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# Automation for intensive fish hatcheries

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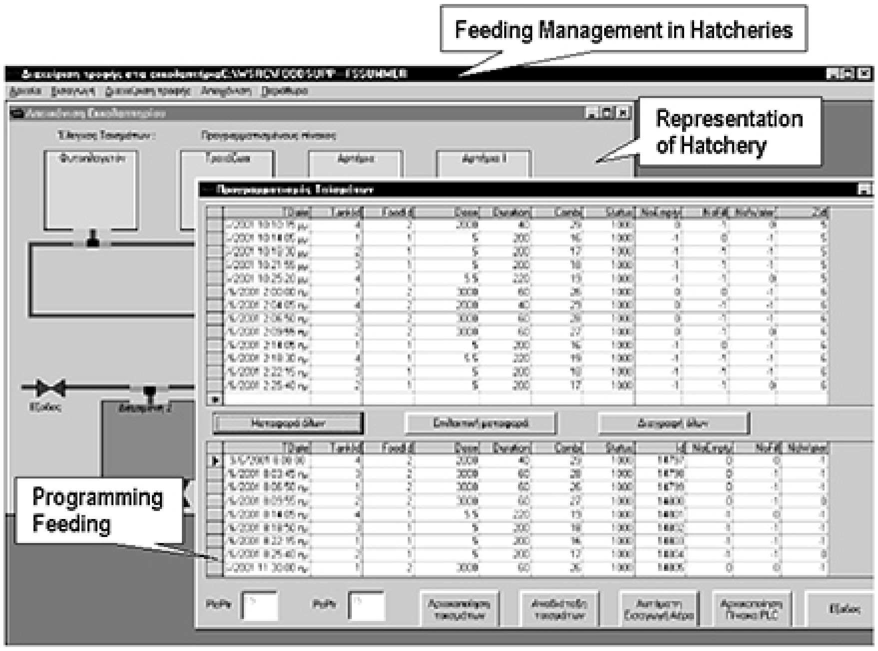
## IMBC develops computer-based feeding system

Aquaculture's recent and rapid development intensified all production stages and caused a need for new approaches to farm management – including the automation of several production steps. In response, computer-based systems were developed for monitoring abiotic parameters, feeding in cages, fish sorting, and simulation and decision support.

In hatcheries, successful larval rearing depends upon meeting larval metabolic demands with continuous feeding. A pilot-scale computer-based feeding system developed at the Aquaculture Department of the Institute of Marine Biology of Crete (IMBC) may now provide a user-friendly control environment adapted to the conditions of intensive industrial hatcheries.




Screen view of IMBC feeding programming interface.

## Automated quantity and frequency

Developed from previous studies on the feeding requirements of sea bream (*Sparus auratus*), the system is based on a standard feeding table that describes feed quantity and distribution frequency per food type according to the age of the reared larvae.

From these standards, a proposed daily feeding table is created by the system for each rearing tank. Based on predefined rules and user-defined parameters, the system groups feedings according to food type, and mobilizes the actions for cleaning the transferring circuit with fresh water and/or air.

## System controls

The hardware of the system comprises a personal computer with installed software, and a programmable logic controller (PLC) connected to the PC. The PLC controls the feed distribution equipment, which consists of a peristaltic pump that transfers plankton organisms from their stocking silos to the larvae tanks, and solenoid valves that control the direction of flow.

The Windows®-based software makes it possible to program the system through menus, view its operation, and import production data. The system is initiated with the introduction of new egg batches identified by the incubation and hatching date. Following this, the required substructure for the monitoring of each batch is created for the rest of the rearing period.

## Modes

Two feeding modes are available: manual and programmable. In the manual mode, the user can easily define the food type and quantity to be applied to each tank. In programmable mode, the standard feeding table is used. Every day the user recalls the proposed feedings for all tanks, and the system creates a table with the feedings for the day, which the user can easily adjust if needed.

In the programmable mode, the system is autonomous for 24 hours. Optionally, the system can be connected to online monitoring systems for abiotic parameters (temperature, dissolved oxygen concentration, and pH) in larval tanks.

However, it is difficult to accurately predict quantitative feeding requirements for optimum growth during larval rearing. Even when known, these requirements can change according to the behavior and other characteristics of each population reared. Thus, computer-based feeding systems require tools for adjusting the amounts of food delivered, based on the particular current needs of the targeted population.

## Optimized feeding

In this system, "fuzzy logic" was used to develop a controller to optimize feeding. It is based on the input from several linguistic variables describing the system.

