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 resurge 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.

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01/01/2016 → 31/12/2019

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

Collaborators: Danish Center for Wild Salmon

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).

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Anglers Mobile App: A mutual service platform between research and citizens (39122)

Recreational fishing is an extremely popular pastime in Denmark, with as many as 400,000-500,000 regularly engaging in the activity. In order to secure that fish are available for the anglers and at the same time understand how fish stocks interact with biotic and abiotic factors, knowledge about the fish stocks in Danish lakes, rivers and coastal areas is crucial. However, data gathering on national scale, and at regular intervals is expensive and logistically prohibitive. This lack of data limits scientific understanding as well as sustainable management. Consequently, DTU Aqua has developed a mobile internet devices offers a unique opportunity to use a citizen science approach to bridge the gap between the lack of knowledge, research and impact of recreational fishermen in a mutually beneficial way. In that perspective DTU Aqua are first movers. Moreover, in time, the platform has the potential to instill responsible stewardship among recreational fishermen i.e. to engage and educate as much as 5 % of Denmark’s population on a regular basis. This project is coordinated by DTU Aqua. The project is funded by the Danish Rod and Net Fishing License Funds.

Evaluations of tagging effects (39124)

Much of the science-based management of fish and fisheries are based on results from various electronic tagging methods be it radio-, acoustic-, Data Storage- or PIT tags. This project aims to investigate and document possible effects of commonly used tagging methods and improve these methods to ensure that results from tagging studies are representative and unbiased. Hand in hand with this goes animal welfare issues, where we try to reduce the impact on each fish as well as refine the methods used for capture, handling and tagging, according to the 3R’s. In field-based research post-treatment evaluations are difficult and thus rare, however needed. Within this project we will focus on evaluation of sub-lethal effects of surgical implantation, identify size thresholds for PIT-tagging small fish and testing new suture materials. The project is coordinated by DTU Aqua. The project is funded by Danish Rod and Net Fishing License Funds.

Fish index for streams (39024)

One of the (many) Danish shortcomings in fulfillment of the WFD requirements is the lack of a fish-based assessment method for rivers. DTU Aqua and Danish Centre for Environment and Energy (Aarhus University) was asked by the Danish Nature Agency to make basic analyses to enable the development of a national fish index to be used to produce the WFD required water plans. The challenge was to find a method to evaluate the ecological quality of small streams with only very few fish species. Using the extensive DTU Aqua database, a single-metric system was developed and tested. The results showed that the density of 0+ trout and salmon is a well-suited indicator that reflects water quality, physical modifications and connectivity. The method has now been implemented in the legislation and is used in the national water
Aqua project (Living North Sea Project). Results from the 6000 SNPs will be used to identify a subset of SNPs that are SNPs (Single Nucleotide Polymorphisms) on an Illumina iSelect bead array. The SNP chip is developed in another DTU selected in a manner that ensures a good coverage of Danish trout populations. These are genotyped for 6000 candidate adapted to spawn under certain environmental conditions or at certain times. Individuals from approx. 50 rivers are causes for maintenance of genetic differentiation between populations, e.g. whether certain populations are genetically knowledge of whether individual stocks are adapted to life in their particular environment can be applied in identifying maintenance genetic diversity. This tool will be used to define management units and assessment of evolutionary potential.

Populations that are locally adapted or differs genetically from other populations and therefore are particularly important for will become an important tool for conservation and restoration of natural trout. It will be applied for identifying trout 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 maintenance genetic diversity. This tool will be used to define management units and assessment of evolutionary potential.

Flatfish nursery grounds (38176)
The aim of the project is to determine what constitutes a good nursery area for specific flatfish in coastal soft bottom areas in the inner Danish waters using a combination of empirical and theoretical approaches. Field studies on juvenile flatfish feeding, growth and condition use both wild and released fish. One approach is to explore different statistical methods to determine potential nursery grounds for different flatfish based on physical parameters such as wave exposure, sediment type and abiotic variables such as temperature, salinity and depth. This research coupled with the development of tools to map different coastal habitats will provide the basis for advice on management of coastal fish nursery areas. Implementation of PIT-tag technology in coastal marine waters will be developed in order to build up expertise to sample released individuals in different habitats. The project was coordinated by DTU Aqua. The project is funded by the Danish Rod and Net Fishing License Funds.

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
Handbook for management of lake fish and fisheries (38826 & 39169)

This project has developed a web based handbook in lake fisheries management. The end goal was to provide local anglers and lake managers (who are often not biologists) with knowledge about the biology of focal species as well as a tool box on how to manage these with regards to both environment and fisheries. A central part of the handbook focus on compiling thorough descriptions of species and their ecology, environmental requirements etc. based on existing knowledge from our own research and the literature. Focus is also on a description of different measures that can be used to protect or enhance abundance of specific fish species. The handbook incorporates existing legislation on freshwater fisheries and management as well as a description of angling techniques. In addition we give advice on how anglers specifically and citizens in general can participate in the process, i.e. by practical help or cooperation with the municipalities or other authorities that may be responsible for the lake management. The handbook covers all types of lake fishery preferences (species, sizes, quantity, etc.), with due consideration to authenticity and environmental conditions. All pages include FAQ’s to answer the most common inquiries, as well as email addresses of the authors of the text which facilitates that users of the handbook easily can interact with the researchers. The lake handbook was published on line in 2013 as an integrated part of the existing homepage www.fiskepleje.dk. It is continuously updated when new knowledge is available, always providing latest knowledge on fisheries management to a broad audience of users. Lake ecology and fish population dynamics is complex and often very lake specific. Unfortunately knowledge on the environment and fish populations of specific lakes is often scarce or lacking, making fisheries management difficult. A part of the project has focused on how to use citizen science to increase our knowledge. Hence, we explore the use of anglers log book as a method to get knowledge on fish populations and we initiated a nation-wide anglers log book for pc and cellphones (which in 2013 became an independent project expanding from lakes to cover all freshwater and marine habitats). The project also explores the use of citizens reporting on environmental parameters in lakes. We have by now recruited a corpse of citizens (‘Water Environment Agents’) who measure Secchi depths and presence of the invasive zebra mussel in various lakes on a regular basis. We continue recruitment of citizens for this purpose. Another part of the project has been aimed at establishing a web-based platform, named The Knowledge Base, where citizens and authorities can find knowledge about specific lakes. The cornerstone is a web-library, where close to 1000 reports on lake environment or fish covering the last ca. 75 years can be found in pdf-format. Some reports has never been published before, others has been very hard to find (only paper-versions in The National Library). A large collection (1000+) of historic (1915-1960) photos of Danish lakes and rivers taken by former employees of the department (C. V. Otterstrøm and Knud Larsen) has been digitalized and will be available online in fall 2016. The primary search method is via a GIS-based map. This will be supplemented with a more traditional database search option fall 2016. The project is coordinated by DTU Aqua. The project is funded by the Danish Rod and Net Fishing License Funds.

