be stripped of eggs and sperm and then fertilised artificially. Like many marine species, cod is a multiple spawner and spawns every three days for a period of two months. The eggs are collected and transferred to incubators (< 7ºC) where they hatch after 12 to 14 days. At the time of hatching the embryonic development is still incomplete. Larvae are dependent on the yolk sac until the gut and the mouth become fully functional about 1 to 3 days after hatching.

The type of live feed used for the first feeding depends on the mouth size as well as nutritional requirements of the larvae. Live feeds like algae, rotifers, and Artemia are used for startfeeding of most marine larvae. Rotifers are small in size and in most cases easy prey for the larvae to catch. To ensure good survival and growth of the fish, the rotifers need to be available in high densities, and are thus usually added in batches two or three times a day. Different species of algae are used in the tanks to create green water, giving the larvae conditions similar to the sea. Artemia is used in later stages when the larvae require bigger prey, and for large juveniles like halibut.

Live feeds are expensive and labor-intensive to produce, but can be replaced by formulated diets after the initial period to reduce production costs and to ensure the production of high quality juveniles. Several feed companies are producing special feed for early weaning with special nutritional and technical qualities.

As soon as the larvae are able to eat formulated feed, the weaning process starts. When the larvae are weaned to formulated feed, it is essential to start the grading process. If the size variation of fish in the tank is too big, there will be competition for food, which can cause poor growth and high mortalities. Another problem may be cannibalism, which is the natural way to ensure the survival of the strongest individuals in a population.

The next stage of the production includes transferring the fish either to a separate nursery for further growth, or to on-growing facilities by car or boat. There is often a benefit to keep the fry in tanks on land for a few months to allow for good growth under controlled conditions. Small fish have a high growth potential and if this is utilised, the total growing time can be reduced.

Modern large scale hatcheries produce between 5 and 25 million juveniles (2 to 3 grams per fish) annually. To use these facilities effectively, it is necessary to have continuous production and to deliver high quality juveniles at all times.

Grethe Adoff
Norwegian Seafood Centre
Norway

Net cages in Norway, © Thomas Bjørkan

Fish catch, © Eurofish

Fish farming in Estonia – a possible future development towards value-added products for the domestic market

Estonia has a fish farming sector producing small volumes of several different species. Trout dominates, accounting for up to 80 % of production, followed by carp, eel and crayfish. A major issue facing the Estonian aquaculture sector is how products from freshwater aquaculture will be able to compete with marine farmed fish. Over the last decade in Estonia, like elsewhere in the Baltic Sea Region, marine farmed fish has been seizing market share from freshwater aquaculture. Other challenges that freshwater farming faces is the need to deliver large volumes, consistent quality, and offer competitive prices.

In Estonia the sector is fragmented in terms of size, species, and technical systems used for production. The size of the market for aquaculture products has been calculated at 4,000 to 5,000 t. Trout farmers are going to have to utilise at least 80 % of the capacity that they have invested in, but success will also depend on what products importers are placing on the market. Norwegian salmon is a significant threat, Russia is now also investing heavily in aquaculture capacity, and will be looking at neighbouring markets when that capacity goes on-stream.

A future scenario for development can be to focus on the Estonian domestic market and build up a leading position there by concentrating on more value-added fresh products and not trying to compete with traditionally imported products. At the same time, the sector would look for opportunities to develop and export niche products.

The Estonian aquaculture Producer Organisation (PO) can play a leading role in this development. The PO, which represents about 50 % of the trout farmers, has recently started building its own processing facilities. Those farmers who produce up to 200 t a year will sell their fish to the PO for processing. This way the PO will be able to combine the farmers' output to supply the volumes and uniform quality that is desired by the retail chains in a way that the small fish farmers cannot. This will also give the PO greater bargaining power when negotiating with buyers.

The Estonian strategic aquaculture plan for 2014 through 2020 was developed by the Institute of Future Studies, an independent institute under Tallinn University in cooperation with the Estonian University of Life Sciences. Since the start of 2013 a series of workshops have been held with stakeholders including representatives from the aquaculture sector, from the Ministries of Agriculture and Environment, from financial institutions, and from universities. The workshops have focused on analysing the sector, identifying the options available, outlining a vision, and discussing the strategic direction that can achieve that vision. According to Jüri Sakkeus from the Institute of Future Studies, the process has created an understanding among the participants of the individual perspectives of each stakeholder, which provides a good foundation for a strategy that can be supported by all, which is crucial for its successful implementation.

