

CATALOGUE ON PROJECTS

Section for Freshwater Fisheries and Ecology

2012

Contents:

Reporting tagging experiments - project no. 38250	1
Salmonid freshwater habitats - project no. 38256.....	2
Evaluation of the National Salmon Management Plan - project no. 38257.....	4
The marine life and survival of sea trout - project no. 38258	5
Population development of sea trout after removal of migration obstacles - project no. 38259	6
The colonisation of <i>Anguillicoloides crassus</i> parasites in Danish eel populations and their negative effects on the eel - project no. 38260.....	7
Population dynamics of stocked eel in a river system - project no. 38261	8
Monitoring of glass eel recruitment to Danish inland waters - project no. 38263	9
The development of the fish community in lakes after biomanipulation: key factors in the development of a good population of piscivorous fish species - project no. 38264	10
Predator fish populations - the impact of behavioural and physical-biological parameters - project no. 38267.....	11
Management of the fish population in lakes under heavy human influence - project no. 38268	13
The distribution of Danish freshwater fishes - project no. 38269	14
Behaviour of lake-dwelling fish; natural and fishery induced impacts - project no. 38270	15
European Eel: Investigation and assessment of their decline (EELIAD) - project no. 38410	17
Migration and spawning behaviours of brackish water perch and pike - project no. 38413	18
Marine behaviour of Atlantic salmon - project no. 38825	20
Handbook for management of lake fish and fisheries - project no. 38826	22
The population of whitefish (<i>Coregonus lavaretus</i>) in Ringkøbing Fjord: Effects of fishery, stocking and natural reproduction - project no. 38827	24
Genetic mapping of Danish trout populations - project no. 38828	25
Predation from birds and mammals and the significance for populations of freshwater fish - project no. 38829.....	27
Living North Sea – fish migration from sea to source (LNS) - project no. 38872	28

Reporting tagging experiments - project no. 38250

Objective: Managing, reporting and elaborating on tagging experiments with salmon and trout. Abstract.

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, registering 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'ies and until recent years numerous tagging experiments have been conducted on salmon and trout at the institute (FFI). 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 of 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 analyse results on data from several countries around the Baltic Sea in corporation with relevant national institutes.

Salmonid freshwater habitats - project no. 38256

Objective: Improve and obtain knowledge on stream restoration measures and stream maintenance activities.

Abstract:

The procurement of knowledge in this project aims at improving the basic knowledge available for advice 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 with other Danish universities (Roskilde University, Aalborg University, Aarhus University), local authorities, Environmental centres and anglers associations.

In the coming years it is expected that several issues will be particularly relevant, such as stream restoration (particularly the 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 to place tubes below the gravel in order to allow sediment transported by the stream to be transported past the area with spawning gravel. Investigations on artificial spawning areas constructed with tubes will be carried out, measuring the content of fine sediment in the gravel on comparable artificial gravel areas with and without tubes.

A database with ongoing and previous stream restoration projects has been created. This is continuously being updated, to enable meta-analysis on relevant variables with the purpose of providing advice on restoration projects. Focus will be on the identification of factors influencing restoration effects towards fish populations.

A number of restoration projects (addition of spawning gravel) are being followed over a longer time span (years). Habitat parameters such as depth, water velocity, substrate composition and vegetation cover was initially measured before the restoration together with fish species and size composition. The same variables are measured annually to register effect from and durability of the restoration.

In a stream where approximately half of the productive area was previously inaccessible to migrating trout, all obstacles are being removed in a major restoration project. Habitat parameters are being measured for the entire system, aiming at modelling the effect of the removal of barriers on trout production (cooperation with project 38259).

In a study on brown trout population dynamics and effects on the population from sports fishing two sections (total length approx. 8 km) have been mapped for habitat quality. All fish with sufficient size for tagging inside the two sections have been tagged (PIT tags) and migrations in and out of the experimental section is monitored. A controlled fishing pressure is being applied to one of the sections in order to evaluate the effect on trout population from sport fishing.

Evaluation of the National Salmon Management Plan - project no. 38257

A National Management Plan 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 aims at covering the information gap and provides basic information on the salmon runs to enable proper management decisions. Every year monitoring will be carried out in one of the 4 rivers covered by the MP, so each river will be surveyed every 4 years.

