# Cod are smarter than you thought!

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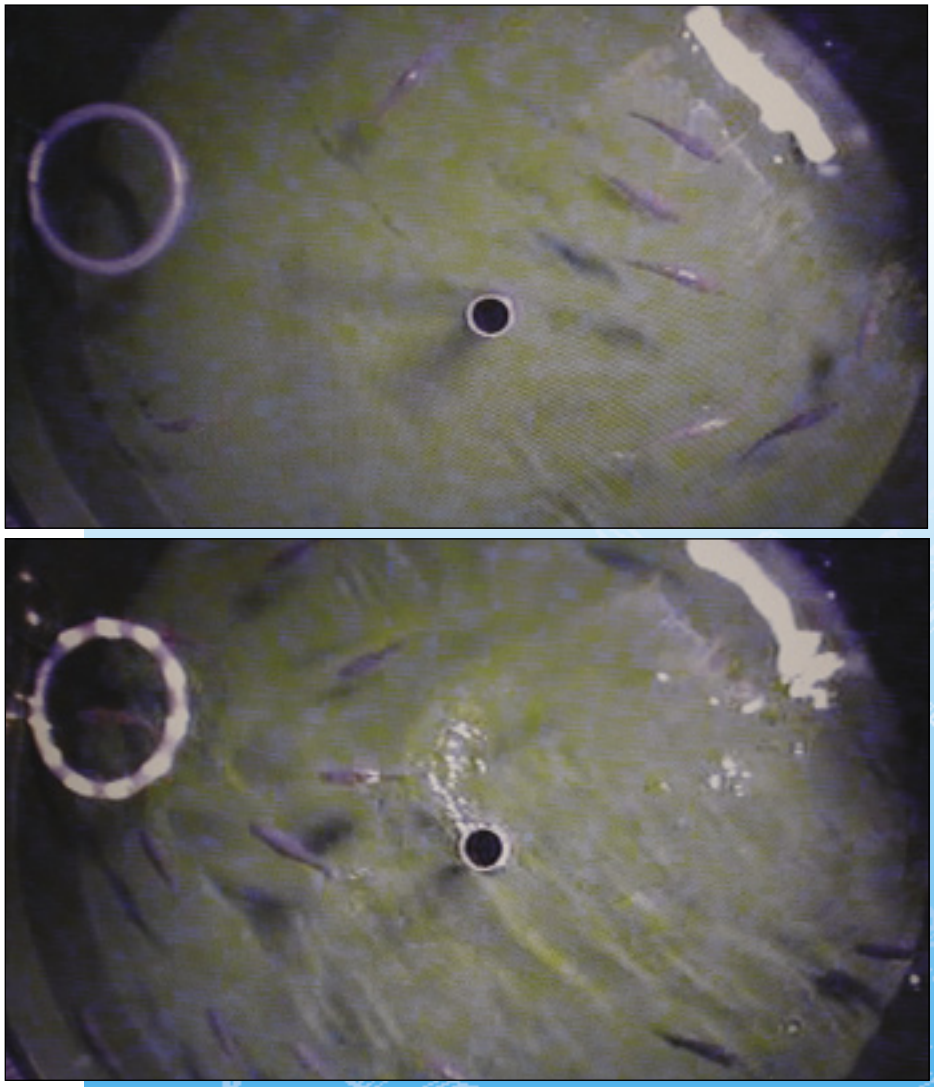
***There is a popular myth that fish can only remember anything for a few seconds, which suggests that they are poor learners. Our experiments have shown that cod have no problems in remembering associations that they had learned three months previously.***

The environment of a fish can be very variable, e.g. in terms of changes in the amount of prey available and meetings with predators. For this reason, fish have developed a natural ability to learn from life, in order to be able to adapt rapidly to such changes. The environment of farmed fish also varies, and they are liable to find themselves in unusual and unnatural situations. Can we train fish to adapt to new, stressful situations? And can we use such an ability to improve the welfare of farmed fish?

