TOOLBOX AQUACULTURE

UNIVERSIDAD DE MURCIA

Planning and management of Mediterranean fish farming

SUGGESTED USERS	PLANNING PROCESS	TYPE OF AQUACULTURE
Aquaculture producers Regulators	EIA Environmental Monitoring	Marine fish pens

SUMMARY

Using MERAMOD (a particle tracking model used for predicting flux of particulate waste material and associated benthic impact of fish farms) and RAC package (too model individual bioenergetic balance for certain fish and shellfish species) for planning and management of Mediterranean fish farming.

DESCRIPTION

The models used in the present study were MERAMOD and RAC. MERAMOD® is a particle tracking model containing grid generation (bathymetry, cage layouts), particle tracking, resuspension and benthic impact response modules and derives from DEPOMOD® model developed for salmon in Scotland (Cromey et al., 2002). RAC model simulates the rearing cycle of *Dicentrarchus labrax*, *Sparus aurata*, *Ruditapes philippinarum* and *Mytilus galloprovincialis*, both at the individual and the population level.

THE ISSUE BEING ADDRESSED

The main residue derived from marine finfish farming is the organic matter released to the environment in the form of uneaten feed or fish metabolic wastes (Focardi et al. 2005). Such organic enrichment may have environmental drawbacks, especially if organic matter and nutrients surpass the threshold if their carrying capacity. Other substances derived from fish feed, even in much lower concentrations (metals, medicines, vitamins, hormones, etc.) or from other sources associated with fish farming activity (antifouling, external biocides for fish, etc.), may also have an impact on the benthic system (Olsen et al. 2008, Holmer et al. 2008). Seabed is affected depends on the type and quantity of particulate materials being released from the cage site and on the local physical conditions such as bathymetry and prevailing water currents. Particulate waste dispersion models can be helpful in supporting decision-making for environmental regulation and management by testing several pre-production scenarios for given environmental situations (Corner et al., 2006).

In the last decades, fish farming in the Mediterranean Sea has substantially increased. The main producing countries are Greece, Turkey, Spain, France, Italy, Cyprus, Malta and Egypt. Nowadays, several different species are cultured in the Mediterranean Sea, such as shellfish, trout and marine fish species. However, production focuses mainly on high value and high demand species such as turbot, gilthead seabream and European seabass. In Europe, several modelling strategies have been designed to improve managing environmental impacts of marine aquaculture (Cromey et al., 2002). The principal goal of the case study is to provide data for the validation of the modelling approach that is being developed in the Western Mediterranean.

THE APPROACH

The MERAMOD model was combined with RAC package to simulate effects of seawater temperature in the area of study on fish growth and metabolism. The RAC package simulates the rearing cycle of farmed European seabass (*Dicentrarchus labrax*) and gilthead seabream (*Sparus aurata*) at the population level (Baldan et al., 2018). RAC is released as open-source and can be freely downloaded from its website, https:// cran.r-project.org/package=RAC. The RAC package solves individual based bioenergetics balance allowing to extend the results to population level, using a set of Monte Carlo simulations in which some growth parameters are perturbed in order to reflect the natural individual variability. Water temperature time series for 2017–2018 were used to run the seabream population model at the case study. In order to upscale the individual to population model, a number of 5200 runs, each representing one individual with different initial weight, 80 ± 8 g, and ingestion rate, 0.09 ± 0.018 g food g fish day^{-1}, were run via Monte Carlo simulation. This number of model runs was empirically found to be the minimum needed to stabilize the results. The bioenergetics balance ordinary differential equation (ODE) is solved by using a 4th order Runge-Kutta method (Baldan et al., 2018). The equations implemented, and the parameters used are described in detail in Brigolin et al. (2014). Results outputs of population simulation were standardized to individual.

THE RESULTS

The population simulation of RAC model showed the increase of weight. Simulation of organic wastages reflects the seasonal variation of growth due to environmental condition of Mediterranean. These results were introduced in MERAMOD model to refine flux of waste material.

THE BROADER APPLICABILITY

This tool is easily applicable by the fish farming of the Mediterranean. This instrument provides a new approach by which producers can simulate management strategies taking into account their own limitations and the environmental restrictions imposed by the regulatory authorities. Incorporating this model in the management of an aquaculture company would be very useful in the planning and evaluation of the environmental degradation that may cause in the area that is located, or that will be located in the future. Therefore, the information obtained in this model serves as a support in decision-making when making the timely environmental assessment of aquaculture production, helping to reduce the impact that the company in question may have on the marine environment. Likewise, with this instrument they will be able to encourage the development of better practices that lead to a better perception and image of aquaculture. Cooperate to improve management measures such as, characteristics of the feed, quantities supplied in each shot, distribution of the species grown in the polygon, consider the changes caused by the change of seasons in management practices, etc.

