PhD projects at DTU Aqua

March 2019
Preface

This web-publication “PhD projects at DTU Aqua” presents 47 PhD students enrolled at DTU Aqua’s PhD school as of 1 March 2019.

Each PhD project is described by the PhD student. You will additionally find information on research section affiliation and supervisor. 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.

Our mission is to make sure that our PhD students engage themselves with front line research, whether it is for utilizing new technological approaches in their data collection and processing, for statistical treatment and evaluation of data, or for mathematical modelling. Our ambition is to secure the next generation of innovative and broadly educated applied aquatic scientists that can face the challenges that e.g. climate change and an increased utilization of aquatic resources present to us.

Ken H Andersen
Head of the PhD School at DTU Aqua

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Anna Luiza Farias Alencar

**Background**
Viral diseases are responsible for major economic losses in fish production worldwide while Viral Hemorrhagic Septicemia virus (VHSV) and Infectious Hematopoietic Necrosis virus (IHNV) stand as the most significant threats for European salmonid aquaculture and therefore are notifiable listed diseases in the EU. VHSV is responsible for an acute systemic disease with similar symptoms to those caused by IHNV. Both diseases represent serious threats for fish farmers thus efficient diagnostic tools allowing active and passive surveillance are required. VHSV has been isolated not only from farmed fish but is endemic among marine fish species in European waters, being an important reservoir. It is known for causing severe disease in rainbow trout characterized by the destruction of endothelial lining and therefore internal hemorrhagic foci is a common clinical sign. Affected fish become slow and lethargic. Mortality varies but it can be up to 100% in rainbow trout fry. VHSV isolates from wild marine fish typically produce medium to no mortality in rainbow trout following waterborne challenge, and the reverse situation (challenge of marine fish species with isolates from rainbow trout) generates similar results. However marine VHSV isolates are indistinguishable from freshwater isolates by common serological means. It is therefore of urgent need for the fish farming industry to have tools to discriminate between the virulent and non-virulent forms of these viruses.

**Project**
My project aims to identify putative virulence markers of VHSV and characterize these markers through a reverse genetics system with the generation of recombinant viruses (chimeric and site directed mutagenesis). This PhD project is carried out within the framework of the project NOVIMARK funded through ERA-net anihwa as a transnational project by the Danish Council for Strategic Research.

**Perspective**
The expected outcome is therefore improved understanding of immunity and virulence and improvement of diagnostic tools and strategies to be used in commercial European aquaculture.

Sofie Hansen

**Background**
The Mediterranean aquaculture industry is compromised by nodavirus infections causing considerable disease and mortality in European sea bass (Dicentrarchus labrax) and recently also gilt-head sea bream (Sparus aurata), the two main cultured marine fish species in the region. This project is part of a large collaborative EC H2020-supported research and innovation action focusing on improved competitiveness and sustainability of Mediterranean aquaculture production. Currently, one of the major bottle-necks for the development of aquaculture of sea bass and sea bream is Viral Encephalopathy and Retinopathy (VER) also known as Viral Nervous Necrosis (VNN), an infectious disease caused by betanodavirus, a member of the family Nodaviridae.

**Project**
This project will focus on optimizing a vaccine prototype against nodavirus infection in sea bass based on recombinant VLPs (virus like particles). A nodavirus infection model will be established in sea bass at the facilities at DTU and this model will be used for testing different vaccination strategies, including dose, delivery and adjuvant aspects and to characterize the vaccine induced immune response, protective mechanisms and safety aspects as well as. Protection across viral genotype/serotype will also be assessed under experimental conditions. Finally, the vaccine will be tested under field conditions in Mediterranean fish farms.

**Perspective**
A safe and efficient vaccine against nodavirus will directly improve the survival rates of sea bass in Mediterranean fish farms thus improving the sustainability and competitiveness of Mediterranean fish farming.
Valentina Donati

Background
*Flavobacterium psychrophilum* is a Gram-negative bacterium and a worldwide-known pathogen in salmonid aquaculture. It is in fact the responsible agent of rainbow trout fry syndrome (RTFS), infective disease causing devastating economic and ecological effects in most rainbow trout hatcheries. Due to the rise of antibiotic resistance and the unavailability of a commercial vaccine, novel methods need to be developed to control this infectious disease. Bacteriophages (phages), host-specific viruses of bacteria unable to replicate in eukaryotes, represent a potential alternative. The research project titled “Bacteriophage based technology to control Flavobacterium pathogens in aquaculture” aims to increase salmonid welfare and survival in hatcheries reducing the need for chemical and antibiotic treatments. FLAVOPHAGE is a collaboration of Baltic partners and focuses on the development of a phage-based technology to fight Flavobacterial infections in rainbow trout, *Oncorhynchus mykiss* (Walbaum).

Project
My PhD project mainly focuses on the development and optimization of a phage-based treatment. An experimental challenge model with *F. psychrophilum* will be set up and phages will be orally administrated to rainbow trout fry. In order to evaluate the potential of the phage treatment, fish survival, welfare and growth will be quantified as well as the spread of phages in fish organs. The project will also investigate how the fish gut microbiota is affected by the phage treatment. In addition, contributions will be provided in the characterization of virulent *F. psychrophilum* bacteria and in the study of the interactions of *F. psychrophilum* with rainbow trout eggs.

Perspective
The results of my PhD project will contribute to the development of a phage-based treatment with the aim of reducing the use of antibiotics in aquaculture and increasing welfare and survival in rainbow trout farming.

Esther Beukhof

Background
Marine ecosystems are exposed to both environmental and anthropogenic stressors, such as climate change and fishing, leading to concerns about the influence of such stressors on ecosystem processes, goods and services. Traditionally, fisheries management has focused on single species and populations. However, more emphasis is now put on developing management tools that can aid in assessing whole fish communities and their relation to ecosystem functioning. Trait-based approaches are a promising way to increase our understanding of fish community dynamics. Traits related to size, growth, diet and reproduction are believed to hold information on how organisms will respond to changes and how they impact ecosystems functions.

