False maturation in the salmon on-growing industry

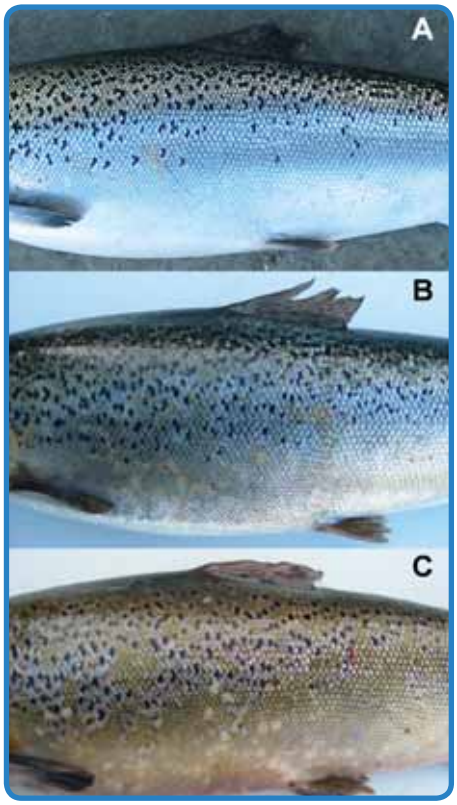
Herve Migaud, Reproduction Group

A three-year BBSRC Industrial Case studentship has been awarded to Dr Herve Migaud and Dr Kim Thompson, Department of Genetic and Reproduction and Aquatic Vaccine Unit respectively, on "Characterisation of Atlantic salmon false maturation and development of a maturation detection kit". This is a collaborative project involving Marine Harvest Scotland, Aquatic Diagnostics Ltd, the Reproduction and the Vaccine units of the Institute of Aquaculture.

False maturation is identified as one of the main problems in the salmon industry leading to economic losses (up to 30% harvest rejection by processing plants) and difficulties in site management. However, although this phenomenon has been reported within the industry, no study to date has investigated it in salmon. Photoperiod manipulation is routinely used within the salmon farming industry during on-growing to inhibit maturation prior to the attainment of a suitable harvest weight and subsequently to minimise maturation-associated immunosuppression and mortality. However, specific to salmon is the fact that a large proportion of fish still go through a "dummy run" or false maturation. These fish exhibit temporary external skin pigmentation, but their gonad development seems to be arrested and immature silver appearance returns within a few weeks. Furthermore, large variability in the incidence of such a phenomenon is reported between on growing sites. Therefore, one of the greatest problems faced by the industry in relation to sexual maturation is the ability to accurately detect and predict the onset of maturation on-farm.

A former M.Sc. student, Eric Leclercq, is back at the Institute after gaining field experience in the Scottish salmon industry. His PhD project will involve extensive field research throughout the production cycle at selected Marine Harvest sites.

The PhD project aims to investigate the phenomenon of false maturation, identify potential causes at the genetic/physiological and environmental levels and develop new technologies and practises that allow salmon farming systems to be managed more precisely (e.g. new measurements, diagnostics and models). The complexity and diversity of interactions in salmon on-growing systems necessitates a quantitative and mathematical approach to develop predictive models to enhance sustainability, reduce economic loss and identify key factors contributing to the problem. This project also addresses fish welfare issues as maturing salmon become aggressive and more prone to disease. Expected outcomes for the salmon industry are the refinement of grilse assessment with the use of a new maturation detection kit together with guidance on husbandry practices minimising the occurrence of this phenomenon.



Difference in skin pigmentation between A- silver immature, B- false maturing and C- matured (grilse) 1+ Atlantic salmon observed during grilse assessment at a Marine Harvest cage site in autumn 2005.

Development of new management strategies for cod mariculture

Herve Migaud, Reproduction Group

Two new projects have been funded by both the 6th EU Framework Programme on "Light Technology for Photoperiod Regulation in Cod Mariculture (CodLight-Tech)" and a Norwegian Research Council grant on "Novel narrow bandwidth lighting technology in cod farming and its impact on performance from early stages to adult fish".

These projects are run in collaboration with the Icelandic Fisheries Laboratories (IFL), the Institute of Marine Research in Norway (IMR) and a number of SMEs including Intravision Group AS (Norwegian lighting manufacturer) and Johnson Seafarms Ltd in Shetland. The projects started in 2006 and Stirling involvement is coordinated by the Reproduction Group (Dr Herve Migaud with support from Dr Andrew Davie and Dr John Taylor) in collaboration with the Aquatic Vaccine Unit (Dr Kim Thompson and Prof. Alexandra Adams). The overall aims of these projects are to enhance the productivity of Atlantic cod farming by optimising techniques through the development and deployment of novel lighting technologies that are specific to both the sensitivities of the fish throughout the production cycle and the rearing systems

used. This goal will be achieved through a combination of laboratory-based studies focusing on light perception in cod at the physiological and endocrinological level, in conjunction with proof of concept on-farm trials to demonstrate the efficacy of the newly designed lighting systems.

