Monitoring of invasive species in Danish harbours (MONIS4) (39451)
The overarching objective is to carry out proof-of-concept for monitoring of invasive species in 16 Danish harbours. Monitoring methods include multiple types of conventional observation methods as well as eDNA based assessment of presence/absence of a total of 20 prioritized species for which eDNA assays have been developed by the project consortium in the previous project MONIS 3. The project is funded by the Danish AgriFish Agency through subcontracting by NIVA DK.
Bekkevold, D., Project Manager, National Institute of Aquatic Resources, Section for Marine Living Resources
Støtrup, J. G., Project Participant, National Institute of Aquatic Resources
01/03/2017 → 30/06/2018
Keywords: Research areas: Population Genetics & Coastal Ecology
Project: Research

Distribution of mackerel, herring and sprat (MAKSIBRI) (39434)
The overarching objective of the project is to increase knowledge about the spatial distribution of populations of herring, sprat and mackerel in the North Sea, Skagerrak and Kattegat. Application of new genetic marker based analyses has proven especially useful in this context and the project aims to apply newly developed markers in herring and sprat. In mackerel, the distribution of stock components in the North Sea will be examined using existing material and data. For herring, focus is on validating genetic and morphological methods and testing them to assess samples of herring bycatch from the sprat fishery. In sprat focus is on determining population components in the North Sea and Skagerrak using both genetic and modeling other types of biological data. The project is coordinated by DTU Aqua and is funded by the European Maritime and Fisheries Fund (EMFF) and the Danish Fisheries Agency.
Bekkevold, D., Project Coordinator, National Institute of Aquatic Resources, Section for Marine Living Resources
Mosegaard, H., Project Participant, National Institute of Aquatic Resources
Christensen, A., Project Participant, National Institute of Aquatic Resources
Lindegren, M., Project Participant, National Institute of Aquatic Resources
Mena, B. J., Project Participant, National Institute of Aquatic Resources
06/09/2016 → 26/01/2019
Keywords: Research areas: Marine Populations and Ecosystem Dynamics, Population Genetics & Marine Living Resources
Project: Research

Gene flow from stocked salmonids to wild populations (38273)
The aim of the project was to develop and implement genetic marker based methods to assess population characteristics, such as genetically effective population sizes and exchange of dispersers among salmonid populations, focusing on brown trout, Salmo trutta. Strong focus was on an assessment of the genetic effects of stocking wild populations based on releases of juveniles of native wild brood-stock or from domesticated hatchery strains. Analyses of temporal samples, both archived and continuously sampled, have contributed to an understanding of effects of stocking on wild populations on short to long term.
Bekkevold, D., Project Manager, National Institute of Aquatic Resources, Section for Marine Living Resources
01/01/2001 → 31/12/2015
Keywords: Research area: Population Genetics
Project: Research

How Danish fisheries can exploit the CFP discard ban – An elucidation (39075)
European fisheries should ultimately operate without discards. This is clearly expressed by both the European Union and the most important fishery nations outside the Union in Europe. This is in accordance with the overall intention to reduce the ecological impact through changing production and consumption patterns. The most important tool introduced by the Union is the Landing Obligation (LO). The new Common Fisheries Policy (CFP) will move towards a gradual elimination of discards on a case-by-case basis (EC, 2013). This policy is fully implemented in 2019. To be in due time, before the implementation of the LO, a project trying to describe the consequence of this new policy, was done in the years 2012 to 2014. The state of the art of knowledge of discard and the future use of this fraction that will be landed have been evaluated. The final report suggests that the practical implementation of the LO-principle may take place as a scheme where large scale trials on results based management demonstrate the possible needs of prescriptive regulation in addition to full catch accountability. The report thoroughly investigates the issues related to a management that can give the fishermen the incentive and tools to comply with full catch accountability It assesses the amounts of discard and offal in Danish fisheries and it points to solutions regarding handling and marketing of the “discard fraction” in the form of fresh raw material or silage solutions. The report recommended to: - Evaluate the economy of a silage solution on vessels and in relevant harbours. The evaluation should be made as a commercial venture projects including storage, handling, distribution, marketing and economic performance. - Analyse the values fish under reference sizes if sold for human consumption. - Establish reliable and cheap methods to quantify species composition in silage. 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).
Strengthening the Danish populations of Atlantic salmon – Increasing populations, genetic resources and recreational fishing (39340)

In the beginning of the 1980"ies indigenous Danish salmon populations were close to extinction due to habitat degradation and stocking with non-native strains. Conservation efforts, led to a resurgence of the populations in western Jutland. However, following the initial increases, Danish salmon populations have stagnated in recent years. Whether this is a response to limiting local factors or a correlated response across population (e.g. to climate change), is unknown. A profitable recreational fishery has developed on the Danish salmon. If the productivity of Danish salmon populations can be improved, this fishery and the related economical gain have the potential to increase correspondingly. Atlantic salmon has a highly complex and specialized life cycle where the weakest link(s) determines the productivity of the salmon population. Accordingly, there is a need for a multifaceted research project. The main objectives of this project will be reached through six work packages aiming to: 1. Identify key local and global bottlenecks production of salmon across four life-stages, 2. Determine genetic characteristics (‘quality’) of local populations and identify how measures of ‘quality’ should be implemented into stocking programmes and 3. Communicate and implement insights on optimal management and exploitation to stakeholders. The overarching aim of the project is to provide research based knowledge that can be directly implemented into a self-sustainable management framework that maximizes salmon population sizes, and hereby vastly increases local income from a recreational fishery with a high economic potential. This project is coordinated by Danish Center for Wild Salmon. The project is funded by Innovation Fund Denmark.

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

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 quantitative 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 coordinated by DTU Aqua and is funded by the European Maritime and Fisheries Fund (EMFF) and the Danish Fisheries Agency.
**Genetic adaptions underlying population structure in herring, Clupea harengus (GENSINC) (39355)**
The objective is to document genetic differentiation and local adaptations in Atlantic herring populations spanning the majority of the species’ distribution in the Northeast Atlantic, thereby strengthening the scientific basis for management of herring stocks. This will be done by using new genomic analyses and by taking advantage of unique multi-generational experimental populations under controlled environmental conditions. Whole genome resequencing of 19 populations of herring from East Atlantic (including the North Sea, Skagerrak, Kattegat, and the Baltic Sea) revealed low genetic differentiation at the great majority of examined genes. This supports earlier genetic studies suggesting that genetic drift at selectively neutral loci is extremely low in these populations. However, highly significant differentiation at a limited number of loci (Bekkevold, D., Project Participant, National Institute of Aquatic Resources, Section for Marine Living Resources 01/01/2016 → 31/12/2019
Keywords: Research area: Population Genetics
Collaborators: University of Bergen, Queen's University Belfast, Uppsala University, Institute of Marine Research
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.
Worsøe Clausen, L., Project Coordinator, National Institute of Aquatic Resources, Section for Marine Living Resources
Rindorff, A., Project Participant, National Institute of Aquatic Resources
van Deurs, M., Project Participant, National Institute of Aquatic Resources
Berg, C. W., Project Participant, National Institute of Aquatic Resources
Mosegaard, H., Project Participant, National Institute of Aquatic Resources
Bekkevold, D., Project Participant, National Institute of Aquatic Resources
Mortensen, L. O., Project Participant, National Institute of Aquatic Resources
Christensen, A., Project Participant, National Institute of Aquatic Resources
11/11/2015 → 17/08/2018
Keywords: Research areas: Marine Living Resources & Population Genetics & 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