Keywords: Research area: Freshwater Fisheries and Ecology

Project: Research
The population parameters; growth rate, numbers, sex and age at silvering are used to describe the yield of the stockings.

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in a downstream fish trap. During 1987, 1988 and 1992 the area was stocked with 1.6 million elvers. In 2001 and 2002

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studies however showed, that the eels either suffer high mortality or disperse to downstream sections of the streams

way to examine the salmon's movements in the sea is to investigate the chemical fingerprints of fish's scales (Svendsen et

method. Both types of tags are (still) too big for smolt, so kelts will be the most obvious group of salmon to tag. Another

tags are passive tags that records information about the fish's environment and store them. Upon retrieval the data can be

A PSAT tag is essentially the same type of tag, but also contains a satellite device that can send the recorded information

to the ARGOS satellite system and a release mechanism. At a predetermined time, the tag detaches from the animal and

offloaded to a computer. The tag is labelled providing an address and information about the reward by for return of the tag.

This project is coordinated by DTU Aqua. The project is funded by the Danish Rod and Net Fishing License Funds.

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01/01/2011 → 31/12/2016

Keywords: Research area: Freshwater Fisheries and Ecology

Collaborators: Lund University, Municipality of Viborg

Project: Research

Marine behaviour of Atlantic salmon (38825)
The last years of development of the salmon stocks in western Jutland has been a success. This is achieved through

specific management focus on removing the constraints identified in freshwater and coastal areas, as well as a modified

release practices. One of the major challenges for the continued successful management is knowledge of the salmon's

marine life. This is the project's overall objective, to obtain more knowledge about this part of the salmon's life, so as to
describe the salmon's marine life. So far it has not been possible to make more specific behavioural studies of Danish

salmon marine life for two reasons. First: there were very few salmon, and second: there has simply not been technology
available to get behavioural data from the fish, apart for the very expensive marine expeditions. Especially with the

development of electronic tags, such as data storage tags (DST) and pop-up satellite tags (PSAT) it is now possible. DST
tags are passive tags that records information about the fish's environment and store them. Upon retrieval the data can be

offloaded to a computer. The tag is labelled providing an address and information about the reward by for return of the tag.

A PSAT tag is essentially the same type of tag, but also contains a satellite device that can send the recorded information
to the ARGOS satellite system and a release mechanism. At a predetermined time, the tag detaches from the animal and

rises to the surface sending stored information to the satellites. These new types of tags allow you to record information
about the fish’s environment with an unprecedented accuracy and both types of labels have large application possibilities
(Neuenfeldt et al. 2009, Aarestrup et al 2009). Currently, the limitation is the size of the transmitters and attachment
method. Both types of tags are (still) too big for smolt, so kelts will be the most obvious group of salmon to tag. Another
way to examine the salmon’s movements in the sea is to investigate the chemical fingerprints of fish’s scales (Svendsen et

al. 2009). The method is a consequence of the fact that a number of stable compounds from the fish food items are
incorporated in the fish scales and otoliths. By analysing the fish's scales or otoliths a "chemical fingerprint" depending on

where the fish were and what they have eaten can be obtained. Scale samples will be taken from the tagged salmon and the

"chemical fingerprint" from these Danish salmon will be compared with "chemical fingerprint" of scales from other

population where salmon has been tagged with PSAT tags. The project is coordinated by DTU Aqua.

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01/01/2011 → 31/12/2015

Keywords: Research area: Freshwater Fisheries and Ecology

Collaborators: Norwegian Institute for Nature Research, Aalborg University

Project: Research

Population dynamics of stocked eel in a river system (38261)
The objectives are to evaluate the effect of stocking eel in a river system, and examine how anthropogenic factors such as
weirs, trout farms and ponds in a river system may delay or hinder the downstream migration of silver eel. A few studies have
previously been performed to assess the biological value of stocking elvers in small to medium size streams. The studies
however showed, that the eels either suffer high mortality or disperse to downstream sections of the streams

where monitoring by electro fishing is not possible. Thus, only limited information on the fate of the stocked elvers is
available. This project seeks to alleviate this shortcoming. No, or only very little, natural recruitment occurs to the upper
part of River Gudenà. Therefore, the area is excellent for eel stocking experiments, and all migrating fish can be monitored
in a downstream fish trap. During 1987, 1988 and 1992 the area was stocked with 1.6 million elvers. In 2001 and 2002
coded wire tagged eels of size 3.5 gram and 10 gram were stocked. The size and age composition of the silver eel run at

Vestbirk fish trap suggest that most males from these stockings have by now, left the feeding areas during the spawning
runs, whereas older females are immigrating in these years. All eel passing the trap are being recorded and measured.
The population parameters; growth rate, numbers, sex and age at silvering are used to describe the yield of the stockings.
Silver eels leaving the upper reaches of the River Gudenå have to pass several weirs and lakes when migrating towards the sea. How these obstructions influence the migration is largely unknown, but a delay and possibly a higher mortality may be expected. Migrating silver eels are equipped with telemetric tags (PIT) and the progression rate of downstream migrants will be recorded by automatic listening stations and manual tracking. 

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01/01/2011 → 31/12/2013
Keywords: Research area: Freshwater Fisheries and Ecology
Project: Research

Predation from birds and mammals and the significance for populations of freshwater fish (38829)

It is a well-known fact that predation can be a keyfactor for many fish populations and in some areas predation may even be themost important regulating factor for fish stocks of major recreationalimportance. Several species of predators were earlier persecuted, but are nowprotected and have experienced high population growths recently. This include spouses like: cormorant, grey heron, seals and otter. Thus, the protection of these species has been a conservation success, but has also caused severeconflicts between various user-groups. To handle and mitigate these conflicts, scientific documentation is severely needed. During a long period, DTU Aqua has carried out anumber of projects that directly or as side-results have assessed the magnitudeof predation and its impact on various fish stocks. This has provided someinsight in when, where and by whom the important recreational fish species are being eaten. This project gathered and synthesized this knowledge to provide an overview of the significance of predation. Outputs:- Synthesis and analyses of existing knowledge/results.- Method evaluation for scanning for PIT tags in cormorant/heron colonies.- Investigations of possible causes for the recent drastic decline in grayling (Thymallus thymallus) populations. The project was funded by the Danish Rod and Net Fishing License Funds.

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01/01/2011 → 31/12/2013
Keywords: Research area: Freshwater Fisheries and Ecology
Project: Research

Reporting tagging experiments (38250)
The project 1) manages expenses (rewards) and databases with results from tagging experiments and 2) elaborates results on selected previously not reported issues from former tagging experiments. 1) Handling incoming reports on recaptures of tagged fish comprises payment of rewards and registering of recaptures. Reports from previous experiments are normally received over a longer period of time and it is practical to locate expenses in one continuous project. Dating back to the 1970’s and until recent years numerous tagging experiments have been conducted on salmon and trout at DTU Aqua. The use of tags and tagging has been and remains a key method in fish studies. Results from tagging experiments has previously been stored in separate databases, but one objective of the project is to assemble results in a single database accessible using GIS software in order to facilitate access to conducted experiments, being relevant both for research and advisory activities. 2) The elaboration of results from former tagging experiments, where results may already have been used for their primary purpose, aims at extracting as much as possible the information available in the results. Information from the experiments are extracted ad hoc for various purposes, and elaborated for reporting on selected issues. Presently work is being carried out on a series of tagging experiments on wild and reared sea trout (smolt and adults) in river Kolding Å, as well as on catch pattern of salmon in the Baltic Sea in relation to fishing effort and environmental variables for a selected time series. It is the intention to analyze results on data from several countries around the Baltic Sea in corporation with relevant national institutes.

