Spinout company Xelect Ltd\(^1\) is adding £600 per tonne to the value of farmed Atlantic salmon through genetic approaches to increase salmon fillet yield. The company, established in 2013 by Professor Ian Johnston\(^2\) and Dr Tom Ashton\(^3\) from the University of St Andrews, provides genetic services to major aquaculture companies. Building on technology and expertise in genetics and molecular biology developed during BBSRC-funded research, the company has identified genetic ‘markers’ for certain valuable traits, such as fillet yield, that can be used by fish breeding companies to improve their breeding populations.

So far, Xelect has agreed an exclusive European licencing deal and on-going royalties for their technology with major salmon producer SalmoBreed A/S\(^4\). They also have a trial licence with UK company Landcatch Natural Selection\(^5\) to use the technology on salmon farms in Chile.

“SalmoBreed became acquainted with Ian Johnston’s work about four years ago,” says Dr Håvard Bakke, Head of Genetics at SalmoBreed A/S. “We were especially interested in the gene effects for growth and yield in Atlantic salmon that Professor Johnston had found. Together with Johnston and his people we have done further studies on the effects of the genetic markers he had identified. The effects are now well documented and we are using the markers to select fish with added fillet yield. This is a valuable addition in our breeding program and a genetic tool that makes salmon production more efficient.”

In 2013 the Scottish salmon farming industry produced more than 163,000 tonnes of salmon, worth £667M\(^6\) at farm gate prices. At secondary processing an increase of £600 per tonne would add £97.8M to the value of the Scottish salmon industry alone.

Techniques developed during the research which led to Xelect are also in use in the quality control processes of Marine Harvest and Young’s Seafood.

Much of Johnston’s research was supported by BBSRC. In particular, BBSRC follow-on funding enabled Johnston and post-doctoral researcher Dr Tom Ashton to gather the data they needed to validate the technology and establish Xelect. “To us, the follow-on funding was invaluable. We probably wouldn’t have this company without it,” Johnston explains.

Xelect employs five people full-time and has made a profit in both of its first two years of operation. It also increased turnover in its second year by 50%. The company is expanding into traditional breeding and genetic testing, as well as applying the technology to different fish species and to different traits in salmon.

Industry collaboration
Johnston has been interested in fish genetics since the 1990s, and in particular the relationship between the genetics and physical characteristics of fish in the ‘salmonid’ lineage that includes Atlantic salmon and trout. Much of this research was supported by BBSRC and underpinned the technology developed by Xelect.

In particular, in the early 2000s Johnston received three BBSRC grants; LINK grants in agri-food\(^7\) and food quality and safety\(^8\), and an Industrial Partnership Award\(^9\). “The LINK programmes were very helpful, as they helped me think about the opportunities there were in aquaculture, and build
Salmon genetics technology from Xelect Ltd boosts global aquaculture industry

Around the same time as the LINK grants, Johnston was approached by major fish processing company Young’s Seafood to help them understand the genetic factors that affect the quality of salmon flesh. To do so, the researchers developed methods to measure accurately the texture of salmon fillets, which are now used for quality control at Young’s Seafood and Marine Harvest. Young’s granted them access to one of their processing facilities, and halted production on several occasions to allow Tom Ashton to collect precise measurements from individual fillets on the production line.

The collaboration also gave Johnston the opportunity to collect data on the genes that influence fillet yield. From this, Johnston constructed a database of DNA samples and associated measurements taken from salmon fillets. The database enabled him to pinpoint several genes that were associated with fillet yield. “There were two in particular which, if selected together, were associated with a 4% increase in fillet yield,” says Johnston. “It may not sound much, but it is worth about £600 per tonne.”

“It was at that point we realised we had the basis of a business,” he adds.

**Xelect Ltd founded**

Xelect’s core business is to discover genetic markers that could be used for “marker-assisted selection” by fish breeding companies to improve their breeding population, or broodstock.

Marker-assisted breeding depends on identifying small changes in the DNA of an organism that are inherited together with genes of interest. By looking for markers for specific beneficial traits such as fillet yield, or disease resistance, in a population of fish, breeders can identify the animals carrying those genes. They can then use that information within their usual breeding programme to ensure the genes are passed on to the next generation. The approach is commonly used in cattle and pig breeding, as well as in crop breeding programmes.