**Danish Fisher-Researcher Network (39315)**
The project aims to bring the active Danish fishing sector and operational fisheries research closer together through “fisher- researcher” networking activities. The project will contribute to the collection and exchange of information and knowledge on fisheries and research herein across sectors and generations. This knowledge exchange will take place at several levels of education (secondary schools, university studies and training of working fishermen). The project will support innovation and development of sustainable fisheries through collation of ideas as well as preparation and planning of project cooperation for the solution of current and future challenges about fisheries, fish stocks and management. Bringing the primary fishing industries in direct contact with research and management in a network will support local skills in fishing ports to serve the development and succession in the coastal communities. Workshops and demonstrations of novel development are intended to direct technology transfer, innovative collaborative proliferation of businesses and recruitment of newly qualified academic staff. In addition, Danish fishing industry participation at the international level will be strengthened through increased technical scientific support from DTU Aqua before and under meetings in e.g. Thematic and Regional Advisory Councils. The project is coordinated by DTU Aqua and is funded by the European Maritime and Fisheries Fund (EMFF) and the Danish Fisheries Agency.
Mosegaard, H., Project Coordinator, National Institute of Aquatic Resources, Section for Marine Living Resources
Pedersen, E. M., Project Manager, National Institute of Aquatic Resources
06/11/2015 → 06/11/2017
Keywords: Research areas: Marine Living Resources & Observation Technology & Population Genetics
Collaborators: Danish Fishermen's Association, Danish Pelagic Producer Organization
Project: Research

**CodStory (39308)**
The main objective of this project is to examine spatiotemporal genetic and trophic change of North Atlantic cod populations over the last millennium, a period of significant temperature fluctuations. This project addresses several important issues in current conservation and resource management, for example, population size fluctuations, migrations and distribution shifts of Atlantic cod in relation to climate change. The project will provide long term data (approximately 1100 years) on the genetic population structure, adaptive genetic change and trophic ecology of a single species, the Atlantic cod, expanding the application of cod as a model species in historical eco-genetics. Specific research questions include: - How have climate fluctuations affected migration, gene flow, distributional shifts and interactions of Atlantic cod populations in the North Atlantic? - How have climate fluctuations affected the trophic niche of Atlantic cod through ecological regime shifts and change in Atlantic cod feeding migrations? - How have climate fluctuation affected the trophic niche and trophic position of seabirds and do directional changes in seabird isotope values, together with isotope values from Atlantic cod, indicate specific ecosystem effects? - How has climate change affected the adaptive evolution of Atlantic cod at centennial scales as revealed by spatiotemporal SNP analysis with broad genomic coverage? This project is coordinated by the University of Iceland, the project is funded by the Icelandic Research Council.

Eg Nielsen, E., Project Manager, National Institute of Aquatic Resources, Section for Marine Living Resources
Hansen, J. H., Project Participant
01/03/2015 → 28/01/2018

Keywords: Research area: Population Genetics
Collaborators: City University of New York, University of Iceland, National Museum of the Faroe Islands, University of Saskatchewan
Project: Research

**Expertise in marine and aquatic ecology and genomics for sustainable management of fish and shellfish in Skagerrak-Kattegat-Øresund (MarGen) (39301)**
The marine and freshwater regions encompassing Skagerrak, Kattegat, Øresund and the North Sea are biologically highly productive and contain plentiful living aquatic resources that are important for the region. At the same time the coastal areas are densely populated and industrialized, fish and shellfish resources are heavily harvested, and waters are subject to pollution and eutrophication. The region is also markedly affected by the ongoing global warming, with sea temperature rising nearly 2 degrees C during the last 40 years. These environmental pressures call for investigations into the consequences for aquatic organisms, their potential for adapting to environmental changes, and for identifying management strategies that could mitigate deteriorating environmental conditions, using state-of-the-art methodology. Here, we will capitalize on the revolutionizing developments in genomics, electronic tagging and computer modelling to obtain insights on the ecology, evolution and management of aquatic biodiversity in the region. The ØKS region harbours leading scientific environments within the aquatic, marine and genomic sciences that are complementary with respect to research and education and that would strongly benefit from better integration and networking. This proposal also aims to establish a research cluster and expand the number of active PhDs, postdocs and senior researchers within the region, thereby fostering an innovative research and educational network in the ØKS region. This project is coordinated by DTU Aqua. The project is funded by EU, InterReg (regional collaboration).

Hansen, J. H., Project Manager, National Institute of Aquatic Resources, Section for Marine Living Resources
Bekkevold, D., Project Participant, National Institute of Aquatic Resources
Aarestrup, K., Project Participant, National Institute of Aquatic Resources
Kristensen, M. L., PhD Student, National Institute of Aquatic Resources
Mensberg, K. D., Project Participant, National Institute of Aquatic Resources
Meldrup, D., Project Participant, National Institute of Aquatic Resources
Mikkelsen, J. S., Project Participant, National Institute of Aquatic Resources
Le Moan, A., PhD Student, National Institute of Aquatic Resources
01/07/2015 → 30/06/2018

Keywords: Research areas: Population Genetics & Freshwater Fisheries and Ecology
Collaborators: Aarhus University, University of Oslo, Institute of Marine Research, University of Gothenburg, University of Agder, Norwegian Institute for Water Research
Project: Research

**Optimising and enhancing the integrated Atlantic Ocean Observing Systems (AtlantOS) (39243)**
The vision of AtlantOS is to improve and innovate Atlantic observing by using the Framework of Ocean Observing to obtain an international, more sustainable, more efficient, more integrated, and fit-for-purpose system. Hence, the AtlantOS initiative will have a long-lasting and sustainable contribution to the societal, economic and scientific benefit arising from this integrated approach. This will be achieved by improving the value for money, extent, completeness, quality and ease of access to Atlantic Ocean data required by industries, product supplying agencies, scientist and citizens. The overarching target of the AtlantOS initiative is to deliver an advanced framework for the development of an integrated Atlantic Ocean Observing System that goes beyond the state-of-the-art, and leaves a legacy of sustainability after the life of the project. The specific task of DTU Aqua is to conduct analysis of environmental DNA (e-DNA) using an
Environmental Sample Processor (ESP). All living organisms secrete DNA to the surrounding environment. Recently it has been shown that such “e-DNA” can be extracted from seawater and used to identify the organisms present within a designated sea area. The “ESP” is a moored automated DNA laboratory, which can be deployed for up to three months for in-situ analysis and at the same time send back real-time analytical results. Hitherto it has been used for identification of marine bacteria, phyto- and zooplankton with very good results. We will modify the ESP to allow its use for e-DNA analysis. The aim is to conduct unprecedented “proof of concept” of e-DNA sensors for monitoring of important species in a number of sea areas and time periods. The project is funded by EU, Horizon 2020. This project is coordinated by DTU Aqua and has 54 additional partners across Europe.

Eg Nielsen, E., Project Coordinator, National Institute of Aquatic Resources, Section for Marine Living Resources
Hansen, B. K., PhD Student, National Institute of Aquatic Resources
22/07/2013 → 01/05/2015

Keywords: Research areas: Marine Living Resources & Population Genetics
Collaborators: Cefas Weymouth Laboratory, Sir Alister Hardy Foundation for Ocean Science
Research Council, Institute of Marine Research, GEOMAR - Helmholtz Centre for Ocean Research Kiel, Marine Institute, International Council for the Exploration of the Sea
Project: Research

Short-term projections for short-lived species managed under MSY: Management of the sandeel stock in the North Sea (39148)
The industrial fishery for small short-lived species represents the economically most important fishery in Denmark, and traditionally the North Sea sandeel (Ammodites marinus) has played a key role in this fishery. Currently, quota advice for sandeel is based on the so-called B-escapement strategy, the purposes of which is to ensure that the spawning stock biomass remains large enough to maintain the survival of the population even after fish-eating fish, birds, and mammals have taken their share; and whatever is left is made available to the fishery. This type of management strategy relies on accurate predictions about the size of the incoming year class (the recruitment), if the criteria of MSY are to be fulfilled.
The aim of the project was therefore to ensure that the short-term prognosis reflects current knowledge about the biology of sandeels in the North Sea and applies all relevant data time-series. A new recruitment index was introduced. Seasonal and spatial patterns in log-book based catch rates of age-1 fish were analysed and compared to recruitment indices from the year before. Spatial differences in local larval retention strength were found. A genetic tool that allowed us to distinguish between different sandeel species in a quick and accurate way was developed. Lastly, development of a state based assessment model that can handle seasonal data (something which is necessary for sandeel) and estimate shifting selection patterns was initiated. All of this work is currently contributing significantly to the preparation of the coming North Sea sandeel benchmark assessment in ICES to be held in the fall of 2016. This project was coordinated bu DTU Aqua.
The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).
van Deurs, M., Project Coordinator, National Institute of Aquatic Resources, Section for Marine Living Resources
Worsøe Clausen, L., Project Manager, National Institute of Aquatic Resources
Mosegaard, H., Project Participant, National Institute of Aquatic Resources
Azour, F., Project Participant, National Institute of Aquatic Resources
Christensen, A., Project Participant, National Institute of Aquatic Resources
Bekkevold, D., Project Participant, National Institute of Aquatic Resources
22/07/2013 → 01/05/2015

