AquaModel: Comprehensive Aquaculture Modeling Software

9

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AquaModel is a sophisticated, PC-based simulation program that provides data needed to evaluate the performance and ecological effects of proposed fish aquaculture farms. It is the first truly comprehensive model for net-pen aquaculture that simultaneously accounts for both water column and benthic effects. Interlinked submodels of fish physiology, hydrodynamics, water quality, solids dispersion, and assimilation were designed and preliminarily validated using field and laboratory data.

Decades of experience reveal a widespread confusion and misunderstanding of the effects of floating marine fish farms in the United States and elsewhere. The public, the news media, some government regulators, and even many scientists do not understand the basic principles of organic waste discharge and assimilation by marine food webs that permit well-sited fish farms to operate with little adverse effect and some marked positive effects on the aquatic ecosystem. AquaModel may also be used as a tool to graphically demonstrate how this occurs.

The system provides the user a 3-dimensional simulation of growth, metabolic activity of caged fish, associated flow and transformation of nutrients, oxygen, and particulate wastes in adjacent waters and sediments (Fig. 1). Often, other models deal only with benthic effects, run on mainframe computers and in sequential modules, do not allow the users to easily change key parameters, and do not allow interactive display of results for short and long time periods. In contrast, AquaModel runs on personal computers and describes benthic and water column effects concurrently. It has additional features not found in other models such as oxygen deficit plume modeling, sediment oxygen perturbation, phytoplankton stimulation, and zooplankton growth results from nutrient addition. A few options are shown in Figure 2.

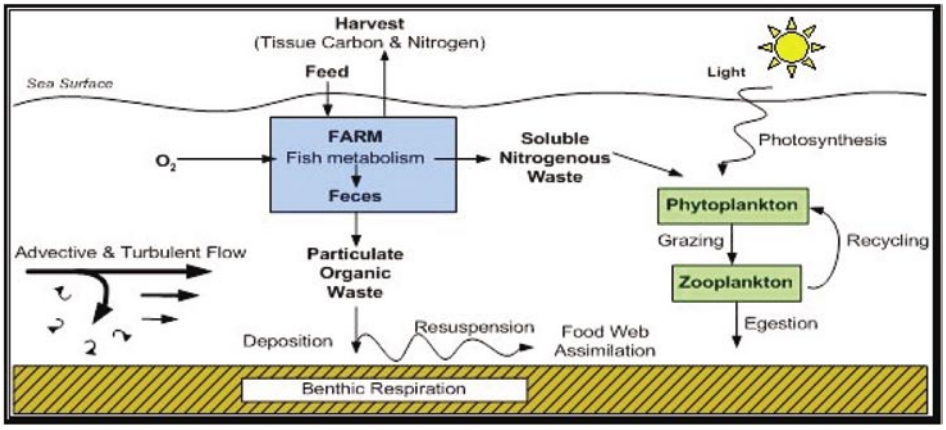

Figure 1. Overview schematic of AquaModel components and dynamics in the marine ecosystem.