- 1) Number of spawners: Intensive electrofishing from boat is carried out just after the season closure (October) in the main river and in some tributaries and 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 provide 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.
- 2) Spawning areas: In each of the 4 rivers the most important/preferred spawning areas will be identified using radiotelemetry. During the first electrofishing, 50-60 salmon will be equipped with a surgically implanted radio tag and followed by manual tracking and Automatic Listening Stations to map the spawning areas chosen by each fish. Naturally spawned fry will be genetically analysed 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.

The marine life and survival of sea trout - project no. 38258

Aim: This project aims to increase knowledge on the behaviour of the entire marine phase of the sea trout. This will be done by using novel methods in telemetry such as PIT tags, acoustic tags and DST tags.

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 of 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 behaviour 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, makes 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 behaviour 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. in prep a & b). Meanwhile, further studies of survival and behaviour in other systems are necessary in order to make any conclusions – as well as the rest of the survival and behaviour of the sea trout in the sea not yet is clarified. This project aims at getting information on the behaviour of the marine phase of the sea trout. Besides valuable information on the marine life of the sea trout the project will also give a number of detailed information on the survival in salt water, survival of spawning, survival of repeat spawner 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”. Rumour 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 38258: Population development of sea trout after removal of migration obstacles and both collaborates with the EU funded project “Living North Sea” (LNS). LNS are a 15 partner Interreg management project with the specific aim to focus on specific issues and potential solutions for fish migration.

Population development of sea trout after removal of migration obstacles - project no. 38259

Aim: This project aims to increase knowledge on effects of river restoration on sea trout populations.

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 in connection with the passage of dams by which the fish are prevented access to important habitats. Both when it comes to downstream and upstream migration. The dams' 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 led to a number of model reflections on the impact on the fish stock if the dam are removed (Olesen & Aarestrup 2006). Though, this model hasn't 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 the dams 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 dam. 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 dam. The run has been estimated in 2008 and 2009 before weirs where removed. The trapping operations gave an estimated smolt run of 4500 and 6500 smolt migrating into Mariager Fiord, respectively. The restoration project will be finished in 2011 and estimation of the run should be repeated in 2013-2015. The project provides us with valuable information on the potential for optimize 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 "Living North Sea" (LNS). LNS are a 15 partner Interreg management project with the specific aim to focus on specific issues and potential solutions for fish migration.

The colonisation of *Anguillicoloides crassus* parasites in Danish eel populations and their negative effects on the eel - project no. 38260

Objectives: To scrutinize the parasite abundance and variation in eel populations from fresh and brackish waters. To assess the harm caused by the parasite to the health of infected eels in general, and to the host's swim bladder in particular.

Abstract: The swim bladder worm *Anguillicoloides crassus* was introduced to Europe from the far east in the beginning of the 1980s. It was discovered in Danish wild eels in 1986. 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 since 1988 been monitored in several fresh and marine water bodies to assess the abundance of parasites, as well as their effects on the swim bladder 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 1.6 million annually stocked eel are free of parasites. The current results suggest that the parasite is well established in Danish eel populations and the policy to avoid recontamination by the parasite e.g. by stocking infected eels are justified, because the presence of large number of parasites in a swimbladder seem to cause rigid swim bladders probably unfit for the transatlantic spawning migration. Monitoring is continued to assess trends in parasite abundance.

Population dynamics of stocked eel in a river system - project no. 38261

Objectives: The objective is to evaluate the effect of stocking eel in a river system, and examine how anthropogenic factors such as weirs, trout farms, ponds in a river system may delay or hinder the downstream migration of silver eel.

Abstract:

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 Gudenå. Therefore, the area is excellent for eel stocking experiments, and all migrating fish can be monitored in a downstream fish trap.

During 1987, 1988, 1992 the area was stocked with 1.6 mill elvers. In 2001 and 2002 coded wire tagged eels of size 3,5 gram and 10 gram was 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 coast. How these obstructions influence the migration is largely unknown, but a delay and possibly a higher mortality may be expected. Migrating silver eels will be equipped with telemetric tags (PIT) and the progression rate of downstream migration will be recorded by automatic listening stations and manual tracking.