Keywords: Research areas: Marine Living Resources & Population Genetics
Collaborators: Cefas Weymouth Laboratory, Sir Alister Hardy Foundation for Ocean Science
Project: Research

Sustainable management of Kattegat cod; Improved knowledge about stock components and migration (39346)
The Kattegat cod has been categorized as a data limited stock, mainly due to a large unallocated mortality, which may be caused by migration between Kattegat and neighbouring areas. In this project, we aim to improve our understanding of migration patterns and mixing of different stock components within the Kattegat through a novel combination of genetic and micro-chemical signatures for individual fish. Results from the project will feed directly into the ICES advisory process, including a scheduled benchmark meeting in early 2017 where new procedures for stock assessment will be discussed.
As cod are also caught as bycatch in other fisheries, a more robust stock assessment for cod will also be important to fisheries for other species under the landing obligation, which is scheduled for implementation in the Kattegat in 2017.
The project is coordinated by DTU Aqua and is funded by the European Maritime and Fisheries Fund (EMFF) and the Danish Fisheries Agency.
Hansen, J. H., Project Coordinator, National Institute of Aquatic Resources, Section for Marine Living Resources
Hüssy, K., Project Participant, National Institute of Aquatic Resources
Eero, M., Project Participant, National Institute of Aquatic Resources
Thygesen, U. H., Project Participant, National Institute of Aquatic Resources
Storr-Paulsen, M., Project Participant, National Institute of Aquatic Resources
Meldrup, D., Project Participant, National Institute of Aquatic Resources
Levinsky, S., Project Participant, National Institute of Aquatic Resources
01/03/2016 → 28/02/2018

Keywords: Research areas: Population Genetics & Marine Living Resources & Fisheries Management
Collaborators: Danish Fishermens' Association
Dynamic user-driven marine e-maps for the advancement of Danish industrial fisheries (GUPD-VIND) (39246)
This project aims at strengthening Danish industrial fisheries development in order to (i) reduce the search time and fuel consumption per ton of fish caught (revenues: 16 million DKK/year), (ii) make better use of the sprat quota (revenues: 15 million DKK/year, by a full quota uptake), (iii) pave the way for sustainable self-management of resources in the industrial fisheries sector and (iv) contribute to creating and maintaining jobs in the local fishing community. The specific objectives of the project: Development of an IT tool that will contain (i) a platform to improve sharing of knowledge and registration of observable and derived variables (data), and (ii) user-defined and user-controlled digital Marine Maps with those specific data that fishermen consider important as background information in the planning and implementation of fishing trips. These marine data include (but are not limited to) a portfolio of Marine Maps spanning from the North Sea hydrography and bottom conditions over distribution of plankton and fish to water-DNA. The needs for a technological development of this fishery comes from increasing average vessel size, while the number of large vessels is reduced to about 1/8 of what it was in the past. The immediate consequence is a reduction in the collective search performance and knowledge sharing. In addition, the area based management of the sandeel fishery introduced in 2011 has contributed to a reduction of fishermen's opportunities to diversify fishing and explore a wider variety of fishing grounds. Finally, the sprat fishery is uncertain because of by-catch limits and a very variable CPUE driven by wind and weather. This has led to an underutilization of the sprat quota by around 100,000 tons per year. Fisherman knowledge of good fishing opportunities is based on the correspondence between historical catches and observable variables at the time of capture, such as the seasons, wind, waves and tides, and it is precisely this kind of knowledge that the project wants to combine with a technological solution, so that all relevant data is made widely available to the fishermen by developing user-controlled dynamic digital Marine Maps. The project includes a business plan for the IT company Anchor Lab, which develops the user-controlled Marine Maps, and plans for derived effects in terms of better utilization of the sprat quota and fuel savings through the use of the Marine Maps. Besides the economic effects, the project contributes to CO2 reduction, and supports the technological development of a modern industrial fishery sector, based on a natural resource to be managed by the EU in accordance with ICES' advice. This project is coordinated by DTU Aqua. The project is funded by the Ministry of Environment and Food of Denmark through the Green Development and Demonstration Program (GUDP).
Mosegaard, H., Project Coordinator, National Institute of Aquatic Resources, Section for Marine Living Resources
Pedersen, E. M., Project Manager, National Institute of Aquatic Resources
Christensen, A., Project Participant, National Institute of Aquatic Resources
Stage, B., Project Participant, National Institute of Aquatic Resources
Eg Nielsen, E., Project Participant, National Institute of Aquatic Resources
Worsøe Clausen, L., Project Participant, National Institute of Aquatic Resources
van Deurs, M., Project Participant, National Institute of Aquatic Resources
Andersen, N. G., Project Participant, National Institute of Aquatic Resources
01/01/2015 → 30/06/2018
Keywords: Research areas: Marine Living Resources & Marine Populations and Ecosystem Dynamics & Population Genetics & Observation Technology
Collaborators: Danish Meteorological Institute, Anchor-Lab
Project: Research

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).
Eero, M., Project Coordinator, National Institute of Aquatic Resources, Section for Ecosystem based Marine Management
Hansen, J. H., Project Participant, National Institute of Aquatic Resources
Mariani, P., Project Participant, National Institute of Aquatic Resources
Berg, C. W., Project Participant, National Institute of Aquatic Resources
Hüssy, K., Project Participant, National Institute of Aquatic Resources
Huwer, B., Project Participant, National Institute of Aquatic Resources
Nielsens, A., Project Participant, National Institute of Aquatic Resources
Eg Nielsen, E., Project Participant, National Institute of Aquatic Resources
17/07/2013 → 30/04/2015
Keywords: Research areas: Ecosystem based Marine Management & Marine Populations and Ecosystem Dynamics & Population Genetics & Fish Biology & Marine Living Resources & Fisheries Management
Project: Research
DiscardLess will help provide the knowledge, tools and technologies as well as the involvement of the stakeholders to achieve the gradual elimination of discarding. These will be integrated into Discard Mitigation Strategies (DMS) proposing cost-effective solutions at all stages of the seafood supply chain. This project is coordinated by DTU Aqua. The project is funded by EU, Horizon2020.