Project
The main aim of the project is to gain insight into the spatial and temporal distribution of traits in marine fish communities around the globe. By collecting and combining data of fish species distributions, fish traits, environmental conditions and ecosystem functions, relationships between them will be tested through statistical modelling.

Perspective
Understanding how the structure of fish communities in terms of their traits relates to environmental conditions and anthropogenic pressures, can be used as input for predictive models. For instance, a trait-based model could be developed that predicts the consequences for ecosystem functions under different scenarios of climate change and fishing intensity.
Tróndur Jónsson Kragesteen

**Background**
The aquaculture industry has seen a steady high growth over the last two decades and the production of Atlantic salmon was alone 2 m tonnes in 2015. However, there is also a growing challenge to combat sea lice infestations, which has also seen a growth in abundance as well as resistance in the last decade. Managing sea lice has not been effective due to the lack of understanding how sea lice spread in a local and regional scale. Therefore countries like Norway, Scotland and Canada are developing numerical models of the dispersion of sea lice that could be used as a managing tool in the industry.

**Project**
This PhD is the first attempt to construct such a numerical model for Faroe Islands (the third largest Atlantic salmon producer in Europe) of sea lice dispersion. The work is an industrial PhD in collaboration with Fiskaaling A/S, an aquaculture institute in Faroe Islands. In the first part of the PhD I will look at how the Faroese aquaculture farms are hydrodynamically connected with reference to salmon lice. A second part of the research will focus on implementing a SIR model for Faroese salmon farms. This model can provide information on how important the external and internal infections are to the population dynamics. The third part will focus on making the model operational by improving process descriptions, like wind, freshwater and salmon lice behaviour. The operational model will be validated with all available sea lice data and it will be used to help identify the most effective treatment management plan for Faroese salmon farms.

**Perspective**
The problems facing the aquaculture industry due to sea lice is rapidly growing. Therefore constructing a reliable numerical oceanographic model that can project the dispersion of sea lice around Faroe Islands will greatly benefit the aquaculture industry by making it possible to develop a robust and sustainable treatment management plans.

*This is an industrial PhD in cooperation with Fiskaaling A/S, Faroe Islands.*

Aurore Maureaud

**Background**
The effects of changes in marine biodiversity on the ecosystems are still unknown and need further exploration, especially in the context of biodiversity loss threatening ecosystem services. The link between biodiversity and ecosystem functioning has been investigated in science for more than two decades. The biodiversity-ecosystem functioning (BEF) relationship has been largely tested experimentally, on enclosed ecosystems, on small parts of the food web, mainly on terrestrial ecosystems or using empirical data. Hence, there is a need in marine science to investigate the BEF relationship, using global observed data and modelling methods.

**Project**
The aim of this PhD is to explore the shape and characteristics of the BEF relationship in marine ecosystems, using a broad range of metrics for biodiversity and functions. This project will use a comprehensive set of spatio-temporal data on marine species distributions, abundances and traits sampled across trophic levels as well as modelling and statistic tools. The established links can reveal the shape and nature of the BEF relationship and shed light on key ecological processes in marine food webs, such as trophic cascades, functional complementarity and ecosystem resilience.

**Perspective**
To create a global picture of marine ecosystems, environmental forcing and anthropogenic impacts must be considered. A perspective in this PhD is to assess the impacts of fishing, climate change and natural environmental variability and to the possible extent establish some potential projections of this BEF relationship.

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Title: Reduction of salmon lice infestation in Faroe Island
**Supervisor:** Ken Haste Andersen

Section: Centre for Ocean Life

Title: Understanding the biodiversity-ecosystem functioning relationship through large scale observations and modelling
**Supervisor:** Martin Lindegren

Section: Centre for Ocean Life
**Neil Maginnis**

**Background**
Anthropogenic impacts and rapid climate change are leading to species losses. How this affects ecosystem functioning will depend on the relationship between Biodiversity and Ecosystem Functioning (BEF). If small losses of diversity have significant impacts on ecosystem functioning then anthropogenic impacts on the natural world will need to be reduced dramatically.

**Project**
I will explore the BEF relationship in coral reef ecosystems. In particular, this project will investigate the role of trait diversity at multiple trophic levels, testing whether diversity of coral growth forms promotes greater functional diversity in the fish community. I will then investigate the influence of functional diversity in the fish community upon ecosystem recovery following disturbances. Coral reefs vary in their diversity and recent bleaching of corals across this gradient of diversity provides a test case for the role of diversity in maintaining ecosystem functions.

**Perspective**
The BEF relationship is underexplored in the marine realm, particularly in coral reefs. By focusing on coral reefs, this project will address a gap in our understanding of BEF relationships in these highly diverse systems. Their response to species losses will be of great importance to the approximately 500 million people that depend upon them.

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**Maria Camila Serra Pompei**

**Background**
Copepods play a key role in shaping the marine plankton community by imposing a top-down control on the microbial system, and by partly regulating composition and abundance of planktivorous fish. Additionally, copepods largely contribute to the biological pump, enhancing carbon sequestration into the deep ocean. One of the main gaps in plankton models is the implementation the complex life cycle of this multicellular organism, which is most likely to affects both the microbial domain and the dynamics of its predators.

**Project**
The aim of this project is to develop a set of trait-based models of copepod populations and communities to better understand the observed seasonal succession and the environments that select overall copepod traits. Two approaches are adopted to model ontogenetic development: Stage-structured models and physiologically-structured models. The overarching aim is to embed this model of multicellular organisms into a larger model that includes the overall planktonic ecosystem ranging across several trophic levels. The model will be validated with data from the California Current, a system characterized by strong temporal variations and steep environmental gradients, being in many respects representative for other major upwelling systems supporting large fisheries of planktivorous fish.