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01/01/2011 → 01/01/2009
Keywords: Research area: Freshwater Fisheries and Ecology
Project: Research

Salmonid freshwater habitats (38256)
The procurement of knowledge in this project aims at improving the basic available knowledge for advising on restoration and stream maintenance activities. Realizing that the question of stream restoration is huge, focus is on selected issues often in cooperation with external partners whenever relevant. Regular cooperation has been done with other Danish universities (Roskilde University, Aalborg University, Aarhus University), local authorities, Environmental centers and anglers associations. In the coming years it is expected that several issues will be particularly relevant, such as stream restoration (removal/sanitation of barriers and restoration of spawning areas), implementation of EU Water plans, fine sediments and sand transport in streams. Realizing that erosion and transport of fine sediment (sand) is a major problem in many Danish streams, several methods to mitigate this have been tested. One attempt to prevent the embedment of excessive amounts of fine sediment in spawning gravel, has been placing tubes below the gravel in order to allow the
Silver eel biomass and non-fishing mortality (38845)
The EU-plan for restoring the European eel population, requires for each MS to issue a national Management Plan and report status of the eel population to the EU Commission in 2012 (and 2015, 2018). Among other things, the report must include estimates of the total production of silver eels (from freshwater), the magnitude of non-fisheries mortality and the reduction of this due to management measures. This project aimed at providing solid estimates of mortality and biomass. This was be done by trapping silver eels in a number of representative river-systems and extrapolate the results to a national level. The mortality in association with hydropower passage has already been measured (and published), but the mortality of silver eels migrating pass fish farms (with weirs) was measured using radio-telemetry. Sixty migrating silver eels will be radio tagged (surgical implants) and followed on their way downstream in the river Kongeå, where they had to pass 3 fish farms to reach the sea. The results revealed massive loss and delay of silver eels at fish farms. This project was coordinated by DTU Aqua. The project was funded by the Danish Ministry of Food, Agriculture and Fisheries.

Survival and growth of eel in coastal habitats (38830)
Very little is known about settling, habitat utilization and survival of European eel (Anguilla anguilla) in coastal areas (fjords and estuaries). We don’t know what proportion of elvers take residence in the coastal zone. For eels stocked in fjords and estuaries, only little is known about survival and growth. In Denmark it has been suggested that the main production of eel takes place in the coastal areas and not in freshwater. Thus, it is very important to obtain some information about this to enhance our management of this threatened species. The overall objective is to investigate the importance of various marine habitats for settlement, density, survival and growth of eel. In relation to survival, the importance of fishing and cormorant predation will be sought estimated. In the first stage (pilot) new sampling methods are being tested in order to be able to generate data about the juvenile eel in the coastal habitats. This is not trivial as no methods have proved effective in sampling small (Jepsen, N., Project Manager, National Institute of Aquatic Resources, Section for Freshwater Fisheries Ecology Pedersen, M. I., Project Manager, National Institute of Aquatic Resources Aarestrup, K., Project Participant, National Institute of Aquatic Resources Mikkelsen, J. S., Project Participant, National Institute of Aquatic Resources 01/01/2011 → 31/12/2016 Keywords: Research area: Freshwater Fisheries and Ecology 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 otherspecies 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. Th enatural 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. The lagoon holds the largest population of whitefish in Denmark. The official landing statistics (only covering the commercial catches) show 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 in whitefish 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, with special emphasis on salmonids, by a combination of experimental fishery, monitoring selected commercial fishing trips and a questionnaire the fishermen on their effort. A number of different approaches re time and place of fishing and net construction is tested to describe how much by-catch can be minimized. The result of natural spawning in River Skjern is investigated by a combination of catching newly hatched larvae with drift nets and e-DNA analysis of water samples from the river. The latter method is a very novel approach. Through the experimental fishing, supplemental data on the whitefish, salmonids as well as other species (less detailed) are collected to describe population dynamic parameters (size and age distribution, growth, condition etc.), primarily of whitefish and salmonids. The results show, that by-catch of sea-trout in whitefish gill-net fishery is unavoidable, but also that the by-catch can be reduced substantially by employing specific gears and methods. The by-catch of salmon is insignificant while the by-catch of other species, especially flounder is substantial. These results will be reported in autumn 2016. The investigation on natural reproduction in the River Skjern is still ongoing and will be reported in 2017. This project is coordinated by DTU Aqua. The project is funded by the Danish Rod and Net Fishing License Funds.

**Workshop on Baltic Sea Trout Helsinki, Finland, 11-13 October 2011 (38836)**

In order to provide solutions for the possible implementation of management initiatives suggested in ICES recommendations a three day workshop was established. An updated status of sea trout populations in the Baltic Sea was presented directly to invited managers from all countries around the Baltic Sea and to the EU Commission DG MARE/E2. The status in each country was presented by national experts from all countries around the Baltic Sea. For a wider perspective the status of sea trout in Scandinavia, the status for Norwegian trout populations was presented by an invited expert from Norway. Possible solutions to problems for the sea trout already implemented in some countries were presented and discussed between managers and scientists. Furthermore expected effects from additional implementations and the need of these were discussed. A set of statements were formulated. Project report can be downloaded from aqua.dtu.dk This project was coordinated by DTU Aqua. The project was funded by Nordforsk, Nordic Council of Ministers.

**Migration and spawning behaviors of brackish water perch and pike (38413)**

Brackish water populations of pike and perch have decreased severely along the coasts of the Baltic Sea. In Denmark a drastic decline in catches of brackish water pikes has been recorded during the last 30-40 years. Both brackish water pikes and perch are well estimated in angling and commercial fisheries on the brackish coastlines around the southern part of Zealand and the southern islands. Very little is known about their behaviour and life history, for instance the possible dependence of access to freshwaters to spawn. Obstacles in rivers and hereby blocking of migratory routes can therefore be crucial to reproductive success and survival of brackish fish populations along with deterioration of spawning areas in freshwater. In some areas perch is known to migrate into rivers to spawn in freshwater, but perch are also observed to spawn in brackish waters. In the Gulf of Bothnia perch have different spawning and migration strategies and some perch spawn in the bays with salinities of 6 ppt, whereas the upper limit of salinity tolerance during spawning is not known in Danish areas, where salinity is often 8-10 ppt. The present project aims to initiate investigations of the dependence of perch for access to freshwater lakes and bogs for spawning. In particular it will be explored if it is possible to enhance brackish water perch recruitment by creating or reopening of access to lakes and bogs along a river system.
and this way to be able to re-establish or increase the brackish water perch fishery. This is highly relevant to local authorities that manage restoration of rivers and lakes. For this purpose the perch population of a large number of lakes and bogs along river systems with present or historical migration of brackish water perch will be monitored. Some of the lakes have connection to the river, some not, and in the latter a connection will be created afterwards. The fish population and recruitment of perch will be studied before and after the intervention. Scale chemistry will be explored and possibly this will be able to define whether large perch caught in the lakes and bogs during spawning actually had a brackish water life history. The project also aims to elucidate the salinity tolerance of perch under Danish condition to establish whether it is possible that some perch spawn along the coast and bays of southern Denmark. The project is done in close cooperation with municipalities around southern Zealand. The project is coordinated by DTU Aqua.

