The overarching aim of SORTMUND is to establish a profitable and environmentally sustainable fishery after the invasive round goby in inner Danish waters. Round goby was first seen in south-eastern Danish waters in 2008 and have since increased rapidly in abundance along the coastline where it has severe negative effects on local biodiversity and the traditional coastal fishery. We aim to launch the fish as a high-quality Nordic product for human consumption, in addition to the assessment of stocks status and management advice is based on best available scientific information.

The aim of the project is to improve the knowledge and data basis for stock assessment and management for cod in the eastern Baltic Sea. In later years, changes in growth and natural mortality of cod have presumably taken place and new knowledge on these parameters is essential for restoring analytical stock assessment for Eastern Baltic cod that is currently lacking. Improved knowledge on cod growth and mortality is therefore a prerequisite for being able to evaluate the stock status in relation to management targets and implement management plans that are built on quantitave stock assessment. Ecological situation in the Baltic Sea has changed in later years, which requires updated biological information. This is done in the project using different approaches, bringing together expertise of different research areas. The approaches applied include molecular-genetic analyses of cod growth, bioenergetic modelling, and analyses of monitoring data on predation and condition/growth of cod. An important component of the project is cooperation with fishing industry to support tagging experiments of Baltic cod, to obtain updated estimates of cod growth. Finally, the project combines the new knowledge on cod that becomes available from this and other relevant projects to ensure that the assessment of stocks status and management advice is based on best available scientific information.

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

**Eastern Baltic cod - New knowledge of growth and mortality is the way to improved management advice (39366)**

The project is coordinated by DTU Aqua and funded by Velux Fonden.

**Marine litter in the water column of the North Sea (MARLINS) (39561)**

MARLINS (Marine litter in the water column of the North Sea) will utilize a unique collection of marine litter, sampled in connection with annual herring larvae surveys, to investigate the composition, amount, distribution and potential sources of marine litter in the North Sea. In contrast to most other investigations on marine litter which are largely focussed on beach surveys, bottom trawl surveys or sampling in surface waters, the present project will provide information about marine litter in the entire water column.

The main output of the project will be a marine litter database and a detailed description of the composition of the marine litter by different categories, colours and sizes as well as maps of the spatial distribution, amount and where applicable weight of the different litter categories in the entire North Sea area. In addition, drift model runs will be conducted to further investigate potential source and sink areas of the litter.

The knowledge gained from the project is expected to be relevant for various stakeholders and authorities such as Ministries of Environment and Fisheries, nature conservation organizations, tourism organizations as well as the International Council for the Exploration of the Sea (ICES) and the scientific community in general, in particular in relation to the Marine Strategy Framework Directive. For example, information about the most likely sources of litter and identification of potential source areas for certain litter types may allow responsible authorities and stakeholders to investigate if actions can be taken to reduce or entirely prevent the continuing, future introduction of certain types of litter into the marine environment by diminishing or completely shutting down the sources.

The project is coordinated by DTU Aqua and funded by Velux Fonden.

**Sustainable use of the invasive round goby in favour for the fishery and the environment (SORTMUND) (39336)**

The overarching aim of SORTMUND is to establish a profitable and environmentally sustainable fishery after the invasive round goby in inner Danish waters. Round goby was first seen in south-eastern Danish waters in 2008 and have since then increased rapidly in abundance along the coastline where it has severe negative effects on local biodiversity and the traditional coastal fishery. We aim to launch the fish as a high-quality Nordic product for human consumption, in addition to the assessment of stocks status and management advice is based on best available scientific information.
The project is coordinated by DTU Aqua.
The project is funded by the European Maritime and Fisheries Fund (EMFF) and the Danish Fisheries Agency.

For an optimal management of sandeel.

Fundamental prerequisites defined in collaboration between management, fisheries and science in order to form the basis for discussions possible management strategies for sandeel in the North Sea. These discussions will imply a number of considerations relevant for management. Among these will the sandeel population structure and its influence on stock assessment, recruitment from unfished banks. The project will perform a statistical evaluation of fisheries-independent data for sandeel concentration of fishing effort on certain banks potentially causes an error in the stock assessment in relation to ecosystem reference points. Throughout the project period, a series of workshops and meetings will be held in order to discuss possible management strategies for sandeel in the North Sea. These discussions will imply a number of fundamental prerequisites defined in collaboration between management, fisheries and science in order to form the basis for an optimal management of sandeel.

This project is funded by BalticSea2020.