**Perspective**
Developing mechanistic models of copepod’s life cycle will help understanding the observed dynamics of these organisms in nature, and will improve the performance of ecosystem models at predicting effects of climate change on higher trophic levels and on the biological pump systems.
Josephine Grønning

**Background**
It is estimated that via their photosynthesis, phytoplankton account for more than half of the world’s oxygen production. Phytoplankton is a highly diverse group of organisms, of which many have evolved what is believed to be defence mechanisms. Examples include hard shells, colony formation, and toxin production; all believed to reduce predation mortality. However, the trade-offs are often not documented, neither the benefits nor the costs, and even more rarely quantified. Many presumed defense mechanisms are inducible, that is, they are only harnessed in response to the presence of grazers (or grazer signals, e.g., chemical cues), and that may apply also to both colony formation and shell thickening in diatoms.

**Project**
My PhD project explores defense mechanisms and trade-offs in diatoms. The overarching aims of my project are to firstly provide a mechanistic description of how (and if) shell- and colony formation in diatoms provides protection. Secondly, to quantify the costs and benefits of these assumed defense mechanisms, and finally examine how the costs are paid, i.e. as a reduction in nutrient affinity (competitive ability), as a change in resource allocation from growth to defense, or as elevated mortalities due to other grazers.

**Perspective**
This project will provide a good mechanistic understanding of defence mechanisms in diatoms, provide estimates of the trade-offs and of how these trade-offs depend on the presence of different types of grazers. This information will form the basis for more robust trait-based models of plankton, their structure and function, that are currently being developed at the Centre for Ocean Life.

Fredrik Ryderheim

**Background**
Much like terrestrial plants, phytoplankton have developed a wide range of defense mechanisms. These defense mechanisms have likely evolved due to predation pressure as a form of grazing deterrent, and while several benefits of being defended have been documented, the associated trade-offs are often poorly described or not quantified. To consider defense mechanisms adaptive there must be associated costs. otherwise non-defended species or strains would be outcompeted and all species would be equally defended, which they are not.

**Project**
My PhD work aims at identifying and quantifying the trade-offs and benefits of physiological defense mechanisms in marine dinoflagellates. It has been suggested that these costs are small or insignificant, but research that is more recent propose that they might only be detectable under nutrient limiting conditions. The experimental designs of my work will revolve around limiting the available nutrients, thus making the organism choose where it expends resources, i.e. growth, or defense. The focus of my initial project will be on the production of toxins in marine dinoflagellates. Many of these toxins work as grazer deterrents and can vary among dinoflagellate species, but as of yet there have been no real quantification of the associated trade-offs. I will also look into bioluminescence as a possible aposomatic signal used by dinoflagellates to warn grazers of toxicity.

**Perspective**
The results of my work will improve our understanding of predator-prey interactions in the plankton food web. We expect to add to the knowledge of toxin production as a defense mechanism and establish the potential fitness costs and trade-offs and under what conditions they occur. This will help improve understanding of the mechanism and the evolution of inducible toxin production as a trait.
João de Jesus Gregersen

Background
Aquaculture has experienced a large and fast growth over the last 40 years. The advance of recirculation aquaculture systems (RAS) is a result of this development and has enabled not only an increase in the production but also a partly decoupling of the production from the environment. Recirculation aquaculture systems rely on in-farm, biological and mechanical filtration technologies that remove nutrient waste from the water and allow it to be reused for longer periods of time, reducing total water requirements. One of the main waste products removed by the different filtration methods in aquaculture are suspended solids. However, the removal of suspend solids is mostly limited to large particles, leaving micro particles to accumulate in the systems. This results in a deterioration of water quality and an increase in surface area available for the development of bacteria.

Project
The main focus of this project is to improve the knowledge on the dynamics of micro particles in RAS, as well as their implications in fish health and the systems performance. To do so, the main objectives of this project are to: 1) Identify the current status of Danish aquaculture with respect to micro particle loadings and dynamics, 2) identify causes and effects of micro particles in RAS, 3) assess the impact of micro particles on fish health and immunological responses, and 4) explore ways of reducing the amount of micro particles in RAS.

Perspective
The project will allow for an improved understanding of important water parameters and help to develop better management protocols for aquaculture productions. The improvements obtained by more stable and cleaner water conditions should allow for increase welfare of the fish produced in aquaculture, as well as increase aquaculture production efficiency via increased fish performance, while allowing for a reduction on the discharge levels of particles to the environment.

Renata Gonçalves

Background
The European lobster, *Homarus gammarus* L., is a commercially important and highly-priced decapod species in northern Atlantic area. A general decline in catch per unit effort has been observed, with occasional stock collapses. The release of hatchery-reared post larvae in the wild has been used as a fisheries management tool to counteract this decline. The success of stock enhancement depends on the production of high-quality juveniles with higher chances of survival after release into natural habitats. A major bottleneck of lobster culture concerns the low survival rates given their highly cannibalistic nature, particularly if the feed is sub-optimal. A promising solution is moving away from live/frozen food and embracing a dry formulated diet. This type of diets can offer several advantages, in particular, a more consistent nutritional quality. However, the development of formulated dry feeds for lobsters has received little research effort compared to the improvement of water quality and rearing technologies. Thus, commercially dry feeds specifically designed for European lobsters are not yet available. Some attempts to grow lobsters on dry feeds have been tried with fish and shrimp pelleted diets, but they are likely to have sub-optimal protein, carbohydrate and lipid composition.

Project
The focus of this PhD project is to explore the nutritional requirements and metabolism of European lobster larvae and post-larvae. The specific goals are 1) to define macronutrient requirements of post larvae, 2) understand nutrient metabolism of larvae, and 3) evaluate performance of post larvae fed optimized experimental feeds under temperature stress.

Perspective
Generated knowledge from this project will provide valuable insight for the formulation of nutritionally balanced dry feeds specifically designed for the species at each developmental stage. Ultimately, a species-specific formulated diet will contribute to an improvement of growth and survival rates in lobster production units.
Tilo Pfalzgraft

Background
The continuous growth of the aquaculture sector puts pressure on finite marine ingredients such as fishmeal and fish oil. These ingredients are bottlenecks in the feed production for aquaculture, necessitating the full or partial substitution of these ingredients with land-based alternatives. Currently, vegetable oils are already used to provide large parts of the lipid fraction in fish feed. High inclusion rates of terrestrial lipids however, may result in decreased production efficiency and exert a limitation on the physiological and metabolic performance in salmonids.

