Launch of ozone application in freshwater fish farms (Lanozo) (39595)

The accumulation of suspended bacteria and micro-particles poses a great challenge for recirculating aquaculture systems (RAS). Microparticles (1-40 µm) cannot be removed by traditional measures (sludge-cones, drum screen filter) and protein skimming is only done in saltwater due to the characteristic surface tension, small bubble size and associated removal efficacy.

The aim of this project is to explore and test well-known water treatment technologies (ozone and protein skimmers) to improve water quality in freshwater fish farms by removing accumulated microparticles. The project include both controlled lab experiments and tests performed in full scale commercial RAS.

The expected work package activities in the project include:

• Identify technologies to effectively remove accumulated micro-particles in freshwater.
• Testing methods for removing microparticles and foams on fish farms.
• Evaluate combination of ozone and protein skimmer under controlled conditions.
• Document potential of ozone and protein skimmers with tests on a commercial fish farm.

The project is coordinated by DTU Aqua and is funded by the European Maritime and Fisheries Fund (EMFF) and the Danish Fisheries Agency.

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01/01/2019 → 31/12/2020

Keywords: Research area: Aquaculture
Project: Research

Optimizing water sanitation using alternatives to formalin (39500)

This applied project is a collaboration between Danish Aquaculture, Danish fish farmers, KU Sund and DTU Aqua. The aim is to improve the efficacy of water treatment with easy degradable chemicals that can substitute or reduce the use of formalin. The particular concern is effective water treatment to reduce abundance of skin- and gill parasites (Costis and gill amoeba).

The project has four work packages:

• Practical trials on fish farms (all).
• Test and development of a method to assess disinfection demand (DTU Aqua).
• In vitro test with Costia and use of different chemicals (KU Sund).
• PCR identification of amoebic gill disease (KU Sund).

The project is coordinated by Danish Aquaculture Association and is funded by Direktør Ib Henriksen's Fond.

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01/01/2019 → 31/12/2020

Keywords: Research area: Aquaculture
Project: Research

Future growth in sustainable, resilient and climate friendly organic and conventional European aquaculture (FutureEU Aqua) (39567)

The overall objective of FutureEU Aqua is to effectively promote sustainable growth of resilient to climate changes, environmentally friendly organic and conventional aquaculture of major fish species and low trophic level organisms in Europe, to meet future challenges with respect to the growing consumer demand for high quality, nutritious and responsibly produced food. To this end, FutureEU Aqua will promote innovations in the whole value chain, including genetic selection, ingredients and feeds, non-invasive monitoring technologies, innovative fish products and packaging methods, optimal production systems such as IMTA and RAS, taking into account socioeconomic considerations by the participation of a wide spectrum of stakeholders, training and dissemination activities.
To achieve the objective and to relate to the work program, nine work packages will contribute to improvements of future aquaculture. To ensure sustainable and resilient production of fish FutureEUAqua will work with tailor made fish and feed, and validate fish performance and water quality in cost effective production systems. Consumer demand and awareness of how to choose sustainable and climate friendly seafood. With the increasing production of seafood, we face space-conflicts, which, in combination with the current regulatory frameworks will be considered. Wireless sensor technology for health and welfare monitoring and novel technology for product quality and packaging to meet future demands, will be implemented.

Stakeholders’ knowledge and views will be important, and communication, dissemination as well as training sessions will be emphasized.

The project is coordinated by NOFIMA, Norway and is funded by HORIZON 2020 Blue Growth Programme.

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01/11/2018 → 30/09/2022

Keywords: Research area: Aquaculture


Project: Research

Restocking of lobster at stone reefs in the sea at North West Jutland (39555)

The overall idea is to capture mature female lobsters, hatch the eggs and grow larvae to juveniles for restocking in coastal waters around Hirtshals to Løkken. Partners are NSC, Hirtshals/Løkken Fisheries Associations, fishermen and restaurants. DTU Aqua is involved in optimizing knowledge about nutritional requirements of lobster larvae and juveniles to ensure a high survival and growth.

The project is coordinated by the North Sea Centre and is funded by "ENV"-Fonden and FLAG (Local Actions Groups within Fisheries).

Lund, I., Project Manager, National Institute of Aquatic Resources, Section for Aquaculture
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01/07/2018 → 30/06/2020

Keywords: Research area: Aquaculture

Collaborators: Villa Vest (restaurant), North Sea Centre, Hirtshals Fisheries Association, Løkken Fisheries Association, Lilleheden (restaurant)

Project: Research

Nordic Centre of Excellence Network in Fishmeal and Fish oil (39498)

Due to the change in markets and demands there is an urgent need for improved knowledge about the nutritional value which fish meal and fish oil can provide in the feed industry in order to increase the value of these commodities, to facilitate and strengthen the Nordic cooperation – and bio economy – this Nordic Centre of Excellence in Fishmeal and Fish oil is established. A detailed review of the current knowledge on raw material quality and seasonal variation, processing methods and the nutritional properties and characteristics of fishmeal and –oils will be provided. Background knowledge of protein production intended for human consumption from various raw materials, and how these products have been utilized up to date will also be established. Literature will be reviewed on processing methods, both traditional and new, applied analytical methods, effect of producing fish proteins from various fish species on the nutritional properties and characteristics of fishmeal and –oils, their seasonal variation, preservation methods throughout the value chain, food grade production regulations and more. References will be sought both in peer reviewed articles, reports and other published sources, as well as from personal communications with the industry and specialists within the field. The obtained knowledge will be summarized and published in a scientific review (workshop review) and communicated in a simple way e.g. infographics, fact sheets and 1-2 videos. The results will create a road map for future research projects to create innovations in the field and to improve the Nordic bio economy.

This project is coordinated by Matís ohf, Iceland and is funded by the Nordic Council of Ministers and EU Fishmeal.

Jokumsen, A., Project Participant, National Institute of Aquatic Resources, Section for Aquaculture

01/01/2018 → 31/12/2018

Keywords: Research area: Aquaculture

Collaborators: EUfishmeal and Marine Ingredients Denmark, Matís ltd., Fiskernes Fiskeindustri, Havsbrún, Nofima, TripleNine Group A/S
**Peracetic acid as a potential treatment for amoebic gill disease (AGD) in Atlantic salmon (39544)**

The overarching aim of PERAGILL is to explore the potential of peracetic acid as an alternative and sustainable treatment to amoebic gill disease, a threat in the Norwegian Atlantic salmon aquaculture.

The project includes several workpackages, in which the following topics will be:

- To investigate the amoebicidal activity of PAA and identify factors influencing this feature.
- To assess the impact of PAA treatment on fish health and welfare.
- To determine the potential environmental risk of PAA treatment.
- To develop integrative assessment toolbox to evaluate treatment impacts and efficacy.
- To characterise the different factors affecting the dynamics of PAA treatment in AGD-infected fish.
- To compare conventional AGD treatments with PAA application.

The project hence include controlled prolonged trials with Atlantic salmon post smolts (exposure and recovery), where samples of gills, skin and plasma will be analyzed. Controlled degradation trials in seawater will be performed and in vitro experiments will be conducted.

The project is coordinated by NOFIMA, Ås, Norway and is funded by the The Norwegian Seafood Research Fund (FHF).

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01/01/2018 → 31/12/2020

**Keywords:** Research area: Aquaculture

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**Green switch in Danish Aquaculture by changeover to recirculation (GODAOR) (39462)**

The overall aim of the project is to disseminate scientific knowledge and practical experiences regarding optimum use of recirculation technology in land based fish farming.

The main concrete aims are:

1. To promote green and economic sustainability in recirculation fish farming by optimum use of recirculation technology to minimize the specific discharge of nutrients (nitrogen, phosphorus and organic matter) from the fish production.
2. To strengthen green switch by increased use of recirculation technology by supporting the changeover from traditional pond farming to modern recirculation technology. This is based on knowledge and experience from research- and development projects. E.g. will optimum designed farms and management reflect less fish diseases, less mortality and improved feed utilization concomitant with better fish welfare.

This project is coordinated by the Danish Aquaculture Organisation and is funded by Green Growth and Development Program (GUDP).

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01/07/2017 → 30/06/2021

**Keywords:** Research area: Aquaculture

**Collaborators:** University of Copenhagen, The Danish Veterinary Association, Danish Aquaculture Association

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**Supporting veterinary measures (39362)**

The project is a collaboration between the Danish Aquaculture Association, DTU Aqua, DTU Vet and KU SUND with the help of practicing fish veterinarians, Aquapri and several trout and shellfish farmers.

The project addresses three specific veterinary issues in Danish aquaculture:

- Skin disorders in rainbow trout.
- Water quality and the importance of microparticles for breeding fish in RAS.
- The importance of the parasite Bonamia ostreae for oyster farming in the Limfjord.

The project is coordinated by the Danish Aquaculture Association and is funded by the European Maritime and Fisheries Fund (EMFF) and the Danish Fisheries Agency.
Veterinary improvements of trout RAS with focus on water quality and design (Recirk-vet) (39593)
The purpose of project Recirc-Vet is to study and evaluate the implications of altered farming practice from flow through systems to recirculated aquaculture systems in DK. The project will evaluate the rearing conditions on four selected trout RAS and try to identify important factors affecting fish and system performance. The project will compare the farms and look into temporal patterns, based on traditional water quality parameters, new microbial assays and monitoring of oxygen and carbon dioxide.

The project consists of a network, which includes veterinarians, researchers and farm managers. They will try to link rearing conditions and fish diseases as well as fish welfare indicators.

The project is coordinated by Danish Aquaculture Association and is funded by the European Maritime and Fisheries Fund (EMFF) and the Danish Fisheries Agency.

Design and operation optimization of constructed wetlands at rainbow trout farms (39430)
This project aims at improving the design and operation of constructed wetlands with respect to the removal of waste nutrients and organic matter deriving from model trout farm systems type I and III. The project contains five work packages: 1. Selection of representative fish farms to be part of a user group and where testing and measurements will be carried out.2. Mapping and characterization of selected wetlands.3. Measuring the effects of flow velocity, water column depth, and hydraulic retention time on the removal of nutrients and organic matter.4. Data analysis.5. Project management, administration and dissemination of results.

The project is coordinated by DTU Aqua and is funded by the European Maritime and Fisheries Fund (EMFF) and the Danish Fisheries Agency.
Resource efficiency in practice: from sugar beet waste to fish feed ingredient (Starfish) (39368)

Sugar beet is a commonly cultivated crop in Denmark and the waste pulp is primarily sold as cow feed. The pulp, however, contains a potential prebiotic compound (pectin) that, if added to fish feed at low concentrations is hypothesized to:
1) improve the feed utilisation by the fish allowing more fish to be produced per amount of feed applied
2) stabilize the structure of the faecal waste so that it may be easier collected and removed reducing the discharge of nitrogen- and phosphorous
3) improve the overall immunological system/health status of the fish whereby the use of medicine and therapeutics may be reduced.

The objective of the project is to test these potential, beneficial effects of pectin in rainbow trout (Oncorhynchus mykiss) and tilapia (Oreochromis niloticus) by adding different molecular sizes and concentrations to the feed and measuring the effects on feed utilisation, faecal structure and fish health.

The project is coordinated by DTU Aqua.
The project is funded by Ministry of Environment and Food of Denmark through the Green Development and Demonstration Program (GUDP).

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01/08/2016 → 31/07/2019
Keywords: Research area: Aquaculture
Project: Research

Development of an electrochemical method to remove nitrate in RAS (Electro-nitrate) (39337)

This project is done in collaboration with two industrial partners, testing the nitrate removal potential of an innovative technique applied to aquaculture.

Nitrate is a dissolved N-waste product from fish production in recirculating aquaculture systems (RAS). The amount and concentration of nitrate in the effluent are determined by the daily feeding, biological filtration and the feed loading (kg feed pr. m3 water exchange) among others.

Discharged nitrate is a main factor affecting the recipient hence important to reduce in order to obtain sustainable production in RAS.

As an alternative to denitrification, electrochemical reduction of nitrate to N2 is considered in this project. Electrochemical water treatment rely on physio-chemically controlled redox processes that includes a flow cell with two electrodes connected to an external current source This aim of this project is preliminary test and screening of different types of electrode material and combinations and investigate factors affecting removal capacity. The effect of current density, flow rates, substrate concentrations and pH on nitrate removal will be tested and removal capacity will be evaluated.

This project is coordinated by DHI.
The project is funded by Innovation Network for Environmental Technologies (Inno-MT), Danish Agency for Science, Technology and Innovation.

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01/02/2016 → 31/12/2016
Keywords: Research area: Aquaculture
Collaborators: AquaPri A/S, DHI Water - Environment - Health, Electrocell A/S
Project: Research

Efficient and innovative fish production via best available technology (RAS2020) (39328)

This project includes a full scale test and development of a conceptual recirculating aquaculture system (RAS) for king fish production. The innovative aspect of this modular RAS2020 concept regards the design—a one unit circular module designed to have a 1200 MT/Y capacity.

The aim of this project is to build and develop a RAS unit with small footprint, low cost and reduced construction time. The RAS2020 unit includes state of the art treatment units (Hydrotech drumfilters, Krüeger biofilters—nitrification and denitrification) and is build with flexible interconnected rearing sections. When the RAS2020 is built and stocked with kingfish, an extended sampling and monitoring program will be performed in order to assess system performance in particular N, P and organic matter removal.

This project is coordinated by Sashimi Royal.
The project is funded by the Danish Environmental Protection Agency.