Tabe: "Tagging Baltic cod (TABACOD) (39333)"
The aim of this project is to improve the management of eastern Baltic cod by 1) providing new information on growth and mortality patterns, and 2) develop a validated method for deriving this information from historic and future samples. In recent years, the traditional age-based stock assessment had to be abandoned owing to extensive uncertainties in stock trends. These uncertainties were to a large extent attributable to inconsistencies in age estimation. As a consequence thereof, the current stock status is unknown. Estimates of growth and mortality rely on unbiased age information. TABACOD will provide this information through a large scale tagging experiment, where 20,000 cod are tagged with and externally visible tag as well as with an internal tag on their otoliths. This experiment will also provide the samples for the development and validation of a new age estimation method based on the chemical composition of the cod's otoliths. The knowledge gained will be incorporated in length-based assessment models and their performance compared to the traditional methods evaluated in order to provide the ICES stock assessment group with the relevant tools to provide a reliable advice and to improve stock exploitation.

This project is coordinated by DTU Aqua.
The project is funded by BalticSea2020.

Hussey, K., Project Coordinator, National Institute of Aquatic Resources, Section for Oceans and Arctic
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Andersen, N. G., Project Participant, National Institute of Aquatic Resources
Storr-Paulsen, M., Project Participant, National Institute of Aquatic Resources
Thygesen, U. H., Project Participant, National Institute of Aquatic Resources
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01/01/2016 → 31/12/2019

Keywords: Research areas: Marine Populations and Ecosystem Dynamics & Fish Biology & Marine Living Resources
Collaborators: Enspire, NF340 Lasse III, Gilleleje Fillet Factory, National Food Institute, Danish Fishermen's Association, Gemba Seafood Consulting
Project: Research

"Forward management of sandeel in the North Sea (39316)"
The project will define and align the management of sandeel considering the goals and desires of the fishing industry, administration and science while taking the biology and importance of the sandeel in the ecosystem into account. The project is structured by several work-packages, each dealing with specific aspects of sandeel biology and/ or fishery relevant for management. Among these will the sandeel population structure and its influence on stock assessment, CPUE and counselling be discussed. Analyses of fisheries development and sandeel availability over the fishing season will enable a more accurate calculation of fishing mortality. Furthermore, it is examined whether the increasing concentration of fishing effort on certain banks potentially causes an error in the stock assessment in relation to recruitment from unfished banks. The project will perform a statistical evaluation of fisheries-independent data for sandeel in the North Sea and evaluate existing and alternative methods of stock assessment for sandeel in the North Sea with current and alternative management areas, including implementing an analytical stock assessment of sandeel in sandeel area 4. Finally the project will evaluate existing biological and management reference points, and discuss these in relation to ecosystem reference points. Throughout the project period, a series of workshops and meetings will be held in order to discuss possible management strategies for sandeel in the North Sea. These discussions will imply a number of fundamental prerequisites defined in collaboration between management, fisheries and science in order to form the basis for an optimal management of sandeel.

The project is coordinated by DTU Aqua and is funded by the European Maritime and Fisheries Fund (EMFF) and the Danish Fisheries Agency.
BONUS BIO-C3 Cruise (39117-DCH)

The multidisciplinary research cruise (16-30 September 2015) was aiming to investigate the distribution, abundance, biomass, production, nutritional condition and genetic diversity of several, trophically interlinked Baltic key species, ranging from zoo-, and ichthyoplankton over gelatinous organisms to adult fish, including non-indigenous species. The collected samples and data are used in the BONUS project Biodiversity changes—causes, consequences and management implications (BIO-C3), aiming to significantly advance our knowledge base towards the importance and management of the Baltic Sea biodiversity in an ecosystem perspective.

The project was coordinated by DTU Aqua.

The project was funded by Danish Center for Marine Research.

Köster, F., Project Coordinator, National Institute of Aquatic Resources
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Tomkiewicz, J., Project Manager, National Institute of Aquatic Resources
Lundgren, B., Project Participant, National Institute of Aquatic Resources, Arctic Section
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Neumann, V., PhD Student, National Institute of Aquatic Resources

16/09/2015 → 30/09/2015

Keywords: Research areas: Marine Populations and Ecosystem Dynamics & Fish Biology & Marine Populations and Ecosystem Dynamics & Fisheries Management & Ecosystem based Marine Management

Collaborators: Danish Fishermen's Association, Danish Pelagic Producers Organisation, Marine Ingredients Denmark

Project: Research

Underwater time of flight image acquisition system (UTOFIA) (39240)

This project offers a compact and cost-effective underwater imaging system for turbid environments and will fill the current gap between short-range, high-resolution conventional video and long-range low-resolution sonar systems. The camera system utilizes high frequency laser pulses synchronized with rapid shutter operations on nano second time scales to radically reduce the interference of back scatter on visual images. Using this range-gated imaging technology, the system will extend the imaging range by factor 2 to 3 over conventional video systems. At the same time, the system will provide video-rate 3D information. UTOFIA offers a new modus operandi for the main targeted domains of application: marine life monitoring, harbour and ocean litter detection, fisheries stock assessment and aquaculture, seabed mapping, offshore industry and civil security.