Marco Frederiksen
Eurofish
Denmark

Island of Saaremaa, Estonia , © Katrin Kaldre

Chelon labrosus in a cultivation project, © EMB

Laminaria saccharina in an IMTA in Kiel Bay, © Yvonne Rößner

Perspectives to bolster European marine aquaculture

Aquaculture is often cited as „the fastest growing sector within food industries", but according to European aquaculture figures provided by the European Commission, Europe seems to be cut off from this development, with a stagnant production since 2000. On the other hand, the EU is one of the main seafood markets in the world, EU waters have the capacity for larger aquaculture production and EU aquaculture is renowned for high quality, sustainability, environmental awareness and consumer protection standards.

Aquaculture requires accessible sites with good water quality. The coastal zone in Europe is extensively used and aquaculture requirements collide with tourism, transportation, and environmental protection claims. Numerous public offices, such as environmental, food security, and waterways authorities, and pieces of legislation at the EU, national, and regional levels add administrative obstacles for farmers.

Environmental sustainability can overcome the standstill

Europeans are very aware of environmental topics, and environmental concern about aquaculture is relevant to election behavior and thus to political decisions. A truly sustainable aquaculture will transport a positive political message. Crucial for sustainable aquaculture are the reduction of nutrient emissions and the replacement of wild fish as source for aquaculture feed. In eutrophied coastal areas extractive (or "non fed") aquaculture such as mollusc or algae cultures could achieve both these objectives.

Integrated MultiTrophic Aquaculture (IMTA) strives at zero-emission of nutrients by combining fed (= fish) and non-fed (= seaweed, molluscs) species in balanced proportions. This design is realised in some pilot systems. In future, even more species can be integrated, such as invertebrates and microalgae production systems. However, for a closed nutrient budget the production of non-fed species has to be considerably higher than that of fish, resulting in a marketing imbalance.

An IMTA can thus minimise nutrient emissions. In order to improve the feed problems fish need to be fed by alternatives to conventional pellets.

Farmed marine fish in the EU are predators which require high quality feed and add to the global aquaculture consumption of fish meal and fish oil from wild fish stocks. The potential of non-carnivorous fish, as for example the thicklip grey mullet, has yet to be explored.

The past years have shown impressive progress in replacing fish meal and fish oil in aquaculture feed by vegetable sources, but several marine fatty acids remain indispensable. A study by Coastal Research & Management (CRM) and Kiel University has shown that mussel meal can replace fish meal completely, showing identical food uptake and growth rates in young turbots.

The silver bullet will be a polyintegration of IMTA approaches, many species, and new feeding strategies. Aside from improvements in the sustainability of aquaculture operations, a positive image must be created. Emphasising the advantages of sustainable mariculture for employment, food security, and environmental stability, it can even turn into a tourist attraction. A regional marketing concept will show that high quality and sustainably produced food will yield appropriate prices.

Peter Krost
Coastal Research & Management
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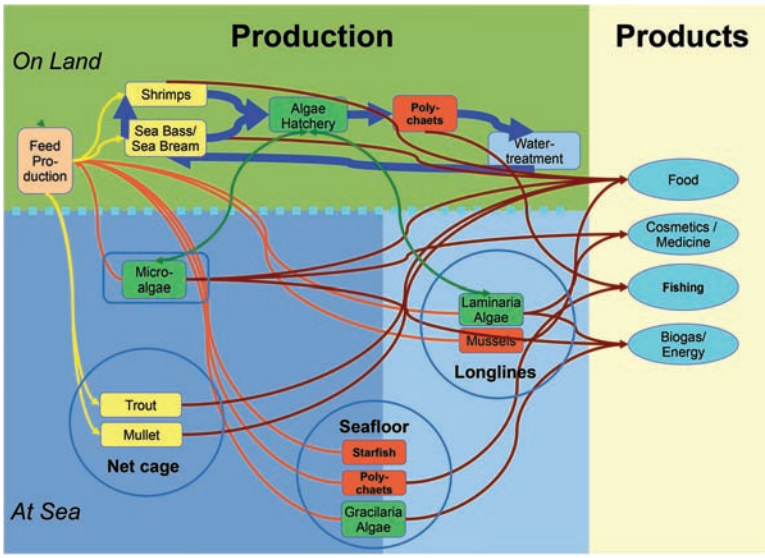

A truly "multitrophic" aquaculture. Fish feed are based upon local marine primary producers. Warm water species cultivation uses process heat from local industries, © Peter Krost

