AQUA EXCEL

Aquaculture Infrastructures for Excellence in European Fish Research

Key Achievements **2011 – 2013**

Booklet 1 April 2013


KARL MAGNE

INTRODUCTION

AQUAEXCEL Key Achievements 2011 – 2013 is the first in a series of four booklets that will introduce the project, its core functions, as well as its progress to date. The booklet focuses on AQUAEXCEL's key achievements and provides detailed summaries of each. The aim of this booklet is to communicate to a general public how AQUAEXCEL's work is benefitting the research community and industry as well as helping to achieve significant value creation.

Introduction to AQUAEXCEL

AQUAEXCEL (Aquaculture Infrastructures for Excellence in European Fish Research) is an EU FP7 project that aims to integrate key aquaculture research infrastructures across Europe in order to promote their coordinated use and development. Through collaboration with 17 partners and 23 facilities, AQUAEXCEL offers access to top class research infrastructures for both basic and applied research, giving aquaculture research groups the opportunity to utilise AQUAEXCEL's facilities.

AQUAEXCEL's work is important because it provides essential benefits to improve aquaculture research in the EU. One of its unique selling points is that all types of EU aquaculture systems and species are part of AQUAEXCEL.

AQUAEXCEL's purpose is to bring together very different infrastructures and to develop common ways of thinking and of conducting research, thereby leading to a decompartmentalisation of EU aquaculture research, which is usually rather species-centered. It is also expected that transnational access to AQUAEXCEL's unique set of infrastructures will help emerging research teams produce good research on aquaculture target species, as well as develop and strengthen collaboration networks, thus benefiting EU aquaculture research beyond the AQUAEXCEL project. An additional benefit will be the development of new methods and tools for more cost-efficient and applicable research. In a nutshell, AQUAEXCEL is here to improve aquaculture research capacities in the EU.

Why Do We Need Research Infrastructures?

Research Infrastructures (RIs) play an increasingly important role in the advancement of knowledge and technology. They are a key instrument in bringing together a wide diversity of stakeholders to look for solutions to many of the problems society is facing today. RIs offer unique research services to users from different countries, attract young people to science, and help to shape scientific communities.

New knowledge and, by implication, innovation, can only emerge from high-quality and accessible RIs: for example, radiation sources, data banks in genomics, observatories for environmental sciences, systems of imaging or clean rooms for the study and development of new materials or nano-electronics are at the core of research and innovation processes.

Moreover, RIs help to create a new research environment in which all researchers – whether working in the context of their home institutions or in national or multinational scientific initiatives – have shared access to unique or distributed scientific facilities (including data, instruments, computing and communications), regardless of their type and location in the world. RIs are therefore at the centre of the knowledge triangle of research, education and innovation, producing knowledge through research, diffusing it through education, and applying it through innovation.

The overall objective of the 'Research Infrastructures' element of the FP7 Capacities programme is to optimise the use and development of the best research infrastructures existing in Europe. Furthermore, it aims to help to create new research infrastructures of pan-European interest in all fields of science and technology. The European scientific community needs these to remain at the forefront of the advancement of research, and they will help industry to strengthen its base of knowledge and technological know how.

INTRODUCTION

Knowledge generation and, by implication, innovation, directly depend on the quality and availability of research infrastructures, which include facilities such as observatories, data banks, radiation sources and communication networks.

AQUAEXCEL Areas of Activity

AQUAEXCEL has three main areas where it concentrates its activities:

1. Transnational Access (TNA)
2. Networking Activities (NA)
3. Joint Research Activities (JRA)

1) Transnational Access (TNA)

AQUAEXCEL offers Transnational Access (TNA) to a number of unique excellent aquaculture research facilities for international research and technology development. The aim is to enable scientists and researchers to freely access aquaculture research infrastructures not available in their own countries.

On a regular basis the AQUAEXCEL project invites proposals from European research groups for scientific research that utilises the facilities of any of the participating Aquaculture Research Infrastructures. The AQUAEXCEL project unites major aquaculture experimental facilities with capacity to undertake experimental trials on a selection of commercially important fish aquaculture species and system types.

The facilities available cover the entire range of production systems (recirculation, flow-through, cage, hatchery and pond systems); environments (freshwater and marine, cold, temperate and warm water); scales (small, medium and industrial scale); fish species (salmon, trout, sea bass, sea bream, cod, common carp etc.); and fields of expertise (nutrition, physiology, health and welfare, genetics, engineering, monitoring and management technologies).

Interested researchers can propose projects that are compliant with the EATIP Strategic Research & Innovation Agenda, and that involve visits of one or two people to a Research Infrastructure that provides facilities not available in their own country, for periods of up to three months. Access to the research facilities and associated travel and subsistence expenses are paid for under the project.