The project is a collaborative effort between engineering companies producing the laser components, the camera systems, the software control and processing systems as well as the deployment platforms. The project also involves companies charged with integrating the system and its commercialization into the market place. The role of DTU Aqua is...
twofold; it is responsible for a series of field and laboratory trials to demonstrate the proof-of-concept and to feed back into the engineering design process, and it is responsible for the exploitation and dissemination dimension of the project, particularly with respect to marine science, fisheries and aquaculture applications.

The consortium is coordinated by SINTEF, Norway. The project is funded by EU, Horizon2020.

Visser, A., Contact Person, National Institute of Aquatic Resources, Section for Oceans and Arctic
Mariani, P., Project Participant, National Institute of Aquatic Resources
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Stage, B., Project Participant, National Institute of Aquatic Resources
Brida, J., Project Participant, National Institute of Aquatic Resources
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Behrens, J., Project Participant, National Institute of Aquatic Resources

01/02/2015 → 30/04/2018

Keywords: Research areas: Oceanography & Fish Biology & Observation Technology
Collaborators: Odos Imaging Ltd., SINTEF, Subsea Tech, AZTI-Tecnalia, Fraunhofer-Gesellschaft, Bright Solutions Srl
Project: Research

**Development of seal-safe fishing gear (Seal-Safe II) (39188)**

Increasing numbers of seals in Danish waters have in recent years made it difficult to conduct a economically sustainable coastal fishery with gillnets and hooks/lines. The objective of Seal-Safe is to improve the viability of these fisheries by developing efficient, environmentally friendly and seal-safe pots for catching cod. The pots will make it possible for the coastal fishermen to conduct a sustainable fishery without damages inflicted by seals.

The specific goal of Seal-Safe is to increase the catch rate to at least 4 kg cod per pot per day. Seal-Safe will attain this through a combination of fishing trials on board commercial fishing vessels and research into the behaviour of fish and seals around the pots.

This 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).

Larsen, F., Project Coordinator, National Institute of Aquatic Resources, Section for Ecosystem based Marine Management
Kindt-Larsen, L., Project Manager, National Institute of Aquatic Resources
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01/06/2014 → 31/07/2016

Keywords: Research areas: Ecosystem based Marine Management & Fish Biology
Collaborators: Swedish University of Agricultural Sciences, Aarhus University, Neksø Vodbinderi ApS
Project: Research

**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 gonadotropic 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
Stærrup, 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
Biodiversity changes - causes, consequences and management implications (BIO-C3) (39117)

BIO-C3 will investigate the dynamics of biodiversity in the Baltic Sea, their causes and the consequences for the function of food webs, including implications for biodiversity management policies.

Baltic biodiversity is historically dynamic responding to various drivers operating at different time and space scales. Species diversity is generally low and contains many recent immigrants and glacial relict species because of low salinity and relatively young age. Nevertheless, Baltic food webs sustain many goods and services valued by society.

We focus on functional consequences of ongoing and projected distributional and compositional changes of benthic and pelagic communities with a focus on invasive and resident key species. Using spatial and temporal projections of abiotic/biotic drivers including their interaction (climate change, eutrophication, species invasions, fisheries), we will assess how biodiversity (e.g., of species, traits, habitats) responds in time, space and along gradients of human impact and hydrography. We will investigate the potential and genetic basis for colonisation, acclimation and adaptation of species and populations to the Baltic Sea, and how compositional and adaptive changes of Baltic biodiversity affect ecosystem functions with an emphasis on trophic linkage and food web dynamics.

Results will feed into impact assessments that guide management policies including improved operationalization of status indicators, and guidelines for MPAs.

The project is coordinated by Helmholtz Centre for Ocean Research, Kiel (GEOMAR). DTU Aqua is co-coordinator. The project is funded equally by EU, BONUS (Science for a Better Future of the Baltic Sea Region), ERA-NET.

Neuenfeldt, S., Project Coordinator, National Institute of Aquatic Resources

Integrating spatial processes into ecosystem models for sustainable utilization of fish resources (INSPIRE) (39118)

The BONUS INSPIRE Project conducts pilot ecosystem field surveys that help resolving the habitat requirements of different life-stages of the focal species by combined use of traditional methods and application of modern advanced analysis and modelling techniques.

The research is conducted in a matrix approach with four species specific case (cod, herring, sprat and flounder) and five research work-packages. The work packages deal with (i) habitat requirements and survival probability for different life stages, (ii) connectivity between habitat occupied in successive life stages, (iii) spatial scaling from local events to regional population dynamics, (iv) spatially explicit analytical stock assessments (including a comprehensive flatfish programme), and (v) ecosystem-based management and Marine Strategy Framework Directive indicators.

