

**Seafood CRC Industry Bursary:
*Fish Breeders Round Table Meeting,
Norway***

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AUSTRALIAN
SEAFOOD
COOPERATIVE
RESEARCH CENTRE

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TITLE : Industry Bursary - Fish Breeders Round Table Meeting, Norway

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OBJECTIVES OF INDUSTRY BURSARY:

- Improved knowledge of alternate approaches to breeding problems
- Understanding of the commercial structure of breeding companies, hatcheries and on-growers in other parts of the world.
- International presentation of the current status of the Tasmanian Atlantic Salmon Selective Breeding Program.
- Feedback from World leaders on the current strategies for genetic improvement in Tasmanian Atlantic Salmon

NON TECHNICAL SUMMARY:

The primary reason for travel was to attend Fish Breeders' Round Table discussions of molecular genetics and breeding in Norway.

The Fish Breeders' Round Table is an international forum that is held every 4 years in Norway, where knowledge and experience is exchanged between fish breeding researchers and those involved in applied genetic improvement work on a commercial basis. The forum is structured such that at least one person per attending company or institute gives a presentation at the meeting. No proceedings are published, ensuring that outcomes of the meeting are for those actively attending only.

To take full advantage of the support provided I also undertook visits to breeding companies and scientific service providers throughout the European Atlantic salmon breeding sector.

I was able to spend time in the offices and field stations of AquGen and Marine Harvest in Norway, and Landcatch Natural Selection in Scotland.

The contacts that I have made, and the knowledge that I have gained, will be invaluable in ensuring the continued development and improvement of the Tasmanian Atlantic salmon selective breeding program (SBP) in the future.

OUTCOMES ACHIEVED TO DATE

The key outcomes arising from activities supported by the CRC industry bursary are:

- Enhancement of my knowledge and understanding of the various approaches taken to genetically improve Atlantic salmon stocks in the major salmon producing countries of Norway, Scotland and Chile.
- A greater understanding of the commercial structure of breeding companies, hatcheries and on-growers in other parts of the world.
- Presentation to an international audience of the current status of the Tasmanian Atlantic Salmon Selective Breeding Program.
- Feedback from World leaders on the current strategies for genetic improvement in Tasmanian Atlantic Salmon was positive, with our program being able to provide insights for others that are moving towards a system of freshwater maintained broodstock.
- Linkages were made with international experts in fish and animal breeding. Opportunities for ongoing collaboration within this network will prove invaluable as the Tasmanian SBP moves on from the current research agreement with CSIRO.

OUTPUTS DEVELOPED AS RESULT OF INDUSTRY BURSARY:

Conference presentation

- **Evans BS 2011.** Tasmanian Atlantic Salmon Breeding Program (SBP). Presentation to the Fish Breeders Round Table Meeting, September 1-3, 2011, Stavanger, Norway.
- **Evans BS 2011.** Tasmanian Atlantic Salmon Breeding Program (SBP). Presentation to the management of AquaGen AS, September 5, 2011, Trondheim, Norway.

BACKGROUND AND NEED

There will be significant change in the Tasmanian Atlantic Salmon Selective Breeding program (SBP) when the current collaborative research agreement with CSIRO concludes on June 30th, 2012. The SBP will move from a research and development platform to one of commercial production and ongoing improvement. There is a recognised need to ensure that the SBP is taken forward utilising the world's best practice in commercial breeding and my travel to Norway and Scotland allowed me to meet and learn from the world leaders in salmon breeding.

RESULTS

Travel itinerary

August 31st Meeting with Dr Morten Rye, Akvaforsk Genetics Centre (AFGC), Stavanger, Norway

The AFGC is the leading provider of applied genetic improvement services to aquaculture industries worldwide. They promote themselves as being the 1) leading designer of breeding programs for profitable and sustainable production systems; 2) a center of excellence in genetic evaluation, and 3) a supplier of genetically superior germ-plasm.

This meeting was very beneficial in that it was able to put the provision of genetic services into a commercial framework for me. The AFGC has been operating as a commercial entity with no additional public money since 1999.