View of a computer-based feeding system in a larval-rearing unit.

The output is provided by an inference procedure using a knowledge base with a set of "if-then" rules. These rules incorporate and describe experimental data and previous experiences with the system to optimize its performance.

Total larvae length, mortality rate, and the amount of food delivered were chosen as the main linguistic variables describing the system, together with a variable describing zooplankton availability to the larvae. The controlled variable defines the changes that should be applied to the food quantity.

## Expert system

The function of the controller is to maintain the system as close as possible to the conditions determined as optimum. However, the rule base (consisting of 316 rules) is designed to support better performance of the population in terms of growth and survival, when improved conditions occur. The final result is considered an "expert system."

## Pilot testing

The IMBC feeding system was tested on a pilot scale with sea bream, a species of high economic interest for the Mediterranean. It showed a significant reduction in the time required for feeding, with an

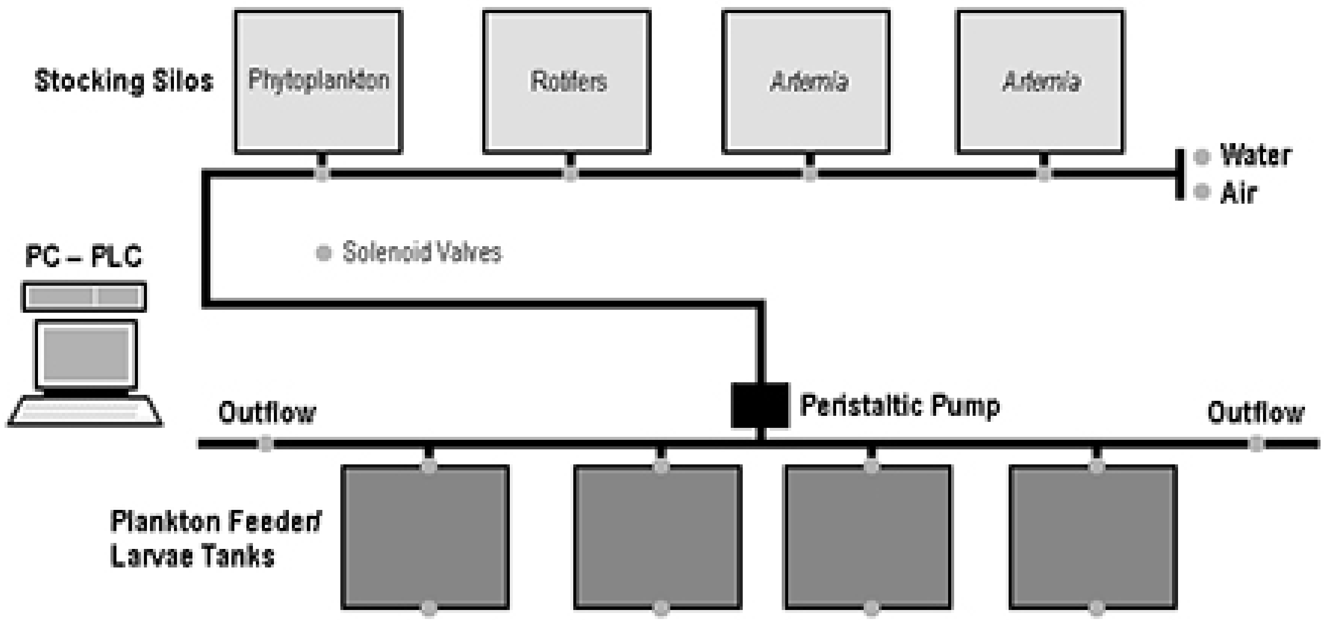



Diagram of the IMBC feeding system, with live food tanks (phytoplankton, rotifers, and Artemia) and automated feeding equipment, including the transferring circuit.

estimated reduction in labor required of 30 to 40 percent. The food distribution pattern selected allowed stable zooplankton availability to the larvae, in contrast with the classical method, when shortages can occur during the night.

# Conclusion

The computerized system for automated feeding developed by the Institute of Marine Biology of Crete requires limited hardware, is compatible with other software, and can incorporate user requirements. In initial form, the feeding system has shown good biological and managerial results.

The system's programmable logic controller facilitates the use of computer-based feeding during the early stages of larval fish by following changes in the population and potential fluctuations between actual and estimated larval requirements. When connected to current monitoring equipment, the system shows additional potential for the management of intensive hatcheries.

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