PhD Projects at DTU Aqua

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DTU Aqua
National Institute of Aquatic Resources

Preface

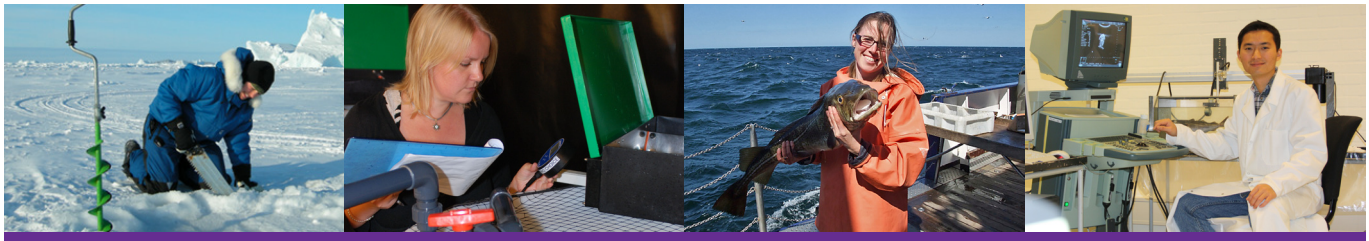
This web-publication "PhD projects at DTU Aqua" presents the 32 PhD students enrolled at DTU Aqua's PhD school on 1 July 2011.

Each student here describes the PhD project in terms of background, project contents and perspectives, and you will additionally find information on research section affiliation and supervisors. Most PhD students at DTU Aqua have co-supervisors as well. However, for the sake of simplicity we have not provided the entire list in this publication.

One third of the PhD students currently enrolled at DTU Aqua are international students. This is at the same level as the average for Danish universities in general. We are proud to be trend setters with regard to our uptake of female students (60 %). This is way beyond the average across the DTU institutes (35 %).

To the extent possible we struggle to make sure that our PhD students engage themselves with front line research, utilizing new technical approaches in their data collection and new concepts for data treatment and evaluation. Our ambition is through our PhD programme to contribute to securing the next generation of innovative and broad minded applied aquatic researches that can face the challenges that e.g. climate change and an increased utilization of aquatic resources present to us.

Helge Abildhauge Thomsen
Head of the PhD school at DTU Aqua



Content

Mie Hylstofte Sichlau

Background
The main task of any sexually reproducing organism is to mate and reproduce. This applies to planktonic copepods as well. Copepods reproduce sexually and are hence potentially subject to sexual selection. Sexual selection theory has proven powerful in explaining the morphology, behaviour and population biology of many animals and plants. Copepods are the most abundant metazoans in the oceans and are ecologically important as a link in the food chain between microscopic algal cells and juvenile fish. Despite their ecological importance, the issue of sexual selection in pelagic zooplankton has received little attention.

Project
This project will through the building of quantitative cases, examine the intensity and direction of sexual selection and asses the implications of sexual selection for the biology of individuals, the dynamics of populations, and the functioning of the pelagic ecosystem. The goal is to use insights in sexual selection in the plankton to make predictions of the behaviour, the mortality rates and the population dynamics.

Perspective
Population dynamics emerge from individual behaviours and life histories, and in that sense sexual selection has implications for the whole population dynamics. Sexual selection is likely to be a very strong determinant of the evolution of the morphology, behavior and ecology of plankton.

Title:
Sexual selection in marine plankton

Supervisor:
Thomas Kiørboe

Section:
Ocean Ecology and Climate

Hannes Höffle

Background
Although most cod stocks are heavily overfished, the species is still an important food fish in European waters. Fishing quotas are currently set by a modeling of future recruitment success, based on a relationship between observed environmental conditions and recruitment. However, climate change may cause such extrapolations to be unreliable in the future, and there is a need for further insight into bio-physical linkages during the early life of cod.

Project
The major goal is to examine spatial linkages between physics and distributional patterns from the egg stage until the cod is settling for a demersal life, taking into account potential influence of climate change. A secondary goal is to determine the background for cod taking up a demersal life, based on the hypotheses that this is due to changes in prey availability. The nursery areas of eggs found in the early survey will be linked to data on age of the 0-group Gadoids, by model backtracking. The investigations at large will provide a basis for the development of marine ecosystem models.

Perspective
The project is embedded within a larger ongoing project (SUNFISH: Sustainable fisheries, climate change and the North Sea ecosystem). The overall goal of SUNFISH is to understand and evaluate effects of climate change and to quantify effects on the population dynamics of commercially important fish. This project will contribute to enabling a sustainable management of these stocks.

Title:
Spatial patterns in the distribution and early life characteristics of North Sea cod under the influence of climate change

Supervisor:
Peter Munk

Section:
Ocean Ecology and Climate

Rasmus Swalethorp

Background
Today, fishery accounts for 85 % of Greenland's exports and supports many of its inhabitants. The Atlantic cod is of great historical, cultural and economic importance to the West Greenlandic communities. However, the cod population has experienced a steady decline since the 1960's and is today primarily composed of smaller reproducing stocks in inshore waters. The largest of these is located in the Godthåbsfjord where the fjord branch Kapisigdlit appears to be an especially important spawning site.

Project
Kapisigdlit is characterized by a shallow inner creek in which the majority of the cod spawning occurs. The mesozooplankton community and potential prey for cod larvae is dominated by the copepod genus *Metridia*, while *Calanus, Pseudocalanus* or *Microsetella* dominate in other parts of the fjord system. The aim of this study is to investigate what makes Kapisigdlit suitable as spawning ground for cod. The project will: (1) determine the retention of cod eggs and larvae based on a spatial and temporal analysis of distribution patterns in relation to hydrography and bathymetry, (2) analyze the spatial and temporal variability in growth and mortality of cod larvae, (3) determine the position of cod larvae as predators within Kapisigdlit, their food basis, the spatial and temporal overlap between larvae and prey, and the degree to which *Metridia* enters into larval food spectra, and (4) assess the predatory impact of cod larvae, other fish larvae and carnivorous macro zooplankton on the plankton community.

