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Enhancing the POND© Decision Support System for Economics, Education, and Extension

Ninth Work Plan, Decision Support Systems Research 3 (9DSSR3)
Progress Report

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Abstract

This study deals with development of decision support tools for warmwater pond aquaculture. Efforts are directed at refining the POND© software and developing a new farm-level decision support tool. Refinements to POND© focus on general issues related to program maintenance, enhancements to the enterprise budgeting tool within POND©, and a task-oriented interface for assisting users in accomplishing specific activities within the tool related to educational and extension application. A brief summary of AquaFarm©, a new aquaculture decision support tool developed in part with PD/A CRSP support, is presented.

Introduction

Successful pond planning and management requires the integration of a host of information related to pond dynamics and water quality interactions, fish growth and development of diverse culture organisms, and economic analyses. Decision support software provides a vehicle for collecting, organizing, and analyzing this information in a consistent manner. Decision support tools can capture current state-of-the-art knowledge of system dynamics, processes, and interactions, and organize these in manner that allows users a convenient ability to further their understanding of the system of interest.

The PD/A CRSP has been involved with the development of decision support software for aquaculture systems for a number of years, resulting first in the PONDCLASS software (Lannan, 1993) and then the POND© software (Bolte et al., 2000). POND© provides the ability to simulate pond dynamics and fish growth for warmwater pond aquaculture facilities and to compute enterprise budgets relating various costs and returns from a particular facility to determine short- and long-term profitability. The growth and water quality models embedded in POND© have been widely validated using data from both PD/A CRSP sites and other warmwater aquaculture sites. Previous efforts at developing POND© have focused primarily on developing the underlying model used by POND© for decision support, and these efforts have been largely successful. Current efforts are focused more on improving the usability of POND© for addressing specific, frequent tasks and increasing its enterprise budget capabilities.

The POND© software has had limits in the types of systems it could be applied to. For example, to maintain a relatively simple learning curve, POND© focused exclusively on semi-intensive, warmwater systems. More recently, as more-intensive systems have become an important part of commercial aquaculture, the need for more-sophisticated models and decision support tools, addressing more-sophisticated systems, has become apparent. To address this need, a new tool, developed partially with PD/A CRSP support, has been created.

Approach and Results

The underlying approach for the development of the POND© software has been described elsewhere in detail (Nath, 1996); here we provide only a brief summary of this approach. POND© was built using an object-oriented design paradigm. Object-based systems represent the target system by providing representations for the underlying components of the real systems and by defining behaviors describing the interactions of these components. For POND©, fish ponds and fish lots provide the key representations of objects in the production facility. Additional objects representing "experts" managing the facility were defined. These experts included:

1) An aquatic chemist, with the ability to perform a wide range of water chemistry calculations;
2) An aquatic biologist, with the ability to perform functions related to fish growth and algal dynamics;
3) A weather manager, with the ability to estimate weather conditions for specific sites;
4) An aquacultural engineer, with the ability to perform heat and water balance calculations, among others; and
5) An economist, capable of performing enterprise budget analyses and managing costs of various facility operations.

By collecting instances of these objects together in a simulation framework, it becomes possible to simulate facility dynamics in a way that closely mimics the dynamics of real aquaculture facilities. In POND© these include fish performance, water temperature, water quality dynamics, and primary and secondary productivity. Models of water quality dynamics are organized hierarchically into two levels, allowing users to perform different kinds of analyses based on data availability and output resolution requirements. Level 1 models are fairly simple, require minimal data inputs, and are intended for applied management and rapid analysis of pond facilities. At this level, the variables simulated are fish growth (based on a bioenergetics model) and water temperature. Consumption of natural food by fish is assumed to be a function of fish biomass and appetite. Fertilizer application rates are user-specified, but

the model optionally generates supplementary feeding schedules. Level 2 models provide a substantially more sophisticated view of pond dynamics, allowing prediction of phytoplankton, zooplankton, and nutrient dynamics (carbon, nitrogen, and phosphorus), in addition to fish growth and water temperature. This modeling level is intended for detailed pond analysis, management optimization, and numerical experimentation. Fish can feed from natural and/or artificial food pools. Consumption of natural food (phytoplankton and zooplankton pools) by fish is predicted on the basis of a resource competition model and also depends on fish appetite. At this level a constant user-specified concentration of pond nitrogen, phosphorus, and carbon is assumed. Mass balance accounting for each of these variables is maintained, allowing estimation of fertilizer requirements necessary to maintain steady-state levels. Both fertilization and feeding schedules are generated by the models.