Approximately 80% of their business is what they term technical genetic services, in which they are heavily involved in all aspects of the breeding programs from their design and implementation to the analysis of data and estimation of breeding values. They currently employ between 12 and 15 full time geneticists to provide these services to 12 large scale programs world wide.

The rest of their business stems from working with companies that have developed breeding programs in place. In these instances they are not required to have a thorough understanding of the species as this knowledge is present within the company. In these cases there will be an initial consultant phase, followed by an annual service fee and a royalty fee based on the number of animals used or produced.

September 1st to 3rd Fish Breeders' Round Table meeting, Stavanger, Norway

This meeting was the main purpose of my travel and it was an exceptional forum for the transfer of ideas and presentation of recent advances in the area of applied fish breeding. The meeting also had invited guests from other areas of animal breeding such as Dr Mike Goddard of the University of Melbourne who shared his extensive experience of selection and genomics in livestock industries.

I was able to give a short presentation outlining what has been established in our SBP in Tasmania and describe the challenges that were faced in establishing the SBP. Some of which are unique such as AGD, and others that are of interest globally such as freshwater reared broodstock, triploidy and all-female commercial production. The presentation was well received and there was a lot of discussion about the issues faced and the solutions that have been found and implemented.

Presentations of specific interest at the meeting

Sven Arild Korsvoll (AquGen AS): Atlantic salmon breeding in Chile

This presentation focused on the issues faced by a commercial breeding company that had based much of its business model on the production of eggs in Norway for sale into Chile for on-growing. The banning of importation of Norwegian salmon eggs into Chile in 2009 has forced a major change in business model and the alteration to the biosecurity laws in Chile has meant a move to freshwater recirculation systems for the growing of broodstock.

Much of the presentation focused on the difficulties of selection for marine traits in broodstock that are held in freshwater. This is despite restrictions only requiring the broods to be transferred from the sea into freshwater a minimum of three months before spawning.

Because the current commercial production outside of Tasmania is mixed-sex, they are able to use excess families from their breeding nucleus as commercial broodstock. They currently hold their breeding nucleus families in family tanks until large enough to PIT tag. Once PIT tagged, some are held in freshwater to become broodstock, and others sent to sea for performance testing in much the same way that the Tasmanian SBP operates. They also reported that the genetic correlation between freshwater growth and seawater growth is poor.

Their primary selection traits are HOG Wt in freshwater, HOG Wt in Sea Water (double weighting) and IPN resistance. They also sell an IPN resistant strain of selected eggs that has been developed using the QTL for IPN resistance that they developed in house.

Ashie Norris (Marine Harvest): Heritability of spinal deformity in Atlantic salmon

This presentation described a group of production broodstock that displayed very high levels of a single deformity of the humpy type at one of two grow-out sites. The issue for the breeders was that the two groups of broods that had been produced in that year class had undergone different incubation temperatures in the hatchery in order to synchronise first feeding for eggs produced 1 week apart. The concern was that the rearing temperature had led to the high incidence of the humpy deformity of between 30 and 50%.

Dissection and X-ray revealed that all of the deformed fish had 2 or more vertebrae that had fused, and that the incidence was as high as 86% when X-ray was used.

Group 1 had been incubated under normal temperature conditions, group 2 had been incubated under elevated temperatures from 90 degree days to first feeding. Upon

examination of pedigree, the high incidence of deformity was actually from the normal temperature group.

Further examination revealed that the deformities were only present in a small number of families at one site, and those families were unaffected at the other site. The interesting finding was that there was a high genetic correlation between mean family weight and deformity (0.81). The hypothesis was raised that the fish had undergone a growth spurt after normal harvest size during which time they had been nutrient limited. Questioning of the marine site staff revealed the use of a non broodstock diet during this period at the site that produced high levels of deformity, whilst a broodstock specific diet had been used at the site that showed no deformity.