Although part of the work is focusing on early stages (larvae, juveniles), the priority

is on the control of maturation during the on growing stage as cod held in intensive culture mature within two years of hatching, resulting in a reduction of somatic growth rate, decrease of condition and deterioration of flesh composition. A delay or cessation of maturation during on-growing is therefore crucial for profitable farming. Seasonally-changing day length (photoperiod) is the natural time-keeping mechanism used by finfish from temperate latitudes to entrain a number of important physiological processes, including sexual maturation and overlaying of artificial illumination on the natural day-night cycle masks this seasonally changing signal. Such techniques have been shown to successfully regulate maturation in a number of tank-based studies in Atlantic cod (Dr Andrew Davie PhD Thesis: http://hdl.handle.net/1893/109) in which a complete cessation of maturation and up to a subsequent 60% improvement in growth have been observed. When such test photoperiods are applied at a commercial scale in open floating cage systems, it is believed that ambient light can have a major regulatory influence and as such the results reported have not been consistently reproducible. The research focuses on the development of a new lighting technology based on cold cathode light tubes, and then appropriate lighting protocols for application in cod mariculture.

The specific objectives of these projects are therefore to:

1. Develop new narrow bandwidth lamps and light systems for use during the cod production cycle that are effective in improving performances at the hatchery and delaying sexual maturation in sea-cages, easy to use in the fish farming environment and represent an energy efficient solution (collaboration with Intravision).
2. Determine cod light sensitivity (intensity and spectrum) at key life stages using *in vitro* culture, micro-spectrophotometry and electrophysiological techniques (collaboration with IMR).
3. Develop and validate a cod maturation detection kit (pregnancy test) allowing up to 4 month on-farm prediction of a spawning event (collaboration with Aquatic Diagnostics Ltd).
4. Test and validate new lighting regimes (photoperiod management) in commercial on-growing and determine effects on survival, growth performance and maturation at various locations (with Johnson Seafarms Ltd).

The results from the project will deliver new tools, protocols and quality schemes that should enable the cod mariculture industry to improve their economic situation, whilst improving cod welfare.

Nile tilapia genome to be sequenced

Dave Penman, Reproduction and Genetics Group.

The genome of the Nile tilapia (*Oreochromis niloticus*) is to be sequenced by the National Human Genome Research Institute in the USA, using a line of fish developed in the Tropical Aquarium facilities of the Institute of Aquaculture, University of Stirling.

A fish from one of the completely inbred red lines of tilapia developed by the Genetics and Reproduction group at the Institute of Aquaculture, University of Stirling.

The human genome sequence was only completed in 2003, and other vertebrates have been added more recently, including model fish such as the puffer fish (which has a very small genome). Sequencing of the zebra danio (important in studies on vertebrate development) genome is ongoing. The tilapia will be one of the first fish of interest to aquaculture to be sequenced. Having access to the complete genome sequence will greatly help in the identification of genes that affect important aquaculture traits such as growth rate, disease resistance, maturity, etc, and should facilitate selection to improve such traits for aquaculture and the development of other biotechnology-based techniques.

The line of fish from which the DNA will be sequenced is a completely homozygous (inbred) line developed by gynogenesis (induced maternal-only inheritance). This means that both copies of each DNA sequence in such fish will be identical, making the process of analysing the DNA sequence easier than in outbred animals, where the DNA inherited from the mother and father will differ to some extent and can lead to some problems in checking for sequencing errors. Gynogenetic lines can be produced in two generations in fish and have already been used for studies on, for example, sex determination, immune responses and behaviour (inbred lines in mice, in contrast, take many generations to produce and are not completely homozygous).

The application for this sequencing project, submitted by the International Cichlid Genome Consortium, was headed by Professor Tom Kocher, from the University of Maryland, with partners from several other labs in the USA, Europe and Japan. Three other species of cichlids will also be sequenced to a lower coverage, furthering studies on cichlid evolution as well as tilapia aquaculture and genetics. Further details can be found at http://www.genome.gov/11007951 and http://www.genome.gov/10002154 (the full proposal can be found by following the link from the latter web page).