Monitoring of glass eel recruitment to Danish inland waters - project no. 38263

Objectives: 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.

Abstract: 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. 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 better quantified by electro fishing in small brooks. Sections of the 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 content of joint ICES/EIFAC working group on eel.

The development of the fish community in lakes after biomanipulation: key factors in the development of a good population of piscivorous fish species - project no. 38264

Objectives: To strengthen the ability of DTU Aqua to consult stakeholders in the management of the fish community in lakes through:

- 1) building time series on the development of the fish population in lakes, which has been subject to biomanipulation,
- 2) make a cross analysis on a large data set, containing information on standardised investigations of the fish community in more than 100 Danish lakes.

Abstract:

- 1) Biomanipulation has been applied to more than 50 Danish lakes, with the objective to recreate lakes 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 content 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

Beginning in 1990 we have build time series of the development of 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 on the Management of Lake Fish) 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 on the Management of Lake Fish.

Pedator fish populations - the impact of behavioural and physical-biological parameters - project no. 38267

Duration: 2005-2009

Project description

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 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 also including the importance of prey fish density. Following, 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, not showing any sunnoise 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 published on pike-behaviour and papers on perch behaviour are under revision/preparation. Results were presented on international and national conferences.

Partners

- **Nationale Institute of Aquatic Resources (DTU Aqua), Technical University of Denmark (DTU)**
- **Senior Research Scientist Lene Jacobsen, project leader**
- **Master student Martin Andersen, project responsible, pike telemetry**
- **Senior Research Scientist Søren Berg**
- **Senior Research Scientist Christian Skov**
- **PhD student Henrik Baktoft, statistics**
- **Limnology, University of Lund, Sverige**

Funding

The project was funded by the Danish Rod and Net Fishing License Funds. Total DTU Aqua project amounts: 2.3 mill d.kr. all external funding.

Management of the fish population in lakes under heavy human influence - project no. 38268

Objectives: To improve our understanding of the importance of the physical conditions of lakes for 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.

Abstract: 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 influence. During the project, several activities relate to this subject has been conducted: i) an experiment demonstrating the importance of water depth for the mortality of 0+ pike; ii) we made 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. iii) We have made a stocking experiment with 0+ pike to find out if stocking is a possible way to enhance a very small pike population 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. iiiii) Finally, we have made 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 successfully in two of these experiments.

The distribution of Danish freshwater fishes - project no. 38269

Objectives: To produce and present an updated distribution map of all freshwater fishes found in Danish fresh waters.

Abstract: Today the geographic distribution of freshwater fishes in Denmark is not known in detail. For many species we only know in which part of the country and maybe in which river system they live or have lived earlier. Thus, our knowledge is incomplete and in general fragmented and hard to find. In addition much of the existing information is old and newly arrived alien species has not been registered correctly. The need for a complete and updated status on the distribution of freshwater fish in Denmark is therefore considerable, and such a status will be a milestone in Danish inland fisheries research. It's value in relation to both research and management as well as giving the public access to correct information will be high. In this project we will 1) collect all existing data on the occurrence of freshwater fish from public and private institutions and 2) gather information from the public on catches and other observations of freshwater fish. In supplement we will 3) make targeted surveys to fill gaps and improve knowledge on rare species. All this information will be 4) combined in a GIS-based database. Finally we will 4) present the complete set of information on geographical distribution of freshwater fishes in Denmark in a book also containing detailed information of the biology and ecology of all species (native and alien) present in Denmark. The book is written in Danish and will contain ca. 750 pages. It is almost finished now and is expected to be published by the end of 2011. The project is conducted in cooperation with The National Museum of Natural History at the University of Copenhagen and is financed by Aage V. Jensens Charity Foundation.

