ICES STATUTORY MEETING 1993 C.M.1993/F:45/Session T

HYDROACOUSTIC MONITORING OF FISH IN AQUACULTURE, - A METHOD FOR AUTOMATIC FEEDING CONTROL BY DETECTION OF FISH BEHAVIOUR.

By
Torfinn Lindem and Driss Al Houari,
University of Oslo,
Dept. of Physics, P.O.Box 1048, Blindern,
N-0316 Oslo, Norway.

ABSTRACT.

A small hydroacoustic system has been designed to work on-line with a personal computer. A wide beam transducer is located under the net cage. Echograms in colour from one to twelve cages can simultaneously be presented on the computer screen.
Fish distribution in different layers close to the surface is monitored and analysed during feeding. Distribution of food is stopped by the computer if feeding behaviour (activity) is reduced to a pre-set level. An accounting is made on total feeding time and food consumed in each cage.
The program has made it possible to reduce/eliminate food waste, - an important factor in reducing pollution from fish farming. At the same time production costs have been reduced.
Different forms of alarms have been tested. On changes in appetite, - an indication of disease or dangerous changes in the environment like blooms of poisonous algae.. On changes in biomass, - an indication on damaged net or theft.
The whole system can be operated via modem. All system commands and pictures of the fish distribution can be accessed by a remote computer.
Up to twelve transducers and twelve feeding systems can simultaneously be handled by the system.

INTRODUCTION.

Diseases and food vast have for a long time been limiting factors for an optimum production of salmon in sea cages. It has become obvious that the future success of this new industry will depend on how able we are to keep the best possible environment in the rearing cages.

Fisheries biologists have been looking for indicators which can give the fish farmer an early warning on changes in environment or health condition. (Bjordal et al, 1986)

Changes in fish behaviour can be used as such an indicator.

Until recently fish monitoring has been limited to inspection of fish activity at the surface. With the development towards larger and deeper cages, the need for hydroacoustic monitoring of fish deep into the cage has emerged. (Bjordal et al 1993).

The Institute of Marine Research, Bergen started to use echo integrators to monitor salmon in net cages back into 1986. However, they where using large and expensive SIMRAD QD echo integrators which put limitations to their work. By making some minor modifications to a small echo integrator which was developed at the Department of Physics, University of Oslo in 1985 we came up with a low cost system for such experiments.

The echo integrator was based on a personal computer and with few modifications we got a program which could keep track of each individual echogram from 12 transducers. Integrated data from fish in different depth layers where put into separate data files .

This system was used for several years in behaviour studies of fish in net cages at the research station in Austevoll outside Bergen.

During these experiments a continuos development in software and hardware took place with Lindem Data Acquisition (LDA) to come up with a system for commercial use in aquaculture. A complete new concept was released in 1990 under the name "Cage-Eye".

The PC based echo sounder and echo integrator is specially designed for use in aqua culture. It has a "20log R" time varied gain function (TVG) with a range from 3 to 40 meter. All mechanical parts i.e. relays have been chosen with care having in mind that these components should last for many millions of operations. After three years of testing it looks that we have got a robust and stable system.

SYSTEM OVERVIEW.

The central unit in the Cage_Eye system is a personal computer with a high resolution display (VGA). Data processing and feeding control is build around a time sharing kernel. This mechanism allows the system to simultaneously process and display data from 12 cages, while having control over the various feeding sessions and regimes.

The echo sounder, multiplexers, the Uninterruptable Power Supply (UPS), modem and sensors are all controlled by this program. Figure 1. shows the diagram of the basic components in the system.