For more details on the Calls for Access, please visit: www.aquaexcel.eu/call_for_access

2) Networking Activities (NA)

The Networking Activities in AQUAEXCEL aim to foster a culture of co-operation between the AQUAEXCEL participants and other scientific communities benefitting from the AQUAEXCEL research infrastructures. The aims are to make better use of existing research infrastructures (WP3), stimulate collaboration across fields, systems, species, national borders (WP4, WP5), and secure provision of the best facilities to solve present and future research problems that may counteract the objectives of competitiveness, sustainability and increased production (WP2).

Key achievements from AQUAEXCEL's Networking Activities:

D2.1 Online Interactive System for Registration of Aquaculture Research Infrastructure Properties

D3.1 Sanitary Prescriptions and Procedures for Transfers and Safety Standards

D4.1/D4.2 Call for Access

D5.4 Protocols for Collection and Collation and Data-Sharing

3) Joint Research Activity (RA)

AQUAEXCEL's Joint Research Activities aim to improve, in quality and quantity, the services provided by the aquaculture research infrastructures (remote access and monitoring, more accurate performance evaluation, limitation of live animals use, applicability of results at industry scale, development of biological models).

AQUAEXCEL develops novel methods to open research infrastructures to new and larger user groups (WP6), to make better use of fish as experimental units (WP7, WP9), and to increase the value and relevance of research results at industry scale (WP8).

The AQUAEXCEL Joint Research Activities will allow significant improvements of the services provided by the Research Infrastructures in four complementary directions:

- Development of the concept of remote access to aquaculture infrastructures, through secured e-access to real-time experimental data and remote control of some experimental parameters. As it takes approximately 1 to 3 years for most fish to grow from egg to commercial size, experiments often have to last sufficiently long to obtain relevant results. Remote monitoring and control of experiments can both reduce the cost/benefit ratio and stimulate the throughput of research. The use of e-infrastructure tools will also be of great value to perform

multi-site experiments with a sufficient level of control, and for teaching purposes. Guidelines on how to set up remote access to the network's infrastructures will be delivered.

- Development of individual phenotyping methods in order to be able to maximise the information given by individual fish and then refine experimental results and reduce the number of animals used (WP7). The focus will be both on acquisitions of phenotypes on individuals and on non-lethal phenotyping, which can both be of high value to reduce the number of animals used, and are moreover extremely useful tools demanded by the selective breeding companies. Links will be established between group phenotypes and individual phenotypes using already existing isogenic lines of trout, as a proof of concept of the interest of such lines which will be produced for other species in WP9.

- Evaluation of the relevance of experiments as a function of scale, through modelling and empirical studies, and the development of scale correction models will lead to standards for a better validation of research results at the industrial level (WP8). This will be done considering both the scale of the fish holding units and of the biofilters used in recirculation systems. Small scale experiments are often preferred by researchers as they allow better environmental control, many replicates at relatively low cost and less use of experimental animals. However, as commercial fish farms tend to continuously increase the size of their rearing units, it is important to study the impact of scaling on research results. This will ensure a better applicability of research results by the commercial sector, and an adaptation of research practices if needed. WP8 will thus contribute to bridging the gap between research results and industrial implementation.

- Development and characterisation of standard fish lines for some of the most important species (salmon, carp, sea bass – trout and tilapia isogenic lines being already available at INRA and University of Stirling), using uniparental reproduction. This process will provide a standardised animal material which will be fully reproducible between sites and years, and which will exhibit between lines variation in important production and welfare traits, making it an extremely powerful tool to study the genetic and environmental determinism of complex traits.

By combining the knowledge and tools produced in the joint research activities, the infrastructure services can be improved in two ways:

- through the development of e-infrastructures and the evaluation of scale effects, researchers will be able to design and interpret large, multi-disciplinary experiments of high relevance to the industry and to the complex challenges typically experienced in the aquaculture sector;
- through the production of standard lines and of advanced phenotyping methods, it will allow an unprecedented level of precision in the study of the biology of aquaculture species.

Key achievements from AQUAEXCEL's Joint Research Activities:

D6.1 Functional Requirements for the AQUAEXCEL e-Infrastructure

D6.2 Design and Experiences from Testing Initial e-Infrastructure Prototype

D8.1 Listing of Simulation Model Modules

D9.1 Optimisation of Gynogenesis in Salmon

D9.2 Optimisation of Androgenesis in Carp and Seabass

KEY OUTPUT 1: Online Interactive System for Registration of Aquaculture Research Infrastructure Properties (AQUAEXCEL D2.1)

At a glance:

- Full Title: D2.1 – Online interactive system for registration of aquaculture research infrastructures (a research infrastructure is a site-specific cluster of research groups and tools that provide essential services for basic or applied research)
- Knowledge Type: Services/Tools
- Where to find it: www.aquaexcel.eu/ri/map
- Who to contact for more information: Marieke Reuver, AquaTT, E: marieke@aquatt.ie T: +353 1 644 9008
- Patents or other IPR exploitation: No, this is an open service based on existing technology

Introduction

The objective of the online interactive system for registration of research infrastructure properties is to create an online inventory of European infrastructures dedicated to aquaculture research and development, presenting available facilities and expertise.