The overarching questions of the BONUS INSPIRE Project are:
- What habitat (both pelagic and benthic) conditions characterize the spatial distributions of cod, herring, sprat and flounder?
- To what extent do fishing and species interaction affect the local and basin-scale distribution of exploited stocks?
- What drives spatial connectivity and migrations of different fish species/populations?
- How does stock structure and separation of natural populations impact stock assessment outcomes?

This project is coordinated by University of Tartu, Estonia.

The project is funded by EU, BONUS (Science for a Better Future of the Baltic Sea Region), ERA-NET.

Neuenfeldt, S., Project Coordinator, National Institute of Aquatic Resources, Section for Marine Ecology and Oceanography

Köster, F., Project Coordinator, National Institute of Aquatic Resources
The early life of eel in the Sargasso Sea – Influence of oceanography and climate (SARGASSO-EEL) (39107)
The recruitment of the European eel has been in dramatic decline during the last 30 years, and is at a severe low of only 3-5 % of earlier magnitude. This change and its influence on the eel fishery have led to an intensified research in the oceanic phase of the European eel.
In order to contribute to further understanding of the life cycle of eel the Danish eel expedition set out in 2014 for the eel spawning grounds in the Sargasso Sea. Here a consortium of Danish scientists and international collaborators focused on the linkages between oceanography, biological production, eel spawning and the growth and drift of eel larvae.
During the expedition, a wide range of organisms was collected: From the smallest plankton of less than a millimeter to very large fish. A number of research groups are now working on samples and data from the expedition and assembling information on key processes in the early life of eels. Preliminary findings indicate that biological and physical changes have taken place in the spawning areas that may affect the eel larvae’s chances of survival and their journey to Europe.
The project was coordinated by DTU Aqua.
The project is funded by the Carlsberg Foundation and Danish Centre of Marine Research (cruise).
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Thomsen, H. A., Project Participant, National Institute of Aquatic Resources
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Malanski, E., Project Participant, National Institute of Aquatic Resources
Jaspers, C., Project Participant, National Institute of Aquatic Resources
Koski, M., Project Participant, National Institute of Aquatic Resources
Christoffersen, M., Project Participant, National Institute of Aquatic Resources
Hansen, S., Project Participant, National Institute of Aquatic Resources

Optimal sustainable use of cod stocks accessible for Danish fisheries (DEL-TORSK) (39147)
Optimal sustainable utilization of cod stocks that contain several biological sub-populations requires taking population structure into account in stock assessment and management. The aim of this project was to develop scientific basis for cod management decisions in the North Sea and the Baltic that takes biological units of cod and their dynamics into account.
Methodological challenges concerning advising on stocks that contain sub-populations with differences in dynamics and biological parameters are common for North Sea and the Baltic. Therefore, the project considered both seas, in terms of developing methodological basis for addressing population structure in management advice. The results were presented at ICES benchmarks for North Sea and Baltic Sea cod in 2015, and used to developing further the management basis for optimal use of cod stocks.
The project included mapping of distribution of sub-populations using genetic analyses and modelling of transport of early life stages. These results were combined with existing knowledge on cod population structure both in the Baltic and North Sea, to identify distribution areas of sub populations. This information was then incorporated in area-specific stock assessment analyses.
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).
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Berg, C. W., Project Participant, National Institute of Aquatic Resources
Huwer, B., Project Participant, National Institute of Aquatic Resources
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Eg Nielsen, E., Project Participant, National Institute of Aquatic Resources

17/07/2013 → 30/04/2015
international networking. This resulted in a series of publications enhanced through collaboration as well as enriched learning by students through collaboration with others. Exchange of students and collaboration between schools has been facilitated by six short-term missions (STSM) of MSC and PhD students performing work at the labs of international partners. A.E. Butts in action management meetings and three AQUAGAMETE conferences. Participation of two students in training short-term training mission (STSM) programs. The action has funded participation of delegates Jonna Tomkiewicz and Ian C. M. A.  Action management and scientific activities comprise meetings, congresses, and workshops, training schools, and development projects. The aim of the AQUAGAMETE COST Action is to reach a consensus on protocols and guidelines (using internationally standardized methodologies) and improve transfer from academia to industry (AQUAGAMETE) (39130) on gamete quality assessment, incubation of eggs) in teleost fish and other commercially important invertebrates used in aquaculture. These new methods can cause highly variable results, even using the same species. Application of these new methods used by most scientists and laboratories, which can cause highly variable results, even using the same species. Assessment of anthropogenic and climatic impacts on aquatic species and application in aquaculture, as well as biotechnology and aquaculture practice. All of these can have far-reaching consequences on conservation of endangered species, assessment of anthropogenic and climatic impacts on aquatic species and application in aquaculture, as well as fisheries management. In particular, it has been recognized that there are many highly diverting details in the practical application of these new methods used by most scientists and laboratories, which can cause highly variable results, even using the same species.

