

Project no. **022656**

Project acronym **SAMI**

Project title **Synthesis of Aquaculture and Marine Ecosystem Interactions**

Instrument **SSA**

Thematic Priority **8.1 Policy oriented research**

## **Publishable final activity report**

Period covered: **from 1.11.2005 to 30.4.2007**

Date of preparation: **20.6.2007**

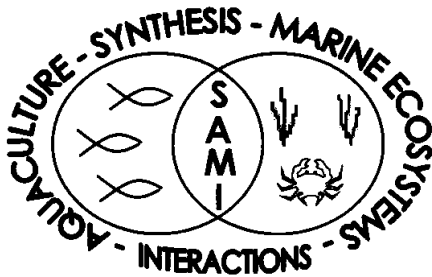
Start date of project: **1.11.2005**

Duration: **18 months**

Project coordinator name **Marianne Holmer**

Project coordinator organisation name **University of Southern Denmark** Revision [**final**]

## 1. Project execution



[www.sami.biology.sdu.dk](http://www.sami.biology.sdu.dk)



### **Project objectives and major achievements during the reporting period**

During the last decade several EU projects have dealt with the environmental issues of marine aquaculture in Europe and the current knowledge in this field has grown significantly. Most of the results are, however, not readily accessible and an overview and synthesis of the most important environmental issues is lacking. It is, therefore, difficult to integrate this knowledge into the environmental requirements of the Common Fisheries Policy (CFP). As several projects have finished recently, there is a risk of losing much of this information unless immediate action is taken. A general overview of environmental issues related to aquaculture has been provided in documents and papers produced in the framework of the MARAQUA concerted action (Read & Fernandes 2001). However, the spectacular progress achieved through the FW5 EU projects as well as by the international scientific community during the last 6 years is not reflected in these documents.

The aims of this project were twofold. Firstly, we aimed to bring experts from the many aspects of aquaculture-environment interactions together for a discussion of the most significant advances in knowledge from completed and on-going research both in Europe and globally, for a discussion of the future perspectives of marine aquaculture within Europe particularly in the environmental context, and for integration of these advances into the environmental requirements of the CFP. In addition to the scientific aspects also the views by the industry and the NGO's was invited to the discussion of the future perspectives.

Secondly, we aimed to disseminate these discussions at several levels. The future perspectives of aquaculture has been presented in Science (Duarte et al. 2007) and one more publication is under preparation (Duarte et al. in prep) to bring the consequences of recent advances to more general attention, to stimulate the scientific community to address gaps in knowledge in their future work, and to provide recommendations for the future EU research agenda.

Comprehensive reviews of the most important issues in marine aquaculture, specifically including each of the main RTD projects funded by the EU over the past decade, are collected in the book "Aquaculture in the Ecosystem", which will be available for the scientific community as well as for regulating authorities, industry, fish farmers, NGO's, students in the field of aquaculture and the public with interests in the field in 2007.

**Summary of objectives:**

- Provide the state-of-the-art on environmental issues of marine aquaculture in Europe
- Provide advice for integration of environmental requirements into the CFP
- Clarify gaps in current knowledge for future directions for EU research policy
- Provide expert perspectives on the sustainable development of marine aquaculture in Europe

To fulfil these objectives the project has:

- Organised a workshop “Environmental Status of Marine Aquaculture in Europe” with experts from Europe and beyond in January/February 2006. (SAMI partners and experts)
- Held an intensive workshop producing a review and a synthesis for high-impact international publication in October 2006 (SAMI partners and Doris Soto FAO and Yngvar Olsen NTU)
- Prepared a book with the title “Aquaculture in the Ecosystem” with contributions from experts in the field for publication with Springer in 2007. (SAMI partners and experts).
- Held a workshop “Synthesis of the MedVeg project” with participants from the MedVeg project in April 2007 (SAMI partners and MedVeg partners)
- Published a paper in Science Perspective Section “Rapid domestication of marine species” (Duarte et al. 2007)
- Produced first draft of paper “Will the oceans help feed humanity?” for submission to Science Review (Duarte et al. in prep)
- Published a presentation of the SAMI project in the Parliament Magazine for EU politicians
- Participated in numerous national and international conferences for public and scientific audiences with presentation/discussions of the SAMI project.