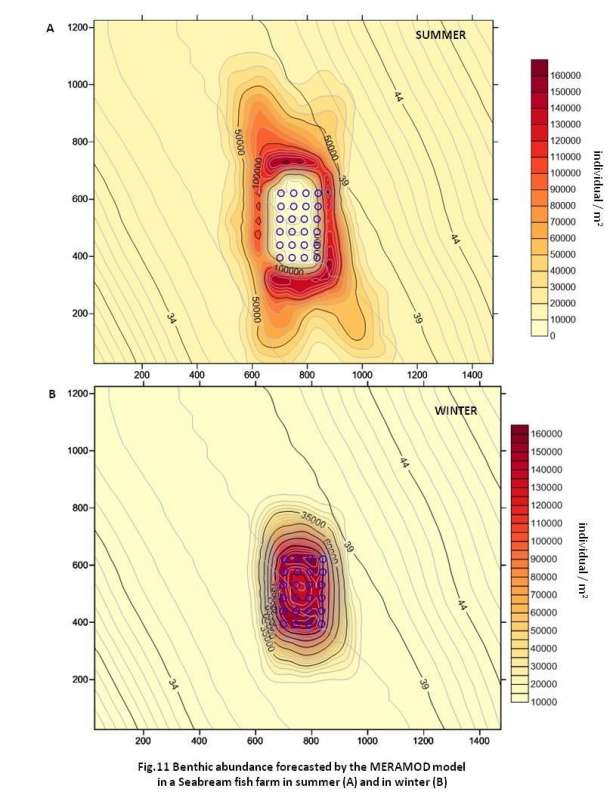


Fig.11 Benthic abundance forecasted by the MERAMOD model in a Seabream fish farm in summer (A) and in winter (B)