*Blue mussels (*Mytilus edulis*), © Peter Leopold*

Fish feed alternatives in aquaculture

Until today in most aquaculture facilities fish feed is based on fish meal and fish oil. This is because the consistence of the basic nutrients in these foods (proteins and amino acids, as well as fats and their fatty acids), correspond with the composition of these substances in many aquatic organisms. This makes the food easy to efficiently digest. Secondly, the costs of fish meal and fish oil were relatively low over a long time period. However, both ingredients are generally products of conventional fisheries, and their price is rising steadily. Currently, up to four kg of feeding fish are needed to produce one kg of farmed fish, e.g. for salmonids. Given its unsustainable nature, fish meal use should be reduced to a minimum. A few less demanding omnivorous freshwater fish species such as carp and catfish have already been successfully and efficiently bred using purely vegetable-based feeds. However, when explicitly carnivorous fish species such as trout or salmon are fed with vegetable feeds, these must be supplemented to enrich or unlock contained nutrients, and to enhance digestibility and efficiency, which raises the cost significantly. Therefore, the search for alternative and ecologically sustainable protein sources for animal feed production continues. Currently, insects and worms are moving into focus. These organisms can often be bred easily, and their biochemical compositions are quite similar to the natural prey organisms of many fish.

Studies on sustainable aquaculture are realized in the project Baltic IMTA at the University of Rostock in cooperation with the State Research Institute for Agriculture and Fisheries - Mecklenburg-Western Pomerania . The project is funded by the European Fisheries Fund (EFF). A rainbow trout net cage near Nienhagen, Mecklenburg-Western Pomerania, will be surrounded by mussel collectors with blue mussels (*Mytilus edulis*) which filter feed residues and other organic particles from the water column. The dissolved nutrients released by fishes and mussels will then be absorbed by macro algae in the next trophic stage, so that the nutrient flux caused by the fish breeding can be recycled into harvestable biomass. Both mussels and macroalgae are of commercial interest for products such as food and dietary supplements as well as cosmetics and medical applications, so they have potential to become part of the value-added chain of an IMTA system.

A diver surveying a frame with cultured blue mussels, © Peter Leopold

In association to the on-going project the utilisation of the lower trophic levels for fish feed production will be investigated. Therefore biochemical analysis of blue mussels and macroalgae will be performed to define the nutritional value of these organisms. Moreover other cultivation site associated invertebrates such as the rag worm (*Nereis diversicolor*) will be tested for their potential. Afterwards the tested materials will be recombined with as less supplements as possible. Different mixtures of feeding pellets will be produced and tested in feeding experiments with rainbow trouts.

The benefit of this method of feed production is the generation of local nearly closed nutritional cycles, comparable to those in natural systems. If the results of the experiments will be positive, another hurdle in reaching sustainability of coastal trout aquaculture may be taken.

Gregor Thum
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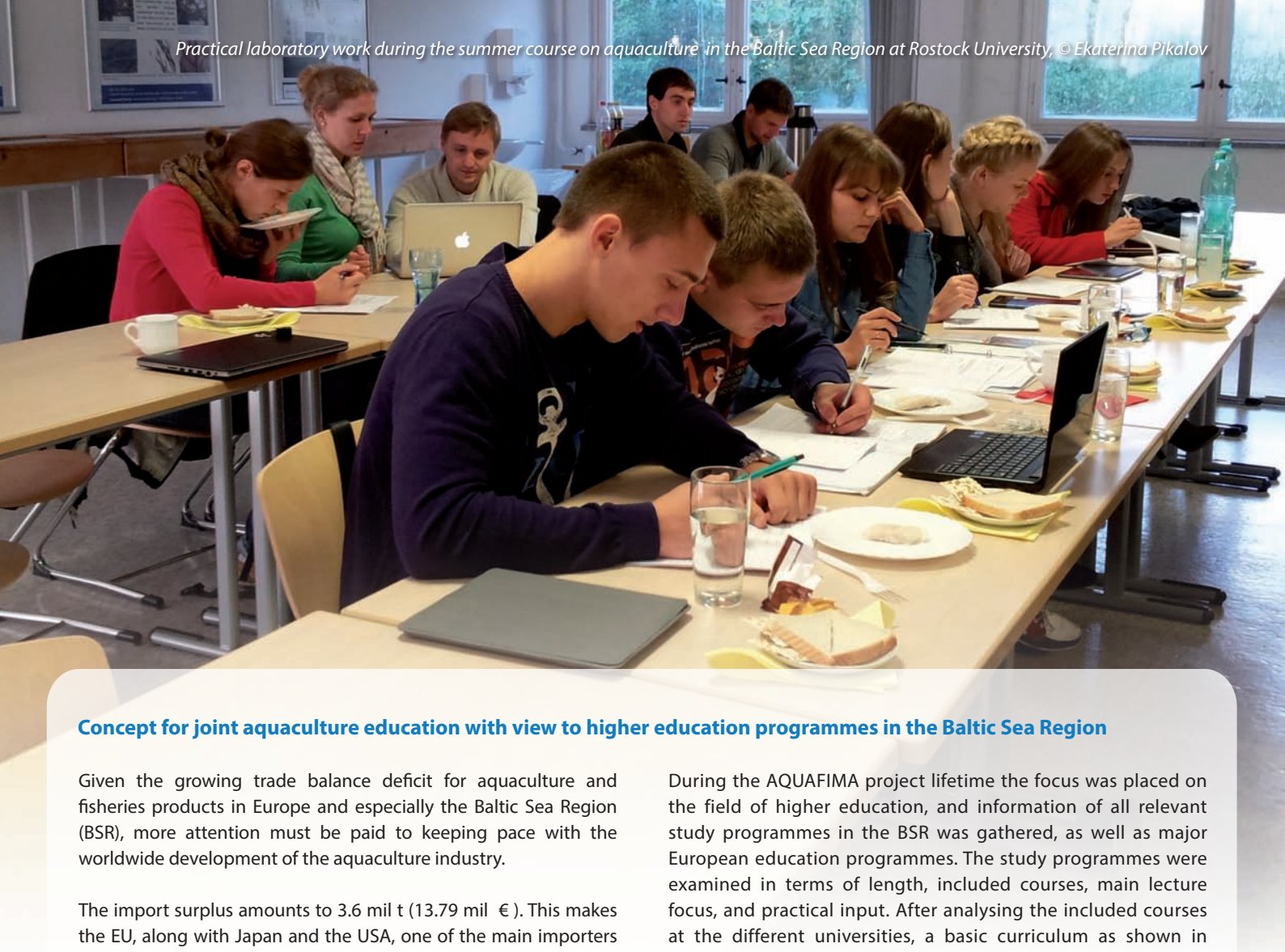
Germany