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01/02/2016 → 31/12/2018
Keywords: Research area: Aquaculture
Collaborators: Danish Aquaculture Association, Sashimi Royal, Aqua-Partners ApS
Project: Research

HPLC – Implementation of new analytical methods (39227)
This is an internally funded project with the purpose of developing and implementing new analytical methods aimed at determining indicators for growth i.e. protein metabolism and synthesis, and includes amino acids and ATP, ADP, AMP in tissue. It is investigated whether a developed technique can be implemented. We will investigate, whether we can use a western blotting technique to enable us to estimate to which degree protein synthesis is stimulated, more specifically by measuring the degree of phosphorylation of certain markers within the mTOR signaling pathway. In addition, selected marker(s) of protein degradation is included. This will enable us to obtain an in-depth knowledge regarding protein synthesis/turnover and protein utilization in fish. We thereby presume to be able to investigate and document which/how nutritional factors (e.g. new protein sources & specific amino acids) and rearing conditions (e.g. feeding strategy, water quality, exercise, stress etc.) affect protein turnover (and thereby growth) in fish. The relationship between growth/protein utilization and mTOR response needs to be investigated further, but potentially this technique may e.g. allow us to compare a large number of diets and very quickly determine the response in muscle tissue. This means that a large number of diets can be screened without the cost of large and long-lasting growth trials, and it may become faster/easier to select the most optimal diets based on the response. As growth and growth efficiency are vital factors in aquaculture, the method might have great potential under a variety of circumstances.
This project is coordinated by DTU Aqua.
The project is internally funded.

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01/01/2016 → …
Keywords: Research area: Aquaculture

Environmental neutral aquaculture water treatment (MIVANAK) (39295)
Despite a transition from flow-through systems to more advanced open water reuse aquaculture systems (e.g. model trout farms), the need for water treatment still exists. In brackish and saltwater reuse systems, blooms of toxic microalgae in an example of a recently new challenge.
The purpose of this project is to further develop current aquaculture water treatment practice and reduce the total amount of disinfectants used.
The project includes 3 different work packages, investigating
- ecological consequences of continuous application of peroxyacetid acid.
- toxicological effects of easy degradable disinfectants.
- alternative biological methods to control / avoid blooms of toxic heterotrophic dinoflagellates.
Trials will include mesocosmos experiments where disinfectants are added continuously or by daily pulses over a prolonged period of time where phyto- and zoo-plankton abundance and compositions will be investigated. Other trials will be made in batch experiments with pure algae cultures, as will prolonged continuous peroxyacid application experiments be made.
This project is coordinated by DTU Aqua.
The project is funded by the Environmental Protection Agency's Programme for Pesticide Research.
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01/08/2015 → 31/12/2017
Keywords: Research areas: Aquaculture & Marine Populations and Ecosystem Dynamics
Project: Research

Welfare, health and individuality in farmed fish (WIN-FISH) (39236)
In modern aquaculture, production costs are the major driver. This has resulted in culture practices and rearing environments aimed at maximizing production capacity. Consequently, fish are exposed to unavoidable stressors, which can be detrimental to animal health and welfare. Moreover, it is increasingly clear that individuality in stress reactions have to be included in the concept of animal welfare. Such differences often take the form of suites of traits, or stress coping styles (SCS), where traits like sympathetic reactivity, aggression and the tendency follow and develop routines show positive relationships. In addition, these traits show a negative relationship with plasma cortisol levels and are also
In transforming such waste streams into high quality protein and oil ingredients. Based on the available waste streams, processing, this raw material is not suitable for direct use in fish feed. The black soldier fly larvae (BSF) are very efficient as protein-rich components in fish feed. Due to the low protein content of waste materials from agriculture and fish milling streams for cellulose fibre production can be used to grow fungi and turned into Single Cell Proteins (SCP), suitable new approaches. This project focuses on turning waste streams into valuable products. Organic chemicals found in pulp raising concerns regarding the sustainability of this arrangement. The industry's growing need for feed therefore requires produced by aquaculture. Aquaculture production will double in the next 15 years and so will the need for protein into systems, the water exchange rates and organic loading applied for biological reasons allow for microbial regrowth in the rearing tanks. Hence, alternative approaches to reduce the chances of disease outbreaks are needed. This project pursues the concept of establishing and maintaining stable microbial systems. Water treatment technology for microbial stabilization in landbased aquaculture systems (MicStaTech) (39277) MicStaTech is a transnational research project (COFASP) between Norwegian, German and Danish research groups. The paradigm of this project is that a stable, elevated microbial abundance in the water phase of land based aquaculture systems can be beneficial for fish health and economically profitable. A common challenge in land based systems, and shown across species, is the loss of fish due to unfavourable conditions and disease outbreaks that may be linked to opportunistic bacteria. A popular approach to prevent this is to attempt to reduce the load of bacteria in the systems by the use of UV, ozone or chemical disinfection. This is however not possible or sufficient in the majority of systems, because disinfection has a non-lasting effect on the numbers and a destabilising effect on the composition of bacteria. In most systems, the water exchange rates and organic loading applied for biological reasons allow for microbial regrowth in the rearing tanks. Hence, alternative approaches to reduce the chances of disease outbreaks are needed. This project pursues the concept of establishing and maintaining stable microbial systems. Water treatment technology for promoting K-selection, which is a selective pressure disfavoring the r-selected opportunists, has shown very promising results for several marine species in small scale experiments, but the up-scaling and optimization for flow through systems (FTS) and recirculating aquaculture systems (RAS) remains. The paradigm favouring a stable and elevated bacterial abundance is foreseen to reduce fish mortality and also reduce water treatment costs. This project will investigate fish health and microbial carrying capacity in experiments performed at three locations – NTNU, DTU Aqua and University of Applied Sciences, Saarlandes, Germany. This project is coordinated by Norwegian University of Science and Technology, Norway. The project is funded by EU, COFASP, ERA-NET. Pedersen, L., Project Manager, National Institute of Aquatic Resources, Section for Aquaculture Pedersen, P. B., Project Participant, National Institute of Aquatic Resources Rojas-Tirado, P. A., Project Participant, National Institute of Aquatic Resources Sproegel, U., Project Participant, National Institute of Aquatic Resources Frandsen, D., Project Participant, National Institute of Aquatic Resources Møller, B., Project Participant, National Institute of Aquatic Resources Nielsen, S. M., Project Participant, National Institute of Aquatic Resources 01/03/2015 → 31/12/2017 Keywords: Research area: Aquaculture Collaborators: Universidad Politécnica de Madrid, Uppsala University, Instituto Zooprofilattico Sperimentale delle Venezie, Norwegian University of Science and Technology Project: Research

Proteins of the future in feed for recirculating aquaculture systems (ProffAqua) (39274) There is an increasing shortage of available high quality proteins for feed. More than half of all aquatic species is now produced by aquaculture. Aquaculture production will double in the next 15 years and so will the need for protein into aquafeed. As substantial amount of worldwide wild fish catch is processed into fishmeal and fish oil for feed production, raising concerns regarding the sustainability of this arrangement. The industry’s growing need for feed therefore requires new approaches. This project focuses on turning waste streams into valuable products. Organic chemicals found in pulp mills streams for cellulose fibre production can be used to grow fungi and turned into Single Cell Proteins (SCP), suitable as protein-rich components in fish feed. Due to the low protein content of waste materials from agriculture and fish processing, this raw material is not suitable for direct use in fish feed. The black soldier fly larvae (BSF) are very efficient in transforming such waste streams into high quality protein and oil ingredients. Based on the available waste streams,
several thousand tonnes of both SCP and BSF can be produced at a very favourable price compared to the current price and quality of fish meal.

The role of DTU Aqua in the project is to evaluate BSF and SCP as protein sources in fish feeds by performing digestibility and growth trials using the two types of protein sources at several inclusion level in the diets.

DTU Aqua participates in the project by performing feeding trials using contaminated feed for Atlantic salmon and seabass respectively. Furthermore, the project also investigates potential effects of microplastic incorporated into feed pellets, on accumulation and elimination of the selected priority contaminants. The feeding trials consist of a 12 week to 15 week accumulation period for seabass and salmon respectively and a 8 week depuration period where all groups are fed control feed. The results obtained from the trail will be the used to develop mathematical models estimating accumulation and elimination of priority contaminants in filet.

This project is coordinated by Matís Itd., Icelandic Food and Biotech R&D.
This project is funded by Nordforsk, Nordic Council of Ministers.
Larsen, B. K., Project Manager, National Institute of Aquatic Resources, Section for Aquaculture
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01/02/2015 → 31/12/2017
Keywords: Research area: Aquaculture
Collaborators: SP Processum AB, Matís ltd., Tydalfisk, Domsjö Fabriker AB, Danish Technological Institute, Veðurstofa Íslands
Project: Research

New physicochemical and technological approach for high quality and sustainable fish feed production (Exipro) (39189)

Aquaculture is the globally fastest growing food producing sector, and extruded fish feed is the largest expenditure in the production of carnivorous fish.

The quality of the different protein raw materials used in fish feed varies considerably, and even small differences in the nutritional quality can have large effects on fish performance, their degree of feed utilization and consequently the environment.

The production of high quality, nutrient-dense fish feed requires that the dietary matrix is extruded into pellets. However, the extrusion process can alter and deteriorate the nutritional quality of proteins. Currently, the extrusion process is based entirely on empirical learning, and little is known about the chemical reactions and physical processes that take place inside the extruder, i.e., the extruder is largely a ‘Black Box’. In addition, little is known about concomitant effects on feed utilization.

The aim of Exipro is to optimize the extrusion process by clarifying the changes and damages on different protein ingredients that happen in the extruder, and to use the knowledge to improve the quality of fish feed. Hence, the objectives of the project are to:
- Determine the effects of extrusion on the physicochemical and chemical properties of proteins in fish feed
- Determine the effects of these changes on fish growth performance, metabolism, protein retention, and nitrogen excretion
- Develop a generic extrusion optimization tool for different protein ingredients.

The project is coordinated by University of Copenhagen.
The project is funded by Innovation Fund Denmark.
Dalsgaard, A. J. T., Project Manager, National Institute of Aquatic Resources, Section for Aquaculture
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Vega, V. V., Project Participant, National Institute of Aquatic Resources
01/09/2014 → 31/12/2017
Keywords: Research area: Aquaculture
Collaborators: BioMar A/S, Aarhus University, University of Copenhagen
Project: Research

Cost efficient solutions for reducing the waste discharged in land-based marine recirculating aquaculture systems (WASTE-TREAT) (39190)

Growth in aquaculture production demands a high degree of environmental engineering to minimize nutrient discharge thereby reducing the environmental impact. This industrial collaboration project aims at finding the cost-efficient treatment methods for reducing the waste discharged from large-scale land-based marine recirculating aquaculture systems. End-of-pipe solutions for minimizing the N, P, and organic matter waste discharge from seawater RAS are to be developed, demonstrated and evaluated.

The project is coordinated by AKVA Group Denmark A/S.
The project is funded by the Danish Ministry of Food, Agriculture and Fisheries through the Green Development and Demonstration Program (GUDP).
Letelier-Gordo, C. O., Project Manager, National Institute of Aquatic Resources, Section for Aquaculture
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Project: Research
**Fluorescence analysis and monitoring of recirculating aquaculture systems (FAMoRAS) (39177)**

FAMoRAS aimed to investigate fluorescence spectroscopy for potential utilization within 3 main areas of recirculating aquaculture system operation:

1. **system "health" monitoring**
2. **treatment performance**
3. **feed utilization.**

Using sensitive lab-scale spectroscopic analysis and mathematical modeling, the project aimed to identify single wavelengths for future use as online, in-situ aquaculture system sensors.

This project was coordinated by DTU Aqua.

The project is funded by EU, Marie Curie.

Hambly, A., Project Coordinator, Section for Marine Ecology and Oceanography, National Institute of Aquatic Resources
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Pedersen, L., Project Participant, National Institute of Aquatic Resources

**Eel hatchery technology for a sustainable aquaculture (EEL-HATCH) (39181)**

Hatchery and rearing technology for commercial production of glass eels is fundamental to sustainable and profitable eel aquaculture. The vision is to enhance existing technology to rear European eel larvae to the glass eel stage, thereby closing the lifecycle in captivity. Pioneering research of the consortium has raised eel breeding from a state of reproductive failure to stable production of viable larvae.

Objectives include: Design "state of the art" hatchery facilities, optimize broodstock feeds, enhance assisted reproductive technology, and develop larval culture systems and diets. The main success criterion is achievement of large scale culture of larvae throughout the larval stage, leading to glass eel production. The establishment of sustainable aquaculture of this endangered species, presently relying on captive glass eel will rebuild the highly profitable market for eel aquaculture and suppliers as well as assist in conservation and stock management plans.

Results obtained during the half of the project period include the design and establishment of a dedicated research facility in relation to DTU Aqua in Hirtshals, involving several partners. The facility applies recirculation aquaculture systems with emphasis on matured water technology and microbial control. Scientific highlights include successful production of recombinant European eel gonadotropin hormones; enhanced reproduction, fertilization and incubation procedures; and optimized larval culture conditions, including e.g. temperature, salinity, and light regime. Larval diets have been developed and tested in first feeding and behavioral experiments, leading to the first published work on larval feeding for this species. Experiments on improved diets and optimized rearing tanks for larval growth are ongoing.

This project is coordinated by DTU Aqua.

The project is funded by Innovation Fund Denmark.

Tomkiewicz, J., Project Coordinator, National Institute of Aquatic Resources, Section for Marine Living Resources
Haslund, O. H., Project Manager, National Institute of Aquatic Resources
Butts, I., Project Participant, National Institute of Aquatic Resources
Støttrup, J. G., Project Participant, National Institute of Aquatic Resources
Lund, I., Project Participant, National Institute of Aquatic Resources
Krüger-Johnsen, M., Project Participant, National Institute of Aquatic Resources
Sørensen, S. R., Project Participant, National Institute of Aquatic Resources
Politis, S. N., PhD Student, National Institute of Aquatic Resources
Kottmann, J. S., Project Participant, National Institute of Aquatic Resources

**New possibilities for growth and robustness in organic aquaculture (ROBUSTFISH) (39159)**

Main aim:
To support the credibility, growth and robustness in the production of healthy and stress resilient Danish organic rainbow trout, considering environmental, ethical as well as economic aspects.