Perspective
This study will provide important information on the preconditions for successful reproduction of cod populations in the northern fringe of their current distribution. Further it will provide insight into the potential impact of future climate changes on Arctic ecosystems.

Title:
Physical-biological influence on the spawning and larval development for an inshore population of cod (*Gadus morhua*) in Greenland

Supervisor:
Peter Munk

Section:
Ocean Ecology and Climate

Sanne Kjellerup

Background
The Arctic areas are particularly vulnerable to climate change. As temperature increases, the sea ice cover and thus the light availability to phytoplankton, the availability of nutrients and the mixing layer will all be affected. Earlier break-up of the sea ice will possibly influence the timing, magnitude and duration of the spring primary production. Copepods account for the majority of the mesozooplankton biomass and are thus the principal link between the primary producers and higher trophic levels. It is therefore crucial to investigate the response of copepods to changed climate conditions which affect parameters such as food availability, temperature and salinity.

Project
Previous studies have focused on the large lipid rich copepods from the genus *Calanus* which dominate the Arctic copepod community during spring and summer. *Metridia* spp. are also numerically important copepods in the Arctic, but their abundance is often severely underestimated during routine daytime sampling of surface layers, as they perform diurnal vertical migration of more than 200 meters. New data shows that *Metridia* is found in high abundances in a spawning area of Atlantic cod and could thus be an important food item. *Metridia* does not overwinter, but stays active all the year round. How *Metridia* meets its energy demands during the low-produc-tive winter and how it captures and consumes different food items is unknown. Key issues addressed are: (1) seasonal cycle of *Metridia* in relation to seasonal successions in the plankton community, (2) *Metridia* as prey item for fish larvae, (3) impact of higher temperature on *Metridia* and (4) swimming and prey capture behavior of *Metridia*.

Perspective
An improved knowledge of the genus *Metridia* is of great general interest and will significantly advance the understanding of energy flow within the climate impacted and generally vulnerable Arctic food webs.

Title:
The importance of the copepod genus *Metridia* in the Godthåbsfjord at present and future climate conditions

Supervisor:
Torkel Gissel Nielsen

Section:
Ocean Ecology and Climate

Cornelia Jaspers

Background
The invasive jellyfish *Mnemiopsis leidyi*, present in European waters since 2006, has raised major public and scientific attention. *Mnemiopsis* has been shown to have a fast population expansion rate leading to mass occurrences with tremendous potential consequences for the ecosystem. This includes the collapse of fish stocks as documented for the Black Sea after the *Mnemiopsis* invasion via ballast water in the 1980s.

Project
The project specifically aims to understand the spatial and temporal distribution pattern of this alien species in the newly invaded Baltic Sea, looking at abundance fluctuations of adults, larvae and eggs during a one year monthly monitoring program. This is complemented by laboratory experiments of their reproduction biology to better understand population fluctuations given the fact that maximum egg production rates are as high as 14000 eggs per day. A detailed study of the population dynamics in a fjord will supplement these results and provide a high resolution base line study to understand small scale population fluctuations before, during and after population outbreaks. Apart from *Mnemiopsis* population size and distribution pattern, direct feeding interactions with the commercially most important Baltic fish species is also targeted.

Perspective
This project aims to understand cascading effects for the Baltic ecosystem from a population dynamic and feeding interaction point of view. Reproduction and life stage dependent mortality will be addressed to evaluate possible limitations functioning as bottle necks for the population expansion of *Mnemiopsis* in the newly invaded Baltic Sea.

Title:
Feeding ecology of gelatinous plankton

Supervisor:
Thomas Kiørboe

Section:
Ocean Ecology and Climate

Karen Riisgaard

Background
Within the last two decades there has been a growing awareness of plankton dynamics in Arctic marine ecosystems due to concerns with regard to the ecological effects of climate changes in these susceptible waters. The protozooplankton is a diverse group of single celled zooplankton found in marine waters all over the World. They are key components in the marine foodweb of temperate waters but their role in the Subarctic and high Arctic regions has to some extent been neglected.

Project
Protozooplankton makes up a group of hardy and resistant organisms that, in contrast to most other zooplankton groups, are able to stay active in the long Arctic winter. The aim of this project is to get a better understanding of the variability and trophic role of protozooplankton in northern marine ecosystems in response to changes in the environment. The data will be incorporated into models to describe the ecological impact of protozooplankton today and in future changing climates.

Perspective
It is expected that the project will contribute not only with improved knowledge on the basic ecological role of protozooplankton in northern marine ecosystems, but also improve our understanding of the effects of physical-chemical factors, such as temperature and pH, on the activity, growth and seasonal distribution of protozooplankton.

Title:
Key processes in North Atlantic marine ecosystems

Supervisor:
Torkel Gissel Nielsen

Section:
Ocean Ecology and Climate

Julie Sainmont

Background
All organisms in the Arctic have to contend with extreme physical conditions - in particular the short growing season and the long cold winters with very little food available. In Arctic seas, the zooplankton biomass is dominated by three species of *Calanus* copepods. They play a key role in Arctic ecosystems as they represent a rich food source for fish, sea birds and marine mammals. The copepods have developed a life strategy, whereby they enter a period of reduced activity during winter (diapause) in a pre-adult stage. The success of this overwintering strategy depends on the amount of fats the organisms are able to store from the previous growing season, their overwintering survivorship, and timing of their emergence from diapause with respect to the spring bloom.