Ulrich, C., Project Coordinator, National Institute of Aquatic Resources, Section for Ecosystem based Marine Management
Rindorf, A., Project Participant, National Institute of Aquatic Resources
Larsen, E., Project Participant, National Institute of Aquatic Resources
Feekings, J. P., Project Participant, National Institute of Aquatic Resources
Eg Nielsen, E., Project Participant, National Institute of Aquatic Resources
Mortensen, L. O., Project Participant, National Institute of Aquatic Resources
Bekkevold, D., Project Participant, National Institute of Aquatic Resources
O'Neill, B., Project Participant, National Institute of Aquatic Resources

The genetic changes associated with domestication in aquaculture pose an increasing threat to the integrity of native fish gene pools. Consequently, there is a burgeoning need for the development of molecular tools to assess and monitor the genetic impact of escaped or released farmed fish. In addition, exploration of basic links between genetic differences among farmed and wild fish and differences in important life-history traits with fitness consequences are crucial prerequisites for designing biologically informed management strategies. The project “AquaTrace” will establish an overview of current knowledge on aquaculture breeding, genomic resources and previous research projects for the marine species seabass, seabream and turbot. The project will apply cutting-edge genomic methods for the development of high-powered, cost-efficient, forensically validated and transferable DNA based tools for identifying and tracing the impact of farmed fish in the wild. Controlled experiments with wild and farmed fish and their hybrids will be conducted with salmon and brown trout as model organisms using advanced “common garden” facilities. These experiments will elucidate the fundamental consequences of introgression by pinpointing and assessing the effects on fitness of specific genomic regions. Generated insights will form the basis of a risk assessment and management recommendations including suggestions for mitigation and associated costs. This information and the developed molecular tools will be available as open-access support to project participants and external stakeholders including the aquaculture industry. The project is expected to facilitate technology transfer to the aquaculture sector by promoting better tailored breeding practices and traceability throughout production chain. Overall this initiative will support the development of sustainable European aquaculture and provide “Good Environmental Status” in line with the Marine Strategy Framework Directive. This project involved 21 partners and was coordinated by DTU Aqua. The project is funded by EU, Framework Programme 7.
**Restoration and management of cod in the Skagerrak/Kattegat (CodS) (38969)**

The project had two main aims: - To develop plans for ecosystem based and sustainable management of coastal stocks of cod in Skagerrak/Kattegat. - To develop necessary scientific knowledge needed for a first pilot restoration of a locally extinct stock of cod. The work in the project was highly multi-disciplinary and included aspects of law, policies and institutional rules, socio economy, genetics, ecology, physiology and behavioural ecology. The work was divided into 10 work packages and one work package responsible for coordination. The different WPs addressed the following tasks: - WP1: Genetic mapping of potential donor stocks of cod. - WP2: Genetic characterization of extinct cod stocks in fjord areas of Skagerrak. - WP3: Ecological inventory of fjords with and without cod, to establish the effect of local cod stocks on fjord ecosystems. - WP4: Risk assessment in particular focusing on the risk of contamination of released cod larvae or juveniles that migrate into nearby stocks. - WP5: Legal and institutional aspects of restoring fjord stocks of fish. - WP6: Societal costs and values of cod restoration. - WP7: Establishing production of cod juveniles, for tests of feeding and migration behaviours in relation to individual genotype. - WP8: Developing a step-by-step plan for starting a pilot restoration, including applications for necessary permissions. - WP9: Development of suggestions of management plans for existing or restored fjord stocks of cod. - WP10: Synthesis and final report to stakeholders. (Scientific reports will be submitted for publication in scientific journals, in addition). - WP11: Coordination, internal and external communication including project meetings. The main results of the project were: - Cod was present in very small stocks in fjords in eastern Skagerrak, as found from trawling of fish eggs during spawning period. The eggs found were identified as cod from genetic markers. Thus restoration should wait and instead all possible protection should be applied so that these tiny small groups of local spawning cod can increase in numbers over the years to come. - Several of the fjords in Skagerrak/Kattegat have cod that genetically is a mix of North Sea cod and Kattegat cod. Some fjords along the Norwegian coast have genetically unique elements in the cod stocks. - The Kattegat spawning stock should be a very important source for eastern Skagerrak cod populations, according to our oceanographic models. The project was coordinated by Department of Biological and Environmental Science, University of Gothenburg. This project was funded by EU, InterReg (regional collaboration).

Hansen, J. H., Project Participant, National Institute of Aquatic Resources, Section for Marine Living Resources
Eg Nielsen, E., Project Participant, National Institute of Aquatic Resources
Boje, J., Project Participant, National Institute of Aquatic Resources
Meldrup, D., Project Participant, National Institute of Aquatic Resources
Mensberg, K. D., Project Participant, National Institute of Aquatic Resources
01/07/2012 → 31/12/2014

**Keywords:** Research areas; Population Genetics & Marine Living Resources & Fisheries Management

**Collaborators:** Lund University, Institute of Marine Research, University of Gothenburg

**Project:** Research

**MSC certification of the plaice fishery in area IIIa – basic investigations and development of a management model (39025)**

A management plan is an important requirement for MSC certification of specific fisheries. However, prior to this project, reliable stock assessments, which are necessary for amanagement plan for plaice (Pleuronectes platessa) in area IIIa (Kattegat/Skagerrak), had not been available. These problems most likely originated from insufficient knowledge about the geographical distribution of populations as well as the interactions between populations in Kattegat/Skagerrak and neighbouring areas. Through a mapping of the distribution and dynamics of populations, this project aimed at providing the missing data that would ultimately allow for the development of an amanagement plan for the plaice fishery in area IIIa. The work included information from genetics, tagging, otolith based growth estimation, oceanographic modelling and analyses of survey and fisheries data. Results from the project showed evidence of both local population components in the Kattegat/Skagerrak as well as substantial mixing between North Sea population and these local components, and consequences of lumping or splitting the populations for stock assessment and management were discussed. The outcomes of the work directly influenced the policy decisions since 2015. Decision was finally made to proceed with the lumping option, thus allowing a quantitative analytical assessment and management advice for the area. However, because of the differences in size between the two populations, there is a risk of depletion of the local Skagerrak population if the fisheries on it increase as a consequence of the increase in the North Sea stock. In terms of management, some mechanisms already exist for reducing the fishing pressure in the Skagerrak if deemed necessary, as plaice in the North Sea and in the Skagerrak are managed by two different Total Allowable Catches (TACs). It has therefore been seen that routine monitoring of the survey and fisheries patterns would allow detecting any departures from the current situation, i.e. decoupling of trends in the different areas and the different seasons that could indicate a reduced productivity of the local stock. In the longer term, the current progresses on the biological knowledge of the stock in Skagerrak should be sustained. Additional genetic allocation of individual fish to the different populations should be performed to obtain a better quantification of the mixing in different areas and seasons, and the survey coverage should be improved in the Skagerrak.

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).

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Ecological speciation in salmonids: the genomic background for the evolution of eco-morphs (38957)
Speciation is a fundamental evolutionary process continuously creating the diversity of life. Salmonid fishes have fascinated scientists for centuries due to their iconic and diverse set of habitats and eco-morphs. In addition, the salmonid lineage underwent two whole-genome duplication events that provided an enormous DNA template to support adaptive radiation and speciation. These assets make salmonids excellent model species for studying fundamental issues relating to adaptation and speciation in the wild. This project took advantage of a unique set of replicated samples representing different migratory eco-morphs in two species of salmonids, state-of-the-art genomic techniques and novel statistical methods to - infer the genomic extent of adaptive divergence between different migratory eco-morphs in salmonid species. - identify footprints of selection at genomic regions of importance for adapting to local environmental conditions. Knowledge about the mechanisms and conditions required for species to evolve by adapting to new surroundings is of paramount importance for predicting future responses to climatically (or anthropogenically) induced environmental change. The project was coordinated by DTU Aqua. The project was funded by the Danish Council for Independent Research. Limborg, M., Project Coordinator, National Institute of Aquatic Resources, Section for Marine Aquatic Resources 01/10/2012 → 31/12/2014 Keywords: Research area: Population Genetics Collaborators: University of Washington Project: Research

Development of genetic tools to distinguish Greenland’s cod stocks (38956)
The goal of this project is to develop genetic tools that can improve the management of Atlantic cod (Gadus morhua) in Greenland by enabling identification of separate population components. Building on results from a previous study that demonstrated pronounced population structure among cod inhabiting Greenlanidic waters, we will 1) develop cost-effective DNA tests to reveal the population of origin for unknown individuals, 2) apply these tests in concrete case studies relevant for stock assessment and management advise, and 3) develop a user manual for implementing these tests in the management of cod in Greenland. Therkildsen, N. O., Project Manager, National Institute of Aquatic Resources, Section for Marine Living Resources Eg Nielsen, E., Project Participant, National Institute of Aquatic Resources, Section for Marine Living Resources 01/09/2012 → 30/11/2012 Keywords: Research area: Population Genetics Collaborators: Greenland Institute of Natural Resources Project: Research