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01/01/2010 → 31/12/2014

Keywords: Research area: Freshwater Fisheries and Ecology
Collaborators: Municipality of Vordingborg, University of Copenhagen, Municipality of Naestved, Municipality of Guldborgsund, Aalborg University
Project: Research

**Sustainable smolt production – an integrated approach (SMOLTPRO) (38876)**

Salmonid fish is an important natural resource in Scandinavia. Anadromous salmon and brown trout are important natural resources for recreation and fishing and are a part of our cultural heritage. Human activities however, have impaired the natural production of salmonids considerably. Large numbers of hatchery salmonids are therefore released, to compensate losses in natural production caused by hydroelectric power exploitation and other environmental impact. However, conventionally reared hatchery fish have difficulties adapting to natural conditions and therefore perform poorly after release. New research shows that modifications of the conventional hatchery environment can have positive effects on the development of hatchery reared fish, but their long-term effects on performance in nature are poorly known. Previous research in this area has been too scattered and limited by insufficient infrastructure to conduct large scale experiments over the full life cycle. SMOLTPRO integrated the competence and resources in this field of research using a multidisciplinary approach. We evaluated the effects of modified rearing methods on smolt migration and survival, and its socioeconomic value. Experiments were conducted in a series of full-scale model systems to evaluate the generality of effects across the climate zones in the Baltic Sea, Kattegat and the North Sea. Following a dialogue with relevant stakeholders, the results will have been used to produce new guidelines for sustainable smolt production. The project was coordinated by University of Gothenburg, Sweden. The project was funded by the Swedish Research Council FORMAS.

Aarestrup, K., Project Manager, National Institute of Aquatic Resources, Section for Freshwater Fisheries Ecology

01/01/2010 → 31/12/2014

Keywords: Research area: Freshwater Fisheries and Ecology
Collaborators: Norwegian Institute for Nature Research, University of Gothenburg
Project: Research

**Living North Sea: Fish migration from sea to source (LNS) (38872)**

The Living North Sea project aims to promote free fish migration from sea to source to keep our waters alive. It addresses three essential aspects about the management of migratory fish: 1) Migration routes 2) Threats such as man-made barriers and fish migration measures 3) Influencing future policy at a regional, national and international level and informing the general public. The work on migratory routes will focus on sea trout, eel and salmon, but will be applicable to many other species. The partnership will carry out analysis and visualization of migratory routes, populations and consequences of management actions. New communication and mapping tools for working and sharing data between partners will be explored. The second part involves the innovation of fish migration measures. In the North Sea Region some deltas and estuaries are closed to fish and many more have barriers such as dams and sluices throughout their system. This means that many fish species like the eel, salmon and sea trout cannot reach their spawning and breeding grounds. The partnership focuses on the development of better and innovative migration measures, such as passages or sluice management and the implementation of these in demonstration projects. Last but not least, communication and the dissemination of our findings to policy-makers, local decision-makers and the public. The Living North Sea Project will place emphasis on promotion and publicity because the effect of barriers on fish populations is often not considered when dealing with flooding, drainage, or renewable power generation. Yet healthy fisheries are critical to sustainable development and good ecological status. Intensive communication actions intended to influence regional, national and European policies will be carried out. Creating new partnerships, sharing knowledge and achieving greater awareness and involvement are key elements in this project. The project is coordinated by Association of River Trust, UK.

Aarestrup, K., Project Participant, National Institute of Aquatic Resources, Section for Freshwater Fisheries Ecology

01/01/2009 → 28/09/2012

Keywords: Research area: Freshwater Fisheries and Ecology
Collaborators: Association of Rivers Trust
Project: Research
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.

Eg Nielsen, E., Project Manager, National Institute of Aquatic Resources, Section for Marine Living Resources
01/01/2008 → 31/12/2011

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
Project: Research

Behavior of lake-dwelling fish: natural and fishery induced impacts (38270)

The scope of this study is to investigate the movement behavior in brown trout, Salmo trutta. Movements between Lake Hald and its two major tributaries and outlet are monitored by the use of passive telemetry. Juvenile and adult trout, caught in the tributaries, have been tagged with passive integrated transponder (PIT) tags and subsequently their passages at automated listening stations have been registered. The trout population is per definition landlocked, as barriers allow only for out-migration and prohibit the return of anadromous individuals. The movements in this semi-closed system allowed surveillance of general migration patterns and identification of within-population variations in life history strategies (stream resident, lake resident and migratory). A number of trout have been caught, sampled and released and use in retrospective evaluation of physiology. Measured variables from blood and gill samples were used to identify physiological differences that had discriminatory power between the three identified life history strategies. Additionally, the movements of lake resident spawners will also be looked upon in this study. The trout population has been in decline for the last decade. This coincides with the establishment and growth of a cormorant colony on the lake shore. Furthermore, a heron colony close by has likewise grown in this period. Hence, trout which reside in tributaries and lake are subjected to predation from nearby cormorant and gray heron. The accumulation of PIT tags has been monitored with high temporal resolution, revealing the periods of peak predation pressure and the overall annual minimum predation. This, combined with PIT records, will reveal the habitat a trout has been predated in and hereby expose temporal vulnerabilities of lake and tributaries. The project is coordinated by DTU Aqua.