Sub goals:
1. Develop methods for selecting robust fry.
2. Investigating how sustainable non-fish based feed given early in the development affect the robustness of the fry.
3. Include welfare and environmental aspects in relation to water treatment procedures.
4) Improve economic competitiveness of Danish organic aquaculture.
The project is coordinated by DTU Aqua.
This project is funded by Organic RDD 2 Programme, which is coordinated by the International Centre for Research in Organic Food Systems (ICROFS). It has received grants from the Danish Ministry of Food, Agriculture and Fisheries through the Green Growth and Development Programme (GUDP).
Jokumsen, A., Project Coordinator, National Institute of Aquatic Resources, Section for Aquaculture
Gesto, M., Project Participant, National Institute of Aquatic Resources
Pedersen, L., Project Participant, National Institute of Aquatic Resources
Skov, P. V., Project Participant, National Institute of Aquatic Resources
Larsen, E., Project Participant, National Institute of Aquatic Resources
01/04/2014 → 31/12/2017
Keywords: Research areas: Aquaculture & Fisheries Management
Collaborators: University of Copenhagen, Aalborg University, Danish Aquaculture Association
Project: Research

**Sustainable fish feed development in Ghana (Susfeed) (39158)**
The overall objective of the project is to enable Kwame Nkrumah University of Science and Technology (KNUST) to serve as a centre of excellence for sustainable development of aquaculture and to take a scientific approach to the continued improvement of fish feed formulation using local raw materials, through controlled experiments and in collaboration with the private sector in Ghana. The immediate objectives of the project are to formulate cost effective tilapia feeds assessed for digestibility, nutritional value and amino acid profiles based on local feed ingredients; to facilitate the growth of the tilapia aquaculture industry in Ghana through promoting the production and application of locally developed high quality feeds; to achieve a zero change in nutrient discharge to the environment through the application of balanced feed and efficient feeding strategies; and to improve the methodological and scientific capacity at KNUST to provide a platform of excellence in research and teaching.
The project is funded by DANIDA, Ministry of Foreign Affairs of Denmark.
Skov, P. V., Project Manager, National Institute of Aquatic Resources, Section for Aquaculture
Lund, I., Project Participant, National Institute of Aquatic Resources
Larsen, B. K., Project Participant, National Institute of Aquatic Resources
01/04/2014 → 31/03/2017
Keywords: Research area: Aquaculture
Collaborators: Kwame Nkrumah University of Science and Technology
Project: Research

**Discard survival (DISCO) (39152)**
This project has developed methods and accumulated competencies and facilities, to be able to estimate discard survival and generate knowledge about the factors that affect this. The focus was on two commercially important species, plaice and Norway lobster. These species are relevant because there is a likelihood of a substantial survival.
The first trial was conducted from November to March from a less commercial trawler with Hirtshals as port. There was fishing for plaice with a consumption trawls and towed time was 3 hours. Test plaice were collected at four different time periods exposed to air on the deck, with a half-hour intervals up to one and a half hour. Furthermore, control plaice were collected from hauls with short duration. Plaice was stored in tanks on the vessel and transported to storage tanks on land at the North Sea Science Park in Hirtshals. Here, they were observed for 10 days. On the vessel were also carried out tests of reflexes and damage. The overall mortality rate increased by residence time on the deck of 0% and up to 24% after one and a half hours on the deck. The total mortality was estimated to 11%. Most plaice was above the minimum landing size. Reflexes decreased with increased time on the deck. There was no mortality in the control group. There were also carried out measurements of physiological stress indicators comparing with a reference group.
Another plaice study was conducted in Norway lobster fishing from Skagen in June and July from the same vessel. The plaice was stored in the same way at the vessel as the first experiment, and was transported in a pickup from Skagen to observation side in Hirtshals. Most plaice was below the minimum size. Mortality was totally 86% for test plaice and 0 % to 16 % for the control groups.
A final test was conducted to determine the mortality of lobsters. It was estimated to be from 100 % to 52 % of the individual hauls. Overall the mortality was 84% after 8 days here except experiments where there the refrigerated container was not functioning. Had these individuals been included, the mortality would have been lower. However, there were also deaths in the control group (total 18%) and generating more uncertainty for the estimates.
This project was coordinated by DTU Aqua.
The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).
Madsen, N., Project Coordinator, National Institute of Aquatic Resources, Section for Ecosystem based Marine Management
Methling, C., Project Participant, National Institute of Aquatic Resources
01/03/2014 → 23/05/2015
Keywords: Research areas: Fisheries Technology & Aquaculture
Project: Research
Landbased aquaculture of European lobster (39156)
The aim of the project is to solve remaining biological and technical challenges concerning commercial farming of
European lobster. These include optimizing reproduction and broodstock production, improving larval survival and
examining nutritional requirements and metabolism in the first life stages. Furthermore, the technical system set-up will be
improved.
The work during the first two years have been focusing on survival and growth tests, comparison of diets, respiration tests
and novel cage design for European Lobster farming.
Furthermore, active collaboration and exchange of knowledge have taken part in the established European Lobster Centre
of Excellence (ELCE) group that now includes partners from seven countries (Norway, Denmark, Iceland, Sweden, United
Kingdom, Italy and Spain).
The project is coordinated by Svinna-verkfrædi ehf, Iceland.
The project is funded by Nordforsk, Nordic Council of Ministers.
Lund, I., Project Manager, National Institute of Aquatic Resources, Section for Aquaculture
01/03/2014 → 28/02/2017
Keywords: Research area: Aquaculture
Collaborators: Svinna-Engineering Ltd., Norwegian Lobster Farm AS
Project: Research

Towards stable water quality in RAS by use of a new rapid microbial test (Biostable water) (39154)
Water quality control is central for successful management of recirculating aquaculture systems. Most common and
important chemical parameters (i.e. pH, TAN, nitrite, alkalinity) are measurable, whereas microbial water quality
(abundance and activity) is more complicated to measure. Microbial water quality measurements are important for several
reasons: it can be used to ensure safe and stable conditions (baseline), to identify sudden changes (deviations from
baseline) and potentially contribute to improve system performance by identifying suboptimal treatment component or
practices.
The aim of this project is to test a rapid microbial methods developed by Mycometer; a test that quantifies the microbial
activity in different types of water samples within 30 minutes from sampling to measurement. The Bactiquant® method is
expected to provide new insight of microbial succession within RAS and will be used to monitor microbial water quality in
commercial recirculating aquaculture systems.
The project includes controlled batch experiments where disinfection efficiency and regrowth potentials can be estimated.
The new knowledge can be applied in RAS management, and the project also includes method verification under
commercial RAS conditions. The equipment has been introduced and implemented on a large model trout 3 farm with
mixed effect and valuable experiences. The method is also being introduced to a huge smolt RAS facility build by Billund
Aqua; here daily monitoring as well as intensive campaigns including diurnal measurements will be performed.
The project is coordinated by DTU Aqua.
The project is funded by the Danish Ministry of Food, Agriculture and Fisheries through the Green Development and
Demonstration Program (GUDP).
Pedersen, L., Project Coordinator, National Institute of Aquatic Resources, Section for Aquaculture
Rojas-Tirado, P. A., Project Participant, National Institute of Aquatic Resources
Pedersen, P. B., Project Participant, National Institute of Aquatic Resources
Sproegel, U., Project Participant, National Institute of Aquatic Resources
Møller, B., Project Participant, National Institute of Aquatic Resources
Nielsen, S. M., Project Participant, National Institute of Aquatic Resources
Frandsen, D., Project Participant, National Institute of Aquatic Resources
Larsen, O. M., Project Participant, National Institute of Aquatic Resources
Jensen, R. F., Project Participant, National Institute of Aquatic Resources
01/02/2014 → 01/07/2016
Keywords: Research area: Aquaculture
Collaborators: Mycometer A/S, Billund Aquaculture Service Aps
Project: Research

Enhancing the European aquaculture production by removing production bottlenecks of emerging species, producing new
products and accessing new markets (DIVERSIFY) (39132)
Following the objectives of this Call, DIVERSIFY identified a number of new/emerging, large and/or fast growing finfish
species, which are believed to be excellent candidates for the expansion of the aquaculture industry of Europe.
The emphasis is on the Mediterranean or warm-water cage culture industry, but also addressed is pond/extensive culture,
fresh water recirculation systems and cold-water species. These new/emerging species are marketed at a large size
and can be processed easily into a range of products to provide the consumer with both a greater diversity of fish species
and new processed products. In collaboration with a number of SMEs, DIVERSIFY will build on recent/current national
initiatives for species diversification in aquaculture, in order to overcome the documented bottlenecks in the aquaculture
production of these selected species.
DIVERSIFY will provide knowledge where needed to solve bottlenecks in juvenile production, grow-out, nutrition and
feeding husbandry, new product development and marketing.
The programme will also provide tools for genetic improvement and disease control. This will provide improved efficiency in
production and reduced costs, and identify markets for the new products. The expertise in the consortium and lessons learned, could provide in a 5 year period what took the Atlantic salmon industry 20 years of development DIVERSIFY focuses on meagre (Argyrosomus regius) and greater amberjack (Seriola dumerili) for marine warm-water cage culture, wreckfish (Polyprion americanus) for warm- and cool-water marine cage culture, Atlantic halibut (Hippoglossus hippoglossus) for marine cold-water culture, grey mullet (Mugil cephalus) an euryhaline herbivore for warm-water pond, extensive and integrated culture, and pikeperch (Sanders lucioperca) for freshwater intensive culture using Recirculation Aquaculture Systems (RAS). The project is coordinated by the Hellenic Center for Marine Research. 31 research institutions etc. are involved in the project. The project is funded by EU, Framework Programme 7.

The project is coordinated by NOFIMA, Norway. The project is funded by EU, Framework Programme 7.

The overall vision of the OrAqua project is the economic growth of the organic aquaculture sector in Europe, supported by science based regulations in line with the organic principles and consumer confidence. OrAqua will suggest improvements for the current EU regulatory framework for organic aquaculture based on:
- a review of the relevant available scientific knowledge
- a review of organic aquaculture production and economics
- consumer perceptions of organic aquaculture.

The project will focus on aquaculture production of relevant European species of finfish, molluscs, crustaceans and seaweed.

To ensure interaction with all relevant stakeholders throughout the project a multi stakeholder platform will be established. The project will assess and review existing knowledge on fish health and welfare, veterinary treatments, nutrition, feeding, seeds (sourcing of juveniles), production systems, including closed recirculation aquaculture systems (RAS), environmental impacts, socio-economic and aquaculture economic interactions, consumer aspects, legislations and private standards for organic aquaculture. The results will be communicated using a range of media and techniques tailored to involve all stakeholder groups. Further, Multi Criteria Decision Analysis (MCDA) and SWOT analysis will be used to generate relevant and robust recommendations.

A wide range of actors from several countries will participate and interact through a participatory approach. The 13 OrAqua project partners form a highly qualified and multidisciplinary consortium that includes four universities, five aquaculture research institutes, three research groups in social science, a fish farmer organisation, a fish farmer and two organic certification/control bodies.

The main outcomes of the project will be recommendations on how to improve the EU regulation, executive dossiers and a Policy Implementation Plan (PIP). Further the project will deliver recommendations on how to enhance economic development of the European organic aquaculture sector.

The project is coordinated by NOFIMA, Norway. The project is funded by EU, Framework Programme 7.

The expertise in the consortium and lessons learned, could provide in a 5 year period what took the Atlantic salmon industry 20 years of development DIVERSIFY focuses on meagre (Argyrosomus regius) and greater amberjack (Seriola dumerili) for marine warm-water cage culture, wreckfish (Polyprion americanus) for warm- and cool-water marine cage culture, Atlantic halibut (Hippoglossus hippoglossus) for marine cold-water culture, grey mullet (Mugil cephalus) an euryhaline herbivore for warm-water pond, extensive and integrated culture, and pikeperch (Sanders lucioperca) for freshwater intensive culture using Recirculation Aquaculture Systems (RAS). The project is coordinated by NOFIMA, Norway. The project is funded by EU, Framework Programme 7.

Network towards phasing out formalin in aquaculture (39140)

Formalin is still used in large quantities in aquaculture systems despite unwanted side-effects and efforts to reduce the amount used. Apparently the need for water treatment increases with shift from flow-through to RAS. This project established a network of fish farmers (8 persons representing different systems), three national fish-vets covering >95% of Danish fish farms, DTU Aqua researchers and Danish Aquaculture organization. The common goal was to identify methods to cease the aquaculture related use of formalin. Recent knowledge, new techniques and practical experience with alternative disinfectants (e.g. hydrogen peroxide or peracetic acid) were applied and tested. In particular, distribution, degradation and automatic dosage of Peracetic acid by digital pumps was analytically verified. The project tested and developed better water treatment protocols for different types of rearing systems (hatcheries and grow out production systems, flow-through, model trout farms to fully recirculated systems) in close collaboration between fish-vets, fish farmers and DTU Aqua. Results from monitoring on a number of fish farms and experience over 2 seasons were obtained and the new practically applied knowledge/information was presented at workshops/seminars with the aquaculture industry as well as reported in a Danish report (Danish Aquaculture 2015-10). A number of veterinarians and fish farms were partners in the project. The project was coordinated by Danish Aquaculture Association.
The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).