Eastern-western Baltic cod: Improved management based on stock discrimination of eastern and western Baltic cod (Øst-Vesttorsk) (38989)
The aim of this project was to improve the management of western Baltic cod by incorporating stock identification routines in order to discriminate between eastern and western Baltic cod stocks. In recent years evidence from fishery patterns and otolith structures have indicated an increasing degree of mixing between the two cod stocks which until 2013 were managed as two separate stocks. Changes in fishing pressure and patterns would therefore result in a risk for local depletion of the smaller western stock. Stock identification methods were based on established approaches using genetic discrimination and otolith shape analysis, and improved by linking these methods. This method provides a tool to estimate the degree of stock mixing using the existing otolith archives. This approach documented an increase of eastern Baltic cod from 30% to 49%; 80% in the eastern part of the western Baltic Sea management area. As a consequence of this stock mixing, a new procedure incorporating stock mixing on an annual basis was set in place, with the aim to improve stock exploitation and reduce the risk of local depletion. The knowledge gained also influenced recent management regulations, particularly a prolongation of spawning closer of the fishery in 2016. The project was coordinated by Centre for Environment, Fisheries & Aquaculture Science, UK. The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF). Hüsey, K., Project Coordinator, National Institute of Aquatic Resources, Section for Marine Ecology and Oceanography Hansen, J. H., Project Participant, National Institute of Aquatic Resources Huwer, B., Project Participant, National Institute of Aquatic Resources Bastardie, F., Project Participant, National Institute of Aquatic Resources Eero, M., Project Participant, National Institute of Aquatic Resources Nielsen, J. R., Project Participant, National Institute of Aquatic Resources Worsøe Clausen, L., Project Participant, National Institute of Aquatic Resources Mosegaard, H., Project Participant, National Institute of Aquatic Resources
Economic yield under selected climatic scenarios were analyzed in unison to ensure the delivery of mutually consistent future stock dynamics limits to sustainable ecosystem exploitation and the fishing levels delivering maximum sustainable resource indicators that combine economic, social and biological indicators and relate directly to the benefit for the society. Susceptible species was estimated along with the effect of discard of by-catch on economic yield. The project developed in multispecies models to provide reliable predictions. The maximum level of fishing effort consistent with sustainment of environment. The improved understanding of recruitment variability was used in individual stock assessment and included determined and survival during early life stages was investigated in order to identify the role of the physical and biological predation induced by differences in the distribution and the amount of alternative food. Effects of technical interactions in area ranging from the Barents Sea to the North Sea. The project used multispecies models to investigate changes in relationships, population dynamics of non-target fish species and economic modelling of fisheries from a wide geographic area ranging from the Barents Sea to the North Sea.

Keywords: Research areas: Marine Populations and Ecosystem Dynamics & Marine Living Resources & Population Genetics & Fisheries Management

Collaborators: Cefas Weymouth Laboratory
Project: Research

Genetic and genomic approaches to the study of Atlantic eels: Speciation, genetic population structure and footprints of selection (38875)

Anguillid eels, including European (Anguilla anguilla) and American eel (A. rostrata) have fascinated scientists for centuries. At the same time, their geographical distribution and life cycle make them highly suitable study objects to address fundamental issues in evolutionary biology related to speciation and adaptation. In this project, wemade use of unique samples of eel larvae collected in the Sargasso Sea during the Galathea 3 expedition. Novel genomic resources generated by 454 massively parallel sequencing and novel statistical methods were used for - testing if the two species represent sympatric speciation. - analysing the demographic history of the species, comparing present declines to historical population declines. - testing whether or not European eel is panmictic, despite widespread geographical distribution of adult eels in continental Europe and North Africa. - testing whether the distribution of both species across subarctic to subtropical environments reflects extreme phenotypic plasticity or if footprints of temperature-related selection is evident at the genomic level. Scientific papers reporting results generated from this project include: - Pujolar, José Martin; Jacobsen, M.W.; Als, Thomas Damm; Frydenberg, Jane; Magnussen, E.; Jönsson, B.; Jiang, X.; Cheng, L.; Bekkevold, Dorte; Maes, G.E.; Bernatchez, L.; Hansen, Michael Møller. 2014. Assessing patterns of hybridization between North Atlantic eels using diagnostic single-nucleotide polymorphisms. Heredity, Vol. 112, 627-637. - Jacobsen, M.W.; Pujolar, J.M.; Gilbert, M.T.P.; Moreno-Mayar, J.V.; Bernatchez, L.; Als, Thomas Damm; Lobon-Cervia, J.; Hansen, Michael Møller. 2014. Speciation and demographic history of Atlantic eels (Anguilla anguilla and A. rostrata) revealed by mitogenome sequencing. Heredity, Vol. 113, 432-442. - Als, Thomas Damm; Hansen, Michael Møller; Maes, Gregory E.; Castonguay, Martin; Riemann, Lasse; Aarestrup, Kim; Munk, Peter; Sparholt, Henrik; Hanel, Reinhold; Bernatchez, Louis. 2011. All roads lead to home: panmixia of European eel in the Sargasso Sea. Molecular Ecology, Vol. 20, 1333-1346. - Bernatchez, Louis; Saint-Cyr, Jérôme; Maes, Gregory E.; Kalujinaia, S.; Cramb, Gordon; Castonguay, Martin; Als, Thomas Damm; Hansen, Michael Møller. 2011. Differential timing of gene expression regulation between leptocephali of North Atlantic eels in the Sargasso Sea. Ecology and Evolution, Vol. 1, 459-467. The project was coordinated by Department of Biological Sciences, Aarhus University. The project was funded by the Danish Council for Independent Research.

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01/01/2010 → 31/12/2012

Keywords: Research area: Population Genetics

Collaborators: Aarhus University

Project: Research

Developing fisheries management indicators and targets (DEFINEIT) (38763)

DEFINEIT constructed operational models of fish stock dynamics explicitly taking into account exploitation and climatic conditions and combine these models with basic economic models. To ensure an outstanding scientific level in each of these areas, the project brought together key competencies in operational multispecies modelling, stock recruitment relationships, population dynamics of non-target fish species and economic modelling of fisheries from a wide geographic area ranging from the Barents Sea to the North Sea. The project used multispecies models to investigate changes in predation induced by differences in the distribution and the amount of alternative food. Effects of technical interactions in the fishing process were considered to avoid delivering management advice for different stocks which is mutually inconsistent. Integrating the knowledge gained, the project suggested methods for estimating reference points. The project identified the main causes of variation in recruitment patterns between stocks as well as the key processes from spawning to recruitment of selected stocks. The consequences of using proxies to describe stock reproductive potential were determined and survival during early life stages was investigated in order to identify the role of the physical and biological environment. The improved understanding of recruitment variability was used in individual stock assessment and included in multispecies models to provide reliable predictions. The maximum level of fishing effort consistent with sustainment of susceptible species was estimated along with the effect of discard of by-catch on economic yield. The project developed resource indicators that combine economic, social and biological indicators and relate directly to the benefit for the society. Future stock dynamics limits to sustainable ecosystem exploitation and the fishing levels delivering maximum sustainable economic yield under selected climatic scenarios were analyzed in unison to ensure the delivery of mutually consistent
management advice. General properties of the ecosystems were used to suggest rules of thumb for management in areas where the amount of data available is insufficient to construct similar models. The project was coordinated by DTU Aqua. The project was funded by EU, MariFish, ERA-NET.

