## Application of System-scale and Farm-scale Ecological Models in Order to Quantify Interactions between Aquaculture and Environment Throughout the World

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Ecological models have been applied at different scales in many parts of the world to simulate the production of cultivated shellfish, and the positive and negative environmental effects of this culture, as well as for carrying capacity and site selection. We present examples of these applications for estuaries, bays, and inland cultivation in ponds, in order to compare the relative roles of different types of aquaculture.

We draw from case studies from Asia, Europe, and South America, for different species of shrimp and bivalves, to illustrate how models can be used for evaluating the environmental externalities resulting from these activities. Tools such as the Farm Aquaculture Resource Management (FARM) model can be used for the assessment of the production, profitability, and environmental footprint of bivalve shellfish cultivation, while the equivalent tool (POND) for land-based cultivation of finfish or shellfish provides decision-makers with an assessment of discharge to coastal areas. Both of these tools quantify a number of the relevant ecosystem goods and services, and allow farmers and decision-makers to experiment with different cultivation densities, siting, etc, without the corresponding financial, environmental, and social costs of direct implementation.

We also present examples from China and Brazil showing how models may be used to evaluate the role of integrated multi-trophic aquaculture (IMTA), both in ponds and open water, as a means to increase the yield of aquatic products, while reducing the environmental impacts of fed aquaculture. Finally, the modelling results from Brazil, Chile, China, and Ireland are extended to analyse the potential role of shellfish aquaculture in helping to manage nutrient inputs from land in the United States and in Europe, particularly as nitrogen and phosphorus loads shift primarily to diffuse sources.

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