Assessing and improving the quality of aquatic animal gametes to enhance aquatic resources – The need to harmonize and standardize evolving methodologies and improve transfer from academia to industry (AQUAGAMETE) (39130)

The aim of the AQUAGAMETE COST Action is to reach a consensus on protocols and guidelines (using internationally defined terminology, units of measurement, and format of reporting) that permit the use of results in relational databases for sound and common application in aquaculture research and commerce. There is an urgent need towards a universal scale to assess both the precise state of sexual maturation (for secure broodstock use) and related life history traits (gamete quality assessment, incubation of eggs) in teleost fish and other commercially important invertebrates used in either bioassays or aquaculture. During the past six years, three international workshops on fish gametes demonstrated a rapid development of methodologies that encompass extensive opportunities for promising use in basic reproductive biology, genetic research, biotechnology and aquaculture practice. All of these can have far-reaching consequences on conservation of endangered species, assessment of anthropogenic and climatic impacts on aquatic species and application in aquaculture, as well as in fisheries management. In particular, it has been recognized that there are many highly diverting details in the practical application of these new methods used by most scientists and laboratories, which can cause highly variable if not contradicting results, even using the same species.

COST action management and scientific activities comprise meetings, congresses, and workshops, training schools and short-term training mission (STSM) programs. The action has funded participation of delegates Jonna Tomkiewicz and Ian A.E. Butts in action management meetings and three AQUAGAMETE conferences, participation of two students in training schools, six short-term missions (STSM) of MSC and PhD students performing work at the labs of international collaborators as well as their participation in AQUAGAMETE conferences. Exchange of students and collaboration has resulted in a series of publications enhanced through collaboration as well as enriched learning by students through international networking.
Forage fish interactions (FACTS) (38781)

Removal of a forage fish has consequences for both predators and prey of forage fish. As everything is connected, every management action has a price which goes beyond the apparent, direct effect on the target species. The fishery on forage fish can therefore not be seen in isolation, as the immediate gain in profit from the fishery has to be discounted by the lowered potential for production of large piscivorous fish. Management actions on other species also influences forage fish, i.e. conservation efforts on marine mammals or sea birds have direct consequences for the predation pressure on forage fish.

The objective of the project was to provide insight and quantitative advice on the ecosystem wide consequences of management actions directly or indirectly related to forage fish.

The two overarching questions were:
- What are the consequences of forage fish fisheries on (a) predator growth and abundance, (b) economic output of fisheries on piscivorous species, and (c) ecosystem stability and the risk for regime shifts?
- What are the consequences of changes in predator populations on forage fish populations and fisheries?

The method was a combination of ecosystem models, process studies aimed at feeding into the models, of economic models, and of data-analysis of existing data sources.

The project covered four ecosystems in detail: Norwegian-Barents Sea, Baltic Sea, North Sea and Bay of Biscay.

FACTS brought together leading European fisheries and university institutes working on creating the tools for ecosystem based management. The active involvement of the institutes in the current management has provided a means for the results of the project to feed into management. The project furthermore included a network component which has ensured a wider dissemination of methods and results within the marine scientific community.

The project was coordinated by DTU Aqua.

The project was funded by EU, Framework Programme 7.

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01/01/2010 → 31/12/2012

Keywords: Research areas: Marine Populations and Ecosystem Dynamics & Fish Biology & Ecosystem based Marine Management
Collaborators: Christian Albrechts University of Kiel, Centre National de la Recherche Scientifique, Wageningen IMARES, Marine and Food Technological Centre, University of Copenhagen, Spanish Institute of Oceanography, Cefas Weymouth Laboratory, L'Institut Français de Recherche pour l'Exploitation de la Mer, University of St Andrews, Leibniz Institute for Baltic Sea Research, University of Southern Denmark, Institute of Marine Research, Finnish Game and Fisheries Research Institute, University of Hamburg
Project: Research

Monitoring and modelling vertical movements of Greenland halibut in Disko Bay (38795)

The project measured and parameterized Greenland halibut behaviour in terms of vertical movement patterns by means of data storage tags. The tags were released (and recaptured) prior to the project period under another project, so that data was available at start of the project.

Previous measurements using Data Storage tags on halibut tagged in Disko Bay have shown that the halibut undertake distinct vertical migrations of several hundred meters at a time during a few hours.

The findings in the project from analyses of the previous tagging’s gave important biological information on the seasonal migration patterns for Greenland halibut in the West Greenland Fjords; icefjords are mainly preferred as wintering habitat for the fish while the outer parts of the fjord systems are summer habitats. Further, the study showed that halibut are fast vertical swimmers most likely when chasing pelagic prey fishes.