Potential fish feed components: Delesseria sanguinea *and* Nereis diversicolor, *© Peter Leopold*



Practical laboratory work during the summer course on aquaculture in the Baltic Sea Region at Rostock University, © Ekaterina Pikalov

Concept for joint aquaculture education with view to higher education programmes in the Baltic Sea Region

Given the growing trade balance deficit for aquaculture and fisheries products in Europe and especially the Baltic Sea Region (BSR), more attention must be paid to keeping pace with the worldwide development of the aquaculture industry.

The import surplus amounts to 3.6 mil t (13.79 mil €). This makes the EU, along with Japan and the USA, one of the main importers of aquaculture or fisheries products. Thus, the development of aquaculture production may result in positive economic and regional development, empowering the member states to participate in the growing market.

What is needed for a striving industry and future development?
Skilled workers are a prerequisite for on-going development, and constant training and education guarantees a pool of skilled employees. Education programmes can be divided into either vocational training or higher education courses concentrating on a more academic approach.

During the AQUAFIMA project lifetime the focus was placed on the field of higher education, and information of all relevant study programmes in the BSR was gathered, as well as major European education programmes. The study programmes were examined in terms of length, included courses, main lecture focus, and practical input. After analysing the included courses at the different universities, a basic curriculum as shown in Figure 1 was extrapolated, illustrating the basic requirements for a joint aquaculture education.

The basic curriculum teaches the most general topics in aquaculture education, with courses in biology, technology, and general concepts or introduction to aquaculture. Each university then focused on its own research profile by adding certain topics to their curricula.

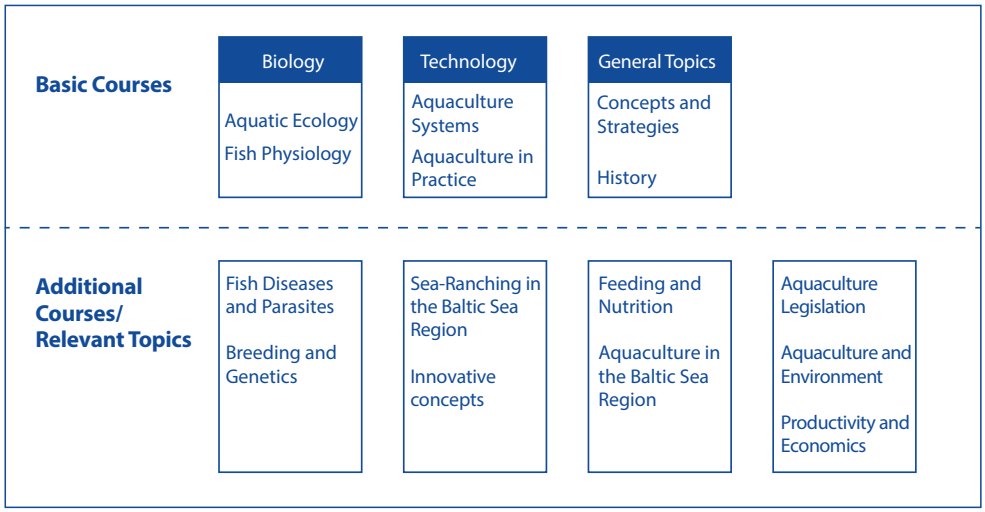


Figure 1: The Basic Curriculum as identified during AQUAFIMA project lifetime

Looking to tie all the higher educational initiatives within the BSR together, an international master's programme was planned, which would have been offered at all partner universities. Unfortunately, administrative regulations and a long decision process within the university hindered its establishment. Therefore the partners focused on an innovative and advanced approach, developing e-learning modules which can easily be included in existing or newly created programmes.