Koed, A., Project Manager, National Institute of Aquatic Resources, Section for Freshwater Fisheries Ecology
Boel, M., Project Participant, National Institute of Aquatic Resources, Section for Freshwater Fisheries Ecology
01/01/2008 → 31/03/2013

Keywords: Research area: Freshwater Fisheries and Ecology
Collaborators: Ministry of Environment and Food of Denmark
Project: Research

Behaviour of lake-dwelling fish: natural and fishery induced impacts (38270)

The project focuses on establishing new and comprehensive knowledge on behavior of lake dwelling fish and the impact of human activities, which can eventually enhance management of freshwater fish populations. The study is based on an acoustic telemetry system, which facilitates fine scale 3D positioning of fish several times a minute with sub meter accuracy. The system has been deployed in a small lake for five consecutive years and has generated data sets on pike, perch and roach behavior with unprecedented details, e.g. activity levels and habitat choice on a diel and seasonal basis coupled to environmental factors such as establishment and break of thermoclines. For instance, studies on pike winter behavior during ice cover have generated new insights and added to the increased consciousness of the importance of year-round knowledge on lake ecology processes. The remote sensed monitoring of the tagged fish without presence of
personnel has allowed for comparison of fish behavior in situations with and without human disturbances, e.g. fishery-related activities. This way a distinct and instantaneous impact of boating on fish behavior has been revealed and the impact of catch and release angling has been addressed. Finally, the system has facilitated studies extending laboratory findings to behavior in the field. For instance, findings of physiological (metabolic rates) and behavioral properties of individual fish in the lab have been linked with behavior of the same individuals in nature by subsequent tagging and release in the lake. Several issues have been studied concurrently the last years and will be continued: A principal focus area has been striving to establish which factors impact and confine natural pike populations. The majority of larger pike in the study lake have been followed for more than three years, which has provided a detailed picture of pike behavior and individual variation. The interactions between pike size groups and whether the behavior of smaller pike is controlled by larger individuals has been studied and has revealed differences in both activity patterns and habitat choice ruled by the largest pike, as well as uncovered extensive cannibalism among large individuals. Pike exploitation of various spawning habitats has been assessed and a genetic analysis of pike individuals and pike eggs will be explored, possibly facilitating assessment of the individual contribution to the population and thus enabling a cross-discipline approach to explore how behavior and reproductive fitness is related. The studies on winter biology are not only covering pike, but are incorporating the entire fish community adding further insights to the limited overall knowledge on winter lake ecology. Further, while simultaneous tracking several species the system allows for studies of predator-prey and species interactions, shoaling etc. in a natural system. The project was coordinated by DTU Aqua.

Jacobsen, L., Project Manager, National Institute of Aquatic Resources, Section for Freshwater Fisheries Ecology
Baktøft, H., Project Manager, National Institute of Aquatic Resources
Berg, S., Project Manager, National Institute of Aquatic Resources
Skov, C., Project Manager, National Institute of Aquatic Resources
01/01/2008 → 31/12/2016
Keywords: Research area: Freshwater Fisheries and Ecology
Collaborators: Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB), Berlin, Fisheries and Oceans Canada
Project: Research

Effects of new-developed lowland lakes on salmonid populations (38265)
Development of artificial lakes is a management tool to reduce nutrient runoff to coastal waters. Denmark has restored more than 10,000 ha of wetlands and lakes in the last 14 years in consequence of “Action Plans for the Aquatic Environment”, that aim to meet the demands of the European Union’s Water Framework Directive. Juvenile, seaward migrating salmonids (smolts) are highly affected by impounded waterbodies, as they are subjected to extraordinary high mortalities due to predation and altered habitat. Pike and birds have been demonstrated to be major predators on brown trout and salmon smolt in rivers and reservoirs. Migration delay of smolts in lakes may cause desmoltification. The objective of this project is to evaluate the effect of lake development on the salmonid smolt run in restored rivers and wetlands. This knowledge is important not only from a scientific perspective, but also in relation to DTU Aqua’s ongoing recommendations and advice given to counties and Ministry of Foods, Agriculture and Fisheries of Denmark on restoration projects. The project is coordinated by DTU Aqua. The project is funded by the Danish Rod and Net Fishing License Funds.
Koed, A., Project Manager, National Institute of Aquatic Resources, Section for Freshwater Fisheries Ecology
Schwinn, M., Project Participant, National Institute of Aquatic Resources
01/01/2008 → 31/12/2016
Keywords: Research area: Freshwater Fisheries and Ecology
Collaborators: Council of Aarhus
Project: Research

European eel: Investigation and assessment of their decline (EELIAD) (38410)
The EELIAD project was a research initiative to investigate the ecology and biology of European eels during their marine migrations, and how these relate to eel condition and population of origin. The information has been integrated into models to determine the most important factors that influence silver eel production and migration success. The fulfillment of this objective will provide a means to evaluate the likely success of the EU eel recovery plan, to enable management actions to be most effectively directed to enhance and conserve eel stocks across Europe, and to determine the dynamics of eel population structure and reproductive success. To achieve this aim we undertook a large-scale field program to determine the migration routes and behavior of silver eels during their spawning migration, and to determine ecological factors that influence the number and quality of silver eels leaving river catchments. These field studies were supported by the use of cutting edge biotechnological analyses to determine population structure and innovative modeling approaches aiming to incorporate these data into fishery management models. In addition, these different studies were linked to studies and observations undertaken in other cooperative projects such as INDICANG which is a network of monitoring programs that report on the status and the development of eel populations over a large area (e.g. Atlantic Area). The knowledge gained from the EELIAD research, aside from its scientific significance, have been of direct use to the conservation of eel stocks because it helps to clarify the reasons for the recent decline in the stock. This information will then be used to change and improve the way that eel fisheries and habitats are managed across Europe, and to help ensure that enough silver eels migrate to their spawning grounds to reproduce and sustain the species. The project was coordinated by Centre for Environment, Fisheries and Aquaculture Sciences (CEFAS), UK. The project was funded by EU, Framework Programme 7.
Aarestrup, K., Project Manager, National Institute of Aquatic Resources, Section for Freshwater Fisheries Ecology
Population development of sea trout after removal of migration obstacles (38259)

Generally, the size of a sea trout population is under the influence of a number of bottlenecks in the life cycle. Reduced spawning- and nursery habitat, as a consequence of sand walk and adjustments of streams, is one of the major obstacles. Another important factor is obstacles in connection with migration. A very important obstacle during migration is the passage of weirs which deny fish access to important habitats, both when it comes to downstream and upstream migration. The weirs’ negative effect on the population of migrating fish is well-documented (Aarestrup et al. 2003; Aarestrup et al. 2006a, b, c; Baktoft et al. 2007). It has lead to a number of model reflections on the impact on the fish stock if the weirs are removed (Olesen & Aarestrup 2006). However, this model has not been validated. The possibility of such a validation now exists in the River Villestrup, where the original model was developed. In this comprehensive restoration project, the plan is to remove all weirs in the main stream. This gives a unique chance to test the size in the stock of migrating fish before and after the removal of the weirs. The study aims at estimating the spring run of smolt and kelts in a number of defined years before and after the removal of the dams. The restoration project was in 2011. The run has been estimated in 2008 and 2009 before weirs were removed and again in 2015-2017 after the completion of the restoration project and allowing for juvenile cohorts to develop. The estimated smolt run before the removals was around 5000 smolt migrating into Mariager-Fiord. In 2015 the smolt run was estimated to app. 20000 smolts. The project provides us with potential valuable information for the potential for optimizing the fish stocks without releases. The project is running concurrently with project 38258 “The marine life and survival of sea trout” and with the EU funded project 39301: “Expertise in marine and aquatic ecology and genomics for sustainable management of fish and shellfish in Skagerrak-Kattegat-Øresund (MarGen)”. MarGen is an interregional management project with a specific aim to increase scientific and management competencies of marine resources in Kattegat/Skagerrak including understanding of fish migration. This project is funded by the Danish Rod and Net Fishing License Funds.