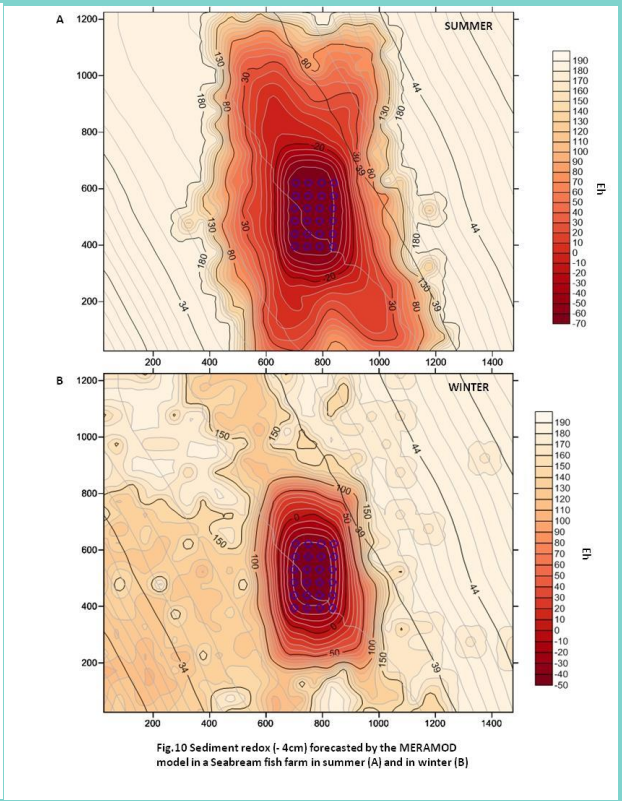
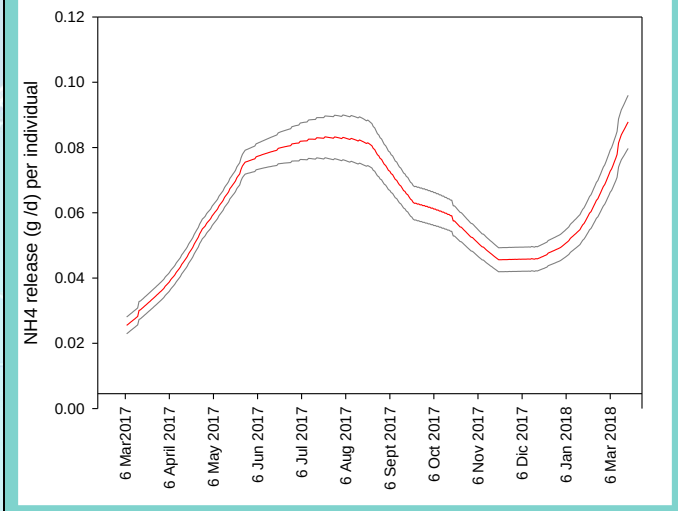
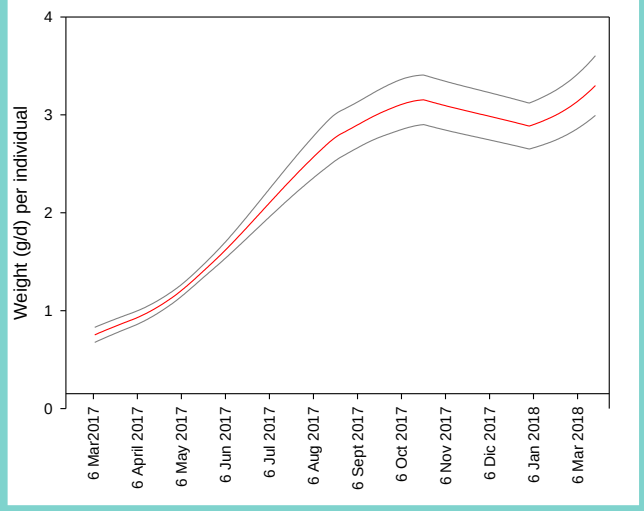
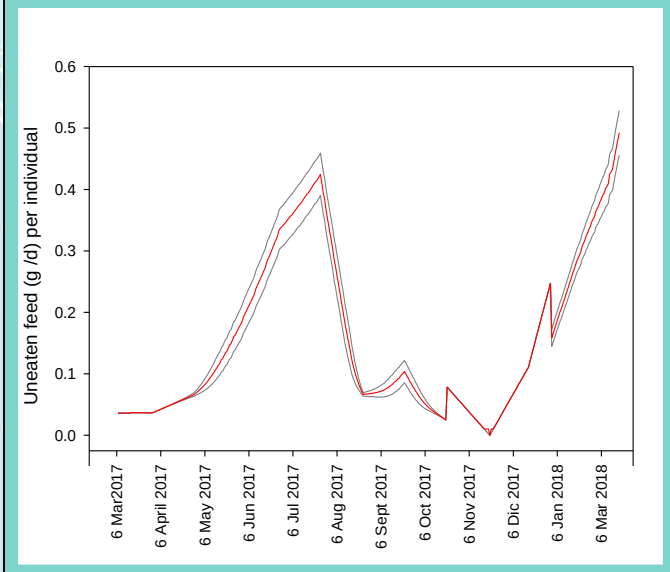
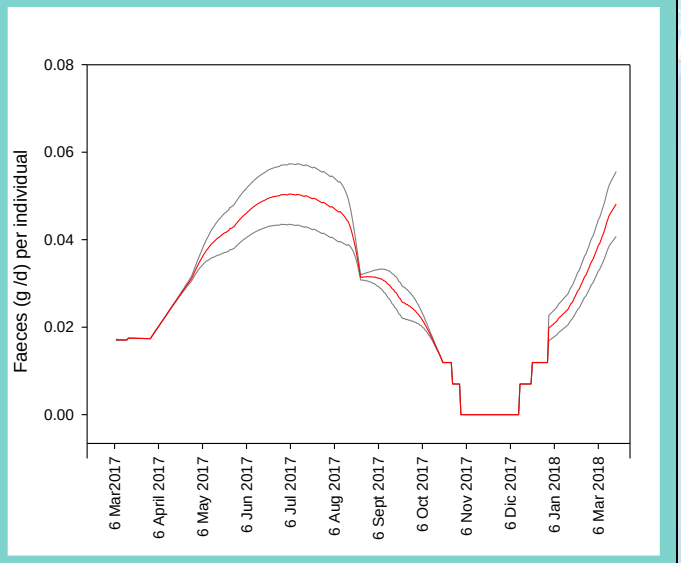


Fig.10 Sediment redox (- 4cm) forecasted by the MERAMOD model in a Seabream fish farm in summer (A) and in winter (B)









SWOT ANALYSIS	
STRENGTHS	If the required data is available, the tool is quick.
WEAKNESSES	MERAMOD model is not free, use Windows XP and it is not easy to use. As the model is hard-coded there are parameters that cannot be changed by the user and some of the assumptions and values used may not be suitable for all areas. RAC model need knowledges about R programme.
OPPORTUNITIES	Can be used to assess environmental impact of fish farming in Mediterranean.

THREATS	Requires measurements from fish marine farming which may not be available.

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LINK	Link to RAC: https://cran.r-project.org/package=RAC Link to MERAMOD guidance document: https://www.int-res.com/articles/aei2012/2/q002p157.pdf