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01/01/2009 → 30/06/2012

Keywords: Ecosystem based Marine Management & Marine Living Resources & Marine Populations and Ecosystem Dynamics & Population Genetics

Collaborators: Imperial College London, Marine Research Institute Reykjavik, University of Southern Denmark, Wageningen IMARES, Institute of Marine Research, Hellenic Centre for Marine Research, University of Copenhagen, Cefas Weymouth Laboratory, University of St Andrews

Project: Research

Fehmarn Belt science provision project: Fehmarn Belt fish and fisheries and related environmental investigations (38669)

Objectives and Background The purpose of the project was to investigate the main 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 Bælt A/S in order to generate knowledge on potential impacts of establishment of the fixed link. Focus was on the most important commercial fisheries and fish stocks in the area (cod, herring, and sprat, but also flatfish and eels).

Tasks and Deliverables The work covered WP0: Prospecting, planning and development of the investigations, producing outline and main contents of the science provision contract and coordination of tasks hereunder with DTU Aqua as inter-national project coordinator; WP1: Review of know-ledge: Review, provision of data, analyses of selected historical data on fish stock and fisheries dynamics; WP2: Extension of existing, standard research surveys and linking to standards survey time series to detect potential effects on important fish stocks; WP3: Evaluation of potential integrated effects on important fish stocks and fish-eries; WP4: Evaluation of potential effects of change and variability in hydrographi-cal features and conditions on recruitment for important fish stocks (cod, herring, sprat); WP5: Evaluation of occurrence effects and migration 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 others by use and further development of complex hydrodynamic models. WP 5 evaluated 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 3 partners with external Funding from Femern Bælt A/S.

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Bridging the gap between science, stakeholders and policy makers (GAP 1 & GAP 2) (38133 & 38860)

Stakeholders and scientists involved in GAP1 initiated cooperative research by making plans to combine knowledge in participatory research through a series of European and regional workshops. GAP1 represented phase 1 of a three-phase program that aimed to explore the complementary nature of alternative knowledge and investigate how to combine it in ways that will enhance understanding and management of natural resources. Tied to knowledge, GAP1 was an evidence-based approach that used participation as the vehicle to improve understanding on fisheries research and management issues of common concern to stakeholders, scientists and policy makers. Through initiation of cooperative research and facilitating the building of the capacity of stakeholders to engage in participatory research, GAP1 contributed towards the wider aspiration of the Science in Society program. In particular, enhancing the democratic debate within more engaged and informed public, thus providing better conditions for collective choices on scientific issues relating to sustainable management, conservation of ecosystem integrity and biodiversity of the marine environment. GAP2 was about making a difference to an issue of significance to the whole of society; the well-being of the marine environment and the sustainability of fisheries upon which society depends for food. It continued the relationships, processes and plans made in GAP1 by enabling Mobilization and Mutual Learning (MML) actions that promoted stakeholder participation in the debate and development of research knowledge and structures relevant to emerging policy on fisheries and the marine environment. The aim was to promote and enable processes for open and effective participation of stakeholders in research and management, demonstrate through specific examples and critical evaluation the role and value of stakeholder-driven science in the governance of fisheries and the marine environment. DTU Aqua was the case study leader of one of the selected cases of GAP2. Find full list of participants at the website of GAP2. These projects were coordinated by the Centre for Environment, Fisheries and Aquaculture Science, UK. The projects were funded by EU, Framework Programme 7.

Conservation of diversity in an exploited species: Spatio-temporal variation in the genetics of herring (Clupea harengus) in the North Sea and adjacent areas (HERGEN) (5512)

The project aims to determine the degree to which the different spawning populations of Atlantic herring in the North Sea, Skagerrak, Kattegat, Western Baltic and West of Scotland can be distinguished genetically. Microsatellite markers will be the main molecular tool employed though allozyme and mtDNA analyses, which will be conducted on subsets of samples for comparison with previous results. Genes of the Major Histocompatibility Complex which are known to be under selection will be used to examine selective genetic differentiation among populations. Otolith microstructure will be used to assist in the delineation of spawning components. Using Mixed Stock Analysis (MSA) we will quantify the proportions (and confidence intervals) of fish from the various regional spawning components, that contribute to mixed aggregations found on common feeding grounds in areas targeted by major fisheries in the North Sea and the Skagerrak-Kattegat. We will examine seasonal and annual variations in stock contributions to mixed fisheries by comparing contribution estimates from repeat samples in both regions. The most appropriate management units and data collection requirements to monitor selected populations will be recommended, taking into account genetic diversity and practical management issues. The data collection requirements to support management needs will be determined, and the most appropriate methods recommended based on a cost benefit analysis. Furthermore, the potential of mixed stock analysis in the management and conservation of herring will be examined. The project was coordinated by Department of Animal Sciences, Wageningen University, The Netherlands.

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01/01/2002 → 31/12/2005
Keywords: Research area: Population Genetics
Collaborators: Stockholm University, Wageningen IMARES, University of Hull, Institute of Marine Research, University of Gothenburg, Marine Laboratory
Project: Research
Genetic mapping of Danish trout populations (38828)
The objective of this project is to map the genetic structure of Danish trout populations and to develop genetic tools for use in management of Danish trout populations. This tool will be used for identifying indigenous populations of trout, and to identify causes for maintenance of genetic differentiation between populations. In the longer term we aim to map the geographical distribution of genetic diversity of most Danish trout populations. The genetic database will also be used to establish a molecular testing system allowing the determination of the river origin of individual sea trout, thereby describing migration patterns. This is done by developing genetic stock identification methods specifically targeting sea trout in Danish waters. A genetic map with more detail (both geographically and genomic) compared to previous genetic studies will become an important tool for conservation and restoration of natural trout. It will be applied for identifying trout populations that are locally adapted or differs genetically from other populations and therefore are particularly important for maintaining genetic diversity. This tool will be used to define management units and assessment of evolutionary potential. A genetic map provides an overview of indigenous populations and conservation units, and will thus have important implications in counselling practical restoration efforts. The identification of local adaptations of specific populations, and knowledge of whether individual stocks are adapted to life in their particular environment can be applied in identifying causes for maintenance of genetic differentiation between populations, e.g. whether certain populations are genetically adapted to spawn under certain environmental conditions or at certain times. Individuals from approx. 50 rivers are selected in a manner that ensures a good coverage of Danish trout populations. These are genotyped for 6000 candidate SNPs (Single Nucleotide Polymorphisms) on an Illumina iSelect bead array. The SNP chip is developed in another DTU Aqua project (Living North Sea Project). Results from the 6000 SNPs will be used to identify a subset of SNPs that are particularly well suited to distinguish between Danish trout populations. These SNPs will be used as a genetic tool in the future and it is therefore extremely important to get proper coverage of Danish trout populations in the mapping of the genetic diversity. The projects was coordinated by DTU Aqua. The project is funded by the Danish Rod and Net Fishing License Funds.

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Aarestrup, K., Project Participant, National Institute of Aquatic Resources

01/01/2011 → …

Keywords: Research areas: Population Genetics & Freshwater Fisheries and Ecology
Project: Research

Evaluation of the National Salmon Management Plan (38257)
A National Management Plan (MP) for the (endangered) remaining Danish populations of Atlantic salmon was issued in 2004. The plan includes stocking, fishing regulations and massive habitat/connectivity improvements, but no monitoring plan to evaluate the effect and assess the current status of the populations/runs in the 4 rivers covered by the MP. This project will seek to close the information gap and provide basic information on the salmon runs to enable proper management decisions. Every year monitoring will be carried out in one or two of the 4 rivers covered by the MP, so each river will be surveyed every 2 or 3 years. Number of spawners Intensive electrofishing from boat is carried out just after the season closure (October) in the main river and in some tributaries, where all salmon are measured (TL, sex) and PIT tagged. In November during the regular electrofishing for broodstock, the proportion of tagged individuals gives a measure of the sampling efficiency and provides basis for an estimation of population size. The composition in terms of size, sex and origin (stocked fish are fin-clipped) can also be estimated. Spawning areas In each of the 4 rivers the most important/preferred spawning areas were identified using radiotelemetry. Both present and potential spawning and rearing habitat will be assessed by standard monitoring and electro-fishing for juveniles in order to judge the present production in relation to the potential production. Naturally spawned fry will be genetically analyzed to assess the number of families present on each spawning area (redd). The presence of several families indicate a well-functioning and well-visited spawning area, whereas few or single families indicate lack of spawners. Annual reports from the project are used for adaptive management measures like quota setting, season and stocking. The project is coordinated by DTU Aqua. This is funded by the Danish Rod and Net Fishing Licence Funds.