Project
My PhD project therefore focuses on the causes behind the performance related decline due to the substitution of fish oil by vegetable oils. Diets containing different fatty acid compositions will be tested to assess the nutrient digestibility as well as metabolic changes of the fish. Dietary fatty acids are used as an energy substrate, but also serve structural functions. Specifically, fatty acids constitute the bulk of cellular membranes, and modifications in composition lead to changes in membrane permeability. It is hypothesized that dietary remodeling of membranes leads to increased energy cost towards maintaining ionic homeostasis. It is a part of the project to figure out if this results in an overall cost of living and a reduced opportunity for activity and feeding. A second objective is to evaluate to what extent stress affects growth performance and nutrient digestibility in fish. This is achieved by examining the consequences of elevated cortisol levels, arising from different stress situations, on the lipid digestibility and metabolism in rainbow trout.

Perspective
The results of my PhD project will help understand the correlation between stress and the use of dietary vegetable oil on production related performance in salmonids, ideally leading to recommendations for feed formulations and a more sustainable aquaculture production of the respective species.

Peter Søndergaard Schmedes

Background
The demand for seaweed is rapidly growing due to the biochemically diversification and health related benefits of the biomass in its multiple applicable usages, such as making fine dishes, ingredient in various food products and feed as well as in cosmetics and medicine. Seaweed cultivation is ecological sustainable compared to harvest of natural populations, but implies a high production cost due to manual work. Seaweed cultivation is still in its infancy in Western countries and focus is to develop cost-efficient cultivation techniques for large-scale open water production for several valuable species. Previous research indicates great losses during the early stages of the cultivation phase.

Project
This PhD study will investigate cultivation hatchery techniques of local valuable seaweeds, such as Palmaria palmata and Saccharina latissima, to provide insight for a cost-efficient cultivation technology. Experimental tasks will address topics on both species investigating the potential of expanding the time window of the hatchery phase by year-round induction of sexual progenies in comparison to the use of vegetative propagation for open water cultivation. In context, it is important to understand the effect of hatchery conditions to ensure optimal settlement and survival for seedlings (progenies). For optimization of kelp farming in eutrophic waters the effect of ecotype selection is assessed.

Perspective
Eventually, research and innovation in seaweed cultivation will lower the production cost in Western countries. A seaweed production sector will potentially create new jobs and a value chain of products and services based on commercial food producers and bio-refinery enterprises. Seaweed cultivation and harvest will contribute in recycling wasted nutrients in marine waters.

This is a joint degree PhD with Norwegian University of Science and Technology.

Title:
The role of lipid source, stress and exercise on lipid uptake and metabolism in salmonids

Supervisor:
Peter Skov

Section:
Aquaculture

Peter Søndergaard Schmedes

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This is a joint degree PhD with Norwegian University of Science and Technology.

Title:
Investigation of seaweed hatchery techniques and cultivation systems for cost-effective production of valuable local species

Supervisor:
Jens Kjerulf Petersen

Section:
Danish Shellfish Centre
Daniel Patrick Taylor

Background
Enhancement of environmental quality of coastal waters impacted by anthropogenic nutrients is increasingly recognized as a globally established objective to restore and increase resiliency of coastal ecosystems and is a key part of the EU Water Framework Directive. Highly enriched aquatic environments experience ecological instability, requiring multiple concerted mitigative mechanisms for nutrient reduction that are economically tenable. Mussel aquaculture has been advocated as a means to mitigate eutrophic conditions through top-down biofiltration control of primary production. Cultivation techniques maximizing nutrient extraction (i.e. mussel biomass) exhibit intriguing potential in terms of remediating coastal water quality and provision of high quality protein.

Project
To evaluate the potential impacts of mitigation mussel culture on catchment nutrient loading, this project will undertake field studies examining cultivation and husbandry configurations to optimize nutrient extraction and maximizing biomass yield. Nutrient flux at study sites will be observed in addition to parameters indicative of ecological conditions. Modeling dynamic nutrient flows in regards to mussel growth and total biomass will contribute both to our understanding of mitigation culture interactions with the coastal environment, as well as describing nutrient pathways. Furthermore, valuation of mitigation mussel culture in these contexts will be characterized in terms of ecosystem services and as an alternative protein and lipids source for animal feeds.

Perspective
In the efforts to remediate coastal waters, the conversion of excess nutrients into high quality biomass through mitigation bivalve culture can equip coastal management programs with a value-added tool in the nutrient management toolbox. Increased value of expanded ecosystem services from mitigation culture will contribute to growth of the ‘blue economy’. Consequently, mitigation culture can present cost effective ecological remediation while also providing additional income and economic stimulus for coastal communities.

Tiago Malta

Background
With the reform of the Common Fisheries Policy and the introduction of a landing obligation the ability of fishers to adjust the selectivity of their gears to suit the quotas which are available to them will be an important factor in determining the revenue and rentability in the fishery. For this to be realised, simple and cost effective solutions which can be quickly coupled with existing gears will be in demand. These solutions will need to be implemented quickly in order for them to solve the issues at hand without losing substantial income. The top-down management system is often considered a slow and inflexible system, where gears take several years to get passed through legislation and proposing solutions to legislated or alternative gears is almost impossible. The inflexibility of most regulatory systems provides fishers with little possibility to develop and test more selective fishing practices. Furthermore, the top-down management approach is considered to reduce the sense of ownership the fishermen have over their fishery.

Project
To increase the ownership of the gears available to the industry the PhD project will aim to scientifically test a gear selectivity solution developed by the industry with the aim of solving the issues faced under the new CFP. The project will also attempt to understand whether gear selectivity data collected by the industry can be used as a fast and cost effective way to obtain efficient and accurate data on species and size selectivity in the gears.

Perspective
By discussing the strengths and weaknesses of industry collected gear selectivity data and how its collection can be streamlined under the new CFP we hope to increase our understanding of a wider range of fishing gears selectivity issues. Furthermore, we expect that new and innovative solutions will be presented by the industry and that the project will be able to provide guidelines for a faster implementation of those solutions in the legislation.

