



# THE MERAMED PROJECT

## Development of monitoring guidelines and modelling tools for environmental effects from Mediterranean aquaculture

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### DEVELOPMENT OF MONITORING TECHNIQUES AND MODELS FOR THE ASSESSMENT OF THE ENVIRONMENTAL IMPACT OF FISH CAGES IN THE EASTERN MEDITERRANEAN

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### Introduction

The EU funded MERAMED project is adapting environmental monitoring techniques and developing a model based control system for fish cage farms in the eastern Mediterranean. The project has evaluated procedures used in the regulation and monitoring of marine cage fish farms in Norway, Scotland and is proposing an appropriate set of protocols, monitoring systems and techniques for the control of fish farms in Mediterranean conditions. It has carried out a field research programme to provide appropriate data on the environmental impact of marine cage fish farms in a range of conditions in the eastern Mediterranean. It is developing a predictive model to simulate the environmental response at Mediterranean sea cage farms to differing cage stocking levels and feeding regimes. Special emphasis has been given to the effects on the environment of solid wastes from cage farms of sea bass and sea bream (uneaten feed and faeces) and on the influence of free-living fishes on the fate of these wastes.

# MERAMED

## Materials and Methods

The project has undertaken three cruises, a scanning cruise of 7 farms in Greece with a wide variety of locations and environmental conditions followed by two cruises investigating 3 of the farms in more detail.

Environmental conditions were assessed at the farm sites by taking measurements made by electromagnetic current meters, DGPS drogue arrays and conductivity/temperature/depth probes, to allow model parameterisation using suitable real or synthetic current data sets. Sediment profiling imagery (SPI), ROV and underwater photography was used for the rapid assessment of the condition of the seabed and wild fauna beneath the farm cages.

Detailed water column and sedimentary sampling was carried out at 3 of the farms for geochemical and faunistic variables. Data on production, food type and feeding rates, were obtained from fish farmers. Spatial changes in sedimentary geochemical and biological variables (Redox, organic C, N, total P, ATP, sediment particle distribution, sediment water content, macrofaunal abundance, biomass, species composition and diversity) with increasing distance from the fish farms was determined. This data was used to help develop and validate an aquaculture impact model for the Mediterranean.

When existing aquaculture impact models such as DEPOMOD (Cromey et al., 2002) have been used to investigate the deposition and impact of Eastern Mediterranean aquaculture, over prediction of impacts has been evident. This new hydrographic and benthic data allowed validation of the DEPOMOD model for numerous Eastern Mediterranean sites and conditions.

## Results

The benthic sampling results were used to select the minimal set of environmental variables needed to properly describe the benthic conditions.

The model MERAMOD has detailed bathymetric and hydrographic data sets for the seven MERAMED sites. Benthic data for each of the sites will also be available shortly to allow quantification of benthic effects given a predicted level of deposition. Additional components have been added to make the model more suitable for use in the Mediterranean. This includes the addition of a wild fish module, where waste food and faecal particles arising from the farmed fish are removed by wild fish. Detailed experimentation has also been undertaken to accurately measure the settling velocities of seabass and seabream food pellets and faecal material to allow validation of the particle tracking component.

The logo for MERAMED, featuring the word "MERAMED" in a stylized, pink, italicized font. The letters are bold and have a slight shadow effect. The logo is positioned at the bottom center of the page, below a large, faint, pink circular graphic that contains a white geometric pattern of overlapping triangles and lines, resembling a stylized globe or a network diagram.