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01/01/2008 → …

Keywords: Research areas: Freshwater Fisheries and Ecology & Population Genetics
Collaborators: Danish Center for Wild Salmon
Project: Research

The Atlantic cod (Gadus morhua) in Greenlandic waters – past and future under climate change (38873)
This project aimed at understanding and predicting the population dynamics of Atlantic cod (Gadus morhua) in Greenlandic waters in response to climate change. This was achieved through biological, chemical and genetic analysis of unique cod otolith collections, generating historical time series on growth, food composition and genetic population structure. Relationships between environmental changes and the historical distribution, size and growth of individual cod populations was elucidated and used to predict their dynamics under different climate scenarios. The project generated fundamental insights, but also contributed significantly to proactive management of cod in Greenland. The
The project we estimate the catch of whitefish and the by-catch of other fish species in the whitefish gill-net fishery, very high. Investigations on the subject of by-catch in gill-nets set for whitefish in the Baltic Sea supports this hypothesis. In endangered salmon (Salmo salar) from the lagoon is prohibited and the discard mortality for sea trout is considered to be a size of 3-4 cm before stocking in late May. The population of sea trout (Salmo trutta) in the main tributary of the lagoon, has been stocked in the lagoon each year. 3.6 million are stocked as newly hatched larvae in April. 0.4 million are raised to of 1.2 m DKK. This constitutes 75-95 % of the total Danish whitefish fishery. Since 1986 ca. 4 million hatchery reared fry that the catch through the 20th century typically has varied between 10 and 60 tons per year (e.g. mean 1980-2000 25.1 largest population of whitefish in Denmark. The official landing statistics (only covering the commercial catches) shows the number of recreational fishers in the area, a substantial amount is caught by this group as well. The lagoon holds the extensive fishery for more than 100 years. The fishery is primarily performed by commercial fishermen, but estimated from Jutland in particular. Thenatural population of whitefish in the Ringkøbing Fjord Lagoon has been the subject of an results will provide a much better basis for the management of whitefish populations in Denmark in general and in Western geographical scales in this and other marine fishes. The project was coordinated by DTU Aqua. The project was funded by the Danish Rod and Net Fishing License Funds.

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01/01/2010 → 31/12/2013

Keywords: Research area: Population Genetics
Collaborators: Aarhus University, Greenland Institute of Natural Resources
Project: Research

Population genetics of flounder in Danish waters (38819)
Knowledge about population structure and local adaptation is central for successful management of both freshwater and marine fisheries. For instance, recently accumulated knowledge about the geographical scale and extent of local adaptation in anadromous fishes has resulted in the abandonment of fish transplants and releases of foreign fish into natural populations, because such activities threaten the survival of natural populations. In coastal habitats, local fishermen have expressed interests in moving marine fish between geographically distant areas, but until now a lack of scientific knowledge about the scale and extent of local adaptation has prevented any detailed advice on the scale that such movements may be possible. In one particular case, it was proposed to move European flounder from the western parts of the Limfjord to the Bay of Aarhus in order to support a fishery in the bay where the species had reached very low abundances. Since these two areas are both geographically distant and environmentally different, it is possible that fish are also adapted to local environmental conditions. However, although earlier work has strongly suggested that populations of European flounder may be locally adapted, no study had directly compared samples from these areas. In this project, we aimed to use a combination of genetic markers previously found not to be affected by selection (so-called “neutral markers”) and markers situated in or close to genes which may be important for local adaptation. The application of such a combination of genetic markers may allow the assessment of geographical patterns and scales of both population structure and local adaptation in natural populations. The first stage of the project was the development of new genetic markers through screening candidate genes, identified as differentially expressed in relation to various stressors in laboratory experiments, for the presence of suitable genetic markers. Genetic markers were subsequently analyzed in individuals collected from the target as well as reference populations in 2011 and in additional reference samples available from 2003/2004. Results showed markedly different levels of genetic variation in putatively neutral and candidate gene associated markers throughout the species’ distribution. Furthermore, different frequencies of genetic variants near the stress response candidate gene, Hsc70, were observed between the Limfjord and the Bay of Aarhus, suggesting local adaptation to the two areas. Consequently, it was advised that fish were not moved between these two regions. In addition to providing information about the specific case, these results could also be important for guiding future research on finer geographical scales in this and other marine fishes. The project was coordinated by DTU Aqua. The project was funded by the Greenland Climate Research Centre.

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01/01/2010 → 31/12/2013

Keywords: Research areas: Population Genetics & Coastal Ecology
Collaborators: Northwest Jutland Recreational Fishermen’s Association
Project: Research

The population of whitefish (Coregonus lavaretus) in Ringkøbing Fjord: Effects of fishery, stocking and natural reproduction (38827)
Objectives of the project are to improve our knowledge on the whitefish population in the Ringkøbing Fjord Lagoon and effects associated with the commercial exploitation of the population, i.e. to what extent the traditional gill-net (46 mm monofilnets) fishery for whitefish affect both the whitefish population and other species of fish in the lagoon. Another goal is to establish how much natural reproduction and stocking of hatchery reared fry contributes to the adult population. These results will provide a much better basis for the management of whitefish populations in Denmark in general and in Western Jutland in particular. Thenatural population of whitefish in the Ringkøbing Fjord Lagoon has been the subject of an extensive fishery for more than 100 years. The fishery is primarily performed by commercial fishermen, but estimated from the number of recreational fishers in the area, a substantial amount is caught by this group as well. The lagoon holds the largest population of whitefish in Denmark. The official landing statistics (only covering the commercial catches) shows that the catch through the 20th century typically has varied between 10 and 60 tons per year (e.g. mean 1980-2000 25.1 tons per year). Since 2001 the landings have increased to a mean of 55 tons per year (range 14-94 t), with a mean value of 1.2 m DKK. This constitutes 75-95 % of the total Danish whitefish fishery. Since 1986 ca. 4 million hatchery reared fry has been stocked in the lagoon each year. 3.6 million are stocked as newly hatched larvae in April. 0.4 million are reared to a size of 3-4 cm before stocking in late May. The population of sea trout (Salmo trutta) in the main tributary of the lagoon, the River Skjern, is much smaller than expected, considering the environmental conditions of both the river and the lagoon and the size of the river. One possible reason is by-catch of whitefish in the fishery. The landing of sea trout and the endangered salmon (Salmo salar) from the lagoon is prohibited and the discard mortality for sea trout is considered to be very high. Investigations on the subject of by-catch in gill-nets set for whitefish in the Baltic Sea supports this hypothesis. In the project we estimate the catch of whitefish and the by-catch of other fish species in the whitefish gill-net fishery,
Fish populations and traceability (FishPopTrace) (38283)
The underlying rationale of FishPopTrace was to address challenges arising from the development of traceability tools within a forensic framework for four judiciously chosen target species: cod (Gadus morhua), hake (Merluccius merluccius), herring (Clupea harengus) and sole (Solea solea). Previous information on levels of population structuring in traits such as life histories, morphometrics, genetics and physiology was used to inform sample choice. The new data was restricted to markers at two levels: - Routine screening: selection of markers that exhibit maximal discriminatory power to identify populations, though with discrete and controlled variance enabling validation (single nucleotide polymorphisms (SNPs) and otolith microchemistry and morphometrics). Data from DNA based methods provided a mechanism for traceability throughout the food supply chain (“fish to fork”) and indicated discrete spawning populations, whereas otoliths aimed at providing an independent on-board traceability system of fish provenance. - Testing of novel tools: additional tools were tested on a selection of populations to assess validity and potential for traceability and validation, including fatty acid analysis, proteomics, gene expression analysis and the generation of high-throughput microarray platforms for SNP genotyping. Thus, FishPopTrace provided information relating to geography (“population tag”), as well as regional signatures that indicate biological differentiation in relation to spawning identity. The project was coordinated at the University of Wales Bangor, UK. The project was funded by the EU, Framework Programme 7. The project was funded by the EU, Framework Programme 7.