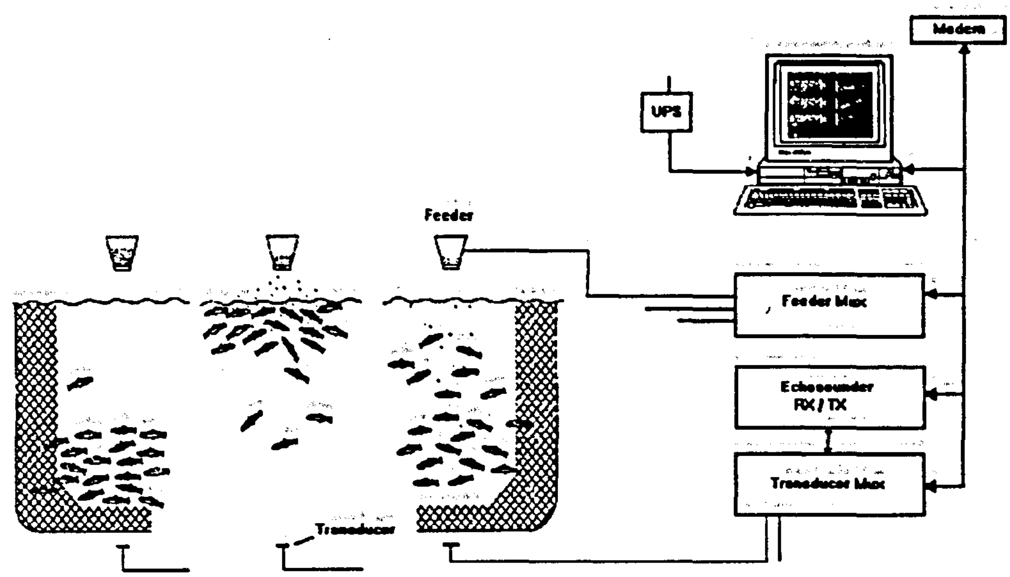


Figure 1. General configuration of the Cage-eye system. The three boxes to the right are from the top; Feeder multiplexer, Echo sounder with receiver/ transmitter (RX/TX) and Transducer multiplexer at the bottom.

An upward facing transducer is suspended under each cage. The volume covered by the beam is dependent on the opening angle and the depth at which the transducer is located.

For net cages of "normal size", 10-15m Ø , we have found an opening angle of 42 deg. to be most useful. Dependent on the cage size, the transducer is suspended deep enough to cover most of the surface layer. However, at the same time one should try to get some distance below the cage bottom. Detection of wild fish under the net cage during feeding will indicate that some food pellets are falling through. This can be used as a signal to reduce the intensity of the feeding system.

The transducer is easy to install. It is hanging free in gimbals and does not attach to the cage. Thus, no additional work is needed when changing cage nets.
The echo sounder is especially designed for this project. The transmitter (TX) can be programmed to give an output power from 5 to 100 watt. The receiver (RX) has a time varied gain (TVG) function applied at the input stage to compensate for geometric spreading of the acoustic energy (20log R). Compensation for the absorption caused by salinity in water and the biomass of fish in the cage is handled by the software.
Due to the large biomass and short ranges inside the cage the acoustic power is normally reduced to 20 watt. This to ensures the receiver system not to saturate even if the surface layer is "saturated" with fish.
Special attention was paid to the problem of tracking and locking to the surface layer, - an important feature if most of the fish are searching for food in this layer. It would cause great problems if the program started to integrate on the surface echo.

ECHOGRAM AND DATA STORAGE.