Eventually, the following master's programme was developed, which also includes a student exchange scheme (Figure 2). Mobility enables students to learn in a different environment and acquire more skills and knowledge.

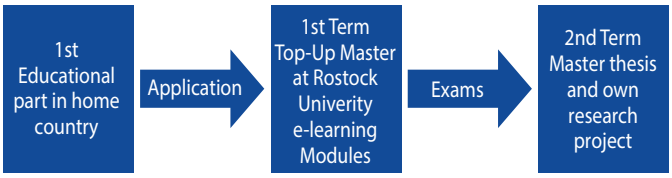


Figure 2: Concept for an international master's programme and an included student exchange scheme

The supplemental master's course of aquaculture in the BSR must have a minimum duration of two semesters, and is divided into different locations. The applicants for the programme must first have passed the basic curriculum in their home country. A successful graduation allows the application for the new course. The first semester is characterised by e-learning modules in the amount of 30 credit points (ECTS), which need to be passed in order to proceed to the next semester with an own research project, the master's thesis. The students are free to choose where they want to pursue their research ideas and interests, as long as it is within countries in the BSR.

This programme serves as an alternative to aquaculture programmes which are often strict and limiting due to administrative and language constrains. Instead, this programme will foster educational activities and offer students a programme where they can choose among the aquaculture educating universities within the BSR. So far, Rostock University has developed three e-learning modules which can also be complemented by different courses from other universities. We aim to generate a pool of courses which will support students in closing knowledge gaps and finding their own research interests and ideas within an international framework.

Enriching study programmes with English e-learning courses will help attract more international students to such a master's course. Additionally, students can reduce their educational expenses, as they do not have to travel when they cannot provide enough funds, but still have the opportunity to participate in the course. Travelling and staying abroad is only necessary for the second term, and for this different national and EU wide funding schemes are available to alleviate travel expenses of students.

This programme can provide a new generation of aquaculture students who are able to support the aquaculture industry within the BSR and overcome the many hurdles that still exist.

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Students practicing the isolation and identification of common fish parasites, © Ekaterina Pikalov

Finnish Aquaculture Facility, © Mika Remes / Aquabest_

Environmental regulation: a major burden on aquaculture in the Baltic Sea Region

The project Aquabest looked for means to promote aquaculture in the Baltic Sea Region. A major component of the project was a comparative study of applicable regulations. Aquacultural entrepreneurs were given questionnaires exploring how their businesses were affected by taxes, employer obligations, accounting obligations and other regulation. In the end, they identified environmental regulation as the most complex and costly regulatory burden on farmers, with environmental permitting seen as especially strenuous.

In comparative studies, the burden of environmental permitting has been established as a significant cause for the reduction of aquacultural production in Finland by almost 40 % since 1995. Finnish fish farms are small and have been unable to expand, because they are not granted permits for larger establishments. In Sweden, environmental aquaculture permits both allow for larger yields of fish and are of longer duration than in Finland: consequently, aquacultural production has doubled in Sweden between 2000 and 2011. This comparison is apt because Sweden and Finland have otherwise similar geographies, climates, tax burdens, and regulations.

The major burden of environmental permitting is the work involved in submitting an application. Fish farmers need consultants to draft the reports required by environmental agencies. To this is added the cost of the permit itself, which in Finland can amount to 20,000 €. The permit also needs to be reviewed or renewed periodically. The average validity of an environmental permit for aquaculture in Finland has been only 9 years.

Some Finnish aquacultural establishments calculated the total cost of applying for and complying with environmental permits and came up with approximately 0.10 € per kg of fish produced. In Sweden, the costs are estimated to be only a fraction of this. All in all, environmental regulation has a serious effect on the competitiveness of Finnish aquaculture. However, this strict permitting is not an isolated phenomenon but a result of EU environmental policy.

The rationale for strict environmental regulation of aquaculture is to combat the eutrophication of local waters and the Baltic Sea. HELCOM's objectives are to reduce phosphorus emissions, and the EU Water Framework Directive prohibits activities that present a threat to the "good ecological status" of waters. But the cultivation of fields, the main source of phosphorus emissions, does not require environmental permits.