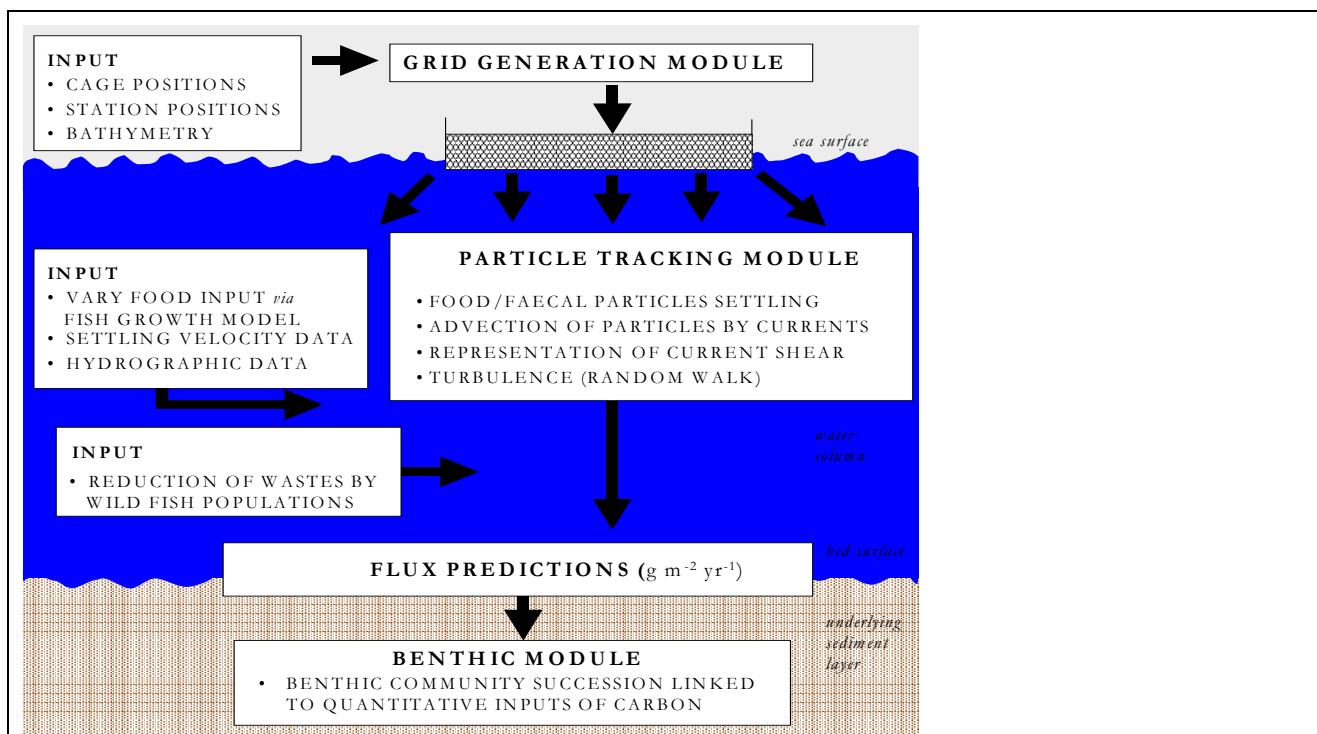


Fig. 1. MERAMOD modules showing the flow of information for predicting deposition and benthic effects of aquaculture.

In order to calculate the amount of feed pellets and faeces from fish cages, the deposition of fish faeces and wasted food was assessed using sediment traps in 24-hours-experiments together with current meters and a meteorological stations. For filtering the trap contents, glass fibre filters were used. This also permitted CN analyses of the trap samples for estimating the fractional amount of wasted feed pellets and faeces in samples from sediment traps.

To calculate the fractional composition of the samples from CN analyses it is necessary to have data on the CN-composition of pure feeds and faeces. Therefore faeces of sea bass and sea bream were collected with sediment traps attached to the bottom of net cages. To avoid mixing of the collected faeces with feed pellets the traps were deployed after the last feeding in the evening and retrieved before the first feeding in the morning. First analyses of faeces of sea bass resulted in a C/N ratio ( $\pm$  standard deviation) of  $9.4 \pm 0.4$ . The difference in C/N ratio between feed and faeces as sufficient for estimating the composition of sediment trap samples.

At one farm, a long-term experiment was carried out using a set of 57 sediment traps underneath and in a range of 50 m from the centre of the selected cage. Other traps were deployed at a control site. Current meters and a meteorological station were installed during the time of the experiment. The cultured sea bream were fed with pellets marked with one percent titanium dioxide as inert tracer. Since titanium-dioxide-marked pellets are lighter in colour and have been proven to be less readily consumed by fish in tank experiments, the colour change was compensated by adding one percent medical vegetable carbon. After recovery of the traps their contents were filtered over GF filters and dried for storage. The analysis of titanium dioxide in the samples will reveal the pattern of organic pollution around the selected cage and thus can be used as a data set for testing the accuracy of the DEPOMOD model.

In order to measure the sinking speed of faeces of various sizes of sea bream and sea bass, a crucial parameter for modelling, the range of pollution from a fish farm, faeces have been collected in sediment traps. These traps, with screw closures on both ends, were attached by divers to the bottom net of fish cages and then carefully transferred to a 2-meter Perspex column where the movement of the sinking faeces has been video-taped for further analysis.

To test whether feed pellets, after having reached the sea floor, are consumed by wild demersal fish, a known number of pellets were placed inside a marking frame (50 x 50 cm) on the seafloor. The reduction of the number of pellets over time was observed photographically or by direct observations. At most sites, the dispersed pellets were eaten almost instantly by wild fishes.

During feeding with titanium-dioxide-marked pellets, wild fish (*Liza aurata*, *Chelon labrosus*, *Oblada mealanura*, *Boops boops*, *Sarpa salpa*) have been caught and the contents of their guts and stomachs have been preserved in ethanol for titanium analyses.

## Discussion

The existing DEPOMOD model that was developed for use in salmonid fish farms in Atlantic Europe, is being used in the MERAMED project as the basis for model development for the MERAMOD model adapted to conditions in the Mediterranean.

MERAMOD will be able to predict impact on the environment based on production data and environmental conditions.

Wild fish have been found to have a greater importance on the impact of aquaculture in the Mediterranean than in northern Europe.

MERAMED will develop a tiered approach to environmental monitoring to allow cost effective methods used appropriate to the scale of impact.

	Simple/cheap	→	Extensive/expensive
Activity	Visual or descriptive	Semi-quantitative	Quantitative
Undertaken by:	Local diver plus farm boat	Farmer with some specialized equipment or small consultancy company	Research institute with specialized boat or large consultancy company
Bathymetry	Sea chart	Echo sounder	Rox Ann
Site Characterization	Diver with photos	Remotely Operated Vehicle	Sediment Profile Imaging
Benthic/sediment samples	Small grabs	Large grabs	Corer
Sediment condition	Colour, smell Beggiatoa	Grain size, Total Organic Carbon	Full chemical workup
Benthic fauna	Visual indicator species	Semi-quantitative analysis	Quantitative
Wild fish community	Presence of indicator species	Partial census	Quantitative census

Table I. Tiered approach to environmental monitoring.

## References

Cromey, C.J., Nickell, T.D. and Black, K.D. (2002). DEPOMOD - modelling the deposition and biological effects of waste solids from marine cage farms. *Aquaculture*, 214, 211-239.

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