Title:
Mitigation cultures of mussels – ecological impact
Supervisor:
Jens Kjerulf Petersen
Section:
Danish Shellfish Centre

Title:
Industry lead gear selectivity improvements, its strengths and weaknesses in the new CFP
Supervisor:
Ludvig Ahm Krag
Section:
Ecosystem based Marine Management
**Ciaran McLaverty**

**Background**
Fishing practices which come into contact with the seafloor have the potential to significantly alter seafloor ecosystems, and accordingly, these activities are subject to considerable scientific and political debate. These practices are also highly important from an economic standpoint, contributing to approximately 20% of global landings. Recent developments in fisheries policy have resulted in a move towards an Ecosystem Approach to Fisheries Management (EAFM), and therefore a need to consider the effects of fishing on benthic ecosystem health, structure, and function.

**Project**
My PhD will seek to describe the result of trawling and dredging activities on seafloor habitats in Danish waters. This will be done by analysing the spatial extent and temporal frequency of Danish commercial fishing data, and combining with benthic faunal data collected in the field. Themes explored will include how experimental and chronic fishing levels can alter benthic community state, size structure, trait characteristics, and recoverability. Where possible, improvements to the sensitivity of fishing impact assessment will be explored, as well as the development of management tools for use in Danish fisheries.

**Perspective**
Although the effect of fishing on benthic ecosystems is relatively well studied, the conclusions reached are often unclear and ambiguous. This may be due to factors such as natural variation, poor experimental design, or the spatial scale of commercial fishery and benthic habitat data. Research is required to improve scientific understanding of the impacts to benthic communities from fishing, and to improve the overall sensitivity of fishery impact studies. Such advances could form the basis of alternative management and monitoring strategies, in the context of an Ecosystem Approach to Fisheries Management. This may also allow for the extrapolation of results to areas not directly sampled, and the ability to identify priority areas of seafloor which may be sensitive to fishing.

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**Sieme Bossier**

**Background**
Achieving good environmental status in the Baltic Sea region requires cross disciplinary and multi-sectoral scientific support tools to compare alternative management strategies. The Atlantis end-to-end whole-of ecosystem model explores climate, eutrophication, and spatial management scenarios which link oceanography, bio-geochemistry, food web, habitat, fish population and human sector dynamics. This approach fits me very well as I have a broad background from geology to a mix of the different branches of marine science with a focus on modelling.

**Project**
A first part of the research consists of the use of the already calibrated and implemented Baltic ATLANTIS model and to further develop, parameterize and calibrate the model such as integrating new input and results from recent runs of the multi-species population dynamic model (SMS), linking the ATLANTIS model with the ROCOSB physical and bio-geo-chemical and hydrodynamic model and further developing the management module of ATLANTIS. A second part will be to apply the newly calibrated ATLANTIS model and use it for different applications and objectives.

**Perspective**
With an improved ATLANTIS model fisheries management will be able to compare alternative management strategies and assess the trade-offs between resource use efficiency and carbon footprint as well as the responses of fish and fisheries to changing climatic and eutrophication conditions given different fishing pressures.
**Kristian Schreiber Plet-Hansen**

**Background**
The interactions and effects of fisheries targeting multiple species are receiving an increased attention in fisheries management, not least in the EU due to the ecosystem-based marine management initiated by the Marine Strategy Framework Directive (MSFD) and the objectives of the 2013 Common Fisheries Policy (CFP), which include a gradual implementation of a discard ban. Commercial fishing vessels operate in a quota system in the EU. It is often a challenge to catch the entire allocated quota for each targeted species while avoiding over-quota catches of some species in mixed fisheries. Because these over-quota catches can no longer be discarded the most limiting quota risk becoming the actual overall quota cap for the mixed fishery (the so-called “choke species” effect) leading to a loss in quota usage and profit.

**Project**
The aim of this project is to develop methods and provide research based advice to limit and mitigate the effect of unwanted catches in mixed fisheries in the North Sea and Skagerrak. The study will investigate spatial and temporal measures to avoid unwanted catches and interactions between unwanted and wanted catches. To investigate the temporal and spatial variations in the occurrences of unwanted catches on a fine scale, logbook and survey data will be supplemented with data from the Fully Documented Fisheries and the fishermen themselves. Finally, the study will incorporate mixed fisheries modelling and eco-economic modelling to assess the effect of unwanted catches for the fisheries and the sustainability objectives of the CFP and the MSFD.

**Perspective**
The European fisheries management is currently undergoing major revision. Knowledge from this study aim at addressing the challenges facing managers and fishermen and at providing scientific advice for approaches to the sustainability objectives listed in the CFP and MSFP while supporting the economic sustainability of the commercial fisheries.

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**Gildas Glemairec**

**Background**
In the European Union, incidental catches of seabirds are responsible for the death of ca. 200,000 animals each year, despite the commitment of the EU to protect its avifauna (e.g. the Birds Directive). Indeed, existing regulations are considered largely unsatisfactory at suppressing the bycatch of sensitive seabird species. Thus, the Commission proposed in 2012 an “Action Plan for reducing incidental catches of seabirds in fishing gears”, which calls upon Member States to assess the scale of this problem in their national fisheries, and to create effective mitigation solutions. Specifically, gillnet fisheries account for most of the bycatch of seabirds. Yet, seabird vulnerability to gillnets, as well as the technical and/or management measures that could ensure a reduction or suppression of the bycatch, are still poorly known, particularly in Denmark.

**Project**
The overarching goal of my PhD is: 1) To provide reliable estimates of the levels of seabird bycatch in Danish gillnet fisheries, and 2) to test new bycatch mitigation methods. Initially, I will analyze several years of video monitoring data, collected at sea on gillnet vessels operating all around Denmark. Later, I will evaluate the magnitude of incidental catches for the most impacted bird species. In the second part of my PhD, I will develop and test mitigation measures to reduce, and where possible suppress, seabird bycatch in gillnets. These novel solutions will need to be acceptable for fishermen, both operationally and economically.