Farmers' costs in a difficult/complex environmental permitting case in Nordic countries. The permit fees are not included. (From Paavola et al. (2013) www.aquabestproject.eu)

	Finland	Sweden	Denmark
Own work in application phase *	9 000	9 000	4 500
Own work in permit consideration phase *	6 000	7 500	6 000
Own work in the petition of appeal *	24 000	7 500	2 250
External services in application phase	50 000	18 300	30 000
External services in permit consideration phase	15 000	16 700	13 400
External services in the petition of appeal	20 000	22 200	1 340
TOTAL	104 000	59 000	56 150

** Total salary and employer costs € 300 / working day*

In Finland, this leads to a situation where both the burden of reducing emissions and of monitoring the aquatic ecological status falls disproportionally on aquaculture. Increasing production at fish farms is seen as a threat to the good ecological status of local water bodies. Most applications for expansion of fish farms are denied for this reason. In many areas, fish farms are the only establishments that require environmental permits, so if the administration needs information on the ecological status of waters, the fish farm is required to produce that information. It remains to be seen if the recommendations that Aquabest gives to policy makers will have an effect on the operational preconditions of aquaculture.

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Finnish Aquaculture Facility, © Susanna Airaksinen

PartiSEApate workshop, © Jonas Pålsson

Aquaculture as a new stakeholder in Maritime Spatial Planning around the Baltic Sea

Maritime Spatial Planning is about to become one of the most important tools for allocating and finding synergies of uses in marine spaces. In order to improve the exchange of information between representatives of the different maritime sectors and spatial planners, the "PartiSEApate" project conducted a series of pan-Baltic dialogues from 2013 onwards.

While aquaculture has been identified as one of the five pillars of the EU's Blue Growth Strategy, it has so far only played a minor role within the Baltic Sea due to natural limitations on open net cage cultivation. New technological developments and knowledge together with the general need to increase fish production may, however, open a door for the sector also in this region. Furthermore, mussel- and algae cultivation may be interesting as environmental remediation measures as well as providing a resource for energy and feed production.

In line with the EU Communication on Aquaculture, which stipulates that MSP may have an important role to play to facilitate the development of the sector, dialogue participants confirmed that they also place great hope in MSP in the Baltic Sea. MSP is mainly seen as an opportunity for the sector to regain its voice and to grow from the "forgotten" sector, which only gets the "leftovers" after all other users have made their claims, into an equal player in the competition for sea space.

So far, related MSP issues do not centre so much around concrete spatial conflicts with other marine users, i.e. summer house owners or the fishery sector. For the time being it is much more important to clarify for what purpose aquaculture is wanted in the Baltic Sea. Shall it mainly deliver fish for human consumption? Or shall it serve as an environmental remediation tool? Is restocking from aquaculture an issue? Depending on these questions, spatial requirements (location and size of sites) differ substantially.

Equally important and related to these questions is the pending clarification of the environmental regulation conditions under which new marine aquaculture sites may be considered. The development of marine fish aquaculture has so far been hampered by a zero nutrient discharge policy. Furthermore, nutrient calculations are region specific, which means that fish farms would currently need to show that their nutrient inputs are taken up within the very same area.

In the current setting, fish farmers have refrained from finding ideal sites, but have instead focused attention on expanding or at least maintaining claims to existing sites, even if those are sub-optimal due to natural and economic conditions.

Demands for changes to this policy have mainly been expressed in Denmark, Sweden, and Finland, the three countries where some established aquaculture businesses still exist. In these countries reform processes have started, where new possible ideal sites are identified for marine aquaculture based on a set of suitability criteria. For instance, studies show that instead of the current set of small farms in coastal areas, future sites should focus more on open offshore areas with better water exchange. This would allow for bigger and economically more efficient units as well as limiting conflicts based on visual disturbance.

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© Nardine Stybel

© Franziska Göttsche

Regional tourism development based on fisheries and aquaculture

In 2011 tourism contributed 267 billion € (4 - 13 %) to the gross domestic product in the Baltic Sea Region (BSR) and provided 7.8 million jobs (4 - 12 % of workforce). Of 57.1 million European tourists, 23 % reported their main reason for holiday travel in 2011 as "nature (lake, landscape, etc.)".

Fisheries and aquaculture have a prime opportunity to expand into tourism, as they determine the maritime flair of coastal regions. Fisheries and aquaculture can be used for tourism purposes by exploiting farmed and stocked fish for recreational fishing, revitalizing and promoting fishery and aquaculture business as a tourist attraction and developing educational tourism offers.

To establish new opportunities for fishery-related tourism the AQUAFIMA project has conducted study reports and surveys focusing on aspects such as the economic value created by recreational fishing tourism activities, water quality in tourism regions influenced by aquaculture and presentation of aquaculture in aquaria and maritime museums.