Havard Bakke (SalmoBreed): Improving lice resistance through selective breeding

This presentation revealed the similarities between the sea lice problems faced in Norway and our own issues with AGD in Tasmania. The issues that we face in the selection of suitable traits to measure and improve are quite similar. SalmoBreed also operate their breeding program in a similar manner to ours in that they maintain a core breeding population as well as producing a multiplier line for commercial production.

Jan Sunde (Cryogenetics Norway): Cryopreservation of milt

This presentation focussed on the provision of cryopreservation of milt as a commercial product. This company seems to be providing this service to all of the major salmon breeding companies worldwide. AquaGen utilises cryopreserved milt to produce their commercial multiplier line, as well as for the backup of genetic resources. Landcatch Natural Selection also utilises the service for the preservation of genetic resources and to link generations.

Anna Sonesson (Nofima Norway): Genetic parameters for obesity traits in Atlantic salmon

Anna presented some of her work which has investigated the link between increased levels of lipids in feed, with increased levels of visceral fat and decreasing heart health (arteriosclerosis in marine fish).

Her work showed that high levels of visceral fat was also associated with high levels of heart fat and smaller hearts and deformed hearts.

She posed the question of whether small hearts were a result of the fatness or if the fish were fat due to lower activity resulting from having a small heart. They are continuing to investigate the issue of heart health under the heading of resilience.

In summary I would highly recommend this meeting to anyone that is involved in applied breeding in any capacity. It is a high level meeting, that focuses on the areas of immediate development in commercial fish breeding and genetics, and it is on a small enough scale that all participants have ample opportunity to meet and share ideas.

September 4th Fish Breeders' Round Table farm tour, Stavanger, Norway

Sunday provided an opportunity to visit Sterling White Halibut, a Marine Harvest company, and the Centre for Aquaculture Competence AS (CAC).

CAC is a large scale experimental fish farm used for documentation purposes which was established in 2003 by Marine Harvest AS, Skretting AS and Akvagrøp ASA. CAC has 3 R&D concessions, a 960m³ barge with a laboratory, 12 steel cages and is fully equipped for large scale experimental use. The facility is used as a test station for Akvagrøp products before commercialisation of their feeding and underwater equipment.

It was interesting to note that they were running a trial on the performance of triploid Atlantic salmon whilst we were there, and they proudly told us that they were using the Tasmanian protocol for inducing triploidy in eggs. Triploid (sterile) production is being investigated as a means to protect genetic improvements and to minimise the risk to the natural salmon stocks from escaping farmed salmon.

September 5th to 7th AquaGen AS, Trondheim, Norway

Dr Arne Storset from AquaGen organised for me to meet with various members of the management team at AquaGen's head office in Trondheim on the 5th of September. These discussions were designed to provide me with an overview of their structure and breeding strategy. I found their presentations very useful and have outlined some of the points of interest below.

The AquaGen strain of salmon represents 60% of total production in Norway, and is a result of 10 generations of pedigree based selection.

Until 2005 they maintained 4 separate breeding lines for their families, but they saw inconsistent performance from one year of commercial production to the next due to differences in the performance and improvement of each of these family units.

In 2005 they merged their 4 groups of families by crossing 2 groups of females with 2 groups of frozen milt to create a single large group of families that is produced every 4 years.

They currently collect data on 22 traits of interest from 800 core families over the four year cycle from egg to stripping.

Their commercial broodstock are produced each year by fertilising eggs from the 4 yo year class (4 YC of Elites are maintained) with frozen milt that is collected from Elite males within the breeding families every 4 years. The use of the same milt to produce the commercial broods in each 4 year block ensures that the product delivered to customers is consistent for 4 years, then there is a jump in performance for the next 4 year block.

On the 6th and 7th of September I was taken to visit the breeding centres at Hemne and Tingvoll. These two areas have sea sites to grow the commercial broods until 4 months prior to stripping when they are brought inside a freshwater recirculation system with photoperiod and temperature control to provide stripping in three batches;

Early: lights used at sea from early spring, no lights in freshwater results in stripping in mid September

Natural: ambient temperature and natural light results in stripping in November

Late: lights from late May through to delay spawning until late December to mid January

Temperatures are held at 17 degrees over summer and dropped by 10 degrees, 30 days prior to spawning. The lighting regime to induce spawning is 8 daylight and 16 hour dark.