Pedersen, L., Project Participant, National Institute of Aquatic Resources, Section for Aquaculture
Pedersen, P. B., Project Participant, National Institute of Aquatic Resources
Sproegel, U., Project Participant, National Institute of Aquatic Resources
Møller, B., Project Participant, National Institute of Aquatic Resources
01/12/2013 → 01/05/2015
Keywords: Research area: Aquaculture
Project: Research

Development of filtering technologies for microalgae and sustainable high quality feed for fry (FIMAFY) (39115)

There is an urgent need for alternative resources to fishmeal and fish oil for the production of fish feed to the aquaculture industry. The resource problem is due to a combination of the rapid growth of the aquaculture, and the fact that catches of fish for the feed industry is stagnating.

The idea to use microalgae as fish feed originated from an on-going EU-project, which aims at demonstrating that algae can be grown on process water from the industry.

The partners in the project will develop, test and demonstrate new technologies for harvesting and refining microalgae. The project will develop a technology to open the cell walls of the microalgae in order to make it possible to extract micro- and macronutrients for use as an alternative resource to fish oil and fishmeal in the production of fish feed for the aquaculture industry.

The project is coordinated by the National Food Institute, Technical University of Denmark. The project is funded by the Danish Ministry of Food, Agriculture and Fisheries through the Green Development and Demonstration Program (GUDP).

Lund, I., Project Manager, National Institute of Aquatic Resources, Section for Aquaculture
Högland, E., Project Participant, National Institute of Aquatic Resources
01/10/2013 → 31/03/2017
Keywords: Research area: Aquaculture
Project: Research

Development of educational opportunities for Danish aquaculture (39157)

Danish aquaculture systems have faced substantial changes during the recent years, which have necessitated further education and practical implementation of new knowledge.

This project was initiated by Danish Aquaculture Organization (DAO). Based on an increasing demand for improved and updated education/training to people in the aquaculture industry, DAO identified various initiatives to develop educational for Danish aquaculture. Key players within the aquaculture sector were identified to support these initiatives.

The outcome of the project was
- Initiation and implementation of a new education at Hansenberg in Kolding, (www.hansenberg.dk),
- Participation in developing the courses for aquaculture trainees (practical/theoretical exercises),
- Production of advertising material (posters, pamphlets) promoting the education and aquaculture in general,
- Production of the first public available E-book (“Aquaculture”: 14 chapters, 360 pp.) (http://www.danskvakultur.dk/uddannelse/e-bog/)

This project was coordinated by the Danish Aquaculture Organization.

Pedersen, L., Project Participant, National Institute of Aquatic Resources, Section for Aquaculture
Pedersen, P. B., Project Participant, National Institute of Aquatic Resources
07/08/2013 → 01/08/2015
Keywords: Research area: Aquaculture
Collaborators: Aarhus University, University of Copenhagen, Danish Aquaculture Association, Hansenberg Technical College, Seges Knowledge Centre for Agriculture
Project: Research

Environmentally effective nitrogen removal in fish farming using sludge hydrolysis (wiN-wiN) (39119)

Reducing nitrogen discharge is important to fish farms and their environmental performance. Removal of nitrogen can be done by applying denitrification filters end-of-pipe (i.e. before discharge) through an anearobic de-nitrification process using organic carbon as energy source.

Using external carbon is costly and introduces additional organic matter into the system. In contrast, sludge produced by the farmed fish might provide the organic matter given that a hydrolysis process can be controlled and optimised according to the needs of the denitrification process.

The project strives to establish, optimize and demonstrate an integrated system in commercial scale able to hydrolyse generated sludge and subsequently use it as energy source for nitrogen removal in end-of-pipe denitrification filters.

This project is coordinated by HME, Denmark.

The project was funded by the Danish Ministry of Food, Agriculture and Fisheries through the Green Development and
Demonstration Program (GUDP) and the partners involved.
Pedersen, P. B., Project Manager, National Institute of Aquatic Resources, Section for Aquaculture
von Ahnen, M., Project Participant, National Institute of Aquatic Resources
Dalsgaard, A. J. T., Project Participant, National Institute of Aquatic Resources
Letelier-Gordo, C. O., PhD Student, National Institute of Aquatic Resources
01/08/2013 → 31/12/2016
Keywords: Research area: Aquaculture
Collaborators: HME, Lundby Dambrug
Project: Research

Organic line mussels – Securing availability for the consumers (ØKOMUS) (39155)
The project objectives was to establish and develop an economically sustainable market for organic line mussels in Denmark by support and development of relevant channels of distribution to secure availability of Danish organic mussels for the consumers.
The project was coordinated by Danish Aquaculture Association.
The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).
Jokumsen, A., Project Manager, National Institute of Aquatic Resources, Section for Aquaculture
01/07/2013 → 31/05/2015
Keywords: Research area: Aquaculture & Shellfish and Seaweed
Collaborators: Danish Mussel Farmers, Danish Aquaculture Association
Project: Research

Priority environmental contaminants in seafood: Safety assessment, impact and public perception (ECsafeSEAFOOD) (39039)
Seafood has been recognized as a high-quality, healthy and safe food type and is one of the most important food commodities consumed worldwide. However, seafood, like other types of food, can also be a source of harmful environmental contaminants with potential to impact on human health.
The research objectives of ECsafeSEAFOOD have been formulated from the research questions addressed in the specific objectives of the European research programme topic on building a Knowledge-Based Bio-Economy (KBBe.2012.2.4-01: Contaminants in seafood and their impact on public health (The Ocean of Tomorrow)). This topic aims to assess food safety issues related to priority contaminants present in seafood as a result of environmental contamination, including those originating from harmful algal blooms and those associated with marine litter and evaluate their impact on public health. ECsafeSEAFOOD will provide scientific evidence to serve as a basis for further development of common food safety, public health and environmental policies and measures, by seeking to establish a quantitative link between the contamination of the marine environment and that of seafood.
The specific objectives of the ECsafeSEAFOOD project include:
- Monitor the presence of priority environmental contaminants in the environment and seafood and prioritise those that are real hazards for human health.
- Quantify the transfer of relevant priority environmental contaminants between the environment and seafood, taking into account the effect of climate change.
- Study the effect of processing/cooking on the behaviour of priority contaminants in seafood.
- Understand the public health impacts of these chemical hazards, through toxicological characterisation in realistic conditions.
- Perform risk assessment to measure the potential impact of seafood contaminants on public health, using in-depth probabilistic exposure tools.
- Develop mitigation measures for risk managers, such as an online tool for different stakeholders, guidelines, phycoremediation (the use of algae to remove pollutants) and processing.
- Develop, validate and provide new, easy and fast tools to assess the presence of environmental contaminants in seafood.
- Confirm/refine the European Maximum Reference Levels in seafood for contaminants that are real hazards and for which no legislation exists or information is still insufficient.
DTU Aqua participates in the project by performing feeding trials using contaminated feed for Atlantic salmon and seabass respectively. Furthermore, the project also investigates potential effects of microplastic incorporated into feed pellets, on accumulation and elimination of the selected priority contaminants. The feeding trials consist of a 12 week to 15 week accumulation period for seabass and salmon respectively and a 8 week depuration period where all groups are fed control feed. The results obtained from the trial will be the used to develop mathematical models estimating accumulation and elimination of priority contaminants in filet.
The project is coordinated by Portuguese Institute of Sea and Atmosphere (IPMA), Portugal.
Larsen, B. K., Project Manager, National Institute of Aquatic Resources, Section for Aquaculture
Larsen, O. M., Project Participant, National Institute of Aquatic Resources
Jensen, R. F., Project Participant, National Institute of Aquatic Resources
15/02/2013 → 15/02/2017
Keywords: Research area: Aquaculture
Collaborators: Hortimare BV, Wageningen IMARES, Portuguese Institute for the Sea and Atmosphere, University of Maribor, Catalan Institute for Water Research, Institute for Agricultural and Fisheries Research, University of Porto,
**Selective and low impact gear for fishing live nephrops (39042)**

The Danish nephrops fishery is important with an annual value of the landings of approximately 300m DDK. The quota is high as many nephrops inhabit the inner Danish waters. However, cod is a frequent by-catch which is problematic due to low cod quotas, and consequently, nephrops quota is rarely fully exploited. Furthermore, nephrops are traditionally fished with bottom trawl which exerts high impact on the seabed. The first aim of the project is to solve the cod by-catch issues by using trawling speed as a selective mechanism, which will take advantage of the superior swimming capabilities of cod as compared to nephrops. Lowering the trawling speed will enable cod to escape the trawl while still ensuring nephrops catch. The second aim is to design and implement a new type of trawl doors that do not touch the seabed and highly reduce impact of the sweeps. Besides, materials used for the new trawl will be produced in much lighter and stronger materials than the traditional trawls. Altogether this reduces the drag in the water and fuel consumption considerably.

Trawling at a lower speed lessens the mechanical damage to the nephrops and this enhances their chances of survival. The project will take this one step further by establishing gentle handling routines on board the ships, in addition to appropriate conditions for keeping live animals. Physiological tests will define threshold levels in relation to temperature, light and moist, and characterise the most favourable conditions for further survival. Besides optimising conditions on board the ships this knowledge will be used in relation to temporary storage and to ensure optimal conditions during transport of live nephrops to southern Europe. The final aim of the project is thus to establish an export chain of live nephrops to markets in southern Europe. This can provide the fishermen up to three times the price as compared to when landing nephrops on ice, and the price that the Danish export companies’ gain will likewise increase.

Within the project we successfully developed and tested pelagic doors for use in the nephrops fishery, showing that it is indeed possible to implement these in this fishery. Using reduced speed as a way to allow escape of round fish from the trawl (i.e reduce catch of these) did however not work as anticipated, and cannot be recommended for future practice. We tested the effects on survival of nephrops of sprinkling with fresh seawater on-board after trawling, light- and air exposure and various temperatures. Of these, air exposure and air temperature (the higher the worse) had the greatest effect on survival and in determining the period it took for nephrops to recover from post trawling and handling stress. Furthermore, a ‘one-tough’ packing system, including optimal conditions for the animals when transported, was successfully developed, tested and implemented, resulting in up to 95% survival of nephrops transported by truck to southern Europe. Finally, a manual with guidelines for optimal practice for fishery and export of live nephrops was made.

The project was coordinated by AquaMind and CATch-Fish.

The project was funded by Danish Ministry of Food, Agriculture and Fisheries through the Green Development and Demonstration Program (GUDP).

**Pilot certification of freshwater farms and sea cages (Aquaculture Stewardship Council – ASC) (39041)**

The project - developed and tested systems and procedures for ASC certification of trout from Freshwater farms and Sea Cages - collected and disseminated knowledge and experiences with ASC certification - aimed at Danish ASC certified trout to be the first on the global market.

The project was coordinated by Danish Aquaculture Organization.

The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).

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**Selective and low impact gear for fishing live nephrops (39042)**

The Danish nephrops fishery is important with an annual value of the landings of approximately 300m DDK. The quota is high as many nephrops inhabit the inner Danish waters. However, cod is a frequent by-catch which is problematic due to low cod quotas, and consequently, nephrops quota is rarely fully exploited. Furthermore, nephrops are traditionally fished with bottom trawl which exerts high impact on the seabed. The first aim of the project is to solve the cod by-catch issues by using trawling speed as a selective mechanism, which will take advantage of the superior swimming capabilities of cod as compared to nephrops. Lowering the trawling speed will enable cod to escape the trawl while still ensuring nephrops catch. The second aim is to design and implement a new type of trawl doors that do not touch the seabed and highly reduce impact of the sweeps. Besides, materials used for the new trawl will be produced in much lighter and stronger materials than the traditional trawls. Altogether this reduces the drag in the water and fuel consumption considerably.

Trawling at a lower speed lessens the mechanical damage to the nephrops and this enhances their chances of survival. The project will take this one step further by establishing gentle handling routines on board the ships, in addition to appropriate conditions for keeping live animals. Physiological tests will define threshold levels in relation to temperature, light and moist, and characterise the most favourable conditions for further survival. Besides optimising conditions on board the ships this knowledge will be used in relation to temporary storage and to ensure optimal conditions during transport of live nephrops to southern Europe. The final aim of the project is thus to establish an export chain of live nephrops to markets in southern Europe. This can provide the fishermen up to three times the price as compared to when landing nephrops on ice, and the price that the Danish export companies’ gain will likewise increase.

Within the project we successfully developed and tested pelagic doors for use in the nephrops fishery, showing that it is indeed possible to implement these in this fishery. Using reduced speed as a way to allow escape of round fish from the trawl (i.e reduce catch of these) did however not work as anticipated, and cannot be recommended for future practice. We tested the effects on survival of nephrops of sprinkling with fresh seawater on-board after trawling, light- and air exposure and various temperatures. Of these, air exposure and air temperature (the higher the worse) had the greatest effect on survival and in determining the period it took for nephrops to recover from post trawling and handling stress. Furthermore, a ‘one-tough’ packing system, including optimal conditions for the animals when transported, was successfully developed, tested and implemented, resulting in up to 95% survival of nephrops transported by truck to southern Europe. Finally, a manual with guidelines for optimal practice for fishery and export of live nephrops was made.

The project was coordinated by AquaMind and CATch-Fish.

The project was funded by Danish Ministry of Food, Agriculture and Fisheries through the Green Development and Demonstration Program (GUDP).

**Pilot certification of freshwater farms and sea cages (Aquaculture Stewardship Council – ASC) (39041)**

The project - developed and tested systems and procedures for ASC certification of trout from Freshwater farms and Sea Cages - collected and disseminated knowledge and experiences with ASC certification - aimed at Danish ASC certified trout to be the first on the global market.

The project was coordinated by Danish Aquaculture Organization.