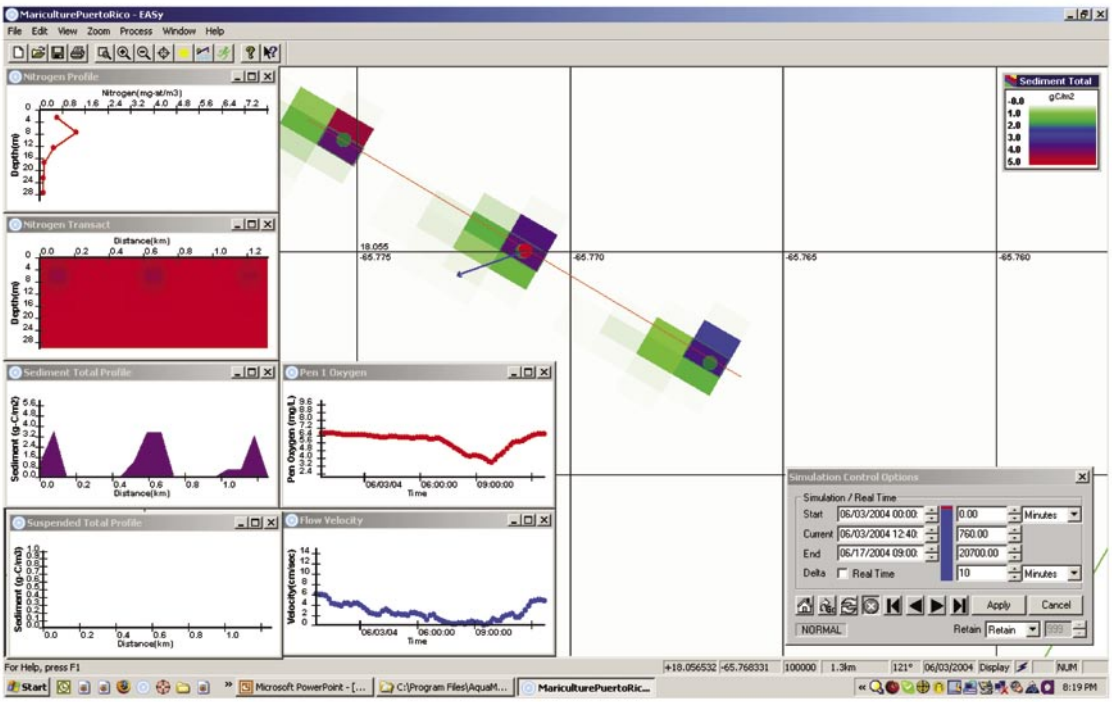

Figure 2. Example screen print of submerged fish farm model run, with main scene showing deposition state of carbon on the sea bottom near three fish farms of differing fish biomass. The dot in the center farm is to position a vertical profiling point, and the diagonal line is a horizontal transect line through all three farms. The X-Y plots show the results of the profile and transect from top to bottom, left to right: nitrogen profile, nitrogen transect, sediment carbon profile, suspended layer carbon profile, oxygen within the center cage, and relatively slow current velocity plot. The box in the lower right contains time step control options.

AquaModel uses Windows® PC operating systems, has drop down menus, uses data from a current meter, tidal cycle, or output from other hydrodynamic transport models, and it includes dozens of easily varied settings (e.g., fecal sinking rates, water temperature, feed rate, feed loss rate, etc.). It allows simulation of the effects of culture of a variety of fish species including salmonids and marine fishes. It resides within a 3-D Geographic Information System (GIS) program known as EASy[1] that was designed for oceanographic use and is compatible with other commonly used 2-dimensional GIS software. State data from user selected locations in the model runs can be exported to spreadsheets to evaluate compliance with sediment or water quality impact zone boundaries. The model allows the viewer to compute, visualize, and store data describing the distribution, transport, transformation, and assimilation of dissolved nutrients and carbon-containing solids. The user can also concurrently evaluate oxygen-deficit plumes, sediment oxygen content, phytoplankton nutrient uptake, and growth and resultant zooplankton grazing.

AquaModel provides a user-friendly means to expedite aquaculture planning and permitting as well as providing a guide to target monitoring over appropriate spatial extents. This comprehensive system supports administrators in evaluating proposed sites or performance standards, provides operators with data needed to obtain permits, and provides investors with information needed to assess risks and opportunities. It is also provides a basis of a future

[1] For more information about AquaModel and links to EASy GIS software see *http://netviewer.usc.edu/aquamodel/index.html*

expanded systems for regional assessment of multiple farms. When it is equipped with real-time sensor input, it provides a means to optimize fish production, minimize impacts, and integrate shellfish and seaweed culture appropriately.

Physiological submodels for Atlantic salmon (*Salmo salar*) have been developed and preliminarily validated for relatively high velocity sites. A cobia (*Rachycentron canadum*) submodel for use in offshore waters of tropical areas has also been developed and data on other marine fish species are being collected. Extensive additional validation and tuning studies for several species are currently being planned, and the developers of the model and software are actively seeking tropical and temperate water fish farms to participate in cooperative monitoring, validation, and research.