Aarestrup, K., Project Manager, National Institute of Aquatic Resources, Section for Freshwater Fisheries Ecology

Aarestrup et al. 2006a, b, c; Baktoft et al. 2007.

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.

Jepsen, N., Project Manager, National Institute of Aquatic Resources, Section for Freshwater Fisheries Ecology

Koed, A., Project Participant, National Institute of Aquatic Resources

Holm, M., Project Participant, National Institute of Aquatic Resources

Population development of sea trout after removal of migration obstacles (38259)

Generally, the size of a sea trout population is under the influence of a number of bottlenecks in the life cycle. Reduced spawning- and nursery habitat, as a consequence of sand walk and adjustments of streams, is one of the major obstacles. Another important factor is obstacles in connection with migration. A very important obstacle during migration is the passage of weirs which deny fish access to important habitats, both when it comes to downstream and upstream migration. The weirs’ negative effect on the population of migrating fish is well-documented (Aarestrup et al. 2003; Aarestrup et al. 2006a, b, c; Baktoft et al. 2007). It has lead to a number of model reflections on the impact on the fish stock if the weirs are removed (Olesen & Aarestrup 2006). However, this model has not been validated. The possibility of such a validation now exists in the River Villestrup, where the original model was developed. In this comprehensive restoration project, the plan is to remove all weirs in the main stream. This gives a unique chance to test the size in the stock of migrating fish before and after the removal of the weirs. The study aims at estimating the spring run of smolt and kelts in a number of defined years before and after the removal of the dams. The restoration project was in 2011. The run has been estimated in 2008 and 2009 before weirs were removed and again in 2015-2017 after the completion of the restoration project and allowing for juvenile cohorts to develop. The estimated smolt run before the removals was around 5000 smolt migrating into Mariager-Fiord. In 2015 the smolt run was estimated to app. 20000 smolts. The project provides us with valuable information on the potential for optimizing the fish stocks without releases. The project is running concurrently with project 38258 “The marine life and survival of sea trout” and with the EU funded project 39301: “Expertise in marine and aquatic ecology and genomics for sustainable management of fish and shellfish in Skagerrak-Kattegat-Øresund (MarGen)”. MarGen is an interregional management project with a specific aim to increase scientific and management competencies of marine resources in Kattegat/Skagerrak including understanding of fish migration. This project is funded by the Danish Rod and Net Fishing License Funds.

Aarestrup, K., Project Manager, National Institute of Aquatic Resources, Section for Freshwater Fisheries Ecology

The marine life and survival of sea trout (38258)

Considering the importance of the species and the fact that it is spending most of its time in the sea, it is striking that the knowledge on the survival and whereabouts of the sea trout in the marine areas is so limited. This is mainly due to technical barriers. The development within telemetry has made it possible to study the behavior of the sea trout by means
of electronic tags. By using the so-called pit tags and acoustic tags it is possible to monitor the fish when it passes a given place - typically at the outlet of the stream, the river or similar. At the same time new types of marks, the so-called DST-marks and the acoustic oxygen transmitter, make it possible to register information about the surrounding environment of the fish with a so far unprecedented accuracy. In the last few years, DTU Aqua has investigated the behavior and survival of postsmolts and kelts in the initial estuarine phase after exit from the river. The results show that wild fish have a relatively high degree of survival after emigration (Aarestrup et al. 2014; 2015). Meanwhile, further studies of survival and behavior in other systems are necessary in order to make any conclusions - as well as the rest of the survival and behavior of the sea trout in the sea that is not yet clarified. This project aims at obtaining information on the behavior of the marine phase of the sea trout. Besides valuable information on the marine life of the sea trout, the project will also give detailed information on the survival in salt water, survival of spawning, survival of repeat spawners as well as a lot of other information such as the time of entering fresh water to spawn and the time of returning to the sea. In some rivers part of the population are said to have an alternative life history strategy and these fish are called "fjord trout". Rumor has it that sea trout with this particular life history only wander into the fjord and not to the sea. Furthermore it has a number of morphological differences compared to the sea trout. The project will try to determine if there actually exist two life history strategies in the form of fjord- and sea wandering trout. The project is running concurrently with project 38259: "Population development of sea trout after removal of migration obstacles" and both collaborates with the EU funded project 39301: "Expertise in marine and aquatic ecology and genomics for sustainable management of fish and shellfish in Skagerrak-Kattegat-Øresund (MarGen)". MarGen is an interregional management project with a specific aim to increase scientific and management competencies of marine resources in Kattegat/Skagerrak including understanding of fish migration. The project is coordinated by DTU Aqua. The project is funded by the Danish Rod and Net Fishing License Funds.

The distribution of Danish freshwater fishes (38269)

The objectives of this project are, for the first time in almost 100 years, to produce and in a book present an updated distribution map of all freshwater fishes found in Danish fresh waters. The results will act as a reference point when analyzing both previous and future changes in the distribution of freshwater fishes in Denmark, e.g. related to climatic changes. Until the beginning of this project the geographic distribution of freshwater fishes in Denmark was not known in detail. For many species we only knew in which part of the country and maybe in which river system they live now or had lived earlier. Thus, our knowledge was incomplete and in general fragmented and consequently hard to find. In addition much of the existing information was old and newly arrived alien species had not been registered correctly. Thus, there was a need for a complete and updated status on the distribution of freshwater fish. Such a status will be a milestone in Danish inland fisheries research and management. Its value in relation to research and management as well as providing public access to correct information will be high. As an example the database has been used to revise the red data list for freshwater fishes in Denmark. In this project we have 1) collected existing data on the occurrence of freshwater fish from public and private institutions and 2) gathered information from the public on catches and other observations of freshwater fish. As supplement we have 3) made targeted surveys to fill gaps and improve knowledge on rare species. All this information have been 4) combined in a GIS-based database. Finally we have 5) presented the complete set of information on geographical distribution of freshwater fishes in Denmark in a book also containing detailed information on the biology and ecology of all species (native and alien) present in Denmark. The book was published in 2012 and contains 700 pages. It is written in Danish and illustrated with a large number of high quality photos of all species. It is written by 5 main authors (two of which are from DTU Aqua) and a few guests (one from DTU Aqua). Even though written to a broad audience, it is fully documented with references in the text. Due to private funding it has been possible to distribute the book at a very low price, 399 DKK (ca. 53 €). The revenue from the sale is reserved for a future revision and re-publishing of the book. The project was coordinated by Natural History Museum of Denmark, University of Copenhagen, Denmark. The project was funded by Aage V. Jensen’s Charity Foundation. The project is funded by the Danish Rod and Net Fishing License Funds.