Broodstock are not fed in freshwater, all growth occurs in Seawater prior to moving inside. Movement inside is simply by pumping fish through a large pipe from a well boat moored alongside the freshwater recirculation facility.

At Hemne, I was shown through the commercial egg production facility, where broodfish are brought inside in transport bins, hung on roof mounted conveyor hooks and bled by cutting the tail. Each fish is moved through a stripping system on this conveyor, such that each staff member has a specific role to play and does not need to move. Eggs are disinfected and moved through into a fertilisation area, then an incubation area prior to packing and distribution. This industrial process is highly optimised and was very interesting to see how such a scale allows the process to be streamlined.

Hemne is also the site where potential broodstock are tested for one of AquaGen's resilience traits using a swim trial machine which they have had purpose built. This allows them to rank each individual and each family for swimming performance, or time to failure, a trait that they have linked to heart condition. This was interesting as the Tasmanian industry has recently supported an application for research in this same area.

I was also able to visit the research station of NOFIMA Marin at Sunndalsøra where I met with researchers who work closely with AquaGen and other companies in Norway to address research questions that have a commercial impact on the industry. I was also able to tour the NOFIMA Marin facilities which are substantial and include a new recirculation system that is used for research but also able to produce 500 000 smolts for commercial sale each year to help fund the maintenance of the facility.

September 9th Marine Harvest AS, Oslo, Norway

In Oslo I met with Dr Petter Arnesen, the director of breeding and genetics for Marine Harvest, the largest producer of Atlantic salmon in the world. Marine Harvest are currently developing a strategy for the implementation of their own global breeding program. They currently work with AquaGen and others to ensure regular supply of improved eggs to their grow-out sites. The development of their own program is designed to provide more control and greater competition in the breeding marketplace as well as providing a marketing platform for their own product.

September 12th and 13th Landcatch Natural Selection (LNS), Alloa, Scotland

In Scotland I spent a day in the offices of LNS, where I was able to meet with Dr Jose Mota-Velasco to discuss the DNA pedigree service that LNS currently provides to SALTAS and the SBP, with Dr Alistair Hamilton who is investigating the utility of new markers for pedigree and sex in Atlantic salmon as well as continuing the search for QTL's for commercially important traits, Dr Derrick Guy who performs the EBV calculations and provides the quantitative genetics advice for LNS' clients and in house programs, as well as Dr Alan Tinch who manages the commercial aspects of the LNS business.

This visit was informative as they were able to tell me about their clients in Chile who have moved towards the same system as ours in terms of holding all of their broodstock in freshwater throughout the life cycle for increased biosecurity. They have seen similar results to ourselves and are also making genetic gains, despite the pessimism shown by the Norwegians for this methodology.

On the 13th of September I was able to travel to the Landcatch brood facility and hatchery at Ormsary and tour the facility and discuss operations with the Breeding Stocks Manager, Mr Keith Drynan. This was highly beneficial as I was able to discuss with Keith the use of ultrasound technology for the identification of sex in smaller broodfish prior to signs of secondary sexual characteristics showing through. There is a lot of similarity between the operations at Ormsary and those of the SBP at SALTAS, and I have already benefited from creating a network of people in similar roles to myself that are happy to discuss issues in salmon breeding, such as Keith.

INDUSTRY IMPACT

PROJECT OUTCOMES (THAT INITIATED CHANGE IN INDUSTRY)

- Modern ultrasound technology will be trialled in the near future to allow the early identification of male Atlantic salmon. These fish can then be culled much earlier leading to a saving in feed costs and an increased capacity for egg production from the existing infrastructure at Saltas.

SUMMARY OF CHANGE IN INDUSTRY

- We are hoping to begin using this technology immediately at SALTAS and due to the cooperative nature of our company, there is a high likelihood of the technology being shared with all participants in the Tasmanian salmon industry

WHAT FUTURE AND ONGOING CHANGES ARE EXPECTED?