**Perspective**
This PhD project will contribute to the EU PoA for reducing incidental catches of seabirds in fishing gears for Denmark, to ultimately minimize seabird bycatch in Danish gillnet fisheries. This is in line with the objectives stated in the Common Fisheries Policy and the Marine Strategy Framework Directive to work toward an ecosystem-based management that incorporates all the components of the ecosystem, including seabirds.
Tobias Mildenberger

Background
The sustainable harvest of natural resources requires the quantitative assessment of population dynamics and anthropogenic impacts. For many fish populations, the assessments are challenged by data-limited conditions. Globally, around 80% of all fish stocks are not assessed analytically, leaving the status of these stocks untold. Length-based methods and surplus production models are suitable for the assessment of data-limited fish stocks, but these single-species models neglect available ecological information. Novel stochastic models are needed which account for ecosystem effects and data uncertainty.

Project
This project will include previously neglected biological and ecological aspects in the formulation of single-species stock assessment methods. It will develop a fully stochastic stage-based biomass dynamic model, which represents differences between the juvenile and mature part of the population more realistically than traditional surplus production models. The assessment of aggregated functional groups allows accounting for interspecies interactions and thus contributing to the ecosystem-based approach to management. Furthermore, this project will implement data-poor methods in a management strategy evaluation framework, which allows identifying adequate harvest control rules, prioritizing input parameters and quantifying the impact of assessment uncertainty.

Perspective
This project will contribute to the sustainable management of marine populations by advancing assessment methods for data-poor fish stocks. Novel stochastic production models and length-based methods will decrease the uncertainty around estimated biological sustainability reference levels and improve the predictability of the stock development. Finally, the results of this study might offer new insights into multispecies reference levels.

Marie-Christine Rufener

Background
Marine ecosystems have been heavily exploited and degraded, which prevents provisioning of important natural goods and services including the sustainable exploitation of fisheries resources. To achieve the sustainability of ecological and socio-economic benefits it is, thus, paramount to minimize both costs and unwanted fisheries side effects. Albeit an increasing development of Ecological-Economic Fisheries Models (IEEFMs), contemporary management actions are not yet adequate to ensure a sustainable fishery at least cost and environmental impact. Within this context, the present PhD project aims to further develop the existing IEEFMs tools and couple them in a unified framework to accomplish more solid conservation solutions that are in accordance with ecological, economic and social requirements.

Project
The main objective of this PhD project is to model the interlinked marine fisheries by considering fish stock dynamics and interactions as well as the fisheries interaction with the benthic habitat, focusing particularly on the ecological and socio-economic impacts in regards to different management solutions. This will involve the application, and further development, of bio-economic spatio-temporal and agent-based modelling techniques in order to investigate the effects of fishing vessels (fishing pressure) on the distribution and abundance of marine commercial species and benthic habitats (ecosystem impact), and the consequences for the fishing industry (socio-economic impact) with respect to different mitigation measures.

Perspective
This unified modelling framework will provide a detailed picture of the fisheries and, as consequence, a sustainable trade-off between ecological and socio-economic demands will be able to be sought while considering the current EU Common Fishery Policy (CFP), the Marine Strategy Framework Directive (MSFD) and the Maritime Spatial Planning Directive (MSPD).
**Isabella Kratzer**

**Background**
One of the most commonly used fishing methods worldwide are gillnets. They are cheap, easy to handle and very efficient. In the Baltic Sea, gillnet fishing largely takes place in coastal waters and forms an important part of the local and cultural heritage as well as the touristic attraction of many regions. Despite being very size selective for fish and having close to no bottom impact, gillnet fishing has been criticized due to unwanted bycatch of flagship species like seabirds and marine mammals.

**Project**
The aim of this project is to develop gear technology solutions leading to minimal bycatch of birds and harbor porpoises while maintaining fishing efficiency. As harbor porpoises orientate themselves via echolocation, we aim to modify the acoustic properties of gillnets in such a way that they are perceived as an obstacle by the animal. To this end, we simulate the echo of a wide range of small objects, subsequently apply the object with the largest echo to gillnets and observe the reaction of porpoises to these modified gillnets. Similarly, we will observe bird reactions to an acoustic cue caused by an underwater loudspeaker and determine whether this noise is perceived as a nuisance by the birds, causing them to avoid the nets. As a final trial, we will test the mitigation methods in the commercial fishery.

**Perspective**
This thesis is part of the larger STELLA project aiming to develop solutions for the conflict between fisheries and nature conservation goals in the Baltic Sea. These gear technology developments will generally be designed for the specific use in the Baltic Sea but could provide the baseline for gillnet modifications to reduce bycatch of birds and marine mammals worldwide.

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**Tim Wilms**

**Background**
Structural complexities of coastal reefs are of major importance in providing suitable niches for many species of fish. For instance, marine boulders provide a stable surface enabling safe anchorage and growth of macroalgal species, while forming complex cavernous reef structures. Such heterogeneous environments attract numerous fish species by increasing the overall food supply and offering refuge from larger predatory species. In Denmark, large-scaled extraction of marine boulders has occurred for over a century until it was banned in 2010 as part of the EU Natura 2000 program. Since then, a number of restoration projects have been initiated in an attempt to recover this important habitat type and its functions.

**Project**
This research project aims to document the ecosystem effects of restoring various coastal reefs in Southern Denmark. The reefs were constructed in late 2017 and surveyed pre- and after restoration by the use of underwater video stations. Of specific interest is the overall restoration effect on the fish community, as well as localized effects from reef designs varying in height and boulder density. Environmental DNA (eDNA) analysis of seawater samples will furthermore allow for a comparative assessment between this newly emerging survey tool and the conventional method of underwater recordings.

**Perspective**
Habitat restoration constitutes a vital step in the recovery of exploited stone reefs, as the extraction of marine boulders permanently alters the seabed structure and ecosystem recovery is unlikely to occur without human intervention. Yet, methods of restoring temperate reef structures are still poorly understood. This PhD study will produce pertinent information for future assessments of reef-associated fish communities and will shed light on cost-effective methodologies for artificial stone reef construction.