Rasmussen, G., Project Manager, National Institute of Aquatic Resources, Section for Freshwater Fisheries Ecology
Berg, S., Project Manager, National Institute of Aquatic Resources

01/01/2006 → 30/12/2012

Keywords: Research area: Freshwater Fisheries and Ecology
Collaborators: University of Copenhagen
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/stock. 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 the Nature Agency, Danish Ministry of the Environment, Denmark. The project was funded by EU LIFE.

Baktoft, H., Project Participant, National Institute of Aquatic Resources, Section for Freshwater Fisheries Ecology

Skov, C., Project Manager, National Institute of Aquatic Resources, Section for Freshwater Fisheries Ecology

cooperation with project no 39270). The use of specially designed "egg traps" has been used successful in two of these tagged pike. 4) An investigation on the spawning habitat choice and spawning behavior of pike in a small natural lake (in a lake with heavy boat traffic and extensive angling. During this experiment we demonstrated that it is possible to prove to be insufficient to achieve the improved environmental conditions expected, including a good population of piscivorous fish. Thus, the lakes environmental quality, as well as the possibility to use the lake for recreational activities including recreational fisheries, might be negatively influenced. During the project, several activities related to this subject have been conducted: 1) An experiment demonstrating the importance of water depth for the mortality of 0+ pike. 2) Another experiment, which showed that it is possible to build an artificial spawning habitat for pike in an urban, artificial lake without a natural littoral zone and that the pike did use it for spawning and that the pike fry used it as nursery habitat. 3) A stocking experiment with 0+ pike to find out if stocking is a possible way to enhance a very low population density of pike in a lake with heavy boat traffic and extensive angling. During this experiment we demonstrated that it is possible to tag 0+ pike of 6-8 cm with PIT tags without mortality, but also that the tagging has a negative effect on growth of the tagged pike. 4) An investigation on the spawning habitat choice and spawning behavior of pike in a small natural lake (in cooperation with project no 39270). The use of specially designed "egg traps" has been used successful in two of these experiments. The project is coordinated by DTU Aqua.

Berg, S., Project Participant, National Institute of Aquatic Resources, Section for Freshwater Fisheries Ecology

Skov, C., Project Manager, National Institute of Aquatic Resources, Section for Freshwater Fisheries Ecology

Baktoft, H., Project Participant, National Institute of Aquatic Resources, Section for Freshwater Fisheries Ecology

01/01/2003 → 31/03/2013

Predator fish populations: The impact of behavioural and physical-biological parameters (38267)

Some of the mechanisms guiding the interactions of fish species in clear water lakes seems to act differently in turbid water, thus more knowledge of these relationships are essential. Both in order to understand how the fish population in a lake will develop when the lake is about to change to a clear water state, but also in order to understand the stability of predator fish populations under various environmental conditions. One of the important related issues can be the capability of predator fish, to hunt in turbid water and the interactions of more predator fish species. The capacity of pike and large perch to hunt in turbid water was tested in extensive pond experiments with different clay turbidity, including also the importance of prey fish density. The experimental approach was supplemented by parallel radio telemetry field studies of both predator species, in order to explain the role of behaviour and the importance for the natural composition of fish populations in turbid and clear water lakes. Pond experiments showed that pike were perfectly able to hunt in turbid water, backed up by the field findings of higher activity levels for some pike in the turbid lake, however in general with a larger variation in behavioural strategy in turbid water. Surprisingly, perch were also capable of hunting in very low turbidity at least in high prey fish densities. The telemetry study showed two alternative behavioural patterns of perch in clear water and turbid water, perch being more active in the turbid water on a diel basis including at night and not showing any sunrise and sunset peaks in activity as was seen in the clear water lake. The alternative strategy in the turbid lake might be interpreted as a means of allocating more time for hunting due to visual constraints. Contemporary studies on prey fish behaviour in the study lakes also revealed different behaviours on a diel basis dependent on turbidity, which can be linked to predator fish behaviour. Two peer-reviewed papers and a master thesis were presented on pike-behaviour as well as two peer-reviewed papers on perch behaviour. Results were presented on international and national conferences. The project was coordinated by DTU Aqua. The project was funded by the Danish Rod and Net Fishing License Funds. Jacobsen, L., Project Manager, National Institute of Aquatic Resources, Section for Freshwater Fisheries Ecology

Andersen, M., Project Participant, National Institute of Aquatic Resources

Berg, S., Project Participant, National Institute of Aquatic Resources, Section for Freshwater Fisheries Ecology

Skov, C., Project Participant, National Institute of Aquatic Resources, Section for Freshwater Fisheries Ecology

Baktoft, H., Project Participant, National Institute of Aquatic Resources, Section for Freshwater Fisheries Ecology

01/01/2005 → 30/06/2016

Management of the fish population in lakes under heavy human influence (38268)

The objectives of this project are to improve our understanding of how the physical conditions of lakes can affect spawning and fry mortality and growth for the most important piscivorous fish species. We will especially focus on the conditions of the littoral zone. This knowledge can be used to insure that the demands of these species in relation to spawning and YOY development are met. The results will be used as part of the web-based "Handbook on the Management of Lake Fish", which is under development. The majority of Danish lakes are strongly influenced by human activity, partly in the form of increased nutrient load, but also direct physical alterations are common, e.g. by regulation of the water level, consolidation of the banks or the consequences of heavy boat traffic. These types of physical alterations are often most common in lakes situated in or close to urban areas. In these kinds of lakes, lake restoration by biomanipulation might prove to be insufficient to achieve the improved environmental conditions expected, including a good population of piscivorous fish. Thus, the lakes environmental quality, as well as the possibility to use the lake for recreational activities including recreational fisheries, might be negatively influenced. During the project, several activities related to this subject have been conducted: 1) An experiment demonstrating the importance of water depth for the mortality of 0+ pike. 2) Another experiment, which showed that it is possible to build an artificial spawning habitat for pike in an urban, artificial lake without a natural littoral zone and that the pike did use it for spawning and that the pike fry used it as nursery habitat. 3) A stocking experiment with 0+ pike to find out if stocking is a possible way to enhance a very low population density of pike in a lake with heavy boat traffic and extensive angling. During this experiment we demonstrated that it is possible to tag 0+ pike of 6-8 cm with PIT tags without mortality, but also that the tagging has a negative effect on growth of the tagged pike. 4) An investigation on the spawning habitat choice and spawning behavior of pike in a small natural lake (in cooperation with project no 39270). The use of specially designed "egg traps" has been used successful in two of these experiments. The project is coordinated by DTU Aqua.