Project
The species of Calanus (*C. finmarchicus*, *C. glacialis* and *C. hyperboreus*) are closely related, but differ in key traits such as size, lifespan and details of their overwintering strategies. The aim of the project is to mechanistically determine how these key traits impact the relative fitness of these species across spatial gradients of their physical environment. The project will develop trait based models of individuals as they develop from eggs through naupliar and copepodite stages to adulthood. These models will be run within specific environmental settings, and the fitness of individual gauged in terms of their reproduction and survivorship.

Perspective
An understanding of the life strategies of the *Calanus* species and how they are impacted by changing climatic conditions is key to understanding how marine Arctic ecosystems are likely to change in expected future climate shifts. Changes in the ratio between *Calanus* species could lead to regime shift, with small pelagic fish and the sea birds being favoured over marine mammals.

Title:
Modelling the competition between three closely-related Artic copepod species under climate change

Supervisor:
Andre W. Visser

Section:
Ocean Ecology and Climate

Nina Overgaard Therkildsen

Background
The expected global climate change will challenge the future persistence of fish populations that faced with altered environmental conditions may respond by (1) going extinct locally, (2) shifting their distributions, (3) adjusting through phenotypic plasticity, or (4) adapting genetically through natural selection. Yet, limited knowledge is available on the genetic background underpinning "functional bio-diversity", i.e. the genes responsible for adaptation to local environmental conditions and to changes in these over time. With developments in DNA methods, it is now becoming possible to assess variation at hundreds of gene loci, and harnessing these new tools will be important for improving our predictions of how fish populations may respond to climate change.

Project
The project investigates changes in the genetic variation of Atlantic cod populations in relation to environmental fluctuations and anthropogenic pressure over the past century. This is achieved by comparing DNA extracted from archived otoliths and contemporary samples, thereby pursuing a unique opportunity for studying microevolutionary processes in "real time" and providing insights into shifts in migration patterns and selection on functional genes. Observed temporal correlations between past environmental variation and genetic differences between samples collected at different time points will help identify what agents are driving contemporary evolution and will be used to train predictive models based on various future climate scenarios.

Perspective
The project will improve our understanding of how environmental factors shape the distribution of biodiversity and functional genetic variation in time and space. This contributes both to our general knowledge about evolutionary processes and adaptation in natural populations and should help improve predictions about the future distribution and abundance of Atlantic cod populations.

Title:
Predicting the consequences of global change for fish populations using genomic methods

Supervisor:
Einar Eg Nielsen

Section:
Population Ecology and Genetics

Kristian Meier

Background
Climate change raises concerns on whether populations are locally adapted and holds evolutionary potential to cope with these changes. In salmonid fish the annual timing of life history events and early life history traits are expected to be affected by increasing temperatures.

Project
The aim of the project is to investigate if brown trout populations are locally adapted and possess evolutionary potential to cope with the predicted changes. The project combines different methods. A common garden experiment is applied focusing on the early life history traits. Based on previous results, the aim is to apply gene expression analysis to identify genes and physical pathways underlying adaption to local temperature conditions. At the molecular level, an outlier scan is applied. The principle in this method is to identify regions of the genome under selection. The method combines a high number of molecular markers, some neutral and some linked to genes possibly under selection. Focus is given to genes involved in temperature regulation and clock genes involved in the circadian rhythm and thereby the annual timing of life history events.

Perspective
By combining different methods aimed at the molecular, transcriptomic and quantitative level it will be possible to identify the genes and physical pathways underlying adaptation to local temperature conditions. This will give us a better understanding of the genes and selective agents underlying local adaptation which can be applied in future management of wild brown trout populations.

Title:
Molecular basis of local adaptation in brown trout (*Salmo trutta L.*)

Supervisor:
Dorte Bekkevold

Section:
Population Ecology and Genetics

Morten T. Limborg

Background
Only a limited number of marine organisms currently inhabiting the northeast Atlantic Ocean and the adjacent North Sea have successfully colonised the brackish Baltic Sea. Conditions in the Baltic Sea exert significant challenges for organisms originating from, and adapted to, a fully marine environment. Most fish species studied so far show genetic differentiation between Baltic and Atlantic populations, suggesting that local populations have adapted to the Baltic environment through evolutionary processes.

Project
The project focuses on the small pelagic fish species herring and sprat for studying population structure and local adaptation in Baltic populations of marine fish species. The aim of the project is to develop genomic markers and identify genes subject to divergent selection in comparative analyses of Atlantic and Baltic populations. Applying an integrative approach using landscape models and genomic databases the project strives to further understand how natural populations are able to colonise and adapt to new environments in the sea.

Perspective
By understanding past evolutionary processes in the sea we can help predict future responses to climate change and fishing pressures of specific fish populations. Knowledge about genetic variation can also be used to develop so called “assignment tools” to assign fish products (e.g. a filet on your plate) to, not only the right species, but also its respective population of origin (e.g. the Baltic or the North Sea). Thus, an overall objective of the project is to improve the usefulness of integrating molecular tools in the preparation of conservation and management plans for marine fish populations.

Title:
Local adaption in Baltic Sea small pelagic fishes

Supervisor:
Dorte Bekkevold

Section:
Population Ecology and Genetics

Zeren Gürkan

Background
Global climate change will challenge management of ecosystems and affect commercially exploited fish at all stages of life. It is therefore important to improve the scientific basis for fisheries management because the use of historically observed statistical relationships to predict future changes will become unreliable due to extrapolating responses to normal climate variability to a new climate regime.

Project
The PhD project addresses specific areas within a large scale project (SUNFISH: Sustainable fisheries, climate change and the North Sea ecosystem) that aims to improve the scientific basis at large and provide an integrated modelling framework for better fisheries management of the North Sea ecosystems. The objective is to develop individual-based models (IBMs) for early life-stages of fish based on key processes controlling feeding, growth and vulnerability to predation. These IBMs will be coupled to operational hydrodynamic biogeochemical models of the North Sea to analyse potential climate change effects in relation to spatio-temporal distribution and composition of warm and cold water zooplankton communities.

