POND© SOFTWARE DEVELOPMENT AND REFINEMENT

Eighth Work Plan, Decision Support Systems Research 1A, 1B, and 1C (DSSR1A, 1B, and 1C)
Final Report

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ABSTRACT

The POND© software has undergone continued development during the Eighth Work Plan. In addition to the model and user interface improvements accomplished during the first year of the work plan, additional work on the development of wizards for automating and completing specific frequently used tasks, model refinement and development, and economic decisionmaking was accomplished. Wizards were refined to improve their usability, and new wizards were developed to assist in determining water balances and water requirements and to interpret simulation results. Models of fish production were refined and calibrated. The ability to schedule tasks of fixed and period duration was incorporated into POND© and the associated enterprise budgeter. An economic module estimating production cycle costs and returns was developed to assist in determining optimal harvest points based on the value of different fish sizes.

INTRODUCTION

The POND© software is in the third phase of iterative refinement (Nath et al., 1995; Nath, 1996). The first phase of development resulted in Version 2.0, which was subsequently improved in Versions 3.0 and 3.5 to include consideration of water budgets, preliminary assessment of feed quality and of nutrient fluxes in pond sediments, improved routine fertilization guidelines, and parameter estimation techniques. Documentation of improvements that have been made to POND© in terms of model refinements and enhanced capabilities for decision support are the focus of this report.

POND© DEVELOPMENT

The development of prototype "wizards" in POND© was initiated in 1997. The intent of the wizard development was to provide an enhanced user interface for accomplishing frequently used, predefined tasks within POND©. The wizards were set up to prompt the user for specific information needed to accomplish the task under consideration, and step the user through the task sequentially, explaining the requirements of each step along the way. The first iteration of wizard development was initiated in the first half of the Eighth Work Plan. The discussion here describes the wizards that have been refined and developed during the second half of the Eighth Work Plan.

The development of specific wizards was driven by: 1) identifying frequently used application areas within POND© and 2) identifying areas which were sufficiently complex to warrant additional user support. This resulted in the development of the following wizards:

- A *pond setup* wizard to enable users to define new ponds at their facility;
- A *lot setup* wizard to enable users to define new lots that are associated with specific ponds;
- A *fertilizer* wizard to generate routine pond fertilization recommendations;
- A *liming* wizard to estimate lime requirements for ponds associated with specific soil types;
- A *feed optimizer* wizard to generate feed schedules that minimize the amount of feed needed to reach a specified fish target weight;
- A *water balance* wizard to conduct water balance calculations and estimate water requirements;
- An *economics* wizard to assist in calculating enterprise budgets and optimizing economic performance; and
- A *simulation* wizard to conduct facility-level simulations at a given site and view simulation results in graphical and tabular formats.

The primary focus of development this past year was on the water balance and economic wizards. The water budget model has been incorporated into POND©. The complete details of the water budget model are presented in Nath and Bolte (1998) and are summarized below.

Water Budget Model

The water budget simulation model is used for forecasting water requirements for aquaculture ponds. Water sources considered in the model include regulated inflow (Q_i), precipitation (P), and runoff (R). For many levee ponds, the latter source is negligible. Water losses include evaporation, seepage, effluent discharge, and overflow. Water sinks include regulated water discharge (Q_o), overflow (O), and evaporation (E). Water seepage (S) may occasionally be a source of water (e.g., for ponds constructed in areas with a high water table), although it is typically considered to be a sink.

Pond water inflow may be either intermittent (e.g., when water is added to maintain a desired pond depth) or continuous (e.g., a flow-through pond). Water gain from rainfall falling on the pond surface is calculated from precipitation data for a given location. The *curve number method* developed by the US Resource Conservation Service (NRCS) offers a simple procedure for estimating runoff from ungauged watersheds (USSCS, 1972). The method involves assessment of the antecedent soil moisture, hydrologic soil group, land use, and hydrologic condition for a given location. The NRCS developed a series of curves that relate combinations of the above factors with the expected runoff given the amount of rainfall produced by a storm. Curve numbers (CN) for different combinations of soil, land use, and hydrologic conditions have been tabulated by the NRCS.