Behaviour of lake-dwelling fish; natural and fishery induced impacts - project no. 38270

Duration: 2008-2013

Project description

The project focuses on establishing new and comprehensive knowledge on behaviour of lake dwelling fish and the impact of human activities, which can eventually enhance management of freshwater fish populations. The study is based on a new automatic acoustic telemetry system, which facilitates fine scale 3D positioning of several hundred fish several times a minute with sub meter accuracy. So far the system has been deployed in a small lake for two consecutive years and has generated data sets on pike, perch and roach behaviour 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. Hitherto, studies on pike winter behaviour 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 personal has allowed for comparison of fish behaviour in situations with and without human disturbances, e.g. fishery-related activities. This way a distinct and instantaneous impact of boating on fish behaviour has been revealed and the impact of catch and release angling has been addressed. Finally, the system has facilitated studies extending laboratory findings to behaviour in the field. For instance, findings of physiological (metabolic rates) and behavioural (boldness-shyness) properties of individual fish in the lab have been linked with behaviour of the same individuals in nature by subsequent tagging and release in the lake. Several issues will be studied concurrently the following years:

(i) A principal focus area will be striving to establish which factors impact and confines natural pike populations. The majority of larger pike in the study lake have been followed for at least two years, which have provided a detailed picture of pike behaviour and individual variation. The interactions between pike size groups and whether the home range of smaller pike is controlled by larger individuals is being studied by marking a large number of smaller pikes. Pike exploitation of various spawning habitats is 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 behaviour and reproductive fitness is related.

(ii) The studies on pike winter biology will be expanded to incorporate the entire fish community adding further insights to the limited overall knowledge on lake winter ecology and (iii) general studies on predator-prey and species interactions, shoaling etc in a natural system will be continued. (iv) Finally, the effect and feasibility of stocking trout in lakes, a theme of high relevance to the management of Danish lakes, will be studied.

Partners

- **Nationale Institute of Aquatic Resources (DTU Aqua), Technical University of Denmark (DTU)**
- **Senior Research Scientist Lene Jacobsen, project leader**
- **Phd Student Henrik Baktoft, principal investigator pikes and linking lab and nature**
- **Senior Research Scientist Søren Berg, principal investigator pike spawning**
- **Research Scientist Thomas Damm Als, principal investigator genetics**
- **Senior Research Scientist Christian Skov, principal investigator winter behavior**
- **Fisheries and Oceans Canada, Central & Arctic Region, Freshwater Institute, Environmental Science, Winnipeg, Canada.**
- **Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB), Germany**

Funding

The project is funded by the Danish Rod and Net Fishing License Funds. Total DTU Aqua project amounts: 3.5 + 3.7 mill d.kr., all external funding.

European Eel: Investigation and assessment of their decline (EELIAD) - project no. 38410

Aim: Eeliad is a scientific research project that aims to resolve some of the mysteries of eel biology, and to use this information to help conserve European eel stocks.

The eeliad project is 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 will be integrated into models to determine the most important factors that influence silver eel production and migration success. The fulfilment 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 are undertaking a large-scale field programme to determine the migration routes and behaviour 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 will be supported by the use of cutting edge biotechnological analyses to determine population structure, and innovative modelling approaches that will incorporate these data into fishery management models. In addition, these different studies will be linked to studies and observations undertaken in other cooperative projects such as INDICANG which is a network of monitoring programmes 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, will be of direct use to the conservation of eel stocks because it will help 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.

Migration and spawning behaviours of brackish water perch and pike - project no. 38413

Duration: 2010-2013

Project description

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 reproduction 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 freshwaters, 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 salinities 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 there will be created a connection afterwards. The fish population and recruitment of perch will be studied before 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 spawns along the coast and bays of southern Denmark. The project is done in close cooperation with municipalities around southern Zealand.

Partners

- **Nationale Institute of Aquatic Resources (DTU Aqua), Technical University of Denmark (DTU)**
- **Senior Research Scientist Lene Jacobsen, project leader**
- **Senior Research Scientist Søren Berg**
- **Senior Research Scientist Christian Skov**
- **Senior Research Scientist Kim Årestrup**
- **Department of Biotechnology, Chemistry and Environmental Engineering, University of Aalborg, Denmark**
- **Municipalities of Næstved, Vordingborg and Guldborgsund**
- **Natural History Museum of Denmark, University of Copenhagen, Denmark**

Funding

The project was funded by the Danish Rod and Net Fishing License Funds. Total DTU Aqua project amounts: 1.8 mill d.kr., all external funding.