Perspective
The models can be used to simulate and forecast responses to changed climate scenarios such as fish recruitment impacted by availability, quality and abundance of zooplankton prey, and to examine scientific hypotheses, e.g. match-mismatch of fish larval hatch and food availability. Overall, models can assist in understanding susceptibility to direct and indirect climate change effects, e.g. trophic cascades, and contribute process knowledge that is important for an operational approach to ecosystem management of the North Sea.

Title:
Individual based modelling of growth and survival of cod and sandeel larvae

Supervisor:
Henrik Mosegaard

Section:
Population Ecology and Genetics

Mette Dalgaard Agersted

Background
The North Atlantic marine ecosystems will most likely be strongly influenced by future climate change. Therefore, it is crucial to understand how key organisms such as krill will respond to changes in their environment, e.g., warmer temperatures, and how that in turn will impact future ecosystem dynamics. Krill are a key zooplankton group in the oceans transferring energy through the food web by acting as a link between lower and higher trophic levels. Furthermore, they are significant contributors to the vertical flux of organic material through production of fast sinking faecal pellets. However, despite of being a key zooplankton group, knowledge on krill biology from the northern Atlantic and the Arctic is inadequate.

Project
The overall aim of this study is to improve our knowledge of the predominant North Atlantic krill species and their role in northern marine ecosystems. This will be pursued by combined field data and laboratory experiments. In the field krill distribution will be investigated in relation to hydrography, potential prey items and competitors. In the laboratory focus will be on functional biology of krill species.

Perspective
This PhD project is a part of the EURO-BASIN project. The overall aim of EURO-BASIN is to improve the understanding of the North Atlantic ecosystems during future climate conditions. This present project will contribute with knowledge regarding the functional biology of krill and this data will be incorporated into various ecosystem models.

Title:
Functional biology of krill in northern marine ecosystems

Supervisor:
Torkel Gissel Nielsen

Section:
Population Ecology and Genetics

Rikke Hagstrøm Bucholtz

Background
Fish exhibit a wide variety of reproduction strategies ranging from species that breed once in their lifetime and die, to species reproducing multiple times and spawning more than a million eggs, to yet other species being live bearers, which develop only few eggs and give birth to larvae. The reproduction strategy thus influences the stock reproductive potential (SRP) of a fish species and SRP is highly relevant for determining the robustness of fish populations to commercial exploitation. However the reproductive strategy and fecundity is little studied, including common exploited species such as whiting and haddock.

Project
The project applies stereology to study the reproductive tissue of female fish. Microscopy of ovarian tissue and stereological software is used to describe the process of recruitment and development of eggs in the ovary, which is essential to identify the reproduction strategy. The method also provides a novel approach to estimate fish fecundity and regulation of egg production. The project focuses on three commercially important species which represent different reproduction strategies found within the marine fish community: Herring, whiting and haddock.

Perspective
The project will apply new efficient and accurate methods to study the reproduction strategies of fish species, and assess fecundity and regulation of egg production in general. The application of the methods will lead to an improved understanding of the reproduction processes of herring and in particular whiting and haddock.

Title:
Stereology as a tool to assess reproduction strategy and fecundity of teleost fishes

Supervisor:
Jonna Tomkiewiez

Section:
Population Ecology and Genetics

Nuria Calduch Verdiell

Background
Many marine fisheries are reported as overfished on a global scale. This overfishing does not only remove fish biomass, but also truncates the age and size structure and reduces spatial heterogeneity of exploited populations because fisheries usually target the large-old individuals. These effects reduce the chances of maintaining populations at levels sufficient to produce maximum sustainable yields, the chances of recovery of populations that have been overexploited and create a selection pressure that favor early-maturing and slow-growing individuals.

Project
Recent evidence indicates that large-old females produce both a higher quality and quantity of eggs than smaller-younger females. However, most traditional management models assume that all female fish contribute equally per unit biomass to future recruitment. The main goal of this research is the development of a general age/size structured model to investigate the effects of overfishing and to understand the role of the large-old females in different types of fish stocks.

Perspective
The findings of this research will have important implications for management of marine fish populations.

Title:
Demography of fished populations: Yield, resilience and evolutionary change

Supervisor:
Ken Haste Andersen

Section:
Population Ecology and Genetics

Christina Frisk

Background
Recruitment of the commercially important Baltic Sea sprat stock has a strong and seemingly unpredictable year-to-year variation due to fluctuations in the physical environment in response to atmospheric forcing and longer term climate trends. Because sprat is short-lived the fluctuations in year class strength generate large alterations in stock abundance, thereby reinforcing the unpredictability of the forthcoming recruitment.

Project
The aim of the project is to develop a model framework of sprat for conducting detailed recruitment studies. The model is closely linked to the habitat of sprat as the observed high variability in the reproductive success in the stock is most likely linked to the interplay between food supply and temperature. We will further evaluate the stock dynamics under future climate scenarios.

Perspective
The research will provide detailed information on processes important for recruitment of sprat in the environment and under different climate scenarios. This improved understanding will enhance our predictive capabilities of the year-to-year variability in sprat recruitment.

Title:
Recruitment of sprat (*Sprattus sprattus*)

Supervisor:
Ken Haste Andersen


Photo Morten Limborg

Section:
Population Ecology and Genetics

Sune Riis Sørensen

Background
In recent years, the wild stock of European eel has seriously declined. This is not only a conservation concern but also the eel aquaculture industry that at present relies exclusively on wild caught juveniles is affected. Among public citizens a growing awareness of overexploited fish species is developing and recently the European eel was included in the CITES appendix II comprising species needing trade restrictions. Issues like this have heightened the rationale behind a focused research on reproduction of European eel in captivity. DTU Aqua has in recent years through a series of national projects improved our knowledge in this field and is currently capable of producing mass hatching of healthy larvae – a major step forward in less than five years.