The project was coordinated by DTU Aqua.

The project was funded by the Commission for Scientific Investigations in Greenland (KVUG).

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Neuenfeldt, S., Project Participant, National Institute of Aquatic Resources
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01/01/2010 → 31/12/2013

Keywords: Research areas: Marine Populations and Ecosystem Dynamics & Fish Biology
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 consortium brought together leading experts in eel reproduction complemented by expertise in disciplines filling gaps in knowledge and technology. The consortium included 15 partners, comprising European research institutes and industry partners as well as an international collaboration partner country (ICPC). Within DTU, the project involved DTU Food, Research Group for Bioactives – Analysis and Application, and several DTU Aqua research areas including Fish Biology, Aquaculture, Marine Populations and Ecosystem Dynamics, and Coastal Ecology.

The project was coordinated by DTU Aqua.

The project was funded by EU, Framework Programme 7.

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

Cardio-respiratory adaptations in cod feeding under hypoxic conditions (CarlsbergTorsk) (38851)
Employment of DataStorage Tags on individual Atlantic cod (Gadus morhua) in the Bornholm Basin has shown that some fish migrate towards the deeper basin centre, presumably to feed. During these voluntary dives, fish expose themselves to oxygen saturations as low as 10% and many individuals spend a third of their total time at oxygen saturation.

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Krüger-Johnsen, M., Project Manager, National Institute of Aquatic Resources
Stettrup, J. G., Project Participant, National Institute of Aquatic Resources
Serensen, S. R., Project Participant, National Institute of Aquatic Resources
Skov, P. V., Project Participant, National Institute of Aquatic Resources
Steenfeldt, S. J., Project Participant, National Institute of Aquatic Resources
Hornum, I., Project Participant, National Institute of Aquatic Resources

01/01/2010 → 31/07/2012
Keywords: Research areas: Marine Populations and Ecosystem Dynamics & Fish Biology & Marine Living Resources

Collaborators: University of Gothenburg

Project: Research

Fehmarn Belt science provision project: Fehmarn Belt fish and fisheries and related environmental investigations (38869)
Objectives and Background
The purpose of the project was to investigate, mainly exploited fish stock and fisheries dynamics in relation to the marine environment with focus on the Fehmarn Belt area in the Western Baltic Sea, and to provide science and research based investigations and results, as well as reports and scientific peer reviewed journal papers on this. The work was associated to the scientific baseline investigations (2009-13) and impact assessment of the projection of the Fehmarn Belt Fixed Link between Denmark and Germany involving a science cooperation between DTU Aqua, Thünen-Institute and Femern Belt A/S in order to generate knowledge on potential impacts of establishment of the fixed link. Focus was on the
were further tested, and farmed and wild eel broodstocks and different treatments were compared. In particular,
extend the longevity of larvae from 12 to 20 days after hatch in first feeding experiments. Methods to induce maturation
Results: The REEL project has accomplished through three series of experiments to consolidate previous results and
Two major projects: Artificial Reproduction of Eels II and III (ROE II and III) succeeded during 2005-2008 to produce viable
Project aim: Enhance methods and technology applied to produce and culture European eel larvae as basis for the
development of a future self-sustained eel aquaculture.
Background: The severe decline of the European eel stock calls for conservation measures including national eel
management plans and establishment of a self-sustained eel aquaculture. In 2005, DTU Aqua, University of Copenhagen
and the eel aquaculture industry started to build up a research and technology platform for the development of methods to
reproduce European eel in aquaculture.
Tasks and Deliverables
The work covered WP0: Prospecting, planning and development of the investigations, producing outline and main
con-tents of the science provision contract and coordination of tasks hereunder with DTU Aqua as inter-national project
coordinator; WP1: Review of know-led-ge: Review, provision of data, and analyses of selected historical data on fish
stock and fisheries dynamics; WP2: Exten-sion of existing, standard research surveys and linking to standard-survey time
series to detect potential effects on important fish stocks; WP3: Evaluation of potential integrated effects on important fish
stocks and fishe-ries; WP4: Evaluation of potential effects of change and variability in hydrograp-hi-cal features and
conditions on recruitment for important fish stocks (cod, herring, sprat); WP5: Evaluation of breeding occurrences and
migra-tions as well as separation of spring and autumn-spawning herring stock components in the area.
WP1 included provision of state of the art knowledge from historical surveys and review of quality of survey indices,
commercial fisheries data, and information on recruitment dynamics with emphasis on fluctuations in distribution and
productivity with respect to environmental and anthropogenic drivers of change including species interactions and
fisheries.
WP 2 included extension of existing standard surveys in the near field area and analyses of both the standard and
extended time series with respect to variability in distribution, density and abundance patterns of relevant stocks, as well
developing advanced scientific survey evaluation models and methods for doing this.
WP 3 analyzed stock and fisheries dynamics by use and development of complex multi-fleet-multi-stock bio-economic
management evaluation models performing analyses on a very high spatial and temporal resolution scale using integrated
fisheries, stock and survey data. The models evaluated different management options and scenarios relevant for the
establishment of the fixed link.
WP 4 evaluated variability in recruitment and important spawning areas according to hydrographic features and in relation
to impact of the fixed link among other by use and further development of complex hydro-dynamic models.
WP Sevaluated herring stock occurrence and migration patterns in the Baltic area by use of genetic identity markers,
otolith micro-structures and information from fisheries and research surveys in order to evaluate impact of the fixed link.
The project has besides a long row of project reports produced around 30 scientific peer reviewed journal papers where
DTU Aqua are first author on more than half and co-author on more than 20 of the papers.
The project was coordinated by DTU Aqua.
The project was funded by the 3 partners with external Funding from Femern Bælt A/S.
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Keywords: Research areas: Fisheries Management & Fish Biology & Marine Living Resources & Population Genetics
Collaborators: Femern A/S, Thunen-Institut
Project: Research
Reproduction of European eel in aquaculture: Consolidation and new production methods (REEL) (38398)
most important commercial fisheries and fish stocks in the area (cod, herring, and sprat, but also flatfish and eels).
fertilization procedures to produce fertilized eggs and embryos and monitoring techniques were enhanced. The technology needed to culture embryos and larvae was substantially improved. The potential for new hormonal treatments was explored and recombinant eel hormones have been produced. New broodstock diets were developed with focus on the lipid composition essential for development and survival of fish larvae. In addition, the experimental facility established by DTU Aqua at Lyksvad Fishfarm was enhanced by improving the experimental and laboratory facilities. The REEL project has provided the basis for the establishment of an EU research project: Reproduction of European Eel: Towards a Self-sustained Aquaculture (PRO-EEL) (38793) coordinated by DTU Aqua. REEL included the partners DTU Aqua, the Danish Eel Producers Association, Billund Aquaculture, BioMar, Bioneer and Copenhagen University of which four are integrated in PRO-EEL.