European Aquaculture Research infrastructures Interactive Map

Key information:

The AQUAEXCEL online interactive system has been developed for the registration of aquaculture research infrastructure properties across Europe. The system allows RI providers, within and outside the AQUAEXCEL consortium, to make information available to the aquaculture community.

Submitting information on aquaculture research infrastructures into the AQUAEXCEL database contributes to:

- opening up to mutual collaboration with European colleagues
- providing a unique chance to promote institutions and their facilities worldwide
- allowing colleagues worldwide to identify institutions, their properties and their researchers
- providing opportunities for international cooperation
- developing networking opportunities

The infobase will be a viable European aquaculture research infrastructure directory in the long term, and a powerful tool for identifying European facilities, genetic and human resources and for promoting mutual collaboration.

- End-user & Application:

  End-user 1: Scientific Community. Applications: (1) Promote and highlight research facilities and technical competencies of the RI and provide opportunities for international cooperation and (2) Researchers can search for collaborators and RIs with complementary and/or additional expertise or facilities.

  End-user 2: Industry. Applications: (1) Aquaculture industry with research facilities open to external users can promote and highlight their research facilities and expertise and provide opportunities for international cooperation and (2) Industry can identify expertise and/or facilities that are needed in industry driven research and innovation activities.

  End-user 3: Research Infrastructure projects in other sectors. Application: The system could be a successful example for a similar system to be developed in other sectors.

  End-user 4: Other sectors. Application: other sectors might also find complementary or additional expertise or facilities, e.g. zebrafish as model fish are also used widely in medical research.
- Impact: Its use may lead to new collaborative projects, increased multidisciplinarity, higher visibility of existing facilities, less duplication, provision of advanced training courses.

KEY OUTPUT 2: Sanitary Prescriptions and Procedures for Transfers and Safety Standards (AQUAEXCEL D3.1)

At a glance:

- Full Title: D3.1 - Sanitary protocols and procedures for movement and transfer of stocks, and safety standards, a definition of the optimum condition in terms of health and welfare for the transport of fish and/or germplasm by means of regulations for the safe transport between different aquaculture research centres.
- Knowledge Type: Guidelines/Standards
- Where to find it: www.aquaexcel.eu
- Who to contact for more information: Fernando Real Valcárcel. Fish Pathology Division of IUSA, E: freal@dpat.ulpgc.es T: +34 928 451182
- Patents or other IPR exploitation: No

Introduction

The guide for "sanitary prescriptions and procedures for transfer and safety standards" has been redacted as a Handbook of Best Practices for the Transport of Fish and Germplasm, in the framework of the AQUAEXCEL project, and aims to define the optimum conditions in terms of health and welfare for the transport of fish and/or germplasm by means of regulations for the safe transport between the different research centres of the project members. The sanitary measures featured in this Handbook of Best Practices are based on the standards officially approved by European Legislation, with specific reference to European Directive 2006/88 EC of 24th October, 2006 and the World Assembly of Delegates of the OIE. This Handbook of Best Practices includes a description of the main diseases that affect the fish species included in the AQUAEXCEL project and corresponding methods of diagnosis, paying particular attention to the diseases identified by the research centres in the initial survey, as well as criteria to evaluate harmlessness in the transport of fish and germplasm, the welfare of the farmed fish during transport and the disinfection of eggs.

Key information:

The purpose of this manual is to make it easier for the different researchers of the AQUAEXCEL project to draw up sanitary measures applicable to the movement of fish and/or germplasm between the different research centres belonging to the AQUAEXCEL project. The recommendations put forward in this Handbook of Best Practices take into consideration the fish species to be transported and the health status of the country of origin and the research centre in order to avoid the disease to which they are applied being introduced into the research centre or country to which the fish and/or germplasm are transported. This means that the recommendations, if correctly applied, confers an optimum level of sanitary security to the transport of fish or germplasm between the different research centres participating in the AQUAEXCEL project. The recommendations of this manual refer only to the sanitary conditions that should be met by the participating research centre and are governed by the principle that the disease is not present in the research centre to which the animals are transported or that the centre is subject to control or eradication programmes. A research centre can authorise the transport of fish or germplasm in conditions that are either more or less strict than those recommended in this manual, but it must base its decision on a scientific risk analysis and abide by the obligations imposed by the provisions of the WTO SPS Agreement.

