Modelling of interactions between inshore and offshore aquaculture - DTU Orbit
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Offshore aquaculture is the subject of intense debate, focusing on feasibility, sustainability, and the potential for effective expansion in the context of competing uses of the coastal zone, and a world requirement for an additional thirty million tonnes of aquatic products by 2050. A modelling framework that integrates the SWAT model for the watershed, Delft3D for ocean circulation, and the EcoWin model for long-term (10 year) ecological simulations, was developed for integrated analysis of catchment, inshore waters, and offshore aquaculture, providing an approach that addresses production, environmental effects, and disease interactions. This framework was tested using a case study in SE Portugal, for a system-scale modelling domain with an ocean area of 470 km(2) and a coastal watershed area of 627 km(2). This domain contains an inshore area of 184 km(2) (Ria Formosa) subject to multiple (often conflicting) uses, including aquaculture of the high value (farmgate price > 10 epsilon kg(-1)) clam Tapes decussatus, and one of the first offshore aquaculture parks in the world, located at distance of 3.6 nm from the coast, at a water depth of 30-60 m, with an area of 15 km(2). The park contains 60 leases, of which at most 70% are for finfish cage culture, and at least 30% for bivalve longline culture. A substantial part of the dissolved nutrients required to drive primary production that constitutes the food source for clams originates from the coastal catchment. Although stakeholder perception is that nutrients are mainly linked to point-source discharges from wastewater treatment plants, watershed modelling indicates that 55% of the nitrogen and 70% of the phosphorus loads are from diffuse sources. The residence time of waters in the inshore area is low(1-2 days), and consequently pelagic primary production takes place offshore, and drives inshore clam production. The longline culture of Mediterranean mussels (Mytilus galloprovincialis) in the offshore park reduces inshore food availability for clams: simulations suggest that a 3% decrease in clam yields will occur due to offshore mussel cultivation, at a cost of 1.2 million epsilon. This is offset by revenue from offshore culture, but is a source of stakeholder conflict. Potential disease spread between the offshore and inshore systems was analysed using a particle tracking model, and allowed the development of a risk exposure map. This illustrates the challenges posed by hydrodynamic connectivity with respect to biosecurity of aquaculture and fisheries, both inshore and offshore. The model framework was also used for optimisation of stocking density, and analysis of combined culture of finfish and shellfish, both in terms of production and environmental effects. In the offshore aquaculture park, the models suggest that integrated multi-trophic aquaculture (IMTA) of gilthead bream (Sparus aurata) and Mediterranean mussels allows for an increased harvestable biomass of mussels, particularly at higher stocking densities, and offsets some of the negative externalities of finfish culture. By quantifying issues such as reduced yields for inshore stakeholders due to offshore activity, and illustrating the need for strong governance to offset disease risks, dynamic models make a valuable contribution in assessing the feasibility of offshore aquaculture, and the general principles that should underpin licensing and regulation of this sector. We stress the need to go beyond the conventional spatial planning toolset in order to ensure an ecosystem approach to aquaculture, and the opportunities that exist for applying a systems framework in an information economy, where the capital costs of software and data have been sharply reduced. (C) 2014 Elsevier B.V. All rights reserved.

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