Johnston’s work with Young’s enabled him to identify the markers associated with genes responsible for higher fillet yield in salmon, which have large, complex genomes. A £62K investment from major Salmon genetics company SalmoBreed A/S allowed Johnston to continue to employ Ashton while they developed plans for Xelect. BBSRC follow-on funding (firstly via a follow-on fund pathfinder grant, and later a full follow-on fund grant) then enabled Johnston and Ashton to gather more data from fish obtained from producers in Norway, Scotland and Chile to validate their approach.

With the additional data, the researchers negotiated an exclusive European licence for their marker technology with SalmoBreed, as well as a contract for other genetic services. Those agreements and the income they provided enabled the researchers to establish the company.

As of early 2014, Xelect had also established a trial licence with Landcatch Natural Selection, a UK company with salmon farms in Chile. “We screened thousands of fish, identified the fish or breeding and they are growing in a fjord in Chile, I think they are 4-500g at the moment, about 100,000 of them. They will be filled ed later this year. Hopefully they will move forward to take a full licence from us,” Johnston explains.

**The global aquaculture industry**

For their core marker discovery services, Xelect charges an up-front licensing fee as well as on-going royalties based on a proportion of the value added by their technology. The company is also expanding into other genetic services, and looking for genetic markers in other species and for new traits in salmon. Much of this work is now funded by Innovate UK and Scottish Enterprise.

For instance, the company has expanded into traditional breeding, offering genetic tests for paternity and relatedness, and customers for these services include a consortium of Danish rainbow trout breeders. Denmark is the largest producer of rainbow trout in the EU.

Funding from Scottish Enterprise and Innovate UK is also allowing Xelect to look for genetic markers for other traits in Atlantic salmon, including the ability to retain the pigment that gives salmon its distinctive colour, which comes from their diet.

Another trait of interest is the number of muscle fibres the fish possess. Salmon flesh is mostly muscle, consisting of...
a large number of muscle fibres which arises significantly between individual fish. During their BBS C-funded research, the researchers found that a larger number of fibres gives the fish fillets better texture and flesh colour. Johnston identified the genetic variations controlling fibre number, and is now aiming to validate that work and understand how the genetic variation affects other traits of interest to breeders.

Xelect also offers a next-day testing service to identify ‘triploidy’ in trout. ‘Triploid’ fish carry three copies of their genetic material, rather than the usual two copies. They are sterile, and therefore cannot interbreed with wild populations. The UK Environment Agency has stipulated that all trout used to restock rivers for angling must be female and triploid, so companies can send samples to Xelect, who provide independent verification that they meet the requirements.

Xelect are also investigating markers for rainbow trout and plan to expand into the barramundi, an Australian fish. According to Johnston, “it’s not just about the fish armed here, but using the expertise and technology developed in the UK for the whole global aquaculture supply chain.”

Boosting tilapia fillet yield

The approach developed in Atlantic salmon also works in other species. In early 2014, Xelect licensed markers for fillet yield in the tropical fish Nile tilapia, which is mainly produced in Asia, Africa and Central and Latin America, to major tilapia breeding company GenoMar AS. The markers were for two genes which, if both present in tilapia, increase fillet yield by 8.6%, which is worth an additional £164 per tonne.

Genomar AS is a Norwegian breeding company focussed on aquaculture genetics. They run a selective breeding programme for Nile tilapia and commercialize tilapia genetic products under the brand GST in different regions of the world. They were introduced to the work of Xelect in 2013 at an industry conference.

“We are always searching for innovations that can create value for our customers of genetic material,” says Dr Alejandro Tola, CTO at Genomar AS. “There is a lot pressure for efficiency in the tilapia industry and we immediately saw a great potential to improve profitability through the application of Xelect’s proprietary markers for fillet yield.

In March 2015, Genomar and Xelect signed an exclusive license agreement for the application of fillet yield markers to Nile tilapia, with the aim of launching new products in one or two years. “Working with Xelect is allowing us as breeders to bring products to market faster and in a more reliable way. Their great understanding of the genetic basis of fillet yield and growth traits allows us to focus our R&D efforts in other areas of interest which are more industry-specific,” ola adds.