- End-user & Application:
  End-user 1: Scientific Community. Application: Researchers can use the manual to draw up sanitary measures (best health practices) applicable to the movement of fish and/or germplasm between different research centres. The recommendations, if correctly applied, confers an optimum level of sanitary security to the transport of fish or germplasm between different research centres.
  End-user 2: Industry. Application: Industry can use the manual to draw up sanitary measures (best health practices) applicable to the movement of fish and/or germplasm between different fish institutions. The recommendations, if correctly applied, confers an optimum level of sanitary security to the transport of fish or germplasm between different fish institutions.
  End-user 3: Education (e.g. fish veterinarians, aquaculture). Application: The manual gives a clear overview and details of many fish diseases, which could be useful for aquaculture/fish disease related courses, and to inform about best health practices.
  End-user 4: Animal Health Authorities. Application: The manual informs and details the Sanitary Status of Research European Infrastructures in Aquaculture (RIs).
- Impact: Number of other research facilities who use the Guidelines and establish Best Health Practices. Will also contribute to a decrease in fish health problems in transfer processes.

KEY OUTPUT 3: Call for Access (AQUAEXCEL D4.1/4.2)

At a glance:

- Full Title: D4.1 First call for access and accompanying guidelines & D4.2 Call for access
- Where to find it: www.aquaexcel.eu/call_for_access
- Who to contact for more information: John Bostock, University of Stirling, E: j.c.bostock@stir.ac.uk T: +44 1786 466575

Introduction

On a regular basis, the AQUAEXCEL project invites proposals from European research groups for scientific research that utilises the facilities of any of the participating Aquaculture Research Infrastructures. The AQUAEXCEL project unites major aquaculture experimental facilities with capacity to undertake experimental trials on a selection of commercially important fish aquaculture species and system types. These facilities are made available to the research community for Transnational Access (TNA) with the support of the European Union 7th Framework Programme for Research and Technological Development (Infrastructures).

Key information:

The facilities available cover the entire range of production systems (recirculation, flow-through, cage, hatchery and pond systems); environments (freshwater and marine, cold, temperate and warm water); scales (small, medium and industrial scale); fish species (salmon, trout, sea bass, sea bream, cod, common carp, etc.); and fields of expertise (nutrition, physiology, health and welfare, genetics, engineering, monitoring and management technologies).

The overall objective of the AQUAEXCEL project is to promote the coordinated use and development of these top class experimental facilities and encourage problem-based research and knowledge transfer to more effectively support the development of a sustainable European production of high quality seafood with reduced environmental impact.

Interested researchers can propose projects that are compliant with the EATiP Strategic Research & Innovation Agenda, and that involve visits of one or two people to a Research Infrastructure that provides facilities not available in their own country, for periods of up to three months. Access to the research facilities and associated travel and subsistence expenses will be paid for under the project.

- End-user & Application:
  End-user 1: Scientific Community. Application: Researchers can use the TNA facility to initiate and explore new collaborative partnerships; access facilities to extend the scope of their current research; or initiate new areas of research through training and experience with new techniques or species.
  End-user 2: Industry. Application: Researchers within industry can use the TNA facility to develop new collaborative partnerships with their selected research infrastructure; access facilities or species that enable them to extend the scope of their current research; or initiate new areas of research through training and experience with new techniques or species.
- Impact: New collaborations formed to address issues critical for the advancement of European aquaculture; scientific advancements made and disseminated through journal articles and conference presentations; new techniques developed and transferred to industry.

KEY OUTPUT 4: Protocols for Collection and Collation and Data-Sharing (AQUAEXCEL D5.4)

At a glance:

- Full Title: D5.4 – Protocols for collection and collation and data-sharing
- Knowledge Type: Guidelines/Standards
- Where to find it: AQUAEXCEL Confidential report (Deliverable 5.4)
- Who to contact for more information: Marieke Reuver, AquaTT, E: marieke@aquatt.ie T: +353 (0)1 6449008
- Patents or other IPR exploitation: N/A

Introduction

AQUAEXCEL put in place a protocol to transfer research outputs (e.g. products, methodologies, findings) to end-users who can make best use of those results, to customise information and knowledge so that it is ready for uptake by different target end-users, and to develop and make use of the latest tools, resources and communication channels resulting in cost effectiveness and maximum impact.

Knowledge resulting from research projects in general, and AQUAEXCEL specifically, could play a pivotal role in the sustainable development of our natural resources, in knowledge-based ocean governance and as a major source of competitive advantage in business. However, capturing knowledge and ensuring it can and will be used by relevant users is historically a significant challenge. Knowledge transfer can be complicated by many factors such as the inability to recognise and articulate "compiled" or highly intuitive competencies – tacit knowledge ideas, language and cultural barriers, lack of incentives, and many more.

AQUAEXCEL has established this protocol to ensure all relevant knowledge coming out of the project will not 'sit on a shelf' but will be transferred and taken up by relevant users.