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**Title:**
- Gillnet modifications to reduce by-catch of seabirds and harbour porpoises in the Baltic Sea

**Supervisor:**
- Finn Larsen

**Section:**
- Ecosystem based Marine Management

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**Title:**
- Coastal marine habitat restoration in the Western Baltic Sea

**Supervisor:**
- Jon C. Svendsen

**Section:**
- Ecosystem based Marine Management
Katrina Bromhall

Background
Fishing with mobile bottom-contacting fishing gear is described as the largest anthropogenic pressure to the seabed. Therefore, this fishery has been subject to debate, particularly when it occurs near, or on, habitats protected under European legislation such as the Habitats Directive and the Marine Strategy Framework Directive. In response, the use of alternative or modified, less damaging fishing gears has been suggested to offer some alleviation; conserving both environmental function and economic sustainability of the fishery. Yet, strong quantitative evidence to support these predictions is lacking.

Project
The PhD project intends to provide quantitative evidence on the benthic impact of three common demersal fishing gears used in Danish waters. Experimental fishing used in Before-After-Control-Impact studies can reliably determine the one-off mortality of a pulse-fishing event. The advantage of using a BACI, rather than a comparative analysis of historical fishing pressure gradients, is the ability to control for differences in environmental conditions; selection of sites with the same physical characteristics, as well as for differences in time. Therefore, the case studies will assess the effects of different gears in different sandy habitats using experimental fishing (BACI design) and, for the first time, quantify the ecosystem impacts of gears described to be of low environmental impact.

Perspective
The insight gained is highly relevant and needed for fisheries management, by providing empirical evidence of the broader ecosystem effects of these fishing gears. The output from my PhD has the potential to provide alternative management strategies, such as better gear-differentiated closures, and to support the use of more environmentally friendly fishing practices.

Maria Sokolova

Background
Commercial fishing with trawls compared to similar industries is a field where the uptake of technology has been low. This means that there are currently both economically and biologically costly fishing activities, where part or the entire fishing process is taking place in blind. The technologies that change this are today available and may be transferred from other sectors and adapted to fisheries. Establishing the future fishing gears that aim to ensure the best possible economic and biological sustainability as well as comply with ambitious management goals such as the EU landing obligation (Common Fisheries Policy, CFP), requires the fishermen to control the catch process and actively respond to what they observe. It is therefore a crucial first step to establish a real-time monitoring of the catch process. There is an expectation that future fishing gear will contain significantly more technology as well as solutions that can actively affect the selectivity of gears without necessarily interrupting the capture process.

Project
The PhD project will be focused on developing and establishing decision-making tools primarily in trawl fisheries. The goal of this approach is to make fisheries more targeted and intelligent in its catch process and to ensure the best possible economic and biological sustainability in the trawl fisheries.

Perspective
Establishment of the real-time monitoring tool allowing fishermen to control the fishing operation will allow to actively react and adjust the capturing procedure and thus will lead to more targeted fisheries and bycatch reduction. Overall, the implementation of such tool will contribute to success of the CFP.
**Marco Nalon**

**Background**
Under the EU Common Fisheries Policy (CFP, 2013) fishermen need to be able to actively adjust the selectivity of their gears according to quota availability. This is a result of the shift from a landing quota system, where discards has no direct value, to a catch quota system, where the entire catch of all listed species has to be landed and counted against quota. As the combination of gear, fishing practice and quotas differs between fisheries and vessels, changes to the selectivity of the gear need to be applied quickly and at a vessel level. To achieve the necessary flexibility, there needs to be a framework where a greater number of new gears, or modifications to existing gear, can be adequately developed, tested, and documented.

**Project**
To make use of the extensive documentation already existing on gear modifications for a variety of fisheries and geographic area, we aim at developing a theoretical meta-analytical approach to define what the best combinations of gear modifications are, depending on specific fishing and quota conditions. Moreover, this approach will incorporate and explore the potential of new technologies emerging in other fields, to improve the economy in the fisheries and reduce their environmental impacts.

**Perspective**
Combining the efficacy of different gear solutions to further improve the selectivity, as well as increase the real-time monitoring of the gear during the fishing activities, could lead to a more efficient and sustainable exploitation of marine resources.

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**Martin Lykke Kristensen**

**Background**
Due to previous technological constraints, knowledge about individual fish behaviour outside the spawning season in migratory marine and anadromous species is scarce. For species that exhibit homing behaviour (returning to natal site to spawn) like Atlantic Cod (Gadus morhua) and Sea Trout (Salmo trutta L.), the behaviours and migratory fate of fish labelled as “strayers” are not well described and it is largely unknown if strayers are generally caught in an ecological trap and fail to spawn. Similarly, little is known about the behaviour of successfully homing fish outside the spawning season.

**Project**
In this PhD project the marine migration behaviour of Atlantic Cod and Sea Trout is investigated by a combination of biotelemetry and genetic stock identification. By employing a combination of these techniques, it will be possible to track the migration of individual fish as they either return to spawn at their natal site or stray elsewhere, possible as result of an ecological trap. Furthermore, by pairing the geographical data with measurements of migration depth for the tagged Sea Trout specimens, the project will also provide unique data about vertical migration patterns for the species which are unknown at the present.

**Perspective**
Knowledge of migration behaviour is vital to obtain proper fisheries management. This PhD project will provide valuable information on the whereabouts of the fish outside the spawning season. Furthermore, it will reveal the return migration patterns and vertical migration patterns of individual fish, thereby increasing our knowledge of marine migration behaviour for the investigated species.
Kim Birnie-Gauvin

Background
In Europe, all major rivers are now fragmented by human-constructed dams and weirs, thereby contributing to the poor habitat quality of freshwater systems in the European Union. Increasingly, barrier removal is viewed as an adequate management strategy to reinstate natural connectivity within and amongst ecosystems, though we have little knowledge to make predictions about the biological and geomorphological trajectory of a system once a barrier has been removed.