An important aspect of POND© is the ability to incorporate the results from the pond dynamics simulations, with additional information, into an enterprise budget. These budgets allow for the accumulation of various types of costs and incomes, summarized and coupled with interest and depreciation expressions, to assess the overall economic viability of a particular production enterprise.

Current efforts for POND© development are focusing on enhancing the economic capabilities of ponds. The first of these is the support of partial budgeting. The second is the inclusion of time-based costs. These can include periodic costs (i.e., costs that recur at specific periodic intervals) and costs that are scheduled to occur only at specific times and with specific durations. The inclusion of such costs has allowed POND© to be used to more directly simulate the medium- to long-term dynamics of production facilities, as well as to facilitate the examination of the economics of facility production during specific production windows.

Additional efforts are focusing on creating task-oriented user interfaces. We started this recently with the inclusion of "wizards" for automating key simulation tasks. We are now extending this metaphor for the development of design and analysis tasks. For example, wizards are being developed to size ponds to meet specific production targets under particular climatic and production regimes, provide optimized feeding schedules to hit particular production targets, and develop nutrient budgets for specific production strategies. We will be continuing to develop these wizards over the next year in collaboration with our cooperators.

In addition to these activities related to the POND© software, we are releasing this year an additional decision support tool, AquaFarm©. AquaFarm© provides simulation of physical, chemical, and biological unit processes, facilities, and management systems for a broad class of aquaculture systems, including semi-intensive and intensive systems. It incorporates and extends many of the components of the POND© model, including economic analyses but further provides more detailed unit process descriptions and more robust analytical capabilities. It allows simulation of broodfish maturation, egg production, and grow-out of finfish or crustaceans in cage, single pass, serial reuse, recirculation, or solar-algae pond systems. AquaFarm© allows the iterative refinement of design specifications for a production facility by simulating production dynamics with feedback when production goals are not satisfied, allowing users to rapidly fine-tune facility design and management to meet specific criteria. A more complete description of AquaFarm© is given by Ernst et al. (2000).

CONCLUSIONS

The design, development, and implementation of the POND© software have provided useful lessons in several areas. As the user base for POND© has grown, we have had the opportunity to solicit feedback on how well POND© is addressing user needs. The first lesson is that a diverse group of users has used POND© to address a diverse group of needs. Although we originally anticipated a research-focused audience, our largest group of users has been commercial aquaculture facility managers. The primary focus of this group has been economic analyses, with the utility of the biological models contained within POND© of secondary importance. An additional audience has been educators using POND© in the classroom as a tool for examining pond dynamics, where the biological models play a more important role. Each of these groups has a different set of interests and a different user interface requirement, and a "one size fits all" approach will not be optimally successful at addressing their needs.

A primary feedback from POND© users involved the ease of use of the software. Although we have spent considerable effort in developing a modern user interface for POND©, because of the underlying complexity of the models POND© employs and our desire to fully expose these models, the user interface proved to be burdensome for many users. While exposure of the underlying models is helpful to those focused on understanding the detailed biological dynamics of these systems, it is less helpful or irrelevant to those focused primarily on economic analyses of facility operations. We are addressing this issue in upcoming releases of POND© in two ways. First, the focus of POND©, from a user interface perspective, is more on decision support and less on models of the underlying biological system. While the underlying models continue to be an essential tool for supporting decision making, they are less apparent to the user, operating in the background but playing a secondary role to higher-level decision-making processes. Second, we have introduced a series of wizards into POND©. These wizards are software tools that walk users through specific frequently used tasks, hiding much of the complexity of these tasks and providing immediate help to users in accomplishing their goals. We anticipate continued development of these wizards to address specific needs of different user groups and to improve ease of use of the program.

The target audience for POND© continues to evolve. The bulk of our requests come from commercial producers looking for tools to improve their ability to design and manage their facilities. A second audience for which we have seen numerous requests is small commercial interests, often new to aquaculture, who are looking for tools to help them explore the financial feasibility of launching an aquaculture venture. Both these groups tend to focus primarily on economic analyses but require some basic understanding and consideration of the biological and chemical processes underlying facility operation. A final audience outside the research community is aquaculture educators. Their requirement is for readily accessible tools that students can use in class to enhance their understanding of the biological processes controlling aquaculture ponds, as well as to complete specific design tasks related to facility management.

ANTICIPATED BENEFITS

This study is expected to result in the following benefits:

- Enhanced ability to perform sophisticated economic analyses of production facilities;
- Development of feed optimization strategies for pond management;
- Improved student understanding of pond dynamics and production management principles;
- Enhanced capability to utilize POND© in applied pond management and facility planning; and
- Enhanced decision support tools for facility design and consulting.

LITERATURE CITED

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