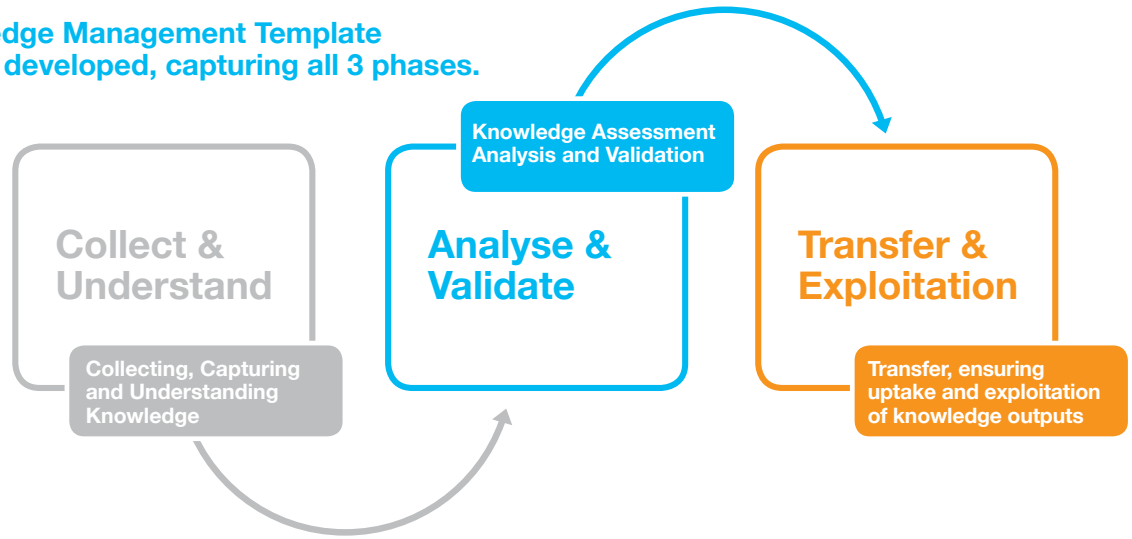
Key information:

The methodology focuses on Knowledge Outputs. A "Knowledge Output" for the purposes of this project is the term used to describe a unit of knowledge that has been generated out of a scientific project. It is not limited to de-novo or pioneering discoveries but may also include new methodologies/processes, adaptations, insights, and alternative applications of prior know-how/knowledge. The methodology consists of the following steps:

1. **Collect and Understand:** setting up protocols for collection and collation of data and knowledge during the duration of the AQUAEXCEL project in order to ensure that no knowledge is lost.
2. **Analyse & Validate:** careful assessment of collected information, request for further information if needed and identification of potential end users and application of the knowledge.
3. **Transfer & Exploit:** identifying the most suitable methods for transferring knowledge with a view to ensuring that any knowledge transfer results in uptake and exploitation.

- End-user & Application:
  End-user: Any research output generator. Application: The methodology can be used to ensure any new knowledge is captured, potential applications identified and transfer carried out to the appropriate end users.
- Impact: Number of other research projects, both national and international, who have adopted the methodology. Number of AQUAEXCEL knowledge outputs being transferred.

A Knowledge Management Template has been developed, capturing all 3 phases.



KEY OUTPUT 5: Functional Requirements for the AQUAEXCEL e-Infrastructure (AQUAEXCEL D6.1)

At a glance:

- Full Title: D6.1 Functional requirements for the AQUAEXCEL e-Infrastructure (which will provide solutions for remote access to the aquaculture research facilities in the AQUAEXCEL project)
- Knowledge Type: Report
- Where to find it: AQUAEXCEL Confidential report (D6.1)
- Who to contact for more information: Morten Omholt Alver, NTNU, E: morten.alver@itk.ntnu.no T: +47 95150321
- Patents or other IPR exploitation: No

Introduction

The overall objective this knowledge output contributes to is to develop, implement and evaluate technical solutions (e-Infrastructure) for providing remote access to highly specialised aquaculture research facilities. This knowledge output specifically describes the technical infrastructures of the AQUAEXCEL consortium, their research facilities and analysis of their functional requirements, specifically in relation to their capacities for remote access.

Key information:

AQUAEXCEL will design and implement an e-infrastructure for European research facilities in the aquaculture field, and this key output describes the technical infrastructures of the research facilities in the AQUAEXCEL consortium, and determines the technical and functional requirements of the e-infrastructure.

- End-user & Application:
  End-user 1: Scientific community. Application: Researchers can consult the report to check technical details on aquaculture research facilities available, in order to assess their relevance for 'external' research and possibilities for exchange programs.
  End-user 2: Facility Managers. Application: Facility managers can compare own technical infrastructure with other facilities as a basis for planning further developments.
- Impact: Number of external researchers carrying out research at available AQUAEXCEL research facilities.