**Description of work**

The project contained 3 work packages for support activities and 1 for project management. The first work package dealt with the organisation and implementation of the workshop for experts in the field of environmental issues of marine fish farming in Europe, which was held in January/February 2006 where 17 experts participated. The objectives of the workshop were to explore the state-of-art on the topic in Europe. The second work package was devoted to a synthesis of the workshop for a scientific audience, including the EU research advisory board. The outputs of this work package have been several scientific papers/manuscripts submitted to high-impact journal and several manuscripts for peer-reviewed journals in the field of aquaculture. The objective of the third work package was to publish a book for a wider audience on the state-of-art knowledge in the field based on contributions from participants in the expert workshop. The book proposal was submitted to Springer publisher in March 2006 and negotiated during the following months, and the manuscripts are planned for submission to the publisher in June 2007. The last work package was devoted to project management.

**Main achievements**

**Environmental Status of European Marine Aquaculture and future perspectives**

The growth of Aquaculture and its future role as a food supplier to human society has environmental, social and economic limitations, affecting marine ecosystems and socio-

economic scales from local to global. These are close links with human health requirements and societal needs for various goods and services provided by marine ecosystems. With regard to regulation and monitoring at present time, the Water Framework Directive (WFD) is being implemented all over Europe and will become important for the regulation of aquaculture and other human activities in the coastal zone (Chapter 1, SAMI book: “Aquaculture in the Ecosystem”). The SAMI project clarifies present understanding of eutrophication and provides an insight into water quality models on as they are expected to be used under the WFD, providing examples from Scotland different scenarios for the future regulation of marine aquaculture in the coastal zones. Monitoring is highly advanced in some parts of Europe, whereas others are in their infancy. In Norway, which is one of the top five producers in the world and where the production of salmon in net cages in the coastal zone is an important contributor to the national economy, the monitoring of environmental impacts of the industry has been developed since the beginning of the industry 30 years ago and is now a classified program according to national standards implemented throughout the country (Chapter 2). As an example of a more recent developed program, the monitoring in Malta is presented (Chapter 2). During the 90’s, the Mediterranean experienced an exponential growth in the production of sea bream and sea bass in net cages and, as the environmental conditions in the Mediterranean are unique (e.g. widespread oligotrophy), some of the environmental pressures differ considerably from those in Northern Europe. One example is the prevalence of seagrass meadows of the species *Posidonia oceanica* as a benthic ecosystem along Mediterranean coasts. As this is a sensitive ecosystem, facing general declines in the coastal zone, it is important to monitor this ecosystem in fish farm surroundings to avoid accelerating declines (Chapter 2). Tuna farming (or ranching) is a major activity in Malta as well as in several other Mediterranean countries and, although it is debated whether this industry is “real” aquaculture or should be considered as a fattening industry instead, the environmental impacts differ from sea bream and sea bass aquaculture due to the use of wet feed (fresh/frozen fish) instead of dry feed pellets.