Pond water may be discharged continually (e.g., in a flow-through pond) or intermittently (e.g., at harvest time or to alleviate poor water quality). The latter situation is difficult to assess *a priori* and is therefore not considered in the present model. Pond water overflow is set to zero unless the water level exceeds a maximum depth, a situation that typically depends on the depth of the drain pipe. Pond water loss or gain by seepage depends primarily on the soil porosity, methods used for pond construction, structural changes that have occurred to the pond basin over time, and pond management practices (Boyd, 1982; Teichert-Coddington et al., 1989). Pond water evaporative loss is estimated as a function of ambient air temperature, relative humidity, and wind velocity.

The model has been validated for ponds located at the Asian Institute of Technology (AIT), Thailand, and at El Carao, Honduras, which are respectively located in the humid and dry tropics. Simulation results indicated that precipitation accounted for 69.8% of the total water gains for AIT and 43.2% for El Carao. Regulated inflow provided 27% of the gains for AIT and 52.8% for El Carao. Runoff gains were minimal at both locations due to small watershed areas. Evaporation accounted for 54.9% and 40.1% of the overall water loss predicted for the AIT and El Carao locations, respectively, with seepage accounting for the remaining loss. Predicted water requirements at AIT over a five-month period exceeded actual amounts by 14.9%, apparently because seepage loss was overestimated. For El Carao, however, predicted water requirements were only 78.2% of the amount actually added, apparently due to poor estimates of evaporative water loss which averaged 0.32 cm d^{-1}, compared to pan evaporative measurements of 0.43 cm d^{-1}. In contrast, the predicted evaporative water loss for the AIT pond (0.47 cm d^{-1}) closely matched pan evaporation measurements (0.45 cm d^{-1}). The availability of relative humidity and cloud cover data for AIT explain the higher accuracy in evaporative water loss estimates, and therefore water requirements, compared to El Carao. If comprehensive weather datasets are available, the water budget model developed herein is a useful tool for estimating pond water requirements at individual facilities located in different geographical regions.

The Economist

One area where we have received considerable interest in further developing POND© deals with its enterprise budget capabilities. The economic analysis module currently is handled by an Economist object which manages economic calculations and enterprise budget generation. The Economist is capable of handling a number of different types of cost and income items, including fixed, variable, and depreciable costs. Enterprise budgeting involves summing all cost and income items, accounting for interest cost and depreciation costs. Within POND©, certain costs and income items are automatically generated based on the results of a facility simulation, e.g., income from produced fish.

Additions to the Economist module accomplished during the second half of the Eighth Work Plan include: 1) the ability to manage time-variant costs and 2) capabilities for optimizing facility management as a function of production cycle length. The ability to manage time-variant costs is important in addressing scheduling issues and costs which are tied directly to a production cycle; they also allow the Economist to generate multiyear budget scenarios tied to extended facility dynamics. This capability also relates to the capability for optimizing facility production based on production cycle lengths. To accomplish this, income values associated with different size classes of produced fish are required. Using this information, the Economist can calculate and present total enterprise costs and income based on the cumulative fixed, variable, and depreciable cost and the value of the produced fish. Optimal harvest, where the marginal cost of increased production is equal to the marginal return in produced income, is readily determined from this information.

ANTICIPATED BENEFITS

The anticipated benefits of this research include improved simulation of production facility dynamics and improved model usability via the wizard interfaces. Also, the incorporation of an extensive water balance module improves POND©s ability to provide reasonable forecasts of water requirements at different sites under different water management regimes. Finally, the enhancements to the POND© Economist to allow consideration of scheduled costs and estimate within-cycle production costs and returns will allow users to determine optimal harvest points during the production cycle.

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