KEY OUTPUT 6: Design and Experiences from Testing Initial e-Infrastructure Prototype (AQUAEXCEL D6.2)

At a glance:

- Full Title: D6.2 Design and experiences from testing initial e-Infrastructure prototype – which is the basis for remote access to selected AQUAEXCEL facilities
- Knowledge Type: Report
- Where to find it: AQUAEXCEL Restricted report – restricted to a group specified by the consortium (including the Commission Services) (D6.2)
- Who to contact for more information: Gunnar Senneset, SINTEF, E: gunnar.senneset@sintef.no T: +47 92026107
- Patents or other IPR exploitation: No

Introduction

The overall objective this knowledge output contributes to is to develop, implement and evaluate technical solutions (e-Infrastructure) for providing remote access to highly specialised aquaculture research facilities. This knowledge output specifically reports on the design and development of an initial prototype AQUAEXCEL e-Infrastructure, and summary of the experiences. This provides a basis for implementing e-Infrastructure solutions for remote access to selected AQUAEXCEL facilities.

Key information:

This document describes the design and the technical solutions chosen as the basis for the initial prototype. The design is based on functional requirements retrieved from the survey in deliverable D6.1 supplemented with detailed technical descriptions and case studies from the partner facilities involved. In addition to the functional and technical requirements, the design of the initial prototype must also accommodate organisational constraints such as security measures, etc. Relevant on-going work within the area of standardising descriptions and exchange of data from observations and measurements must also be taken into account.

The design is described in detail and the experiences from testing and the recommendations for further work are described as well. The initial prototype was developed and tested at SINTEF ACE and NTNU Codtech.

- End-user & Application:
  End-user 1: Scientific Community. Application: Researchers can consult the report to get an overview of the functionality the e-Infrastructure will provide.
  End-user 2: Facility managers. Application: Facility managers can consult the report as input for planning development of own infrastructures.
- Impact: Increased utilisation of research facilities as a direct result of the Knowledge Output (combined with future WP6 deliverables).

KEY OUTPUT 7: A Simulation Model for Effects of Tank and Cage Size on Fish Growth (AQUAEXCEL D8.1)

At a glance:

- Full Title: D.8.1 Parameterisation of a growth simulation model [Listing of simulation model modules]. (Compilation of a list of factors within a fish culture environment that are likely to be sensitive to the physical scale of a production unit. These factors feed into a mathematical model able to simulate how changes in the physical scale of production unit affect the performance (growth and survival) of salmon and sea bass)
- Knowledge Type: Software/Modelling tools
- Where to find it: Currently not publicly available (AQUAEXCEL Deliverable D8.1)
- Who to contact for more information: Morten Omholt Alver, Associate Professor, Norwegian University of Science and Technology (NTNU), Trondheim, Norway
  E: morten.alver@itk.ntnu.no T: +47 95150321
  Bendik Fyhn Terjesen, Senior Research Scientist, Nofima, Sunndalsøra, Norway, E: Bendik.terjesen@nofima.no
  T: +47 40 45 78 74
- Patents or other IPR exploitation: Prototype only at this stage. Not clear at this time (Oct 2012), the predictive power of the final model must be tested

Introduction

When fish of initially similar size and density are reared in a small vs. large tank or cage, many parameters differ that can affect performance (growth, survival). This deliverable identified these scaling factors, which were put into modules as part of a dynamic model. The report provides a detailed description of the mathematical model.

Key information:

This result is intended to provide a detailed description of the mathematical model to simulate how changes in physical scale of the production unit affect the performance (i.e. growth and survival) of salmon and sea bass.

A literature study has been carried out to review possible factors that change due to the physical scale of rearing tanks or cages, and the effect these changes have on fish performance. Based on these factors, and the outcomes of the literature study, a conceptual model of the rearing system has been formed and presented through a series of figures in this report. The conceptual model contains the necessary modules to simulate those aspects of the dynamics of cage or tank cultures that have been found relevant to model the effects of scale changes.

In order to better illustrate the conceptual model, and to begin its implementation, a prototype model has been developed. Utilising previously published models, the prototype implements parts of the model system, specifically the feed dynamics, fish behaviour and physiology. Initial simulations with the prototype have shown the integration of the different model components.

The next step will be to further develop the prototype model with implementations of the missing pieces. The most important piece is a model describing the hydrodynamics and hydraulics within the production unit, i.e. the water velocity patterns and amplitudes in the tank or cage.

- End-user & Application:
  End-user 1: Aquaculture Industry. Application: It can learn about possible effects of rearing fish in tanks or cages of different volumes.
  End-user 2: Scientific Community. Application: The knowledge can be used to design experiments relevant to the aquaculture industry.
  End-user 3: Regulatory Authorities/Certifiers for Quality/Organic Status. Application: As density per m3 is an important issue in fish welfare.
- Impact: With further development, a very useful model may be developed, possibly with high predictive power of the effect on growth when transferring fish from a large to a smaller tank or cage. This will be valuable for the aquaculture industry, since the value in just one cage is now considerable. Further, the research should generate a paper in a peer-reviewed journal and could be instrumental in generating further projects.