Marine behaviour of Atlantic salmon - project no. 38825

Aim: To generate knowledge on migration behaviour and feeding areas in the sea.

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. The information available about Danish salmon's marine phase consists of a few recaptures of Carlin tagged fish from the North Atlantic, which gives a rough idea of the place of residence at time of capture, but nothing about their specific behavior, timing of migration or survival. These factors are totally unknown. 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. The project will in addition to the scientific also contribute managerial knowledge that can be used to assess a potential influence in the form of by-catch of salmon from the changing high-seas fisheries, for example mackerel fishing. So far it has not been possible to make more specific behavioral studies of Danish salmon marine life for two reasons. First, there were very few salmon, and there has simply not been technology available to get behavioral data from the fish apart very expensive marine expeditions. Especially with the development 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 labeled 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 and sends 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 tagging of kelts will be the most obvious group of salmon that tag. In Denmark, this has previously been almost impossible, because of very few salmon in the Danish salmon rivers. However, this has changed significantly in recent years.

In the last few years scientist in Norway has made the first attempt with this type of tagging on salmon and have developed a new tagging method (Rikardsen et al. In prep). We intend to use this method as in brief includes catching descending kelts, store them (up to two weeks) in saline water and then tag the fish under the dorsal fin. Another way to examine the salmon's movements in the sea is to investigate the chemical fingerprints of fish scales (Svendsen et al. 2009). The method is a consequence of the fact that a number of stable compounds from the fish food items is incorporated in the fish scales and otoliths.

By analyzing the fish's scales or otoliths a "chemical fingerprint" depending on where the fish were and what they have eaten can be obtained. It has previously been shown that the chemical fingerprint can distinguish between salmon from the Baltic Sea and Atlantic Ocean. 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 hypothesis is that the difference in marine behaviour may be reflected in different fingerprints. These investigations are conducted in collaboration with University of Aalborg..

Referencer:

Aarestrup, K, Økland, F., Hansen, M.M., Righton, D., Gargan, P. Castonguay, M., Bernatchez, L., Howey, P., Sparholt, H., Pedersen, M.I. & McKinley, R.S. (2009). First empirical results on the ocean spawning migrations of the European eel (*anguilla anguilla*). *Science*. 325, 1660.

Koed, A., Jepsen, N., Baktoft, H. & Larsen, S. (in press). Opgang og gydning af laks i Skjern Å systemet 2008/2009. DTU-Aqua rapport.

Rikardsen, A.H., Davidsen, J.G., Chittenden, C.M., Righton, D., Økland, F., Næsje, T.F., Thorstad, E.B., Halttunen, E.,

McKinley, R.S. & Aarestrup, K. (in prep). Atlantic salmon, a polar and deepwater explorer.

Neuenfeldt, S., Hinrichsen, H.-H., Nielsen, A., Andersen, K.H. (2009) Reconstructing migrations of individual cod (*Gadus morhua* L.) in the Baltic Sea by using electronic data storage tags. *Fisheries Oceanography* 16: 526-535.

Svendsen, T., Vorkamp, K., Svendsen, J.C., Aarestrup, K. & Frier, J.O. (2009). Organochlorine fingerprinting to determine foraging areas of sea-ranched Atlantic salmon: A case study from Denmark. *North American Journal of Fisheries Management* 29, 587-603.

Handbook for management of lake fish and fisheries - project no. 38826

Duration: 2011-13

Project description

The project aims to develop a web based handbook in lake fisheries management as a tool to practical focussed management of fish populations in local lakes in order to be able to exploit and enhance especially the recreational fishery. The project also aims to flash the value of Danish lakes and not least their fish populations, covering all types of lake fishery preferences (species, sizes, quantity, etc.), off course with due consideration of authenticity and environmental conditions.

The work encompasses gathering and merging of existing knowledge on fish in Danish lakes to make it easier accessible to users. Lake ecology is complex and often knowledge on individual lakes and fish populations, which is a prerequisite for management, is scarce or lacking. To supplement existing knowledge the idea is to organize collection of information from e.g. local anglers, who can contribute valuable information on a local scale. This can be both environmental parameters like standardized measured of secchi depth; underwater plant distribution and not least standardized capture reports, which can be done during fishing trips. Information on lakes will eventually be accessible via a GIS based map.