Project
The PhD project links to a Danish research project REEL, *Reproduction of European eel in culture,* successor of the ROE projects, and an EU FP7 project PRO-EEL *Reproduction of European eel in captivity – towards a sustainable Aquaculture.* The aim of the PhD project is to determine experimentally the influence of physical and chemical parameters on eel embryonic and larval development. Main target areas are the determination of suitable temperature and salinity conditions as well as the applicability of probiotics versus antibiotics in the rearing of European eel eggs and larvae. In parallel, quality criteria for successful egg and larval development will be defined and applied in the evaluation of experiments.

Perspective
In the field of artificial reproduction of the European eel the results aim at optimizing methods for egg incubation and development of preleptocephalus larvae. A future production of high quality larvae and hence glass eels could counteract the critical depletion of the natural stock of eels by facilitating a self-sustained eel aquaculture and reduced fishing pressure.

Title:
European eel egg and larval development in relation to biophysical characteristics and gamete quality

Supervisor:
Jonna Tomkiewicz

Section:
Population Ecology and Genetics

Thomas Mosgaard

Background
Environmental factors (e.g. temperature) affect many aspects of fish physiology and individuals often respond to moderate changes in their environment by modifying their behavior. A population's ability to adapt to environmental change and the degree of environmental change it can tolerate, will vary and will determine whether it thrives or collapses when exposed to climate change.

Project
The project investigates how fishes are adapted to different environmental conditions by comparing different life history traits between populations of the same species over an environmental cline. Afterwards, the life history information will be used to predict how life-history strategies are likely to change under divergent climate and/or fishing conditions.

Perspective
Describing how fish will react to environmental change is necessary for the successful management of exploited fish populations. Our ability to predict how a fish population will react to a changing environment could mean the difference between successful stock management and unforeseen collapse.

Title:
Life history adaptations in fish

Supervisor:
Henrik Gislason

Section:
Population Ecology and Genetics

Viola Neumann

Background
Baltic cod (*Gadus morhua*) is one of the most important commercial fish species in the Baltic Sea and played a dominant role in the Baltic Sea food web for many years. Since a dramatic decline in stock size in the 1980's, the upper trophic levels shifted from a cod-dominated to a sprat-dominated system. In recent years, the Eastern Baltic cod stock shows signs of recovery at least partly due to stronger year-classes. Eastern Baltic Cod recruitment success is influenced by various abiotic and biotic factors in its main spawning area, the Bornholm Basin. These include ambient hydrographic conditions as well as predation pressure on early life stages by planktivore clupeids, sprat and herring.

Project
The aim of this PhD project is to estimate basin-wide predation rates on early life stages of cod (*Gadus morhua*) by sprat (*Sprattus sprattus*) and herring (*Clupea harengus*) in the Bornholm Basin of the Baltic Sea. This objective implies to quantify and characterize the small- to meso-scale spatial distribution of cod ichthyoplankton stages and clupeid predators both in terms of abundance and temporal/spatial aggregation as well as overlap. Focus is also on aggregations of both predator and prey and evaluation of aggregation driven predator rates.

Perspective
This study will contribute to the classical stock recruitment research in the Baltic Sea by providing actual information about recent predator-prey interactions in light of a possibly changing biological and physical system, with recovered cod and a declining sprat stock in the central Baltic. It will estimate predation pressure by clupeids on cod early life stages from 2004-2009 and will compare the results to earlier studies (1990-2003) in the same area, under different ecological conditions.

Title:
Externally driven mortality of Eastern Baltic cod early life stages: Impact of predation and hydrography

Supervisor:
Fritz W. Köster

Section:
Population Ecology and Genetics

Anja Oelschlägel

Background
Decades of nutrient loading to Danish coastal systems has resulted in higher primary production and has favored filter-feeders. Nutrient loading has also had adverse effects such as increased occurrence and duration of oxygen depletion events and has raised concerns for ecosystem health. The EU Water Framework Directive (WFD) addresses this concern and requires actions to be taken by the responsible authorities (Danish municipalities) to reduce impact of nutrient emissions and other disturbances in order to achieve good ecological status.

Project
The specific aim of the PhD is to investigate the impact of low salinity and phytoplankton composition on the growth and efficiency of blue mussel cultures in removing phytoplankton and thereby nutrients from eutrophied brackish fjords. The impact of the occurrence of blooms of cyanobacteria on the growth capacity of the mussel cultures and possible alleviating counter measures will also be investigated. This will be achieved through field and laboratory studies of mussel filtration, growth and behavior as a function of salinity and cyanobacteria/phytoplankton composition.

Perspective
The filtration and growth responses of blue mussels to low salinity, cyanobacteria and other phytoplankton will be used to assess the nutrient extraction potential of blue mussel cultures in Danish coastal areas as part of the MUMIHUS-project and in co-operation with its national and international partners.

Title:
Mussel growth and filtration in relation to salinity and food conditions

Supervisor:
Per Dolmer

Section:
Coastal Ecology

Louise Kristensen

Background
It is well established that a structurally complex habitat has a higher abundance of species and individuals than habitats of lower structural complexity. A complex structure provides hiding places for prey species of different sizes while at the same time also attracts predators due to the high abundance of prey. Although the habitat complexity issue has been the focus of many previous studies, it is still difficult to determine exactly how complex a specific habitat is. Some studies have developed methods for quantifying the habitat complexity, but these methods are either only applicable to one particular habitat type or they are very laborious.

Project
The aim of the PhD project is to determine the effect of habitat complexity on the distribution and behaviour of fish related to the sea bottom. On the basis of previous studies, this project will also determine the suite of parameters that are most important for the distribution and behaviour of demersal fish. Parameters expected to have the greatest impact are (1) sediment type (grain size), (2) percentage structural coverage, (3) rugosity of the structure (amount of wrinkles or ridges), (4) vertical release (depth), and (5) size of cavities within the structure (hiding places).