KEY OUTPUT 8: Optimisation of Gynogenesis in Salmon (AQUAEXCEL D9.1)

At a glance:

- Full Title: Development of isogenic lines of commercial species (Atlantic salmon) to replace, reduce and refine the experimental animals available to the aquaculture research community
- Knowledge Type: Scientific Publication
- Where to find it: www.aquaexcel.eu
- Who to contact for more information: Brendan McAndrew, University of Stirling E: bjm1@stir.ac.uk
- Patents or other IPR exploitation: No

Introduction

The objective of this output was to optimise mitotic gynogenesis as a technique for developing isogenic lines in Atlantic salmon. The term "optimise" should be qualified here. Yields of mitotic gynogenetic individuals (as survivors at first feeding stage) are normally low – in general a few percent relative to that observed in control groups (untreated sperm and eggs, normal crosses) – and variable. Some of this variation is due to egg quality (poor egg quality will give disproportionately low yields of mitotic gynogenetics, often zero) and the genetics of the outbred individuals used as parents for the homozygous founders (e.g. recessive lethal or deleterious alleles). In practice, the objective is to be able to produce enough homozygous founders to then be able to go on to produce isogenic lines. Homozygous founders of isogenic lines are completely inbred, so an (unpredictable) proportion will have reduced reproductive capacity.

Key information:

Optimised UV irradiation treatment of sperm produced hatched embryos with typical haploid syndrome, with a very low percentage of embryos of normal appearance. UV irradiation of sperm plus pressure shocks (9500 psi, 5 min. duration) given at 4400 – 4800min°C post-fertilisation resulted in surviving embryos (putative mitotic gynogenetics), while shocks given earlier (3800 – 4200 min°C postfertilisation) did not.

Over 300 fish from these treated groups have been reared, PIT tagged and biopsied. Genetic analysis using 15 markers showed that only two of these fish exhibited biparental inheritance (presumably UV inactivation failure), while all other fish were homozygous at all of the 15 markers for which the mother was heterozygous. These fish are candidate homozygous founders for isogenic lines.

- A series of pressure shocks were given to Atlantic salmon eggs fertilised using UV-irradiated sperm.
- >300 putative mitotic gynogenetic Atlantic salmon were produced from pressure shocks given at 4400 – 4800min°C post-fertilisation.
- These fish are being grown on as potential isogenic line founders.

- End-user & Application:
  End-user 1: Scientific Community. Application: (1) Basis for more work in this area; (2) Increased development of better drugs and vaccines; (3) Develop more disease resistant strains; and (4) Better understanding of basic biology of fish.

  End-user 2: Pharmaceutical Industry. Application: Speed up the rate of development of better drugs and vaccines.

  End-user 3: Breeding Companies. Application: Develop more disease resistant and better domesticated strains.
- Impact: Number of publications using the new strains, development of more robust and efficient farm strains.

KEY OUTPUT 9: Optimisation of Androgenesis in Carp and Seabass (AQUAEXCEL D9.2)

At a glance:

- Full Title: Development of isogenic lines of commercial species (common carp and seabass) to replace, reduce and refine the experimental animals available to the aquaculture research community
- Knowledge Type: Scientific Publication
- Where to find it: www.aquaexcel.eu
- Who to contact for more information: Brendan McAndrew, University of Stirling E: bjm1@stir.ac.uk
- Patents or other IPR exploitation: No

Introduction

The objective of this deliverable was to optimise androgenesis as a technique for developing isogenic lines in European seabass and common carp.

Both androgenesis and mitotic gynogenesis have been induced in several fish species. Androgenesis is inherently more challenging (largely due to the greater difficulties of successfully inactivating the maternal nuclear genome in the unfertilised egg), but attractive in species where males mature earlier than females (fairly common in fish) as a means to shorten the time taken to produce isogenic lines. In both techniques, inactivation of one parental genome produces a haploid zygote; diploidy is restored by giving a pressure or temperature shock to suppress mitosis, resulting in a "dihaploid" embryo (two identical sets of chromosomes, thus completely homozygous).

The term "optimise" should be qualified here. Yields of androgenetic or mitotic gynogenetic individuals (as survivors at first feeding stage) are normally low – in general a few percent relative to that observed in control groups (untreated sperm and eggs, normal crosses) – and variable. Some of this variation is due to egg quality (poor egg quality will give disproportionately low yields of androgenetics or mitotic gynogenetics, often zero) and the genetics of the individuals used as parents for the homozygous founders (e.g. recessive lethal or deleterious alleles). In practice, the objective is to be able to produce enough homozygous founders to then be able to go on to produce isogenic lines. Homozygous founders of isogenic lines are completely inbred, so an (unpredictable) proportion will have reduced reproductive capacity.

