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Modelling the Impacts of Finfish Aquaculture

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Abstract The main components of lagrangian (particle tracking) models used in the assessment of aquaculture impact have been reviewed. Trends in input data requirements have also been examined, with some emphasis on general modelling issues such as standardisation of data and scenario complexity. Specific data aspects were tested in a flux and benthic effects (impact) model and their importance assessed. Dispersion coefficients resolved from drifting buoy data were found to influence model predictions widely depending on the criteria used in the analysis. Different lengths of hydrographic data subsampled from a 206 day record measured at a Scottish fish farm also resulted in different model predictions. This highlighted the importance of taking representative hydrographic measurements for regulatory modelling of maximum farm biomass. Both cage movement and the timing of feeding and defecation events were also tested using observed data and found to be of less importance.

Keywords Aquaculture · Benthic impact · Dispersion · Model

1 Introduction

Models for predicting the dispersion and subsequent deposition of particulate aquaculture wastes have been in common use for a decade or more [1]. Given information on site depth, hydrodynamic conditions, settling characteristics of wastes and discharge rate of waste faecal and food particles, vertical particulate flux (g solids deposited m^{-2} bed yr^{-1}) at the sea bed can be predicted [2]. Through the years, these models have been developed using increasingly complex aspects of these fundamentals such as spatially varying flow fields and detailed bathymetry [3]. These developments have been partially driven by the recognition of certain important processes, but also by the increased availability and accuracy of instrumentation used for data collection. For instance, acoustic profiling instruments sample flow fields more accurately and frequently compared to the rotary instruments used in early studies. Settling velocity experiments are also increasing in accuracy and sample size. Until recently, emphasis was placed on feed pellets [4] as these were regularly wasted and readily available for experimentation. Now, as feed wastage is being reduced, research emphasis is switching to faecal material as this is the main component of the discharged waste. Physical and biochemical properties of the faecal material vary between fish species, size and diet and these are increasingly being measured and modelled.

Although some models which predict vertical flux alone are of interest, these lack processes such as resuspension which are fundamentally important in some environments. Redistribution of waste material and associated chemical components by this process requires quantification if realistic impact predictions are sought. Some advances have been made in validation of aquaculture resuspension models [5, 6], but problems exist in finding tracers representative of the farm waste, or in distinguishing farm derived from natural sediment in the erosion process. Having predicted flux before or after resuspension, many researchers use this information subjectively to assess farm impact. Some models take this a step further and predict benthic effects from relationships between predicted flux and a suite of benthic indices.

Clearly, the main modelling developments in the coming years are likely to be in biochemical components which link flux and benthic effects, as well as in the benthic effects relationships themselves. A model which can predict a biochemical component measurable in the field will be useful for monitoring of existing sites. Key research areas are also likely to be bioturbation and sediment consolidation processes, particularly important as sediment characteristics and fauna change widely along the organic gradient. As newer species are being farmed and different environments with improved husbandry characteristics utilised, refined models will become available.