The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).
- Test of improved mechanical filtration (application of pilot scale protein skimmers on small to medium sized RAS, and application of full scale 4 meter vacuum airlift; an innovative treatment technique tested in full scale RAS)
- Test of chemical water treatment routines using easy degradable disinfectants (Peracetic acid, chloramine-T, hydrogen peroxide) to control and inhibit toxic microalgae,
- Test of electrochemical oxidation disinfection technology to assess the efficacy (radical formation and algicidal effects) of boron doped diamond electrodes.

Numerous batch and pilot scale experiments were made at the section for Aquaculture, Hirtshals. In addition, intensive, diurnal sampling/monitoring and analysis on location was performed on a commercial pike perch RAS facilities facing toxic algae problems.

The project is coordinated by DTU Aqua.
The project was funded by the National Environmental Protection Agency through Programme for Development and Demonstration of Bio-technologies (MUDP).

Pedersen, L., Project Coordinator, National Institute of Aquatic Resources, Section for Aquaculture
Koski, M., Project Participant, National Institute of Aquatic Resources
Pedersen, P. B., Project Participant, National Institute of Aquatic Resources
Sprogel, U., Project Participant, National Institute of Aquatic Resources
Frandsen, D., Project Participant, National Institute of Aquatic Resources
Møller, B., Project Participant, National Institute of Aquatic Resources
Larsen, O. M., Project Participant, National Institute of Aquatic Resources
Jensen, R. F., Project Participant, National Institute of Aquatic Resources

01/01/2013 → 30/11/2013
Keywords: Research areas: Aquaculture & Marine Populations and Ecosystem Dynamics
Collaborators: AquaPri A/S, University of Copenhagen, Billund Aquaculture Service Aps, Electrocell A/S, The Danish Environmental Protection Agency
Project: Research

Pre-feasibility study regarding establishment of hatchery facility for production of juvenile lobsters (Homarus Gammarus) (39035)
Pre-feasibility study to obtain "state of the art" knowledge and to determine the biological as well as physical requirements and economic costs for establishing a lobster hatchery at the North Sea Research Centre for restocking purposes and for public communication.

The project was coordinated by the North Sea Science Park.
The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).
Lund, I., Project Manager, National Institute of Aquatic Resources, Section for Aquaculture
Støttrup, J. G., Project Participant, National Institute of Aquatic Resources

01/12/2012 → 01/04/2013
Keywords: Research areas: Aquaculture & Coastal Ecology
Collaborators: Danish Shellfish Centre, North Sea Science Park
Project: Research

Better use of nutrition resources for sustaining aquaculture production in Central Vietnam under climate change condition (SANSIV) (38975)
The main objective of the project is to contribute to the sustainable development of coastalaquaculture in Central Vietnam under climate change condition through betteruse of available nutrition resources.

ARSINC (Aquaculture Research Sub-Institutefor North Central (ARSINC), under Research Institute for Aquaculture) No.1(RIA1) in Vietnam is the applicant and main responsible while DTU Aqua is the Danish partner. The immediate objectives of this project are:
- Better use of nutrition resources by developing cost-effective formulated feeds for permit (Trachinotus falcatus) and by application of non-feed based and improved integrated aquaculture models as adaptive practices in coping with the impacts of climate change in Central Vietnam.
- Propose and disseminate adapted aquaculture optionsto farmers, authorities and other stake holders in response to climate change condition.

The project management and coordination have so far been in good status. Overall the project made appropriate progress toward achievement of the project's objectives. Reports on analysis of aquaculture system in Central region including Coastal farmer's livelihood and vulnerability to climate change were finalized. The reviews on known environmental effects of traditional diets for fish farming are on their final stage. Workshop on adaptive aquaculture techniques and models in response to climate change condition and proposed recommend policy was organized. These are served for proposing both adaptive aquaculture techniques/models and policies for local authorities. Through training course and study tour adaptive aquaculture techniques/models have been introduced to local farmers and extension workers.

Regarding to development of cost-effective grow-out pellet feed for the selected commercial carnivorous fish species - pompano (Trachinotus falcatus) as case study to replace trash fish irresponsibly to global limitation of fish meal and fish oil, all original planned experiments have completed. Additional experiments required for PhD student's study will be carried out and finished within 2016. Experiments/trials on farming techniques for non-feed based species (hard shell clam Meretrix lyrata, macro alage Kappaphycus alvarezii) and integrated multi-tropic (shrimp and seaweed) have been completed. There have been 5 published articles, of which one article was published in an international peer review journal as the result of joint contribution between Vietnamese and Danish scientists.
All 3 MSC students from Aquaculture Research Sub-Institute for North Central (ARSINC-responsible institute) have finished their education through participation in project experiments by the end of 2015. These MSc staff will contribute to building research capacity and sustainability for ARSINC. Additionally, one MSc student from Department of Science and Technology, Nghe An province, was also educated through participation in project experiments. This project was coordinated by Aquaculture Research Sub-Institute for North Central, Research Institute for Aquaculture, Vietnam.

The project was funded by EU, Framework Programme 7.

Lund, I., Project Manager, National Institute of Aquatic Resources, Section for Aquaculture
Steenfeldt, S. J., Project Participant, National Institute of Aquatic Resources
Pedersen, P. B., Project Participant, National Institute of Aquatic Resources

01/10/2012 → 01/10/2015

Keywords: Research area: Aquaculture
Collaborators: Aquaculture Research Sub-Institute for North Central, Aalborg University
Project: Research

**MiSTRA Working Group for Aquaculture Research in Sweden (38977)**

The main task of the Working Group was to provide MiSTRA's Board with background information for its upcoming decision on whether the foundation should invest or not in aquaculture research. MiSTRA is a Foundation for Strategic Environmental Research.

The Working Group should
- describe current Swedish aquaculture research and perform a state of the art review putting Swedish research in an international context,
- make an overview of Swedish aquaculture industry in a global context,
- briefly compare aquaculture to other food production systems,
- briefly discuss the bottlenecks for Swedish aquaculture development,
- critically analyse the arguments for why MiSTRA should invest in aquaculture research (cf. MiSTRA's statutes),
- suggest scope and focus of a new MiSTRA research initiative (if recommended).

The project was coordinated by DTU Aqua.

The project was funded by Swedish Environmental Strategic Research Foundation MiSTRA.

Jokumsen, A., Project Manager, National Institute of Aquatic Resources, Section for Aquaculture

01/08/2012 → 31/03/2013

Keywords: Research area: Aquaculture
Collaborators: Institute of Marine Research, Finnish Game and Fisheries Research Institute
Project: Research

**Development of sustainable technologies and modeling tools in aquaculture aiming at increasing overall production (UDTÆNK) (39030)**

The project aimed at developing methods and modeling tools that may assist the aquaculture industry in expanding its production while minimizing the environmental impact.

To obtain this, the project included six work packages concerning:
- Increased production of rainbow trout by providing methods for reducing the discharge of nitrogen and organic matter.
- Increased production in net cages by providing academic guidance to social workers on concurrent production of trout and mussels.
- Improved sustainability of the industry by providing guidance on optimal system design with respect to reducing nutrient discharge.

The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).

Dalsgaard, A. J. T., Project Coordinator, National Institute of Aquatic Resources, Section for Aquaculture
Pedersen, P. B., Project Participant, National Institute of Aquatic Resources
von Ahnen, M., PhD Student, National Institute of Aquatic Resources
Letelier-Gordo, C. O., PhD Student, National Institute of Aquatic Resources
Larsen, B. K., Project Participant, National Institute of Aquatic Resources
Steenfeldt, S. J., Project Participant, National Institute of Aquatic Resources

09/07/2012 → 31/05/2015

Keywords: Research area: Aquaculture
Collaborators: Danish Aquaculture Association
Project: Research

**IT-solutions for environmental control of trout farms (39094)**

In the project a IT-solution for direct reporting of environmental performance data from trout farms to the Municipality registration system was developed. Also, calculations of compliance with allowances etc. can be calculated and evaluated regularly by the farmer.

DTU Aqua further developed a discharge prediction model, able to calculate the resulting discharge from a ModelTroutFarm of any given layout and dimensions. This model ("Dambrugsmodellen" i.e. "the Trout Farm Model") is based on the existing Produktionsbidragsmodel ("Waste Production Model") and data and monitoring results from all treatment devices added and incorporated into a prediktive model. Both models are now widely used by the authorities as
well as in the industry.

This project was coordinated by the Danish Aquaculture Association.
The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).

Pedersen, P. B., Project Manager, National Institute of Aquatic Resources, Section for Aquaculture
Dalsgaard, A. J. T., Project Participant, National Institute of Aquatic Resources
von Ahnen, M., Project Participant, National Institute of Aquatic Resources
05/07/2012 → 01/05/2015

Keywords: Research area: Aquaculture
Collaborators: Trout farms, Aarhus University, DHI Water - Environment - Health, Danish Aquaculture Association
Project: Research

Traditional trout farms (39095)
Nutrient removal is imperative for Danish fish farms and upcoming requirements for environmental performance though application of BAT (Best Available Technology) cannot be met by traditional fish farms since simple, low-cost technologies does not exist. Removal of dissolved nutrients in low concentrations and large water volumes is especially difficult.
In the project, potential low-cost technologies for removing nitrogen and organic matter were tested and documented. Removal and turn-over of organic matter and nitrogen in biofilters was studied, and the performance of constructed wetlands on traditional farms was also investigated during a full year. In these farms, wetlands efficiently remove particulate matter and associated nutrients (O and P) whereas dissolved matter is almost not removed due to the hydraulic load and short residence time. Depending on the concentrations in the incoming water, requirements for O and P net-removal could be met, whereas a need for simple, low-cost nitrogen removal was clearly demonstrated.

This project was coordinated by the Danish Aquaculture Association.
The project is funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).
Dalsgaard, A. J. T., Project Manager, National Institute of Aquatic Resources, Section for Aquaculture
von Ahnen, M., Project Participant, National Institute of Aquatic Resources
Pedersen, P. B., Project Participant, National Institute of Aquatic Resources
05/07/2012 → 01/06/2016

Keywords: Research area: Aquaculture
Collaborators: Commercial trout farms, Danish Aquaculture Association
Project: Research

Aquaponics NOMA (Nordic Marine) – New innovations for sustainable aquaculture in the Nordic countries (38987)
A detailed study of the nutritional status of effluents from land-based fish farms as fertilizer for relevant plant species, adapt state-of-the-art technology and compare several aquaponic systems to meet the current and future challenges of both the aquaculture and horticulture industry, to develop commercial Aquaponics in the Nordic countries.

The project was coordinated by Bioforsk Øst, Landvik, Norway.
The project was funded by Nordforsk, Nordic Council of Ministers.
Paulsen, H., Project Participant, National Institute of Aquatic Resources, Section for Aquaculture
Jokumsen, A., Project Participant, National Institute of Aquatic Resources
Pedersen, P. B., Project Participant, National Institute of Aquatic Resources
01/01/2012 → 01/01/2015

Keywords: Research area: Aquaculture
Collaborators: FB Aqua Nor, Aquaponics AS, Matorka, Leithbridge College, Hobas AS, Government of Alberta, Norwegian Institute for Agricultural and Environmental Research, Norwegian Institute for Water Research, Icelandic Food Research, Institute of Global Food and Farming
Project: Research

Perspective analysis of sustainable aquaculture in the Nordic countries (PABAN) (38986)
A broad description of the status of aquaculture for each of the Nordic countries to form the basis for Nordic perspectives with recommendations to the political government on how to include aquaculture in the picture of obtaining green development, industry development and common synergies and use of comparative benefits. A SWOT analysis was developed for each country/region as basis for the perspectives. The report was presented to the Nordic Ministers of fisheries affairs at the Nordic Ministers annual meeting in Trondheim 2012.

The project was coordinated by SINTEF Fisheries and Aquaculture, Norway.
The project was funded by Nordforsk, Nordic Council of Ministers.
Paulsen, H., Project Participant, National Institute of Aquatic Resources, Section for Aquaculture
15/12/2011 → 01/09/2012

Keywords: Research area: Aquaculture
Collaborators: Lund University, SINTEF, Finnish Game and Fisheries Research Institute, Icelandic Food Research
Project: Research
Improved farming technology to optimize production, water quality and disease prevention in model trout farms (FOOP) (38950)

The aim of the project was to identify water quality parameters of significance to production traits and disease resistance in rainbow trout; specifically ammonia nitrogen, nitrite nitrogen, carbon dioxide, oxygen and nitrogen gas. The project further aimed to pinpoint where in the model trout farm changes in water quality occurs. From these findings the project will attempt various rectifying actions to improve water quality. Finally, a series of experiments in collaboration with DTU Vet will clarify the importance of water quality parameters on disease resistance.

Examination of operational conditions at a number of different model trout farms showed that supersaturation with nitrogen gases was a chronic problem, and that dissolved CO2 levels were generally 2-3 fold higher than equilibrium conditions. Nitrogen supersaturation did however not occur at levels that negatively influenced production parameters (feed intake, feed conversion, and growth), however, CO2 levels were shown in laboratory experiments to negatively influence production at the observed levels. Ammonia and nitrogen levels were all within safe thresholds as verified by growth studies performed in the laboratory.

Fixed bed and moving bed biofilters each have their advantages and shortcomings. Hydraulic conditions in fixed bed biofilters caused a reduction in N turnover efficiency; however under laboratory conditions (optimal hydraulic conditions) fixed bed biofilters outperform moving bed. In site observations shown that fixed bed biofilters are also more resilient to variations in operational conditions, and are better at removing chemical therapeutants, possibly due to a higher load of organic material within the filter.

Biofilter performance was shown to be sensitive to both dissolved oxygen levels and alkalinity, but not at levels relevant for daily operation.

The project was coordinated by DTU Aqua.

This project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).