Perspective
When dealing with management, environmental evaluation and protection/ preservation of marine habitats, it is important to know if a habitat is important or not to marine species. The tools developed in this study to quantify complexity will improve our ability to predict the distribution of fish within a given area.

Title:
The importance of habitat structure on distribution and behaviour of demersal species

Supervisor:
Josianne G. Støttrup

Section:
Coastal Ecology

Maria Røjbek

Background
The fish community in the central Baltic Sea is dominated by three closely interlinked species: cod, sprat and herring. Baltic cod prey mainly on sprat and herring and their nutritional value influences growth and reproduction of cod. Low recruitment of cod and a decrease in condition of both sprat and herring was observed in recent decades coincidently with a remarkable delay in spawning time of Baltic cod affecting survival of early life stages of cod.

Project
This project examines the effect of dietary lipid content and fatty acid composition on the maturation process and survival of offspring. The study combines investigations of seasonal lipid dynamics in Baltic cod, sprat and herring and potential limitations in essential fatty acids in the Baltic cod food web with experimental work on the effect of different levels of essential fatty acids on the quality of egg and larvae and the timing of spawning in captive cod.

Perspective
The results will enhance our knowledge of the relationship between the Baltic cod food web and the reproductive success considering impact of climate and environmental changes on ovarian maturation and spawning time. Furthermore results can be used to enhance broodstock feed and improve the quality of egg and larvae in cod farming.

Title:
Cod Reproductive Ecology: Effect of dietary fatty acids on ovarian maturation, spawning time and quality of eggs and larvae

Supervisor:
Josianne G. Støttrup

Section:
Coastal Ecology

Helle Torp Christensen

Background
Blue mussels are a valuable resource for commercial shellfish production both in the context of fishery and aquaculture. The species is an ecological keystone-organism and is also very important in relation to nature conservation and habitat restoration initiatives. Blue mussels construct biogenic reefs providing complex structures to coastal habitats. The structure of the reef is important in relation to interactions between organisms on the reef, including interactions between blue mussels and their predators and aspects of coexistence with other species such as bio-invasive bivalves. The value of the blue mussel both in terms of the potential for biogenic reef formation and water column biofiltration makes it relevant to evaluate the usage of these organisms as a tool in habitat restoration.

Project
The primary goal of the PhD project is to establish a base line ecological understanding of the blue mussel while targeting issues at a number of different scales: (1) Individual - differences in predatory response between seed mussels collected on suspended long lines and on natural mussel beds on the sea bed, (2) Niche - trade off between predatory protection and reduced food availability and coexistence with an invasive species as competitor, and (3) Habitat - the use of blue mussels as substrate providing structure diversity and the growth of seed mussels after transplantation.

Perspective
Biogenic reefs are included in the EU Habitat Directive and mussel beds may consequently be prioritised for protection in protected areas in relation to NATURA 2000 to fulfil objectives in the Habitat Directive. As a natural resource without interference of artificial constructions the use of blue mussels can become an ecological important tool to secure substrate diversity, water quality and biogenic reefs.

Title:
Structure of soft-bottom mussel beds in habitat improvement perspective

Supervisor:
Per Dolmer

Section:
Coastal Ecology

Diego del Villar-Guerra

Background
Sea trout is a primary species for recreational angling in Denmark. It is the most important species in the large coastal fishing as well as the most important catch in river fisheries. A considerable part of the sea trout (*Salmo trutta*) lifecycle takes place in the marine environment. Basic knowledge on survival and behaviour is relatively well documented in the freshwater phase. Equivalent knowledge in the marine phase is, however, very poorly documented. A significant contributing factor has been methodological problems in addressing this phase. However, recent state of the art development within the field of telemetry has now made it possible to study sea trout behaviour in the marine phase more thoroughly, principally by using electronic tags.

Project
The objective is to study important aspects of fish migration and behaviour by applying different telemetry methods including: Acoustic tags, DST tags, PIT tags; alone or in combination, in areas (the marine phase) where the available bibliography for the species is rather sparse or nonexistent. The research addresses how external factors (environmental factors) and internal factors specific to the population (e.g. population demographic structure, population memory, density-dependent habitat selection) affect the migration and survival of the fish in the early and late marine phases.

Perspective
The project aims to expand our knowledge base on sea trout behaviour and survival in the marine environment. In addition the project has the potential to provide detailed information on a number of other important life history events, such as timing of upstream and downstream migration, run timing of maiden vs repeat spawners and potential correlation between run timing of smolt phase and adult phase.

Title:
Marine Survival of Sea Trout

Supervisor:
Kim Aarestrup

Section:
Freshwater Fisheries Ecology

Mikkel Boel Sørensen

Background
Fish can exhibit several life history strategies within a population. The lake dwelling brown trout, *Salmo trutta* L., of Lake Hald is a landlocked population and relies solely on individuals residing in the lake and its tributaries. Although being landlocked for hundreds of years, this population still harbors at least three life history strategies. The underlying differences of life history strategies in salmonids are not yet fully understood. The presence of a fish species in an ecosystem can affect the entire ecosystem it inhabits. Specialist planctivores are known to impose competition on early life stages of predatory fish species. Alewives, *Alosa pseudoharengus*, are specialist planctivores that can exhibit two life history strategies, landlocked and anadromous, which affect zooplankton dynamics differently. Ultimately, this may translate into different influence on concurrent predatory species.

Project
The movements and fates of trout is monitored by using telemetry, passive integrated transponder (PIT) tags and PIT listening stations in the tributaries and the outlet of the lake. This allows the monitoring of trout movements in and out of the lake and the identification of life history strategies within the population; resident, lake dwelling and migratory brown trout. Individuals from these strategies are collected for characterization of strategy related physiological differences. The effect of Alewife life history strategies on concurrent species is evaluated by differences in the ontogenetic diet shifts, the ascent in trophic position and the growth in young-of-the-year Largemouth bass, *Micropterus salmoides*, from lakes that have either no Alewives or one or the other life history strategy.