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01/01/2008 → 31/12/2011

Keywords: Research area: Population Genetics

Project: Research

Monitoring effective population sizes of North Sea houting using genetic markers (38272)
This project was aimed at providing basic information on the genetic structure of lake whitefish and North Sea houting, species where population genetic data are needed in order to improve conservation and management efforts, including principles for stocking. The project focused on North Sea houting within the framework of the EU LIFE project Urgent Actions for the endangered houting (Coregonus oxyrhynchus). It was investigated if there are other remaining indigenous populations than that in the Vidaa River, which is currently assumed to be the last remnant of this species/form. Moreover, effective population size was estimated in order to assess if it was below the threshold where inbreeding and loss of genetic variation is an immediate concern. A paper was published on genetic monitoring of effective population size in North Sea houting, showing that the described methods are useful for monitoring purposes. All analyses were based on microsatellite DNA analysis of contemporary and historical samples. In addition, the results were used in the context of a US-based working group, aimed at defining and developing the emerging field of genetic monitoring, i.e. the use of genetic markers for monitoring populations. The project was coordinated by Nature Agency, Danish Ministry of the Environment, Denmark. The project was funded by EU LIFE.

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01/01/2005 → 31/12/2011

Keywords: Research areas: Population Genetics & Freshwater Fisheries and Ecology

Collaborators: Ministry of Environment and Food of Denmark
Fisheries induced evolution (FinE) (38279)
The project is set up to investigate the prevalence of fisheries-induced evolutionary changes in life-history traits of exploited fish stocks in European and North American waters. The aims are to unravel the underlying mechanisms of change ranging from the phenotypic to the genetic level, to evaluate their consequences on population and fisheries dynamics, and to provide recommendations for evolutionarily enlightened management. This objective necessitates the development and application of novel methodological tools for investigating field data both at phenotypic and genetic levels, together with the setup of relevant experiments on model species and the careful construction of theoretical models suitable for complementing field data analyses and for evaluating managerial options. Earlier investigations have focused on specific aspects such as the analysis of long-term trends in phenotypic data, the investigation of temporal changes in neutral genetic markers, artificial fishing experiments, or the modeling of fisheries-induced evolutionary changes in life-history traits and their demographic consequences for exploited stocks. However, a comprehensive investigation of fisheries-induced evolution at the phenotypic and genetic level and of consequences on fish stocks dynamics are still largely missing, mostly because of the wide range of scientific expertises and approaches required for tackling these challenges. This project aims at combining fields of expertise as diverse as population genetics and quantitative genetics, life-history theory, population dynamics, evolutionary theory, and fisheries science. The project is coordinated by International Institute for Applied Systems Analysis, Austria.

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01/01/2007 → 31/12/2010

Keywords: Research area: Population Genetics
Collaborators: International Institute for Applied Systems Analysis, Spanish National Research Council, University of Wales, Netherlands Institute for Fisheries Research, Federal Research Centre for Fisheries, University of Oslo, Institute of Marine Research, Marine Scotland, UiT The Arctic University of Norway, KU Leuven, Finnish Game and Fisheries Research Institute, IFREMER

Advancing understanding of Atlantic Salmon at sea: Merging genetics and ecology to resolve stock-specific migration and distribution patterns (SALSEA-Merge) (38282)
Over the past two decades, an increasing proportion of North Atlantic salmon are dying at sea during their oceanic feeding migration. The specific reasons for the decline in this important species are as yet unknown, however, climate change is likely to be an important factor. In some rivers in the southern part of the species range, wild salmon now face extinction. This is in spite of unprecedented management measures to halt this decline. Arguably the greatest challenge in salmon conservation is to gain insight into the spatial and ecological use of the marine environment by different regional and river stocks, which are known to show variation in marine growth, condition, and survival. Salmon populations may migrate to different marine zones, whose environmental conditions may vary. To date it has been impossible to sample and identify the origin of sufficient numbers of wild salmon at sea to enable this vital question to be addressed. The aim of SALSEA-Merge was to provide the basis for advancing our understanding of oceanic-scale, ecological and ecosystem processes. Such knowledge is fundamental to the future sustainable management of this key marine species. Through a partnership of nine European nations the program delivered innovation in the areas of: genetic stock identification techniques, new genetic marker development, fine scale estimates of growth on a weekly and monthly basis, the use of novel high seas pelagic trawling technology and individual stock linked estimates of food and feeding patterns. In addition, the use of the three-dimensional Regional Ocean Modeling System, merging hydrography, oceanographic, genetic and ecological data, provided novel stock specific migration and distribution models. This widely supported project provided the basis for a comprehensive investigation into the problems facing salmon at sea. It also acted as an important model for understanding the factors affecting survival of many other important marine species. The project was coordinated by Institute of Marine Research, Norway. The project was funded by EU, Framework Programme 7.

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Keywords: Research areas: Population Genetics & Freshwater Fisheries and Ecology
Collaborators: Norwegian Institute for Nature Research, North Atlantic Salmon Conservation Organisation, National University of Ireland, Swansea University, University of Oviedo, Marine Institute, University of Exeter, Marine Scotland, Genindex, Institute of Freshwater Fisheries, Queen's University Belfast, The Faroese Fisheries Laboratory, Institute of Marine Research, Conservatoire National du Saumon Sauvage, Atlantic Salmon Trust, TOTAL Fondation d'entreprise pour la Biodiversité et la Mer, University of Turku, Finnish Game and Fisheries Research Institute, Loughs Agency

Analysis of historical and contemporary salmon samples in the world's northernmost salmon population (38835)
The project investigates potential genetic changes in the world's northernmost population of Atlantic salmon (Salmo salar) from the Kapisillit river in Greenland. The aims are to elucidate whether geographical isolation in concert with overexploitation and habitat degradation has led to loss of genetic diversity and associated loss of evolutionary adaptive potential. By comparing genetic diversity in DNA extracted from historical scale collections from the 1950's and contemporary samples, migration from other populations, loss of allelic diversity as well as genetically effective population
sizes can be estimated. The research will contribute to setting management priorities for this unique and extremely vulnerable Atlantic salmon population. The project is coordinated by DTU Aqua.

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**Keywords:** Research area: Population Genetics
Collaborators: Greenland Institute of Natural Resources
Project: Research

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**Climate change on marine ecosystems and resource economics (NorMER) (38898)**

Marine ecosystems are under pressure from both anthropogenic climate change and high exploitation rates. A major challenge to managers and scientists is to identify ways that oceans can provide food and other services in a sustainable way under changing climatic and socioeconomic conditions. As physical, biological and socioeconomic factors interact at several levels, cross-disciplinary approaches are needed to meet this challenge. This Nordic project has (1) evaluated climate effects on Nordic marine ecosystems, (2) Build new tools for predicting biological consequences of climate change, (3) quantified impacts on profit, employment, and harvesting of cod. This has been achieved through the work of 16 PhDs, 4 postdocs, 1 climate scientist, and the combined expertise of 45 senior scientists located at 10 institutions in 8 Nordic countries. The project was coordinated by University of Oslo, Norway. The project was funded by Nordforsk, Nordic Council of Ministers.

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**Keywords:** Research areas: Oceanography & Marine Population and Ecosystem Dynamics & Population Genetics
Collaborators: Stockholm University, University of Bergen, University of Oslo, University of Helsinki, Greenland Institute of Natural Resources, Åbo Akademi University, University of Iceland, Swedish Meteorological and Hydrological Institute, University of the Faroe Islands
Project: Research