Berg, S., Project Manager, National Institute of Aquatic Resources, Section for Freshwater Fisheries Ecology

Skov, C., Project Manager, National Institute of Aquatic Resources, Section for Freshwater Fisheries Ecology

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01/01/2003 → 31/03/2013
The development of the fish community in lakes after biomanipulation: key factors in the development of a good population of piscivorous fish species (38264)
The objectives of the project are to strengthen the ability of DTU Aqua to consult authorities and stakeholders in the management of the fish community in lakes through (i) building time series on the development of the fish population in lakes, which has been subject to biomanipulation, (ii) make a cross analysis on a large data set containing information on standardized investigations of the fish community in more than 100 Danish lakes. Target species in lake fisheries in Denmark are the piscivorous species, which will be the focus of this project as well. 1)Biomanipulation has been applied to more than 50 Danish lakes with the objective to restore eutrophicated lakes to a state with clear water, extensive distribution of submerged macrophytes, a higher degree of biodiversity compared to turbid lakes, and a fish community dominated by piscivorous fish species. It is possible to apply biomanipulation to almost any eutrophic lake, but this restoration tool will only have a long lasting effect in lakes with an intermediate or low content and load of nutrients. In lakes where the improved environmental conditions last for several years, changes in the fish community can still be observed many years after the biomanipulation. Thus we want to describe the long term (10-25 years) development of the fish community, to be able to correctly answer what the end product of a biomanipulation is, regarding fish, on both community structure and population dynamics of the piscivorous species. Beginning in 1990 we have built time series of the development on the fish population in 10 Danish lakes, where biomanipulation has been applied as a restoration tool. We use a standardized investigation method, which allows both within and between lakes analysis. Under the project 38826 (Handbook for management of lake fish and fisheries) a status report will be prepared in fall 2011. 2)The cross analysis of the more than 100 lake data set aims at developing models to describe the relation between population density and size distribution for important piscivorous species and factors like food availability, distribution and types of vegetation, nutrient levels and water clarity. This analysis is also done within the frame of the project 38826 (Handbook for management of lake fish and fisheries).

Assess the yield from eel stocking in a marine fjord (38262)
The overall objective of the project was to estimate the outcome of stocking eel in a marine area, to estimate the yield to the fishery and the proportions of eels escaping the fishery. To reach this goal it was necessary to estimate the total catch in the fjord, the fishing mortality and whether eels stay in the fjord area or migrate to adjacent waters. Stocking is a widely used measure to enhance local eel populations throughout Europe. About 1.5 million elvers are stocked annually in Danish marine waters. There are only vague indications that these stockings actually improve the number of fish that are available to the fisheries and the spawning population. In 1998 and 1999 a total of 100.000 coded wire tagged eel were stocked in the inner parts of Roskilde Fjord. During 1999-2015 the eel catches made by professional and recreational fishermen were analyzed for recapture of tagged fish in order to establish the ratio of tagged to untagged fish in the eel catches. Based on the knowledge of numbers of fish caught in the yellow eel fishery as well as the silver eel fishery, the yield to the fishery was calculated. Migration patterns of the stocked eel were studied by collecting data from different strata of the fjord and adjacent fisheries, Isfjord and Arresø. Migrating silver eels were Carlin tagged and released to the fishery in September and October. Based on reported recaptures from fishermen an estimate of fishing mortality was established as well as of the number of silver eels leaving the Fjord and migrating toward the Sargasso spawning grounds. The total catches made by recreational fishermen were established through questionnaires to recreational fishermen. The overall result suggests that about 13 % of the stocking were captured by the fishery in Roskilde Fjord and 5 % left the fjord as silver eels on spawning migration. This project was coordinated by DTU Aqua. The project was funded by the Danish Rod and Net License Funds.

Population dynamics of eel (38280)
The project has 3 main goals: 1) Evaluation of the feasibility of eel stocking In compliance with the National eel MP, 1.3 million pre-fed eel are stocked annually in lakesad rivers. In coastal areas 0.2 million are stocked. Very little is known about the feasibility of these stockings. Due to the long life cycle of eels, both short and long term experiments are carried out. Short-term: Wild and cultured (pre-fed) eels of similar size (2-5 gram) are stocked in a number of large open ponds (old trout farm) and their growth and survival is recorded during their first year. Similar experiments are performed with wild
glass eels stocked in different densities in the ponds. Long-term: Small CW-tagged eel were stocked in the river Gudenåen in 2001, 2002 and 2011. The return from these stockings in the form of migrating silver eels are monitored by scanning eel caught in a trap (at a hydropower station), operating every autumn from 2006-2013. Furthermore, the silver eels caught in the trap are PIT tagged and recorded when reaching the lowermost obstacle in the river (Tange HPS). In Ribe Å, in Vester Vandetlake and in Karrebæk estuary CW-tagged eel were stocked in 2011 and 2012. The monitoring of catches for tagged eel started in 2015 and will continue for several years to get an estimate of how much the stocked eel contribute to the fisheries and how the ratio wild/stocked is, giving an indication of the natural recruitment. 2) Monitoring of recruitment/elvers The recruitment of eel has been continually declining since early 80’s and is now at a historical low. Monitoring of the number of elvers/glass eels arriving every year is therefore very important for the whole of EU. In DK we have two stations, where upstream migrating elvers are caught and recorded on a daily basis. Both stations are on the Danish East Coast. On the West coast the immigration is monitored by electric fishing/sampling in small streams in early summer. 3) Monitoring of the prevalence of the swim bladder parasite Anguillicola in Danish eels The swim bladder worm Anguillicola crassus was introduced to Europe from the far east in the beginning of the 1980’s. The parasites are thought to be one of the causes of the decline of the European eel population. Therefore the colonisation of Anguillicola in Denmark has been monitored in fresh and marine water bodies to assess the abundance of parasites and the general health of parasitized eels. The geographical distribution and the stability of the parasite abundance are of international interest due to the decline of the eel stock, but also because large effort is done to secure that the 1.5 million annually stocked eel are free of parasites. This project is coordinated by DTU Aqua. This project is funded by the Danish Rod and Net Fishing Licence Funds.

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01/01/1988 → …
Keywords: Research area: Freshwater Fisheries and Ecology
Project: Research

Monitoring of glass eel recruitment to Danish inland waters (38263)
The objectives are to collect data on the glass eel recruitment from the ocean to Danish inland waters, to be used in national and international advice on fisheries and stocks. A decline in recruitment of glass eel to the Danish coast and elsewhere in Europe has been persistent through several decades. The yield in fisheries has also declined and the stock is considered by ICES to be outside safe biological limits. Several hypotheses have been proposed for the decline, but no unambiguous cause has been identified. Monitoring of the stock is traditionally a national task, though coordinated international monitoring is needed, especially to evaluate if any change in management have the intended effect on the size of recruitment. In Denmark the monitoring is currently taking place at two hydropower stations where ascending eels are monitored in bypass traps, where personnel at the hydropower stations are doing the daily monitoring. The distance from the ocean to the hydropower dams are 5 and 35 km and the ascending eels do not directly reflect the annual size of the glass eel recruitment, but consist of several age groups (0-5 years). Glass eels recruitment directly from the ocean is also quantified by electro fishing in four small brooks on the west coast of Denmark. Sections of each brook are electro fished three times a year allowing for calculation of numbers and fluctuations in the recruitment to the brooks. The monitoring data are used in the ICES stock assessment group on eel WGEEL.

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01/01/1967 → 31/12/2013
Keywords: Research area: Freshwater Fisheries and Ecology
Project: Research