Perspective
The scope of this study is to contribute to the understanding of life history strategies and interplay with competition and predation.

Title:
Life histories within anadromous fish populations

Supervisor:
Anders Koed

Section:
Freshwater Fisheries Ecology

Henrik Baktoft

Background
The literature is rich on studies on fish physiology and behaviour. However, the majority of these are conducted under laboratory conditions that often show very weak resemblance to a natural environment. Therefore, findings from these studies might be biased by artefacts caused by the experimental settings, obscuring the true picture. Moreover, the ecological significance of findings from laboratory studies has rarely been tested under natural real-world conditions.

Project
Utilising some of the most advanced technologies in the field of fish telemetry, this project will attempt to explore the missing link between the laboratory findings and their significance in a natural environment. Using standard lab protocols, various physiological and behavioural variables will be measured on a group of fish, individually identifiable. Subsequently, the same individuals will be equipped with acoustic transmitters and released in a natural environment in which an array of hydrophones allows for automatic continuous surveillance of the tagged fish.

Perspective
This project aims at linking lab-findings on fish physiology and behaviour with findings in a natural environment. Furthermore, the ecological significance of various physiological variables will be evaluated.

Title:
Individual fish behavior and physiology - linking lab to nature

Supervisor:
Lene Jacobsen

Section:
Freshwater Fisheries Ecology

Marine Roland

Background
One of the issues of the rapidly growing aquaculture sector is to find fish meal substitutes. The main focus has been on plant proteins as a substitute for fish meal in the diet formulation. However, significant incorporation of plant proteins in the fish diet often results in reduced growth and/or feed efficiency. Recent trials have shown that the profile of amino acid uptake varies between rainbow trout fed plant based diet and fish meal diet. This difference in amino acid availability is likely impacting the protein biosynthesis in the fish and could partly explain the lower performance of fish fed plant based diets and also the higher ammonia excretion. Nitrogen is a limiting pollutant in Danish aquaculture in most of the case and its excretion is directly related to the feed and its utilization by the fish.

Project
The project is designed as a series of experiments to further examine how and why amino acid uptake patterns differ. The project will examine the correlation between amino acid profile in the diet and amino acid in the blood following feeding, as well as the possibility of balancing any deficiencies that may arise from a suboptimal diet. The suitability of a variety of plant meals will be evaluated in a second study, which has the additional purpose of identifying changes to the metabolic and digestive system by using enzyme activities as indicators. The project will terminate in a growth study, using best practice/knowledge obtained from the first experiments to identify the most suitable plant protein to balance with amino acids, using digestibility, growth, feed conversion and ammonia nitrogen excretion as the primary indicators.

Perspective
Extended knowledge about the amino acids uptake profile of fish will contribute to the optimization of fish feed formulation in terms of meeting the nutritional demands of the fish with consideration for sustainability, environment and production efficiency.

Title:
Amino acids uptake patterns in fish fed plant-based protein and the effect on protein utilization

Supervisor:
Peter Vilhelm Skov

Section:
Aquaculture

Danielle Caroline Laursen

Background
In the aquaculture industry, fish are exposed to a range of unfavorable conditions, such as high densities, frequent handling and transport. These conditions can induce stress, which may potentially be detrimental to welfare. It has been recognized that decreased welfare may compromise health and quality of the fish, and ultimately have an impact on production efficiency. Furthermore, there is an increasing public concern for the wellbeing of fish from aquaculture. This highlights the importance of carrying out studies to enhance our knowledge base and develop methods to improve rearing conditions for cultured fish.

Project
The project will investigate the influence of stocking densities, water current and cover on fish welfare. This will be achieved through the use of preference testing to investigate the behavioral and environmental needs of farmed rainbow trout (*Oncorhynchus mykiss*). The experimental work will be carried out using a two choice experimental set up. Two tanks, representing two separate environments, will be attached to one another via a closable opening allowing the fish to move freely between the two environments and distribute themselves according to the resources available there.

Perspective
The knowledge obtained from the study will improve our understanding of the social and environmental needs of rainbow trout and the results are expected to be generally applicable directly to the fish farming industry.

Title:
Welfare of farmed rainbow trout (*Oncorhynchus mykiss*), social and environmental preferences

Supervisor:
Erik Höglund

Section:
Aquaculture

Madelene Åberg-Andersson

Background
The production cycle in modern fish farming is closely based on the natural life cycle of the fish. In many salmonids, individual variation in metabolism and timing of the shift to exogenous feeding has been shown to predict social dominance, growth and life history strategy. Individuals that have a fast larval developmental rate and reach first feeding early are usually considered to have a competitive advantage. However these benefits may be offset by other factors such as increased predator exposure. These selective pressures maintain variability in developmental rate in nature and this variability is still present in hatchery stock. However whether such variation affects the performance of fish in hatcheries and aquaculture rearing units remains debated.

Project
The principle and objective of this project is to investigate if there is a relationship between larval development and performance in later life stages of farmed Rainbow trout.

Perspective
This project aims to increase our knowledge about variations in developmental rate in rainbow trout, and utilize this knowledge to increase the effectiveness of fish production and meet the requirements of the modern customer. Ethical quality, for instance, is a subject of increasing concern, and the welfare of farmed fish is an issue of growing importance.

Title:
Individual variation in developmental rate in Rainbow trout larvae; implications for welfare and production aspects in modern aquaculture

Supervisor:
Erik Höglund

Section:
Aquaculture

Kim Schön Ekmann

Background
The aquaculture industry is becoming increasingly important in supplying high quality aquatic products for human consumption. Presently, aquaculture supplies more than 50% of the fish, mollusks and crustaceans consumed worldwide. Two major concerns in aquaculture are the utilization of industrial fishes for feed production and eutrophication of aquatic environments.

