ARCHITECTURE FOR AUTOMATION AND TELEPRESENCE IN A MARINE HATCHERY LABORATORY

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Outline

• Background - automation and marine larval and juvenile production

• The CodTech marine hatchery automation laboratory

• Development of an infrastructure for automation and telepresence in CodTech

• Lessons learned
Larviculture: A process-oriented perspective

Production consists of a set of processes that are:
- dynamic
- interdependent
- asynchronous
- required to operate within certain limits and at certain rates

Production goals:
- Maximize fry quality
- Maximize capacity
- Maximize robustness
- Minimize costs
- ++

+ Water management system
+ Climate control system
+ Hygiene and cleaning system
Controlling the production system optimally is a complex task.

What tools are there to help us?
Automation

The collective use of machines, sensors, computers, ICT and automatic control to optimize capacity, quality, robustness and costs of a production process

- Automation is generic and one of modern society’s “enabling technologies”
- Marine hatcheries should benefit from the lessons learned in other industries where automation is well established
- Traditional view of just saving labour costs is too narrow and must be abandoned
  - Accuracy and consistency in operations → quality and robustness
  - New modes of operation that are impossible to implement with manual labour
- Automation required to achieve productivity and quality goals when scaling up and industrializing marine hatcheries
Automation tools
Challenges

Nevertheless, “larviculture specialities” must be kept in mind:

• Complicated biological processes
  – Process knowledge sometimes limited

• Product is live organisms
  – Careful handling, ethical issues

• Special instrumentation needs
  – Can it be measured in a practical way?

• Challenging environment
  – Delicate electronic equipment in a wet and corrosive environment
CodTech
- Marine hatchery automation laboratory

• Research on larval production protocols
• Initially designed for cod larvae production
• Test-bed for hatchery automation technology
Laboratory sections

• Start feeding
  – 18 larval tanks
  – Robotic feeding

• Live feed production
  – 12 production tanks
  – Rotifers, Artemia, copepods, algae

• Water supply system
  – SW, fresh
  – Raw, matured, recirculated
First feeding section

- 18 tanks, $V = 160$ liters
- Feeding robot
  - 3 live feed silos, 2 dry feed silos
  - Automatic refill station
  - Feeding tables or feedback controlled appetite feeding
- Automatic live feed counting and logging
- Automatic live feed density control
- Water quality and flow monitoring and control
- Lighting control
- In-tank video cameras
- Lab floor video camera
- Network access
Integration issues

• System comprises a diverse set of equipment with:
  – different user interfaces
  – different communication interfaces
  – different modes of operation

→ No common point of entry
→ Communication between subsystems difficult
→ Confusing and inaccessible for the operator
→ Higher risk of doing errors

Solution for “gluing” subsystems together to form one coherent and user-friendly system needed
CodTech automation solution

- Based on Proview – open process control system
- Modular design
  - Development station
  - Process station
  - Operator station (HMI)
  - Storage station
- Open and extensible
- Flexible integration of many types of instrumentation
- Free…
Remote access

• Networked computers monitor and control an increasing number of laboratory tasks
• Makes remote access to laboratory resources over the Internet possible:
  – Real-time data always available
  – Closer follow-up of experiments
  – Adds flexibility to management of experiments
  – Telepresence

→ However, security needs to be handled carefully
• CodTech is part of the EU FP7 Capacities project AQUAEXCEL (Aquaculture infrastructures for excellence in European fish research, www.aquaexcel.eu)

• Supports transnational access to facility for guest researchers

• System for remote access and telepresence in CodTech facility under development to facilitate remote users
  – certain aspects of experiments may be followed up from “home”
  – remote real-time and historical data monitoring
  – visual feedback from the lab floor, from robot and inside tanks
  – use the feeding robot to “move around in the lab doing things”
Architecture for remote access

Network security provided by:

- Physically isolating the automation network
- Forcing all access through a dedicated security appliance
- VPN login and firewall mechanisms
- Introducing user categories and privilege levels
  - Administrator
  - Privileged
  - Guest user
Some lessons learned

• Designing an automation system ad hoc may lead to integration issues as it grows in size and when more advanced functions need to be implemented
  – You will eventually need a solution for tying everything together
  – Good solutions available, but design needs careful planning

• Requirements to the automation system can generally be divided in two categories
  – Standard requirements → solved by “of-the-shelf” components
  – Process-unique requirements → purpose-built instrumentation and control systems must be developed and commercialized

• The latter category demands
  – Resources to R&D
  – A strong and competent industry
  – Cross-disciplinary cooperation between biologists and engineers
Thank you for your attention