Main results are presented in the "Guide of good practices and recommendations" for the regional tourism development in the BSR. Examples of aquaculture presentation in aquaria and museums are rare and there is a further demand for improved information.

Aquaculture Research Facility – Born, Germany
The Aquaculture Research Facility of the State Research Institute for Agriculture and Fisheries Mecklenburg-Vorpommern situated in Born / Darß allows for a fascinating peek into current aquaculture research. The best possible growing conditions for trout, sturgeon, and pike are tested using a closed water recirculation system. The facility offers tours on certain dates during the year: you can find registration for these tours at:
www.lu.mv-regierung.de/anmeldung

Müritzeum - Waren (Müritz), Germany
The Müritzeum not only has the largest tank of freshwater fish species in Germany, but also has numerous smaller aquariums, and a 20 m long simulacrum of a flowing creek, with plants, stones, water plants, and fish. Visitors can also see two large outdoor aquariums, which function as breeding pools typical of inland fish aquaculture.
www.mueritzeum.de

© Franziska Göttsche

Müritzfischer Fishing Pond and learning trail - Bolter Schleuse and fishing museum - Waren (Müritz), Germany
In Bolter Schleuse the visitor can not only fish, but also have a look at the larval and juvenile forms of fish in the breeding house and learn about over 30 native fish species along a fish learning trail. There is also a fishing museum in Waren / Müritz, where visitors can learn about the daily routine of fishermen, both in the past and today. Also on display are examples of typical fishing and trapping devices, preserved giant fishes, and typical animals of the regional lakes.
www.mueritzfischer.de

OZEANEUM Stralsund and the German Oceanographic Museum – Stralsund, Germany
Stralsund has a wealth of facilities available for the marine-interested visitor, with the OZEANEUM's extensive aquariums and exhibitions focusing on the biology of the oceans, while the German Oceanographic Museum focuses more on the human connection with the ocean with topics including marine sciences, marine biology, and fisheries. Both museums have exhibitions that discuss selected forms of aquaculture in the EU and the world, as well as educational offerings for children.
www.ozeaneum.de and **www.meeresmuseum.de**

The NMFRI Gdynia Aquarium – Gdynia, Poland
The Gdynia Aquarium has a strongly developed educational infrastructure, with classrooms equipped with multimedia projectors, aquaria, specimens, microscopes, and chemical water sampling devices. Children can take courses discussing how to cultivate aquatic species in different environments. The aquarium also breeds numerous species of medusa, fish, cuttlefish, sharks, and zooplankton, with some on display.
www.akwarium.gdynia.pl

Museum of the World Ocean – Kaliningrad, Russia
The Museum of the World Ocean has a wide range of maritime offerings, with exhibits in multiple buildings and ships available to the interested tourist. As the center of the Russian national oceanographic research effort, it has numerous excursions available for students relating to fish biology and fisheries research.
http://world-ocean.ru


© Franziska Göttsche

The Tome Hatchery – Latvia
A facility belonging to the Institute of Food Safety, Animal Health and Environment (BIOR), the Tome Hatchery has a small permanent exposition demonstrating the history of both the farm and aquaculture development in Latvia. Visitors can enjoy learning about the history of Latvia's oldest fish farm before going angling for brown trout in its fishing ponds.

Pond Fishing Tourism – Estonia
Fish tourism is a rapidly growing sector in Estonia. While fly fishing at rivers and lakes can be practiced practically without permits, one unique branch of fish tourism known as "put and take fishing" or pond fishing is growing especially quickly. Visitors have the chance to fish at carefully designed ponds and small lakes and catch rainbow trout, carp, pike-perch, and sturgeon stocked from Estonian fish farms. There are now over sixty companies specialising in this practice, with at least seven in Harju County, not far from Estonia's capital of Tallinn.

Christopher Pavia and Nardine Stybel
EUCC – The Coastal Union Germany

REGIONAL PROJECTS INVOLVED

AQUAFIMA (2011 – 2014)
Integrating Aquaculture and Fisheries Management towards a sustainable regional development in the Baltic Sea Region

The fishery sector is an integral part of the Baltic Sea coastal regions and their economies. Yet not all fish stocks are harvested within natural limits, and certain important species are severely overfished. The management of Baltic Sea fish stocks must therefore be improved, and alternatives such as aquaculture, restocking and stock-enhancement (i.e. the release of reared fish into the marine environment) should be taken into consideration. It is important to assess which strategies and technologies are suitable for which fish species and which part of the Baltic Sea ecosystem. The project partners from Denmark, Estonia, Germany, Latvia, Lithuania, Norway and Poland are collecting, bundling, and transferring this knowledge, so that the aquaculture sector in the Baltic Sea Region can finally begin to realise its potentials and lessen the burden on wild fish stocks. **www.aquafima.eu**