## LEARNING WITH SOUND AND LIGHT

Fish are the class of vertebrates that contains most species, more than 25,000 of which display wide variations in appearance and lifestyle. We can therefore assume that, like mammals, they have different learning abilities. In an ongoing project at the Institute of Marine Research we are testing the learning abilities of cod and halibut, and how well they remember. Cod can rapidly learn to associate sound or light signals with feeding, and they can remember such associations for long periods of time. In experiments in which flashes of light was given 20 seconds before each feeding session, only a few repetitions were needed before the cod began to



Cod that have learned that food follows light: before (top) and during (bottom) light flash.

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swim towards the feeding unit when they saw the flash. These experiments also showed, surprisingly enough, that cod are capable of associating events separated in time at a level that is comparable to what we find in mammals. Even when we inserted a delay of up to a minute after the flash before the feeding unit started to operate, "untrained" cod managed to understand the connection. While cod are easy to condition, in puberty halibut have turned out to be poorly motivated students. However, even in the halibut class there are some smart individuals who are easy to condition to light signals, and these can learn just as rapidly as cod.

## A BETTER LIFE IN AQUACULTURE

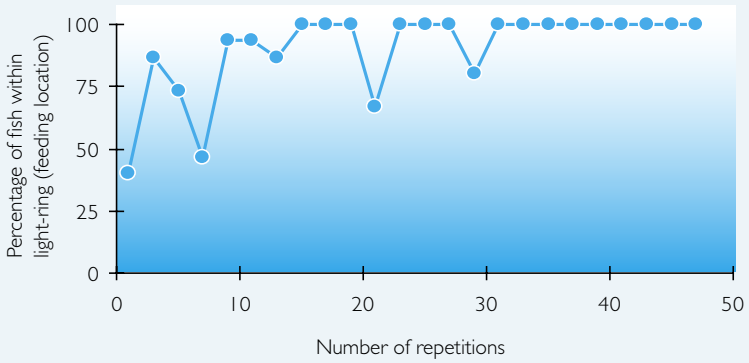
Farmed fish are kept in tanks for the first part of their life. When they are subsequently released into sea-cages they encounter a completely new environment that they need to get to know. It can take some time for them to start eating in the new environment, and some of them never learn to adapt to it. This has consequences both for the welfare of the fish themselves and for the financial situation of the fish farmer. If we can teach fish at an early stage that a feeding signal will tell them when and where food is about to appear, this could probably persuade them to begin to feed sooner when they are released into the sea. Even if the sea-cage environment is new and frightening, the signal will be familiar from their childhood in the tank, and will be associated with food.

We can also teach fish to feed themselves. At the Institute of Marine Research we are currently experimenting with feeding systems which allow the fish themselves to decide when and how much they want to eat. This can be done by means of various methods. A system that has already been tested on other species is a feeding unit that is triggered by a line which the fish can pull. The apparatus is connected to a computer, and the number of pulls registered tells us how actively the fish are working for their food. This method is being used in nutrition research studies at the Institute of Marine Research, in which cod are offered several types of food simultaneously from different feeding units, and the choices made by the fish tell us which feed they prefer.

We have also developed an acoustic feeding system which is based on the density of fish near the feeding unit, and which stops providing food when there are insufficient fish in the vicinity. The most advanced system that we are testing is one in which fish are implanted with tiny radio transmitters that send a signal to start the feeding unit when a fish is at a certain distance from an antenna. This system lets us know which fish are learning most rapidly. We can also check whether all the fish are learning to operate the feeding unit or whether some of them merely follow the smartest fish. We can also use this system to make the fish work for different rewards, so that we can let them put their own subjective price, for example, on different types of feed. The extent to which such self-feeding systems can be used depends on the learning ability of the individual species.

## UNHAPPY FISH UNINTERESTED IN LEARNING

Whether fish make use of what they have learned, for example to respond to a flash of light, probably depends on their condition. A stressed fish will have a lower response rate. This suggests that responses to a conditioned signal could be used in aquaculture as an indicator of wellbeing. A fall-off in interest for what a fish has already learned suggests that something is not quite what it should be. In this way, then, fish can be trained to show whether or not they are enjoying life. By sending farmed fish to school at an early age we can thus teach them to adapt better and more rapidly to the aquaculture environment, and we can get them to tell us something about their feelings and wishes. This can improve their welfare and growth, and thus be in the interest of both fish and fish farmer.




Percentage of fish within the light-ring (feeding area) after 12 seconds light flash, 20 seconds before feed appears.

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