The project was coordinated by DTU Aqua.

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01/01/2009 → 31/12/2010

Collaborators: BioMar A/S, University of Copenhagen, Bioneer A/S, Billund Aquaculture Service Aps, Danish Eel Farmers Association

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

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.
Influence of ecological dynamics and climate change on the marine environment in Danish waters (ECODYN) (38136)
The environment in the open Danish waters is controlled by a complex interplay between physical and biological processes, and it is therefore difficult to determine the exact cause of changes in the environment. This is also the situation for hypoxia, which is caused both by nutrients from sources ashore, by ecological dynamics of the waters, and by the flow in Kattegat and the Belts. This project examined the marine environment through three-dimensional numerical models which describe both physical and biological processes. In parallel, laboratory experiments clarified how temperature affects the biological rates at or near the sea floor. This was used to model the response of the ecosystem to the temperature increases which are expected as a result of climate change, and the future consequences for the marine environment were analyzed.

Through model simulations and oxygen measurements from ships and buoys, the biological processes leading to hypoxia were determined with the so far highest resolution in time and space; this contributed significantly to the understanding of the functioning of the ecosystem in this area.

The connection between the state of the marine environment and the abundance of fish was analyzed, focusing on the distribution and spawning regions of cod, in relation to the oxygen conditions in the inner Danish waters and in the Baltic Sea. Thereby, the project provided a description of interconnections between the ecosystem, the water flow, and the effects of a changing climate.

The project was coordinated by Department of Bioscience, Aarhus University, Denmark.
The project was funded by the Danish Council for Strategic Research.

Artificial reproduction of eels: Phase III (ROE III) (38187)
The steady decline of the European eel stock has adverse consequences for the Danish eel aquaculture as all eel farming is at present capture based relying on wild caught glass eels. In 2005, DTU Aqua, University of Copenhagen and the eel aquaculture industry started to build up a research and technology platform for the development of methods to reproduce European eel in aquaculture.

The focus of ROE III was to follow up the pioneering work on artificial reproduction of European eels performed in the preceding pilot projects ROE I and II. The projects ROE II and III were a collaboration among DTU Aqua, University of Copenhagen and the eel aquaculture industry following up an initial survey ROE I of suited methodology lead by University of Copenhagen.

ROE III comprised the following activities:

(i) Experimental series with different treatment schemes and hormone dosage to improve the maturation process and optimize gamete quality;

(ii) Development of methods to monitor the maturation process on individual level using ultrasound scanning technology and ovary biopsy;

(iii) Analysis of broodstock fishes and improvement of the dietary fatty acid composition;

(iv) Investigation of parameters determining egg quality during incubation;

(v) First-feeding trials with eel larvae testing both artificial and live feed.