A central part of the handbook will be descriptions of species and their ecology, environmental requirements etc., which will be extracted from previous lake research and existing knowledge. These descriptions will be essential for rationalization of which measures can possibly be launched to enhance specific fish species, if the species is not thriving in the lake.

Merging of existing knowledge will most likely reveal gaps in knowledge and to support the project some areas of focus have been appointed, where a more thorough analysis of existing data will be addressed. (i) Data on lake types and predator fish populations as perch and pike will be analysed and long time series on fish population development in biomanipulated lakes will be concluded. (ii) The use of catch reports as a mean to assess fish populations will be addressed by analysing 100 years of existing angler catch reports from Lake Esrum. (iii) Knowledge on carp, especially factors affecting spawning potential in Denmark, will be updated, which is urgently relevant for the effect of carp stocking in different lake types. The Lake handbook will be integrated in the existing homepage www.fiskepleje.dk. It will be continuously updated and make new knowledge and management tools available for a broad audience of users.

Partners

- **Nationale Institute of Aquatic Resources (DTU Aqua), Technical University of Denmark (DTU)**
- **Advisor on freshwater fisheries management Jan Nielsen, project leader**
- **Senior Research Scientist Søren Berg, responsible biomanipulated lakes, carps**
- **Senior Research Scientist Christian Skov, responsible catch reports, fish population analysis**
- **Senior Research Scientist Lene Jacobsen**
- **Advisor on freshwater fisheries management Finn Sivebæk, homepage support**
- **Communication officer Suzanne Rindom, homepage support**
- **Danmarks Sportsfiskerforbund (Danish Anglers Association)**
- **Ferskvandsfiskeriforeningen for Danmark (Freshwater Fisheries Association)**
- **Fiskeringen (The Fishing Trust)**

Funding

The project is funded by the Danish Rod and Net Fishing License Funds. Total DTU Aqua project amounts: 3.6 mill d.kr. all external funding.

The population of whitefish (*Coregonus lavaretus*) in Ringkøbing Fjord: Effects of fishery, stocking and natural reproduction - project no. 38827

Objectives: To improve our knowledge on the whitefish population in Ringkøbing Fjord and effects associated with the commercial exploitation of it. To establish how much natural reproduction and stocking of hatchery reared fry contributes to the adult population and to what extent the commercial fishery affects other species of fish. These results will enable a much better basis for the management of the whitefish populations in Denmark in general and in the Western Jutland populations in particular.

Abstract: The natural population of whitefish in the Ringkøbing Fjord has been the subject of an extensive fishery for more than 100 years. The main gear used is 46 mm monofil gill nets. 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 official statistics shows that the catch through the 20th century typically has varied between 10 and 60 tons per year. Since 2001 the catch has increased and in most years been above 60 tons with 2009 as the record with a catch of more than 100 tons. Since 1986 ca. 4 mio hatchery reared fry has been stocked in the fjord each year. 3.6 mio is stocked as newly hatched larvae in the beginning of April. The rest is raised to a size of 3-4 cm on a diet of artificial pellets before stocking in late May.

Several subjects related to the whitefish population and fishery is of considerable interest to investigate:

The population of sea trout (*Salmo trutta*) in the main tributary of the Ringkøbing Fjord, the River Skjern Aa, is much smaller than expected, considering the environmental conditions of both the river and the fjord. One possible reason is by-catch in the whitefish fishery. The landing of sea trout and the endangered salmon (*Salmo salar*) from Ringkøbing Fjord is prohibited and the discard mortality is considered to be very high. Investigation on this subject from the Baltic Sea indicates this to be true. The by catch of sea trout will be estimated partly thorough experimental fishing and partly thorough surveys of commercial fishing.

It has never been estimated how much the stocking of whitefish larvae and fry contributes to the population in general or to the catchable fraction of the population (legal minimum size 34 cm). We will first establish if otolith microstructure analysis can be used as a method to distinguish between hatchery reared and naturally hatched individuals. If not strontium marking in the hatchery will be used. The best method will be used to estimate how much the stocking programme contributes to the population.