Skov, P. V., Project Coordinator, National Institute of Aquatic Resources, Section for Aquaculture
Pedersen, L., Project Participant, National Institute of Aquatic Resources
Pedersen, P. B., Project Participant, National Institute of Aquatic Resources
01/10/2011 → 01/10/2013
Keywords: Research area: Aquaculture
Collaborators: Danish Aquaculture Association, The Danish Environmental Protection Agency
Project: Research

Organic Fry-1: Development of Danish farming of organic trout fry (38951)

Research based advisory for Danish farmers for conversion and management of the first Danish farms for production of organic fry according to the EU regulation on Organic aquaculture (EC no. 710/2009, article 25e) as well as further development of the applied and scientific platform for development of organic aquaculture in Denmark.

The project was coordinated by Danish Aquaculture Association.

The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).

Jokumsen, A., Project Manager, National Institute of Aquatic Resources, Section for Aquaculture
Pedersen, L., Project Participant, National Institute of Aquatic Resources
01/06/2011 → 31/12/2014
Keywords: Research area: Aquaculture
Collaborators: Producers of Trout Fry, Danish Aquaculture Association
Project: Research

Best available technology applicable to traditional pond farms (38811)

As a consequence of environmental concerns – also following the Water Framework Directive legislations – traditional Danish pond farms need to install and operate (affordable) technology to reduce environmental impact from fish farming.

In this project the best available technology applicable to traditional Danish flow-through pond farms was assessed and defined. Different technologies were installed/evaluated on selected farms and environmental effects were analysed, evaluated and discussed. Based on the study the best available technology and its applicability and effects on traditional farms was established, and the environmental authorities were supplied with details regarding what can realistically be done on this type of farms.

Nutrients (N & P) as well as organics, the pollutants most immediately relevant to the watercourse in such farms, were considered in the assessment.

The project was coordinated by Danish Aquaculture Association, Denmark.

The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).

Dalsgaard, A. J. T., Project Participant, National Institute of Aquatic Resources, Section for Aquaculture
Pedersen, P. B., Project Manager, National Institute of Aquatic Resources
01/01/2011 → 01/01/2013
Keywords: Research area: Aquaculture
Collaborators: Aarhus University, Danish Aquaculture Association
Project: Research
Certification of eel and other minor species (38952)
Implementation of the “Sustainable Eel Standard” (cf. www.sustainableeelgroup.com) for sustainable production of eel in a Danish pioneer eel-farm as well as dissemination of knowledge about eel and assessment of potentials of sustainability certification of other minor species.
The project was coordinated by Danish Aquaculture Association.
The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).
Jokumsen, A., Project Manager, National Institute of Aquatic Resources, Section for Aquaculture
01/01/2011 → 31/12/2013
Keywords: Research area: Aquaculture
Collaborators: Danish Eel Farmers Association, Danish Aquaculture Association
Project: Research

Fish welfare aspects of individual variation in cognition, physiology and behaviour (Cope Well) (38813)
The project targeted welfare aspects of individual variability fish. Such differences include both behavioural and physiological traits, which are often clustered in separate stress coping styles. These stress coping styles seem to be coupled to fundamental differences in how information is processed. The aim of this project was to develop methods for separating fish with respect to stress coping styles, and investigate how fish with contrasting stress coping styles differs in cognitive evaluation of challenges. Moreover, the neural mechanism separating fish with contrasting stress coping styles was investigated. The project was part of a large scale collaborative project, funded by the European Commission FP 7 (Cope Well), aiming to establish, evaluate, and further develop, a new scientific framework for the understanding and application of the concept of animal welfare in farmed fish.
The project was coordinated by Havforskningsinstituttet (IMR), Norway.
The project was funded by EU, Framework Programme 7.
Högland, E., Project Manager, National Institute of Aquatic Resources, Section for Aquaculture
Moltesen, M., Project Participant, National Institute of Aquatic Resources
01/01/2011 → 31/12/2015
Keywords: Research area: Aquaculture
Collaborators: Stichting Dienst Landbouwkundig Onderzoek, Havforskningsinstituttet, University of Stirling, University of Oslo, Uppsala University, Autonomous University of Barcelona, University of Patras, Centro de Ciências do Mar do Algarve, L’Institut Français de Recherche pour l'Exploitation de la Mer, Uni Research AS, Instituto Superior de Psicologia Aplicada, Stichting Katholieke Universiteit, University of Crete, Partnership Transnational Consulting Partnership, Nofima
Project: Research

HPLC and amino acids uptake patterns in fish fed plant-based protein (38803)
One of the issues of the rapidly growing aquaculture sector is to find fish meal substitutes. The main focus has been on plant proteins as a substitute for fish meal in the diet formulation. However, significant incorporation of plant proteins in the fish diet often results in reduced growth and/or impaired feed efficiency. Recent trials performed at our lab have shown that the profile of amino acid uptake (timeline) varies between rainbow trout fed plant based diet and fish meal diet. This difference in amino acid availability might well influence the protein synthesis and could add to the explanation of reduced performance of fish fed plant based diets and also the observed increased ammonia excretion.
Following these initial observations made in 2011 the project will perform a series of experiments to further examine how and why amino acid uptake patterns differ. Correlations between amino acid profile in the diet and amino acid in the blood following feeding will be made for different plant protein sources and added crystalline amino acids.

The concomitant effects on liver enzyme activity and protein synthesis will be examined and relevant indicators for protein synthesis (i.e. growth) hopefully determined. Specific digestibility and nitrogen excretion studies as well as traditional growth studies will be performed to support the findings.

The project is coordinated by DTU Aqua.
Larsen, B. K., Project Manager, National Institute of Aquatic Resources, Section for Aquaculture
Skov, P. V., Project Participant, National Institute of Aquatic Resources
Dalsgaard, A. J. T., Project Participant, National Institute of Aquatic Resources
Pedersen, P. B., Project Participant, National Institute of Aquatic Resources
Rolland, M., Project Participant, National Institute of Aquatic Resources
01/01/2011 → 31/12/2015
Keywords: Research area: Aquaculture
Collaborators: BioMar A/S
Project: Research
Innovative practices and technologies for developing sustainable aquaculture in the Baltic Sea region (AQUABEST) (38924)

In opposite to the global trend, aquaculture production in the Baltic Sea region had stagnated. It is widely accepted that aquaculture had great potential to feed the growing human population in the era of declining wild stocks (“Blue Revolution”), but new production has to be built on sustainable practices and technologies. The European Union has identified this challenge and has adopted aquaculture as a flagship project in the EU strategy for the Baltic Sea region. Firstly, AQUABEST demonstrated that Baltic Sea region aquaculture was capable of becoming a nutrient neutral food production system. This was assessed to be achieved by replacing oceanic feed ingredients and plant products harvested at other continents with regional feed ingredients. Potential regional ingredients included Baltic Sea fish catches and Baltic Sea grown mussels not used for human consumption, as well as plant proteins and single cell proteins produced and processed in the region.

Secondly, AQUABEST adapted lessons from maritime spatial planning projects, developed them into guidelines and by regional testing demonstrated that spatial planning tools can be adapted to create environmentally, economically and socially sustainable aquaculture. Spatial planning activities were completed by activities that could support farmers to move fish cages offshore and which could support mussel farmers to adapt technologies that tolerated harsh winter conditions in the northern Baltic Sea.

New farming technologies using recirculating water have been developed especially in Denmark. The third solution of AQUABEST was to transfer these technologies to other regions and further develop them to adapt to brackish water conditions of the Baltic Sea. Furthermore, although recirculation farms already released much less nutrients in the effluent than conventional farms, nitrogen release of these farms could be further diminished. As the final outcome, AQUABEST carried out regional self-evaluation of current environmental regulation models in aquaculture. A novel ecosystem-based regulation needed new approach, environmental policy instruments and economic incentives. Concrete improvements were proposed after dialogue between major stakeholders. The project was coordinated by Finish Game and Fisheries Research Institute, Finland.

The project was funded by EU, InterReg (regional collaboration).

Jokumsen, A., Project Manager, National Institute of Aquatic Resources, Section for Aquaculture
Pedersen, P. B., Project Participant, National Institute of Aquatic Resources

Suhr, K. I., Project Participant, National Institute of Aquatic Resources
Dalsgaard, A. J. T., Project Participant, National Institute of Aquatic Resources
Pedersen, L., Project Participant, National Institute of Aquatic Resources

01/01/2011 → 31/12/2014

Keywords: Research area: Aquaculture

Collaborators: Association of Marine Aquaculture Ltd, Jämtland County Council, Lund University, University of Helsinki, Belarusian State Agricultural Academy, Danish Aquaculture Association, The Government of Åland, Institute of Food Safety Animal Health and Environment, Thunen-Institut, Finnish Game and Fisheries Research Institute, University of Tartu, Swedish Board of Agriculture, Polish Trout Breeders Association

Project: Research

Local raw materials for production of fish feed for aquaculture (38840)

The aquaculture industry is the fastest growing food production industry in the world and approximately 50% of all fish consumed by humans comes from aquaculture. The main cost factor in aquaculture is the cost of feed. Furthermore, high amounts of feed ingredients from marine sources have been of concern both environmentally and economically. Thus, it is of importance for the aquaculture industry to aim for the development of new locally-produced, cost-effective, beneficial and eco-friendly ingredients for innovative practical feed production. Food production, not least in the marine sector and aquaculture, is one of the main fundamental industries in the Nordic countries. Wild fisheries have stagnated or even declined and the aquaculture in other continents has been increasing substantially. It is therefore essential for these industries to implement innovative solutions to maintain the competitiveness of the region in this field. New opportunities for sustainable aquaculture production are emerging providing the tools.

The main objectives of the project were to test new local raw materials for aquaculture feed and to implement those into the production chain, with the purpose to:

- Move the Nordic aquaculture industry towards a more competitive and sustainable production with focus on efficient and responsible use of local feed sources.
- Lowering carbon footprint of aquaculture production
- Identify novel fish feed ingredients and optimizing use of marine raw materials
- Create added-value of feed sources like seaweed, microalgae and mussel meal.
- Decrease dependency of fish meal and fish oil as fish feed ingredients
- Establish a user driven diversified “green growth” aquaculture production of high quality fish products.

The specific role of DTU Aqua in the project was to evaluate mussel meal as a protein source in fish feed. For this purpose a series of digestibility and growth trials at different inclusion levels of mussel meal, with fishmeal based diets as reference, were successfully performed. DTU Aqua also examined potential environmental effects (nitrogen excretion) of replacing fishmeal with mussel meal. Furthermore, the trials provided tissue and blood-samples for closer examination of physiological effects of mussel meal on gut epithelia as well as effects on various hormones. The latter was performed by partners from University of Gothenburg.

The project was coordinated by Islensk Matorka ehf, Iceland.

The project was funded by Nordforsk, Nordic Council of Ministers.
Management and environmental improvement of recirculating aquaculture systems (38815)
The aim of this project was to identify new applicable measures and management strategies to optimize trout production in recirculating aquaculture systems (RAS), in particular the model trout farms. Model trout farms have gained lots of positive attention since their recent launch, as the rearing concept allows increased production, increased water reuse, and decreased nutrient discharge with obvious advantages for the natural fish fauna. Currently, model fish farms have generally experienced a certain fish mortality related to pathogens and suboptimal water quality. Scopes for improvement have been identified in terms of more focus on chemical and (micro-)biological water quality.

The project included four interrelated work packages:
1) Biological filtration (stable, optimal nitrification, nitrite accumulation issues, biofilter kinetics and management)
2) Denitrification: self-contained, operational end-of-pipe solution to reduce N-total from model trout farms
3) Water disinfection and sanitation: evaluation of UV systems disinfection efficacy, resulting water quality and test of easy degradable disinfectants to replace formalin
4) Gas saturation: consequences and effects of N super saturation and total gas pressure on fish performance in RAS.

Each WP addressed specific issues of concern based on current scientific knowledge and practical experience in dialogue with the aquaculture industry. The investigations included bench and pilot scale experiments conducted under controlled conditions at the research facilities at the Section for Aquaculture, DTU Aqua, Hirtshals. The project also included monitoring campaigns and experiments on commercial model trout farms in collaboration with stakeholders.

The project was coordinated by DTU Aqua.

The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).

Marine model trout farms (38816)
Based on the success with the development and implementation of Danish model trout farms in freshwater, a somewhat similar concept was developed for sea water farming of large trout and potentially also salmon in land-based, recirculating systems. Design and technology for the recirculation unit as well as for end-of-pipe treatment were developed and tested in 3 consecutive seasons.

During the project, design and operation were optimized and documented. End-of-pipe treatment, especially related to nitrogen removal and sludge hydrolysis were also investigated.

Based on the concept and the results achieved in the major unit in commercial scale at DTU Aqua premises in Hirtshals, it can be concluded that there is potential for such open land-based sea water farming units and that they can be operated commercially sustainable. Major issues related to reducing/preventing (toxic) algal blooms and supersaturation in seawater needs to be addressed before commercial operations should be initiated, though.

The project was coordinated by North Sea Science Park, Denmark.

The project was funded by the Danish Ministry of Food, Agriculture and Fisheries through the Green Development and Demonstration Program (GUDP) and the partners involved.

Nordic network and conference on aquaculture recirculation technology (NordicRAS) (38842)
DTU Aqua has taken the initiative to establish a Nordic Network on Recirculating Aquaculture Technology (RAS). The idea is motivated by the facts that: (i) the geographical location and species composition requires certain breeding conditions and solutions, and (ii) the Nordic region has an excellent academic and commercial background for initiating such collaboration.
The purpose of the network is to strengthen Nordic research and research collaboration in RAS and associated water treatment including e.g. application of existing techniques in new setups, resolving potential new research areas, and investigating innovative operation forms that ensure high water quality. We anticipate that the network will become a continuous activity which could result in the establishment of consortiums that perhaps could apply for national and transnational European research funding, exchange of students, development of projects and potential educational programmes, etc.