Key information:

Androgenesis was successfully induced in common carp using both methods (UV and γ irradiation of eggs), but the survival rate using γ irradiation was much lower than with UV. This was primarily due to the logistics of using γ irradiation – stripped eggs have to be chilled, taken to the γ source, brought back to the lab and warmed up again before continuing with fertilisation, heat shock and incubation. In contrast, UV irradiation was carried out in the lab in VURH, with minimal delay between stripping and fertilisation.

Putative common carp homozygous founders (androgenetic and gynogenetic) were tested using scaling pattern markers (some strains) and microsatellite markers to distinguish androgenetics or gynogenetics from biparental diploids (irradiation failures) or meiotic gynogenetics (gynogenesis only). Mitotic gynogenetic carp were successfully produced in both VURH and HAKI, in higher numbers than androgenetics. Both are being grown on to maturity to produce isogenic lines.

Despite exhaustive testing of UV irradiation, no haploid androgenetic sea bass embryos were produced at IFREMER. Sea bass eggs are fairly small and transparent, so should be suitable for successful UV irradiation. Mitotic gynogenesis carried out over the same spawning season produced survivors which are being grown on as putative founders of isogenic lines (will be analysed with genetic markers when large enough to tag).

- Androgenesis was successfully induced in common carp using both UV and γ irradiation to inactivate the egg nuclear genome.
- Higher yields of androgenetic common carp were produced using UV irradiation than γ irradiation.
- For UV irradiation, the numbers of androgenetic common carp produced appears to be large enough to develop isogenic lines.
- Large numbers of mitotic gynogenetic common carp were also produced, and can also be used to develop isogenic lines but with a longer generation time than via androgenesis.
- UV irradiation of unfertilised sea bass eggs was not successful in producing haploid androgenetic embryos
- Large numbers of putative mitotic gynogenetic sea bass were also produced, and females from this can also be used to develop isogenic lines through gynogenesis but with a longer generation time than via androgenesis.

CONTINUED

- End-user & Application:
  End-user 1: Scientific Community. Application: (1) Basis for more work in this area; (2) Increased development of better drugs and vaccines; (3) Develop more disease resistant strains; and (4) better understanding of basic biology of fish.

  End-user 2: Pharmaceutical Industry. Application: Speed up the rate of development of better drugs and vaccines.

  End-user 3: Breeding Companies. Application: Develop more disease resistant and better domesticated strains.
- Impact: Number of publications using the new strains, development of more robust and efficient farm strains.

AQUA EXCEL

PROMOTING EXCELLENCE IN EUROPEAN FISH RESEARCH THROUGH:

1 Open Calls for Access to Aquaculture Infrastructures

AQUAEXCEL invites proposals from European research groups for scientific research that utilises the facilities of any of the participating Aquaculture Research Infrastructures. Interested researchers can propose projects that are compliant with the EATiP Strategic Research & Innovation Agenda and will involve one or two researchers visiting a Research Infrastructure that provides facilities not available in their own country for periods of up to three months. Access to the research facilities and associated travel and subsistence expenses will be paid for under the project.

The next Call for Access opens on the 15th July with a deadline of the 13th September 2013
www.aquaexcel.eu/call_for_access

2 AQUAEXCEL's Aquaculture Research Infrastructures Map

The AQUAEXCEL Aquaculture Research Infrastructure Map is an integrated online infobase listing all aquaculture research infrastructures in Europe and associated countries, including non-AQUAEXCEL partners.

To add your Research Infrastructure to the AQUAEXCEL online infobase, go to: www.aquaexcel.eu/rimap

3 AQUAEXCEL's Aquaculture Training Courses

COURSE 1
Title: Recirculating Aquaculture System (RAS) Technology
Course Provider: Aquaculture and Fisheries Group, Wageningen University (the Netherlands), with the expertise of NOFIMA, IFREMER and IMARES
Location: Wageningen University, the Netherlands
Date: 22-25 April 2013
COURSE COMPLETE

COURSE 2
Title: Applications of Genomic Information to Selective Breeding in Aquaculture of Temperate and Mediterranean Fish
Course Provider: INRA
Location: Jouy-en-Josas, France
Date: October 2013

COURSE 3
Title: Chromosome Set Manipulations and the Importance of Gamete Collection and Management, including Sperm Cryopreservation
Course Provider: Institute of Aquaculture, University of Stirling
Location: Stirling, UK
Date: November 2013

COURSE 4
Title: Efficient Design of Fish Larval Experiments Utilising New Monitoring and Control Systems
Course Provider: NTNU and SINTEF Sealab
Location: University of Science and Technology (NTNU), Trondheim, Norway
Date: April 2014

For more information about these courses, please visit www.aquaexcel.eu

www.aquaexcel.eu

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement no 262336. This publication reflects the views only of the author, and the European Union cannot be held responsible for any use which may be made of the information contained therein.

Designed and developed by AquaTT