- If the technology can be utilised effectively in Tasmanian stocks, then there is the potential for removal of all males from the Elite female lines prior to the fish being moved into the recirculation broodstock system. This doubles the holding capacity of females in temperature controlled conditions over summer, and eliminates feed being wasted on growing unwanted males until they become morphologically apparent, and also eliminates the need for extra handling of the brood fish for sorting at large sizes.

WHAT BARRIERS ARE THERE FOR CHANGES TO OCCUR?

- The technology has been shown to be effective when used by a trained and experienced operator in European and Chilean stocks. The technology will need to be proven in Tasmanian stocks and operators will need to be trained and be given the time to gain experience prior to the full commercial implementation of the technology.

IF NOT ALREADY HAPPENING, WHEN WILL THE CHANGES OCCUR?

- Saltas will develop methodologies and identify the optimal hardware within the next 2 months
- Saltas will train staff to utilise the technology as soon as possible
- Other Tasmanian salmon producers may wish to take up the technology once it is developed by Saltas.

WHAT IS THE LIKELIHOOD THAT THESE CHANGES WILL OCCUR?

- I think it is extremely likely that this technology once developed will be taken up by all companies that hold broodstock within Tasmania

WHAT BARRIERS ARE THERE TO ADOPTION OF THESE CHANGES AND WHAT ACTION COULD BE TAKEN TO OVERCOME THESE?

- The technology is expensive and needs to be purchased
- There are a number of options for hardware that need to be tested before one is chosen
- Operators need to be trained in the use of the equipment
- Operators need to gain experience in discriminating between males and females at the size of fish that is most relevant to their needs.

All of these barriers can be overcome by the industry as the benefits of a working commercial system for the identification of sex in small Atlantic salmon are substantial.

COMMUNICATION OF PROJECT/EXTENSION ACTIVITIES

WHAT IS THE OUTPUT THAT NEEDS TO BE COMMUNICATED?

- That our Tasmanian SBP is well structured and implemented and we have many advantages over other genetic improvement programs due to our integrated cooperative nature.

WHO IS/ARE THE TARGET AUDIENCE/S?

- The Tasmanian Salmonid industry

WHAT ARE THE KEY MESSAGES?

- That a balanced approach to breeding is the standard throughout the world
- That there is benefit in the collection of data for a number of traits, not just those that are being selected for now.
- That the gains that are predicted for our industry are very competitive on a global scale.

COMMUNICATION CHANNELS

(How can these messages be communicated and by who?):

<i>Channel</i>	<i>Who by</i>	<i>When</i>
SBP technical committee	Me	Next meeting_November

LESSONS LEARNED AND RECOMMENDED IMPROVEMENTS

WHAT IS YOUR FEEDBACK?

This industry bursary was essential to support my attendance at the Fish Breeders Round Table meeting in Norway. The knowledge gained and the network developed will help me personally in the development of my own career and will provide benefits to the Atlantic salmon industry in particular and the Australian aquaculture breeding sector in general.

Meetings such as this one and the contacts and networks of animal breeders that I have made will be invaluable as the Tasmanian salmon industry moves to manage it's own SBP in the future, and will also aid in the development of breeding programs in other species within Australia.

FURTHER ACTION REQUIRED IN REGARDS TO COMMERCIALISATION?

Not relevant

ACKNOWLEDGEMENTS

I would like to thank the CRC for supporting this travel through this industry bursary.

I would also like to thank my employer, Saltas, and the Tasmanian SBP Technical committee for recognising the benefits of providing me with a global view of selective breeding in salmon.

I would particularly like to thank:

- Dr Arne Storset from AquaGen AS, Norway for giving up so much of his time to show me around their facilities, to introduce me to his colleagues and collaborators and to drive me to their remote field stations to see the practical implementation of their breeding efforts.
- Dr Alan Tinch from LNS, Scotland for spending so much time explaining the operations of their company to me
- Dr Dereck Guy from LNS for giving up his time to drive me across Scotland to their remote field site in atrocious weather conditions to show me where his quantitative skills are transformed into bigger healthier fish.