Project
The efficiency with which an animal incorporates protein into flesh is termed protein retention efficiency (PRE). Salmonids are considered to be most efficient amongst fish and PRE's as high as 55% have been reported. Gilthead seabream, which is one of the major commercial aquaculture species in Europe, converts protein with only half the efficiency of salmonids. The purpose of the project is to determine the fate of dietary amino acids in Gilthead seabream. The fate of whole protein and amino acids will be traced using stable isotopes, to determine muscle incorporation and excretion rates. Experiments will examine amino acid digestion and rate of uptake, protein synthesis and degradation and potential conversion of amino acids into fatty acids. This should allow the prediction of the dietary amino acid requirements of Gilthead seabream under a given nutritional regime.

Perspective
Accurately establishing the nutritional demands of Gilthead Seabream, will make it possible to accurately balance the nutritional composition of commercial diets to the actual requirements of the farmed species. This will allow for a more responsible and sustainable utilization of marine resources in feed production, and reduce the discharge of substances that contribute to water eutrophication.

Title:
Amino acid metabolism in gilthead seabream (*Sparus aurata*) - the fate of protein derived nitrogen

Supervisor:
Peter Vilhelm Skov

Section:
Aquaculture

Jordan Poul Feekings

Background
Discards within European fisheries have historically been some of the highest in the world. This coupled with the fact that several important stocks are now at an all time low, makes the practice of discarding an issue of great concern. Trawl fisheries in the North Sea, Skagerrak and Kattegat are often characterised as mixed fisheries, where landings are comprised of different species of both commercial and non commercial significance. Due to the limited selectivity of trawls a majority of the landings are discarded, even if of commercial value. It is therefore important to improve the knowledge of discarding patterns, and in particular to identify management options that can be used to reduce discarding.

Project
The principle objective of this project is to investigate discards within the North Sea, Skagerrak and Kattegat demersal trawl fisheries and identify possible mitigation tools. The factors that determine discard amounts, including environmental settings, fishing methods, minimum landing sizes, year-class strength, and species composition shall be analysed. This includes an examination of the efficiency of technical regulations currently in force and retrospective analyses of the efficiency of such measures in the past. A part of the project will be related to projects aiming at developing trawls with improved selectivity patterns. This PhD project collaborates with The Institute of Marine Research (*IMR*) Sweden on issues concerning Kattegat and Skagerrak, and the international EU project:"Bycatch and discards: management indicators, trends and location".

Perspective
Fisheries are an important source of protein and livelihood for the world over and something to be sustained for future generations to enjoy. By understanding the patterns that cause discarding we can improve the management of our fisheries and help to achieve these goals.

Title:
Discarding and identification of possible mitigation tools in demersal trawl fisheries

Supervisor:
Niels Madsen

Section:
Management Systems

Lotte Kindt-Larsen

Background
The harbour porpoise (*Phocoena phocoena*) is the only cetacean known to breed in the Danish waters. In order to protect the population, Denmark has designated 8 marine areas where conservation of the harbour porpoise is of highest priority. Incidental by-catch of harbour porpoise happens in various types of gill nets. There is therefore, a need for improved knowledge on management of gillnet fisheries in protected areas as well as development of new technology to avoid bycatch of harbour porpoise in the gillnet fisheries.

Project
The objective of the PhD study is to develop methods and management tools to accomplish a sustainable management plan. This includes: (1) CCTV monitoring will be installed on gillnet vessels in order to document the fishery, (2) Acoustic signals to make porpoises aware of gill nets will be tested, and (3) Telemetry data from porpoise satellite tags and GPS positions from fisheries will be used to identify areas of overlap between porpoises and fishing grounds.

Perspective
The marine protected areas concept is a widely used tool in marine mammal conservation. Development of technology and sustainable management tools in order to fulfill the conservation plan of a marine protected area is therefore of high importance.

Title:
Management of fisheries in harbour porpoise protected areas

Supervisor:
Bjarne Stage

Section:
Management Systems

An Hoia Pham

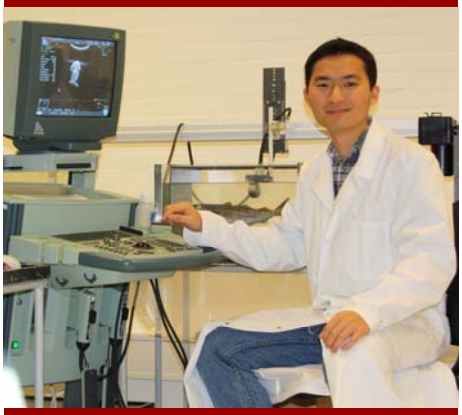
Background
Acoustic fish identification is important both in fisheries research and in commercial fishery. However, there is a critical compromise between image resolution and detection range. Current development of new sensor platforms like AUVs (Autonomous Underwater Vehicles) allows the introduction of short range high resolution sensors and new methods.

Project
Backscattering of ultrasound from fish in the MHz range has been studied by simulation and experiment to determine the frequency range and signal processing needed to differentiate between different fish species. A library of profiles will be generated and used to help identify fish using a single beam transducer. Based on the results, a new method will be developed to identify the fish.

Perspective
A new method will be developed that can enable *in-situ* fish species discrimination using ultrasound.

Title:
***In situ* identification of marine organisms using high frequency, wideband ultrasound**

Supervisor:
Bjarne Stage



Section:
Monitoring

DTU Aqua – National Institute of Aquatic Resources – is an institute at the Technical University of Denmark (DTU).

The purpose of DTU Aqua is to provide research, advice and education within the sustainable exploitation of living marine and freshwater resources, the biology of aquatic organisms and the development of ecosystems.

We have our own PhD School with 30-35 PhD students enrolled. In this publication we present the current PhD projects.

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