Part-financed by the European Union (European Regional Development Fund)

State Development Corporation Mecklenburg-Vorpommern

The State Development Corporation Mecklenburg-Vorpommern, coordinator of the AQUAFIMA project, is a state-owned rural development organisation. The state Mecklenburg-Vorpommern, which is located in Germany's north east, holds 50.5 % of its shares. The company deals with the development of rural areas in Mecklenburg-Vorpommern in a broader sense. The main tasks and services are: land procurement, utilisation and reserve (areas for nature conservation, purchase of land for infrastructure measures e.g. road construction, industrial sites), land consolidation and land re-allocation according to public law, regional development (regional development programmes, regional management and regional marketing), land use planning (municipal land use planning, master plans and urban development planes), village renewal, architect and construction engineering services for buildings in rural areas as well as investment consultancy for farmers. **www.lgmv.de**

Aquabest (2011 – 2014)

Aquaculture has been the fastest growing food production sector globally during the last two decades. In opposite to the global and European trend, the production in the EU and especially in the BSR has stagnated being annually appr. 100.000 tons in the Baltic Sea catchment area of the BSR EU Member States. It is widely accepted that aquaculture has great potential to feed growing human population in the era of declining wild stocks ("Blue Revolution"), but new production has to be built on sustainable practices and technologies. Aquabest creates a strong basis for new, environmental regulation policies. The project strives to demonstrate that the aquaculture in the Baltic Sea region has the potential to become a sustainable and responsible food production system, accepted by all stakeholders. **www.aquabestproject.eu/**

Part-financed by the European Union (European Regional Development Fund and European Neighbourhood and Partnership Instrument)

PartiSEApate (2013-2014)

An increasing number of users compete for a share of the limited and vulnerable Baltic Sea space. As expressed by the new EU Directive, Maritime Spatial Planning (MSP) has by now become the widely acknowledged and necessary tool for coordinating and balancing the spatial use of the sea. Nevertheless actual practice on how to carry out multi-level MSP processes across administrative borders is limited. In PartiSEApate the bodies responsible for MSP across the BSR have joined forces in order to develop and test appropriate methodologies in three concrete pilot projects as well as strengthen the involvement of stakeholders at pan-Baltic level through a series of MSP dialogues. Based on these findings the project will provide recommendations for the future MSP governance system at pan-Baltic level, which in turn will directly feed into the work of the HELCOM-VASAB Working Group on MSP. **www.partiseapate.eu**

Part-financed by the European Union (European Regional Development Fund)

BALTIC IMTA (2013-2015)

The increasing demand for aquaculture products combined with only a few sustainable production processes require innovative technological approaches. Thus, in September 2013 Baltic Integrated Multitrophic Aquaculture was started using funds from the European Fisheries Fund (EFF). The pilot project focuses on the use and benefits of Integrated Multitrophic Aquaculture in the western Baltic Sea. By combining blue mussels and red algae with a versatile rainbow trout net cage in the exposed waters of Nienhagen, Mecklenburg-Western Pomerania, possible synergies and effects onto the ecosystem will be studied. The project involves four research groups at the University of Rostock, Germany: the chairs of Aquaculture and Sea-Ranching, Marine Biology, Aquatic Ecology and Marine Technology. **www.baltic-imta.uni-rostock.de**

Eurofish

Eurofish is an international organisation established to assist the development of fisheries and aquaculture in Central and Eastern Europe focusing on post-harvest fisheries and aquaculture industries. Eurofish contributes to the development of fisheries and aquaculture sector through the publication of marketing and industry related information in the Eurofish Magazine, Eurofish website, Eurofish Magazine website, as well as through the organization of conferences, workshops and seminars, business-to-business meetings and by executing a variety of projects in the fields of trade and market, processing and aquaculture. **www.eurofish.dk**

EUCC - The Coastal Union Germany (EUCC-D)

EUCC-D was established as a non-governmental association in 2002, forming the German branch of the Coastal & Marine Union (EUCC), the largest European coastal and marine organisation. The main objective of EUCC-D is to strengthen German activities within the field of Integrated Coastal Zone Management (ICZM) by bridging the gap between coastal science and practice. Within AQUAFIMA EUCC-D provides national and international magazines about aquaculture, educates coastal practitioners and runs photo exhibitions. Furthermore, we develop information systems, create tools (e.g. databases, learning modules) for international networks and disseminate coastal and marine information via our German Küsten Newsletter or in shared media with our international colleagues. EUCC-D offers memberships for professional and private individuals, and other non-profit organisations. The German membership also includes membership with EUCC International. Please visit **www.eucc-d.de/membership.html** for more details.