The network is coordinated by DTU Aqua, and was founded at a steering committee meeting in April 2011 with country representatives from Denmark, Norway, Sweden, Finland and Iceland.

As one of its first activities, the network organizes a RAS workshop in Helsinki on October 5-6, 2011. The aim of the workshop is to bring researchers and industrial partners with an interest in RAS together, creating a unique opportunity for exchanging practical experiences and scientific knowledge on the newest developments in RAS. We anticipate that the workshop will become a recurrent event every other year in the country holding the presidency of the Nordic Council of Ministers.

Dalsgaard, A. J. T., Project Manager, National Institute of Aquatic Resources, Section for Aquaculture
Pedersen, P. B., Project Participant, National Institute of Aquatic Resources
01/01/2011 → …
Keywords: Research area: Aquaculture
Project: Research

**Nordic Network and Conference on Aquaculture Recirculation Technology (NordicRAS) (38842 & 39099 & 39223)**

DTU Aqua has taken the initiative to establish a Nordic Network on Recirculating Aquaculture Technology (RAS). The idea is motivated by the facts that: (i) the geographical location and species composition requires certain breeding conditions and solutions, and (ii) the Nordic region has an excellent academic and commercial background for initiating such collaboration.

The purpose of the network is to strengthen Nordic research and research collaboration in RAS and associated water treatment including e.g. application of existing techniques in new setups, resolving potential new research areas, and investigating innovative operation forms that ensure high water quality. We anticipate that the network will become a continuous activity which could result in the establishment of consortiums that perhaps could apply for national and transnational European research funding, exchange of students, development of projects and potential educational programmes, etc.

The network is coordinated by DTU Aqua, and was founded at a steering committee meeting in April 2011 with country representatives from Denmark, Norway, Sweden, Finland and Iceland.

The main activity of the network will be to organise a RAS workshop every second year in one of the Nordic countries. The first workshop was held in Helsinki (Finland), October 2011, the second workshop in Aalborg (Denmark) October 2013, the third workshop in Molde (Norway) September - October 2015, and the fourth workshop in Aalborg (Denmark) October 2017. The aim of the workshops is to bring researchers and industrial partners with an interest in RAS together, creating a unique opportunity for exchanging practical experiences and scientific knowledge on the newest developments in RAS. This project is coordinated by DTU Aqua.

In 2011, the project was funded by AG-Fisk (Nordic Council of Ministers) and “Formandskabspuljen” (Nordic Council of Ministers). In 2012, follow-up activities and planning of future activities was funded by AG-Fisk. In 2013 and 2015 it was funded by AG-Fisk.

Dalsgaard, A. J. T., Project Coordinator, National Institute of Aquatic Resources, Section for Aquaculture
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01/01/2011 → 31/12/2021
Keywords: Research area: Aquaculture
Project: Research

**Offshore aquaculture, development of technology for offshore sea farming (38925)**

The Danish sea territory spans 105,000 square kilometers of relatively shallow water with salinities ranging from brackish to fully oceanic. The present Danish sea farms are located in the least exposed regions in the Danish fjords and sounds. Environmental constraints are limiting production increase, and new locations in the coastal zone are rarely allocated. The shortage of suitable inshore sites emphasizes the urge to move to more exposed sites where benthic impacts are reduced or eliminated.

The offshore areas of the Danish sea territory holds vast areas with no or negligible activities apart from capture fishery. Venturing into these areas with aquaculture opens a major window of opportunity, but is also a serious challenge being too great for a single company to lift.

The overall purpose of developing the offshore production system is to create the technical foundation for “farming the
ocean”. In other words to make it possible to locate cage culture facilities in areas now not considered suitable for fish farming because of their exposure to the physical forces of the open sea. The project developed and tested different cage designs, anchoring and mooring systems and serviceability for offshore production. Submersible systems were found to be too unreliable in their operation as well as being difficult to maintain and service. The project found that a modification of conventionally designed cages constructed in more heavy duty materials were well suited for offshore production. Test production of trout showed that even in locations where significant wave heights exceed 3 meters, fish production was possible. Excess water currents were found to negatively influence production efficiency, resulting in poorer feed conversion, and increased nutrient emission from fish production. Similarly, increasing salinity was found to have a major negative influence on feed utilization. Physiologically, it was found to be possible to submerge fish for periods of up to 2 weeks without adverse effects on fish. The project concludes that offshore farming is possible, but also that environmental impact from fish farming and production efficiency are influenced by the physical environment that fish are farmed in, which should be taken into account during site selection. The project was coordinated by Hvalpsund Net, Denmark. The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).

Recirculation technology for future aquaculture (REFA) (38843)
An Innovation Consortia with many industrial partners. In the project, basic and applied research was performed by several partners to support the development of new and energy-efficient technologies for recirculation systems. Some of the research issues were:
- to develop new filter technologies and energy-efficient aeration systems
- to develop process- and CFD models to improve our understanding and insight into dynamic variation in water quality parameters
- to determine the importance of particulate matter for biofilter operation (this was the DTU Aqua research package)
- to develop tools and instruments for advanced regulation and control of recirculating aquaculture systems
- to develop technologies for waste management
Twelve larger Danish companies were further partners in this project. The project was coordinated by Danish Hydraulic Institute, Denmark. The project was funded by the Danish Agency for Science, Technology and Innovation and the participating companies.

Development of a strategy for aquaculture in the Baltic Sea Region (38978) (BESTAQ)
Development of a strategy for aquaculture in the Baltic Sea Region. The acronym is BESTAQ (Baltic Environmentally Sustainable Aquaculture) and the project was a flagship project, including a range of stakeholders along the whole value chain to provide a tool for the governments and industries for decisions for development of aquaculture as well on national as on regional level.

North Denmark Region as strategic development platform for offshore sea farming technology (38805)
The development of offshore aquaculture has reached a point where the next step forward is to physically move the last step from off coast to off shore. This is a challenge though, and will be a multidisciplinary task only to be carried out by a consortium of private sector partners, research institutions and government authorities. The project launches the concept of describing such a development platform based at the North Sea Science Park. This will place the North Denmark Region in the center of a coming national R&D activity and be the foundation for a coming Danish offshore aquaculture production.
The blue revolution: Perspectives for sea based food production (38804)
The project will conduct an investigation of the possibilities for use of a larger part of the Danish sea territory for aquaculture of food as well as non food products.

The project will review the current state of world sea based aquaculture with focus on offshore activities of fish, shellfish and algae. The project will also review the national state of sea based culture of fish shellfish and algae before conducting an analysis of potential transfers of technology to support the Danish development of the sector.

The project will initiate the formation of a national Blue Revolution Network that will link the different activities on sea based production in a network to support exchange of knowledge and cooperation between the different activities on the subject.

A set of recommendations on the future development of Danish sea based production will be outlined and serve as guidelines for the coming development of the sector.

Implementation of Global Certification (Aquaculture Stewardship Council - ASC) for rainbow trout and assessment of sustainable certification of new species (38809)
Aquaculture is globally the fastest growing food producing sector. However, to continue that trend requires efficient solutions to negative environmental and socioeconomic impacts that may be associated with aquaculture production. This project aimed to support the process of global certification of rainbow trout, i.e. to develop global, measurable, performance-based, and transparent standards that minimize negative environmental and social impacts from farming of trout in fresh water and maintain economic sustainability of trout production. The basis was the current types of production and strategies for farming of rainbow trout in fresh water in Denmark from the embryonic stage to marketable size and broodstock fish. Also included were the principles and the main national and EU regulations related to fish farming as well as issues related to feed, veterinary health conditions, and use of antibiotics and therapeutants. Production facilities included the design and construction, of the various types of fish farms (i.e., traditional farms, model trout farms, and Fully Recirculation Aquaculture (FREA) systems). Finally, farming of organic trout in Denmark and the related regulations affiliated with the organic label were included. The project was part of the Aquaculture Trout Dialogue facilitated by World Wide Fund for Nature (WWF) to develop the certification standards in cooperation with the other partners. Once the certification standards were fixed the Aquaculture Stewardship Council (ASC) became responsible for the certification of the produces.

The project was coordinated by Danish Aquaculture Association, Denmark.
The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).

DTU centre for recirculation technology (38159)
Despite the obvious scientific relationship and correlation between recirculation technology, specifically biofiltration, and municipal waste-water treatment only limited scientific knowledge has been interchanged between these two areas.

DTU Environment has for many years been an internationally renowned actor within biofiltration processes and kinetics in waste water treatment. Combining this stronghold with the DTU Aqua expertise in recirculating systems is the basis for this project. Through project cooperation, student interchange and common research set-ups knowledge is exchanged.
In recirculation systems feed is the major input to the system, and the linkage between feed, water quality and system operation is important, yet missing knowledge, which will also be addressed by the group through a combined experimental and modeling approach.

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01/01/2010 → 31/12/2015
Keywords: Research area: Aquaculture
Project: Research

Energy efficiency in the aquaculture sector (38802)
The increased implementation of technologies for water recirculation and the purification, oxygenation and degassing of water used in aquaculture production, has caused the energy costs associated with fish production to dramatically increase. The current energy consumption for the production of 1 kilogram of rainbow trout is estimated at 1.7 kWh. This represents a challenge for the aquaculture industry because national and international ambitions strive for a general decrease in carbon dioxide emissions. The aim is to reduce the energy requirements for trout production to 1 kWh per kg. With an annual production of 35,000 tons, this corresponds to an annual reduction in CO2 emissions of 13,400 tons, and a financial saving of DDK 17.1 million. The purpose of the project is to identify the most energetically efficient methods to oxygenate, degas and move water, or how to improve the efficiency of currently used methods, without compromising water quality parameters. Currently, the primary method for aeration, degassing and water movement is by use of air, using the so-called air lift pumps aka mammoth pumps.

The project will collect data on annual energy consumption from 4-8 selected recirculating aquaculture facilities and compare these values with feed use and fish production. The energy consumption is considered with reference to the technologies in use at a given facility and the construction of the facility. The primary purpose is to evaluate energy efficiency of air blowers currently in use, air delivery per unit of effect, efficiency in aeration and degassing, and variations in the requirement for aeration and degassing over the daily cycle. These results will enable the documentation of any correlations between energy efficiency, technology in use, methods of operation, and will serve in the further development of alternative solutions to aeration and degassing. Emphasis will be on the physical properties and placement of air diffusers in airlift pumps and the feasibility of using trickle towers for aeration, aeration with liquid oxygen or other alternatives. Experiments to determine energy use and efficiency of alternate oxygenation and degassing devices will allow the project to determine whether more suitable technologies exist and make an estimate of potential energy savings.

The project will terminate in a final report and a workshop where the results will be presented to stakeholders in the aquaculture industry (fish farmers, feed manufacturers and equipment suppliers). Suitable alternative technologies and methods for aeration and degassing will be presented in practice.

The project is coordinated by Danish Aquaculture Association, Denmark.
Skov, P. V., Project Manager, National Institute of Aquatic Resources, Section for Aquaculture
01/01/2010 → 01/10/2012
Keywords: Research area: Aquaculture
Collaborators: BioMar A/S, Nielsen Consult, Lokalenergi A/S, Danish Aquaculture Association, Danish Technological Institute, AquaCircle
Project: Research

Further development of Danish organic aquaculture (ØKOAKVA-1) (38808)
The first Danish organic rainbow trout with the Danish red Ø label was introduced to the market in 2005. The demand for organic trout is increasing and Danish trout farmers are currently converting to organic production. However, the development of organic trout production in Denmark has been challenged by a very strict national legislation for organic aquaculture production. However, by the coming into force of the EU regulation for organic aquaculture by 1 July 2010 equality was established between the European organic fish farmers, but new challenges were faced by the Danish organic farmers. Therefore, further development and establishment of sustainable organic fish production in Denmark required strengthened research efforts, i.e. nutritional and environmental aspects, farming conditions, health, green energy and water consumption to improve the competitiveness and efficiency in production. The project aim was to facilitate the implementation of the EU regulation on Organic Aquaculture for the production of rainbow trout in fresh and sea water, organic production of line mussels and sea weed.
The project was coordinated by Danish Aquaculture Association, Denmark.
The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).

Jokumsen, A., Project Manager, National Institute of Aquatic Resources, Section for Aquaculture
01/01/2010 → 31/03/2013

Keywords: Research area: Aquaculture
Collaborators: Danish Aquaculture Association, Danish Veterinary and Food Administration
Project: Research

**Helpdesk for aquaculture (HelpDesk) (38696)**
In the project different environmental issues related to regulation of aquaculture have been addressed according to specific needs and questions from the Ministry of Food, Agriculture and Fisheries and the Ministry of Environment. Specifically, a calculation model for predicting waste generated from fish farming has been developed. This Excel-based model is able to calculate the waste generated by the fish depending only on the fish performance (FCR) and the composition and digestibility of the feed used.
The model, valid for rainbow trout up to 800 g/pieces in freshwater, was verified through various experiments using commercial feed types, and is now a central element in the regulation of the Danish freshwater trout farming industry. It is used throughout the industry and administration and has generated a common background and baseline for all stakeholders.

A group consisting of the Ministry for Food, Agriculture and Fisheries, the Ministry of Environment, the Danish municipalities' organization Local Government Denmark was formed and acted as reference/steering group.
The project was coordinated by DTU Aqua.
The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).