Three experimental series were completed focusing on methods for broodstock enhancement, maturation and fertilization
plus culture of eggs and larvae. Already during the first experimental series, larvae accomplishing the entire yolk sac stage were achieved for the first in history for European eel. The yolksac larvae developed successfully during the period were they entirely depend on nutrition sources i.e yolk and lipid of maternal origin. The larvae were ready to start feeding day 12 post hatch. During the second experimental series, larval longevity was extended to 18 days during first feeding experiments. These recent results are a major breakthrough because they show for the first time that artificial hormone treatment can lead to viable offspring in European eel. Eggs and yolksac larvae were obtained from different hormonal treatments and mass hatchings were regularly obtained. Larval feeding using live and artificial larval feeds developed in collaboration with the food company BioMar were developed towards the end of the experiments and are ready for testing in new and coming projects.

The success of this project on improved methods, quality criteria and larval survival has led to form the basis of the project: Reproduction of European eel in aquaculture: Consolidation and new production methods and later (REEL) (38398) and later the EU FP project: Reproduction of European eel in Aquaculture: Towards a self-sustained aquaculture (PRO-EEL) (38793).

The project was coordinated by DTU Aqua. 
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Keywords: Research areas: Marine Populations and Ecosystem Dynamics & Fish Biology 
Collaborators: University of Copenhagen, Bioneer A/S, Billund Aquaculture Service Aps, Danish Eel Farmers Association 
Project: Research

**Automated fish ageing (AFISA) (38111)**

Most of European fish stocks are assessed using age-based models, the cost of the acquisition of age data from otolith readings raises several million euros annually. Low uncertainty in age estimation is however reached for only 25 % of fish stocks under ICES advising process. The impact of ageing errors on stock assessment is obvious though obscure. In this context, automated ageing systems would provide a mean to standardize ageing among laboratories and to control ageing consistency while reducing the cost of the acquisition of age data. No such system is currently available, although preliminary results provide the basis for such developments.

This two-year project aims at developing fully automated and robust systems for routine ageing. It will comprise four work packages in addition to project management (WP0): the collation of the otolith material and the creation of bases of annotated otolith images (WP1), the development of algorithms for fish ageing automation from otolith features (WP2), the implementation these automated ageing modules in a software platform dedicated to otolith imaging (WP3), the cost-benefit analysis of the proposed automated ageing systems (WP4).

The whole processing chain from the acquisition of otolith data to the actual ageing issue using pattern recognition or statistical inference will be coped with. The demonstration component will include the demonstration of the degree of automation of the proposed systems and a cost-benefit analysis of these automated solutions for three case studies: cod from Faeroes, North Sea and North East Artic, plaice from the Eastern English Channel (VIIId) and Iceland, and anchovy from the Bay of Biscay. The focus will be on demonstrating the consistency of automated age estimation with respect to the major steps of the processing chain and to the joint analysis of ageing precision and acquisition costs with respect to stock assessment objectives.

The project is coordinated by Institut Francais de Recherche pour l'Exploitation de la Mer (IFREMER), France. 
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UNCOVER's objectives were to:

(i) identify changes experienced during stock depletion/collapses,
(ii) to understand prospects for recovery,
(iii) to enhance the scientific understanding of the mechanisms of fish stock/fishery recovery, and
(iv) to formulate recommendations how best to implement LTMPs/recovery plans.

The project recommends that such plans ideally should include:

(i) Consideration of stock-regulating environmental processes,
(ii) Incorporation of fisheries effects on stock structure and reproductive potential,
(iii) Consideration of changes in habitat dynamics due to global change,
(iv) Incorporation of biological and technological multispecies interactions,
(v) Integration of economically optimized harvesting,
(vi) Exploration of the socio-economic implications and political constraints from existing and alternative recovery plans,
(vii) Investigations on the acceptance of plans by stakeholders and specifically incentives for compliance by the fishery,
(viii) Agreements with and among stakeholders.

UNCOVER has provided imperative policy support underpinning the following fundamental areas:

(i) Evolution of the Common Fisheries Policy with respect to several aims of the ‘Green Paper’;
(ii) Contributing to the Marine Strategy Framework Directive with respect to fish stocks/communities;
(iii) achieving Maximum Sustainable Yield (MSY) for depleted fish stocks. This has been done by contributing to LTMPs/recovery plans for fish stocks/fisheries, demonstrating how to shift from scientific advice based on limit reference points towards setting and attaining targets such as MSY, and furthering ecosystem-based management through incorporating multispecies, environmental and habitat, climate variability/change, and human dimensions into these plans.
Keywords: Research areas: Marine Living Resources & Fish Biology

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Project: Research