A new development in aquaculture monitoring and regulation, which will play an important role for future development, is in considering aquaculture as an integrated part of the marine ecosystem. This means that aquaculture should be managed together with a number of other industries and other users of the marine ecosystem (Chapter 3), but also that the production is a part of ecosystem and has to be managed at different scales, not only the water column and sediment floor in the vicinity of the net cages, but also at larger scales in the coastal zones (Chapter 1). One example of scale is presented in Chapter 5, which addresses the issue of introductions of alien species into coastal zones caused by aquaculture operations. This is particularly important since it is well known that aquaculture is the second most important vector for species introductions after maritime transport. Also the attraction of wild fish to net cages adds constraints to the ecosystem structure and function, in particular in areas such as the Mediterranean, where wild fish are abundant around cages and may be more available to fisheries (Chapter 3). Although the presence of wild fishes at the farms can minimize the environmental impacts, e.g. through reducing inputs of organic matter to the seafloor, there are risks such as transfer of diseases to wild populations (Chapter 3). A related issue is the genetic pollution of wild stocks through either inadvertent (as in farm escapes) or deliberate (as in stocking/ranching) introduction of cultured species into the wild (Chapter 4). Genetic impacts have been extensively studied for salmon in Northern Europe, where there are problems with interbreeding, and are now under consideration for other cultured species such as sea bream and sea bass in the Mediterranean and for other species in the tropics (Chapter 4). The SAMI project discusses the possible future solutions to the genetic interactions between farmed and wild fish.

One major constrain to aquaculture growth is the availability of fish meal and fish oil for production of carnivore fish (Chapter 6 and 10). There is currently a major research effort in optimizing feed through substituting fish meal and oil with vegetable flour and oil. As there is substantial scientific evidence of human health benefits from consumption of marine products, primarily due to the omega-3 fatty acids, the aims of the current research is to maintain the composition of the cultured fish product while reducing dependence on fishery-derived feedstocks (Chapter 6). There are also other future options for solving the bottle neck of feed availability, which involve not only breakthroughs in feed technology but also changing the way humanity interacts with the oceans (Chapter 10). Such breakthroughs could be through use of marine plants for feed or moving production from carnivore to herbivore species. Aquaculture is expected to develop along two main lines, either in net cages at sea or on land-based facilities. To keep up with the production needs the size of the farms will expand and net cage farms will move from coastal sites to open-ocean locations. Land based farms have the advantage of reuse of the water and treatment facilities, but are at the present constrained by high energy costs.

In addition to technological constrains there are several other bottlenecks, which are less predictable. These are related to attitudinal issues (Chapter 8 and 10) and to the economic development of the industry (Chapter 9). Aquaculture production has for instance become of active interest to a number of non-governmental organizations (NGOs) around the world, which is discussed in Chapter 7. NGO concerns about aquaculture are not solely in its growth or where the product is consumed. Rather, their interest is in the on-the-ground environmental or social impacts that threaten or undermine the NGO's ability to deliver on their overall missions of conservation or social welfare. Public and consumer attitudes and legislation, related to e.g. ethics, environment and health can play important roles, such as observed with the threatened bird flu pandemic, where suddenly almost every consumer stopped eating chicken. This did affect the sales of salmon from aquaculture positively, whereas the news on high dioxin levels in cultured salmon resulted in a major, if transitory, reduction in the consumption of fish. One possible way to comply with public attitudes and to impose legislation is through resolution of externalities through monetary valuation of the interactions between aquaculture and the environment and vice versa (Chapter 8). Externalities can be used for policy formulation e.g. through introduction of environmental taxes and make the producer aware of the environmental costs.

Changes in the market may significantly affect the development of the aquaculture industry, as production only takes place if there are economic benefits to the producer. Chapter 9 analyses the past development in the economics of the industry and from this analysis predicts future trends. It is predicted that production will move towards a few high-volume species supplemented with a large number of small-volume species for local markets. High-volume species have the advantage of predictability and can be sold in the large and global supermarket chains, where weekly sales can be promoted founded on the stability of delivery. High-volume productions are characterized by relatively low production costs. On the other hand, the small-volume species can be sold at a higher price at local markets depending on season and demand.

**Publications from the SAMI project:**

Duarte, C.M., Marbà, N., Holmer M. (2007) Rapid domestication of marine species. *Science* 316:382-383

Duarte CM, Holmer M, Olsen Y, Soto D, Marbà N, Guiu J, Black K, Karakasis Y. Will the oceans help feed humanity? *Science*, in prep.

Holmer M, Black K, Duarte, CM, Karakassis I, Marbà N. *Aquaculture in the Ecosystem*. Springer, submitted