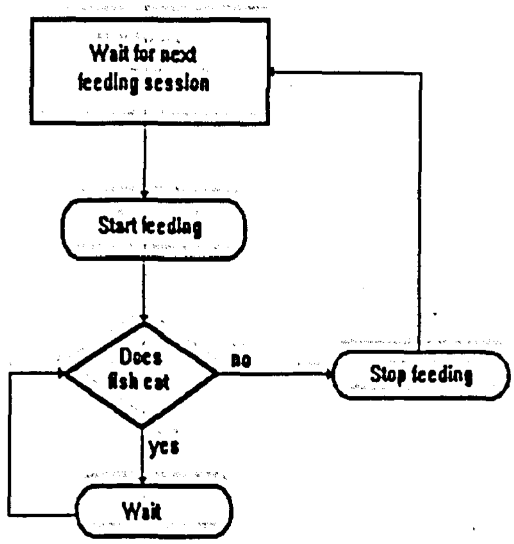
The acoustic pulse of 0.6 ms. duration is sampled every 0.1 ms. - which gives us a vertical sampling each 7 cm. This allows the system to produce colour echograms in high resolution. The echo signals from fish are integrated in 0.5 meter layers and stored in files on the computer hard-disk. These data files contain data for the last 24 hours. They can be displayed and reviewed as echogram or backed up on floppy disks for later analysis. The file size depends on how many "pings" from the echo sounder one wish to store. This is defined by the user and is independent of the system ping rate. If the real-time echogram is updated with one ping pr. sec., - one can send only one ping pr. 30 sec. to file.
All fish data for food consumption and growth are stored in separate files. These data is conveniently displayed as numbers or they can be plotted as charts.
Moreover, all data and statistics can be sent to ASCII-files in CSV format. Such data can easily be loaded into spread-sheet programs like Excel or Lotus for further analysis.

FEEDING ALGORITHMS.

Cage-Eye supports three different feeding regimes. The regime in one cage may be different from the next.

- Fully automatic feeding system: At pre-set hours the system starts feeding. Fish activity (appetite) determines the duration of feeding With the feeding system having feedback from fish, no over or under feeding is allowed. Thus, increased growth versus food consumption and reduced pollution.

- Interactive feeding: In this modus the user can manually start and stop the feeding, - depending on the activities displayed on the computer screen. If the behaviour does not follow the usual "hungry fish" pattern the user can stop the feeding manually from the computer site.



Automatic feeding flowchart

- Feeding by table: The system follows a feeding scheme based on water temperature and fish size. The daily increase in biomass is calculated and taken into account for the next day feeding.

ALARM FUNCTIONS.
The system is continuously monitoring and checking for any abnormal conditions in the cage. Any sudden abnormal change in temperature, fish biomass or fish behaviour causes an activation of alarm. The alarm system can be connected to the modem which will call the administrator.

MODEM UTILITIES.
The system can be fully controlled by telephone or radio. All pictures and control functions can be transferred to a remote personal computer. A unique possibility for the administrator to follow several sites at different geographic locations.

UPS.
The system is operated with an UPS-supply which keeps the system running for at least 30 min after a power failure. The computer senses the power failure by an interface to the UPS and waits for a "low battery voltage" flag. When 20% of the battery power is left the program saves all files and shut down the system. When power returns the system will automatically restart with all data intact. This is an important feature for systems located in remote places with unreliable power supply.

SUMMARY

The system has been tested with good results for limited time periods on several commercial fish farms (Bjordal et al 1993).
We have experienced some scepticism by the farmers to leave the system on automatic feeding. They are afraid of not giving enough food to the fish. However, they seems happy to see where the fish is located in the cage and to follow the dial migration.
They recognise the problem of assessing the general condition of the fish by looking at some few individuals in the surface layer. The system is now on a two year test program in two large Norwegian fish farms. We hope through this period to have received enough feedback from the users to come up with a user-friendly and reliable system which can give less pollution and a better economy in to the fish farming business..

References:

Bjordal,Å., S.Floen,J.E. Fosseidengen, B.Totland,J.T.Øvredal,A.Fernø and I.Huse. 1986. Monitoring Biological and Environmental Parameters in Aquaculture. Modelling, Identification and Control, 1986 Vol.7(4),.p.207-218.

Bjordal,Å. Lindem,T. Juell,J.E. and Fernö. 1993. Hydroacoustic monitoring and feeding control in cage rearing of Atlantic salmon.(*Salmo salar* L.) Paper presented on Fist International Conference, Fish Farming Technology. Trondheim, Norway, 9-12 August 1993.