Finally we will collect data on the age structure and growth of the whitefish. These parameters will be used to evaluate if fishing pressure in this fishery is a major mortality factor.

Genetic mapping of Danish trout populations - project no. 38828

Objective: To map genetic diversity of Danish trout populations for use in the future management of Danish trout populations.

The purpose of this project is to map the genetic structure of Danish trout populations and develop genetic tools for use in the future management of Danish trout populations. This tool could be used for identify indigenous populations of trout, determine migration patterns and identify causes for maintenance of genetic differentiation between populations. In the longer term, we want to map the geographical distribution of genetic diversity of most Danish trout populations, and potentially use this as baselines for identifying migration patterns of sea trout.

A genetic map with more detail (both geographically and genomic) compared to previous genetic studies will be a very important tool for conservation and restoration of natural trout. It will be applied in 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 evolutionary potential. A genetic map could provide an overview of indigenous populations and conservation units, and will thus have important implications in counseling of 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. This might also bring us closer to an understanding of why releases of material from one population are unsuccessful, while releases from local and / or other stocks are successful.

Although trout releases were to be terminated completely, it is important to have a genetic tool in order to determine whether a particular stock can be considered indigenous, or whether it is the result of previous releases. It is therefore important to involve genetic findings in the management of Danish trout populations. Conservation and restoration would also benefit greatly from using this tool, to ensure selection of the optimal material for restoring fish stocks where indigenous populations have become extinct.

By comparing the genetic profile of sea trout caught at different places on the coast with the geographical genetic map it will be possible to determine whether they are primarily from the local population, or a mix of fish from several sources, by assigning each individual to their genetic origin.

As part of the project "Living North Sea" (LNS, <http://www.livingnorthsea.eu/>) we (at DTU Aqua) have started to develop new genetic markers (SNPs) to map the genetic differences and similarities between trout populations around the North Sea. The project is in collaboration with both researchers and local angling organizations from Britain, Norway, Sweden, Holland, Germany and Belgium, and we expect that the methods we develop will be used to look at a wide range of biological questions. Some of trout populations in the western part of Denmark are already covered by the LNS project, which means that we in this project focus more on the eastern part of Denmark, ensuring nationwide genetic maps of our trout populations.

Methods:

The genomes from 16 individuals from different populations are sequenced on an Illumina HiSeq2000 platform (covered by LNS). By comparing genome sequences from these 16 individuals, we identify differences in DNA sequences in order to select 6000 polymorphic loci (Single nucleotide polymorphisms SNPs).

Individuals from approx. 18 different populations (apart from those covered by LNS) selected in a manner that ensures a good coverage of Danish trout populations will be genotyped for these selected SNPs 6000 (Illumina iSelect bead array). Results from the 6000 SNPs would be used to identify the approx. 200 SNPs that are particularly well suited to distinguish between these trout populations. These 200 SNPs will genotyped (presumably using the Sequenom genotyping technology) in additional 20 populations and genetic differences between Danish trout populations will be mapped and genetic populations will be defined. These 200 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.

Predation from birds and mammals and the significance for populations of freshwater fish - project no. 38829

It is a well-known fact that predation can be a key factor for many fish populations and in some areas predation may even be the most important regulating factor for fish stocks of major recreational importance. Several species of predators were earlier persecuted, but are now protected and has experienced high population growth recently. This includes species like: Cormorant, grey heron, seals and otter. Thus, the protection of these species has been a conservation success, but has also caused severe conflicts between various user-groups. To handle and mitigate these conflicts, scientific documentation is severely needed.

During a long period, DTU Aqua has carried out a number of projects that directly or as side-results have assessed the magnitude of predation and its impact on various fish stocks. This has provided some insight in when, where and by whom the important recreational fish species are being eaten. This project seeks to gather and synthesize 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 populations.

Living North Sea – fish migration from sea to source (LNS) - project no. 38872

Aim: The **Living North Sea** project aims to focus on key issues and solutions for fish migration. 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:

- migration routes
- threats such as man-made barriers and fish migration measures; and
- influencing future policy at a regional, national and international level and informing the general public

Migration routes

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.

Fish migration measures

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.

Communication

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.