Pedersen, P. B., Project Manager, National Institute of Aquatic Resources, Section for Aquaculture
Jokumsen, A., Project Manager, National Institute of Aquatic Resources
Jørgensen, A. J. T., Project Participant, National Institute of Aquatic Resources
01/01/2010 → 30/11/2013

Keywords: Research area: Aquaculture
Project: Research

**Integrative Fish Behavioural Neuroscience Network (BIFINE) (38812)**
The aim of the network was to encourage exchange of ideas and stimulate collaboration across disciplines. A multitude of disciplines were represented, each offering distinct and powerful tools for the study of behavioral neuroscience of fishes. The network included leading groups in Denmark, Norway, Sweden and Finland, representing the following research fields: general fish physiology (both at the phenotypic and genotypic level), genetic modification, genotype-phenotype interactions, molecular biology, biomedicine, evolutionary ecology, stress responses and neurotransmitter mechanisms, neuroanatomy and developmental neurobiology.
The integration of the above mentioned disciplines aimed at meeting the growing need to understand underlying mechanisms of fish behavior and how it is affected by environments change, including anthropogenic disturbance and climate changes and at improving our understanding and tackling of key issues associated with fish aquaculture, welfare, restoration and climate change.
The project was coordinated by DTU Aqua.
The project was funded by Nordforsk, Nordic Council of Ministers.

Höglund, E., Project Manager, National Institute of Aquatic Resources, Section for Aquaculture
01/01/2010 → 31/12/2012

Keywords: Research area: Aquaculture
Collaborators: Uni Research AS, University of Bergen, Lund University, Uppsala University, University of Helsinki, University of Gothenburg, Norwegian University of Life Sciences, Norwegian School of Veterinary Science
Project: Research

**Reproduction of European eel: Towards a self-sustained aquaculture (PRO-EEL) (38793)**
Reproduction of European eel (Anguilla anguilla) in culture has become a research priority area due to a severe decline of natural stocks and an increasing interest to breed eels for a self-sustained aquaculture. As eels do not reproduce naturally in captivity, development of methodology and technology was needed for production of viable eggs and larvae from broodstock in a regular and predictable way.

Focus of PRO-EEL project was on the primary bottlenecks in a controlled reproduction of eels, which concern deficiencies in knowledge about eel reproductive physiology and methods applied to induce and finalize gamete development. During a 4-year period, the project significantly expanded current knowledge on the eel reproductive mechanisms and hormonal control of sexual maturation. The consortium developed standardized protocols for assisted production of high quality gametes (egg and sperm) and artificial fertilization, thereby obtaining a stable production of viable embryos. Furthermore, egg incubation procedures and culture of yolksac larvae were established for the first time for European eel, leading to the first feeding stage. The project disseminated novel literature on early life stages, including their ontogeny and requirements thereby describing egg and larval stages still unknown in nature and providing important information for future development of larval diets and rearing technology. Methodology and technology was established using small scale tests and validated in full scale experimental facilities managed by DTU.

The project was an international, EU-funded research project characterized by an integrative and multidisciplinary approach.
The project was funded by EU, Framework Programme 7.

The project was coordinated by DTU Aqua.

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Munk, P., Project Manager, National Institute of Aquatic Resources

Butts, I., Project Participant, National Institute of Aquatic Resources

Krüger-Johnsen, M., Project Manager, National Institute of Aquatic Resources

Stettrup, J. G., Project Participant, National Institute of Aquatic Resources

Sørensen, S. R., Project Participant, National Institute of Aquatic Resources

Skov, P. V., Project Participant, National Institute of Aquatic Resources

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Hornum, I., Project Participant, National Institute of Aquatic Resources

01/01/2010 → 31/07/2014

Keywords: Research areas: Fish Biology & Aquaculture & Marine Populations and Ecosystem Dynamics & Coastal Ecology

Collaborators: Leiden University, Wageningen IMARES, University of Copenhagen, Demokritos National Centre for Scientific Research, Billund Aquaculture Service Aps, National Institute of Sciences and Technologies of the Sea, Norwegian University of Science and Technology, BioMar A/S, Institute of Marine Research, Polytechnic University of Valencia, National Institute for Agronomic Research, Nofima, Ghent University

Project: Research

Animal welfare: social and environmental preferences of reared rainbow trout (38697)

The principle objective of this project is to evaluate the effect of rearing densities, current and cover on animal welfare. We will use preference test to investigate behavioral and environmental needs of farmed rainbow trout. Furthermore, for investigating the effects of not fulfilling these needs we will use neurophysiological and endocrine responses involved in the stress reaction as biomarkers for compromised welfare. The obtained knowledge is expected to contribute to a scientific based governmental guideline for welfare based intensive fish rearing.

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Laursen, D. C., Project Participant, National Institute of Aquatic Resources

01/01/2009 → 31/03/2013

Keywords: Research area: Aquaculture

Project: Research

Edible-, slaughter- and health quality of exercised rainbow trout (38395)

In Danish aquaculture the production of rainbow trout (Oncorhynchus mykiss) in intensive, recirculating systems has increased over the years and this tendency is expected to proceed. Intensive systems are characterized by their potential to apply relatively high water velocities that can be of importance to fish farmers since water currents in earlier studies have been shown to stimulate fish growth. A large part of the growth potential of modern trout strains has however been exploited through breeding and this makes it uncertain to what extent and how modern trout strains respond to increased water velocities in terms of growth. Quality is also a significant parameter in that regard. Fast growth in intensive rearing systems may have implications on trout quality through increased propensities to stimulate lipid depositions in edible parts of the fish and in buccal cavities with concomitant effects on sensory parameters and slaughter yields.

The aim of the project is to study how exercise of rainbow trout may influence their growth and quality. Through collaboration with external partners and internal collaboration in DTU Aqua that has been stimulated through the research area “Individual Biology” numerous competences are involved. The project addresses important aspects of muscle physiology, hormonal control, enzymatic activities, fatty acid metabolism, overall fish growth and industrial fish quality. More specifically, by use of different exercise levels, fish growth and feed and protein utilization is monitored by changes in weights and lengths of the fish together with differences in feed intake. Growth rates are evaluated together with blood plasma content of IGF-1. Furthermore, measurements of plasma cortisol levels together with feed shares indicate the impact on fish welfare. Slaughter yields are determined under common production conditions in industry. Changes in chemical proximate composition of fillets are studied together with fatty acid profiles and the particular change in healthy n-3 fatty acids. Muscle fiber growth and other characteristics in the swimming musculature are studied by use of histological techniques involving light microscopy as well as electron microscopy. Changes in gene expression for mTOR (the mammalian target of rapamycin) are studied for their potential role in muscle fiber hypertrophic or hyperplastic growth and proteom analyses considering other key proteins of importance to both growth and quality are also undertaken.

Changes in the calpastatin/calpain system measured as gene expression and/or electrophoretic are considered important for development of fillet texture that is measured instrumentally. Fillet texture is additionally considered by a trained sensory panel focusing on taste, odors, texture characteristics and appearance of the fish fillets.
The results obtained so far have proven positive with regards to applying exercise in rearing of modern rainbow trout strains. Negative aspects only seem to manifest when strenuous exercise levels are applied. Exercise has the potential to stimulate overall growth and reduce size differences within a stock supposedly owing to less aggression when feeding. Through several changes in muscle physiological components brought about by exercise the fillet texture may increase and there are furthermore indications that fish welfare may be improved.

The project is coordinated by DTU Aqua.
Rasmussen, R. S., Project Manager, Section for Aquaculture, National Institute of Aquatic Resources
Tomkiewicz, J., Project Participant, National Institute of Aquatic Resources
01/01/2008 → 31/12/2011
Keywords: Research areas: Aquaculture & Fish Biology
Collaborators: Aarhus University, Danforel A/S, University of Tasmania
Project: Research

Enzymes in fish feed: Optimization of protein digestibility in fish production (38396)
The demand for aquaculture products is increasing globally and is expected to keep increasing in proportion with the growth in the global human population. A limiting factor for the expansion of the aquaculture industry is the dependency of fish meal, which is the primary protein source in feed for carnivorous fish (trout, salmon, turbot, cod etc.). Increasing world market prices on quality fish meal is reflected in the price of fish feed, and has intensified the international competition for finding ways to optimise the use of alternative plant-based proteins in fish feed.

Enzymes are catalysts that increase the speed of the processes in which they are involved. A high degree of specificity makes enzymes an excellent tool for increasing specific reactions, e.g. the degradation of complex feed ingredients to digestible nutrients. The addition of enzymes to fish feed has the potential of improving the nutritional value of the feed, reducing production costs and loss of valuable nutrients to the environment. Enzymes are already widely used in feed for broilers and pigs, while only phytases have been approved for commercial fish production.

The objective of this project was to promote the use of industrial enzymes in fish feed as a means to improve the utilization by the fish of existing and/or alternative protein sources. The project consisted of four work packages: 1) Identification of relevant enzymes and feed ingredients; 2) Feed production; 3) Test of feed quality in a digestion model; 4) Data analyses, reporting and preparing publications. Low-grade soybean cake, sunflower cake and rapeseed cake were chosen as alternative plant-based protein sources in three diets. The effects of three exogenous enzymes in liquid form (Ronozyme®VP (β-glucanase, pectinase), Ronozyme®WX (xylanase) and an experimental protease) on nutrient digestibility was examined. The study showed that Ronozyme®VP and the experimental protease were able to significantly improve the nutrient digestibility primarily in the soybean cake diet at doses of 150-300 mg kg⁻¹. No clear effect of RONOZYME®WX on nutrient digestibility was observed with any of the ingredients tested. The overall conclusion of the project was that Ronozyme®VP and the experimental protease have potential to increase the nutritional and energetic value of proteinaceous plant-based feed ingredients in fish feed.

The project was coordinated by DTU Aqua.
Dalsgaard, A. J. T., Project Manager, National Institute of Aquatic Resources, Section for Aquaculture
Pedersen, P. B., Project Participant, National Institute of Aquatic Resources
Poulsen, E., Project Participant, National Institute of Aquatic Resources
Larsen, O. M., Project Participant, National Institute of Aquatic Resources
Sproegel, U., Project Participant, National Institute of Aquatic Resources
Frandsen, D., Project Participant, National Institute of Aquatic Resources
01/01/2008 → 31/12/2010
Keywords: Research area: Aquaculture
Collaborators: BioMar A/S, Novozymes A/S, DSM Food Specialties
Project: Research

Strategies to improve health and welfare in rainbow trout farming (38193)
The main aim of the project is the developing of sustainable strategies for improving the health, welfare and quality of cultured rainbow trout by implementing three interrelated approaches: management, immune prophylactics, and selective breeding. The management approach determines how increased water current at given rearing densities and water temperatures can reduce the stress of trout. The immune prophylactic approach determines the relationship between
immune response profiles and induction of protective immunity at different water temperatures and hereby establishing efficient strategies for use of vaccination and feed stimulants in prevention of diseases. The selective breeding approach determines how physiological and immunological traits can improve the genetically basis for resistance of trout to stress and disease.

The project is coordinated by DTU Aqua.
Jokumsen, A., Project Manager, National Institute of Aquatic Resources, Section for Aquaculture
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Larsen, B. K., Project Participant, National Institute of Aquatic Resources
Skov, P. V., Project Participant, National Institute of Aquatic Resources
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01/01/2007 → 31/12/2010
Keywords: Research area: Aquaculture
Collaborators: Aarhus University, National Institute of Aquatic Resources
Project: Research

**Monitoring and Documentation of the Performance of ModelTroutFarms (ModelTroutFarm)**

De-coupling fish production and environmental impact is a sustainable way of increasing aquaculture. In order to achieve increased production and—simultaneously—reduced environmental impact a new farming concept was developed, tested and demonstrated.

Applying cost-efficient technologies from recirculation on large, traditional flow-through farms provided the basic concept for ModelTroutFarms. Through intensified production in concrete tanks, the former earthen ponds could be used as constructed wetlands for end-of-pipe treatment of the discharged water.

Due to recirculation, water consumption was reduced by a factor 25, so damming of natural water courses was no longer needed for supplying water to the farm. As a consequence, dammings could be removed leaving the water course to its natural flow.

A reduction of some 80 % in organic matter and phosphorous discharge was achieved, and 50 % of the nitrogen was removed.

Through the concept, technical and practical means of decoupling fish production and environmental impact was demonstrated in large scale commercial operations. Concomitantly, legislation was changed and now approximately 50 % of the Danish fresh water production is in ModelTroutFarms.

This project was coordinated by DTU Aqua.
Pedersen, P. B., Project Coordinator, National Institute of Aquatic Resources, Section for Aquaculture
Rasmussen, R. S., Project Participant, National Institute of Aquatic Resources
Dalsgaard, A. J. T., Project Participant, National Institute of Aquatic Resources
Suhr, K. I., Project Participant, National Institute of Aquatic Resources
01/01/2003 → 31/12/2008
Keywords: Research area: Aquaculture
Collaborators: Aarhus University, Eight trout farms
Project: Research

**Monitoring and documentation of the performance of ModelTroutFarms (ModelTroutFarm) (38192)**

De-coupling fish production and environmental impact is a sustainable way of increasing aquaculture. In order to achieve increased production and, simultaneously, reduced environmental impact a new farming concept was developed, tested and demonstrated.

Applying cost-efficient technologies from recirculation on large, traditional flow-through farms provided the basic concept for ModelTroutFarms. Through intensified production in concrete tanks, the former earthen ponds could be used as constructed wetlands for end-of-pipe treatment of the discharged water.

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Through the concept, technical and practical means of decoupling fish production and environmental impact was demonstrated in large scale commercial operations. Concomitantly, legislation was changed and now approximately 50 % of the Danish fresh water production is in ModelTroutFarms.

This project was coordinated by DTU Aqua.
The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).
Pedersen, P. B., Project Coordinator, National Institute of Aquatic Resources, Section for Aquaculture
Rasmussen, R. S., Project Participant, National Institute of Aquatic Resources
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01/01/2003 → 31/07/2011
Keywords: Research area: Aquaculture
Collaborators: Aarhus University, Eight trout farms
Project: Research