Project
This research project aims to quantify the impacts of barriers on fish density, diversity and movement, as well as habitat changes, in an attempt to understand the extent to which barriers have altered freshwater ecosystems as a whole. This research will focus on lowland streams within Denmark and Northern England, with the potential for other relevant case studies. Furthermore, this project aims to evaluate the effectiveness of barrier removal as a mitigation tool for fisheries management. This research will be carried out using drone surveys to qualify and quantify stream geomorphology, electrofishing to quantify fish density and biodiversity, as well as telemetry (PIT telemetry) to evaluate fish passage.

Perspective
Freshwater ecosystems are amongst the most threatened ecosystems on the planet, largely due to direct anthropogenic impacts. Freshwater streams and rivers are in dire need of proper management strategies, and barrier removal may be an effective tool to improve the sustainability of fish populations.

Hugo de Moura Flavio

Background
Historically, the Atlantic salmon was distributed in more than 2600 watersheds in the North Atlantic. Many self-sustaining populations have disappeared or are endangered due to human impacts, and the species range has generally contracted and fragmented. During their seaward migration, salmon smolts must cross unfamiliar habitats and deal with new ecosystem conditions (e.g. salinity changes, new predators). Therefore, it is important to unravel high mortality phases (hotspots) during this transitory high-risk life stage. There are multiple potential bottlenecks that may hinder successful seaward migration.

Project
This project will determine the mortality of salmon smolts and post-smolts during their migration through the lower parts of rivers, estuaries/fjords and nearshore areas through case studies using telemetry in five areas: Denmark, England, Ireland, Northern Ireland and Spain. This will enable mortality rates to be determined, together with details of where and when this mortality occurs.

Perspective
In combination with other published results, the research will provide crucial input on migration mortality to existing models used for assessment purposes and test if the measured initial mortality can explain observed variation in return rates. If causality between post-smolt mortality and run size can be established, the findings may inform future management and conservation of (some) Atlantic salmon stocks.
Casper Gundelund Jørgensen

Background
Recreational fishing is an important leisure activity for millions of people on a global scale. The associated economic, sociocultural and ecological effects are immense. Recreational fishing is a multi-billion dollar industry that also holds great sociocultural values for the users, such as social cohesion and environmental education. Additionally, recreational fisheries represent the main use of many freshwater as well as some marine fish stocks. The traditional methods to investigate aspects of recreational fisheries, such as ecological effects and human dimensions, are often time consuming and cost heavy. With the emergence of so-called angler applications (angler apps), the use of smartphones for fisheries management and research poses a promising avenue for collecting data from recreational fisheries directly and efficiently.

Project
The aim of this project is to investigate the strengths and weaknesses of citizen science as a method to collect recreational fisheries data. With special emphasis on smartphone applications for anglers. In 2016 DTU Aqua launched a citizen science platform, Fangstjournalen, where anglers via a smartphone app, can register their trips and catches. Evaluating Fangstjournalen, in regards to the general main challenges associated with angler apps, will be a priority.

Perspective
Angler apps hold the potential to be a cost-effective tool for recreational fisheries management and research that can supplement and even replace the traditional survey methods. However, it implies a better understanding of how best to recruit, retain and potentially reactivate the citizens, i.e. the anglers, on the platform and not least to determine the accuracy of the collected citizen science data.

Johanna Kottmann

Background
European eel, Anguilla anguilla is a highly valued species, but unfortunately the stock has declined. As such management plans have been initiated and aquaculture production now aims at establishing a steady supply of glass eels, which requires the development of efficient breeding protocols for closing the life cycle in captivity. An important factor of early offspring mortality in captive-bred fish is poor egg quality. Common causes for poor egg quality include "suboptimal" nutritional status of broodstock and assisted reproduction protocols.

Project
The general aim of this project is to assess the effects of different assisted reproductive treatments, i.e. hormonal treatments and broodstock diets, on early life history stages (egg to first feeding larvae) using wild-caught and farmed eels that have been reared in captivity. Physiology, development, and survival from egg to first-feeding, including gene expression and utilization of major nutrients in eggs and yolk-sac larvae, will be followed over time to assess requirements as well as assimilation of nutrients.

Perspective
This PhD study will provide novel information on physiological and biochemical markers as well as morphological endpoints that are important for improving egg quality parameters that affect early offspring competence of European eel in culture. Nutritional requirements of larvae will be evaluated in order to better understand the dietary needs during early life stages and the ‘critical’ transition of larvae from the endogenous to exogenous feeding stage.

Title: Citizen science as a method to collect recreational fisheries data; strengths and limitations
Supervisor: Christian Skov
Section: Freshwater Fisheries and Ecology

Title: Egg quality and offspring performance in European eel
Supervisor: Jonna Tomkiewicz
Section: Marine Living Resources
**Alan Le Moan**

**Background**
Marine fishes can be genetically structured into semi-independent populations, with relatively high and heterogeneous genetic differences across the genome. Those genetic patterns may be linked to specific geographical areas called transition zones, corresponding to environmental gradients or physical barriers to dispersal. However, the mechanisms responsible for generating and maintaining population sub-structure in these marine species with high migration capacities are still poorly understood. Recent technological developments in molecular biology allow us to characterize population divergence at genomic scales. This allows a more precise description of the genetic structure and the heterogeneity of genetic differentiation between populations. Moreover, these molecular tools provide better statistical support to differentiate neutral evolutionary processes from processes involving natural selection, and to examine the role of population history for the acquisition of genetic structure.

**Project**
As part of the Nordic EU Interreg fund project, MarGen, we will use a comparative approach through the inclusion of genomic data from several species in this PhD project. Specifically, the aims of this study are to i) improve the genomic resources in marine fishes with a particular focus on flatfish species such as the European flounder (*Platichthys flesus*), ii) characterize and compare the genomic architecture of differentiation between populations across the North Sea-Baltic Sea transition zone for different species of flatfish, iii) investigate the origin of population differentiation and the main processes involved during population diversification by using demographic inferences, and iv) provide relevant data on population connectivity and geographical scales of population boundaries to fisheries management.

**Perspective**
We aim to improve our understanding of evolutionary processes in nature. In addition, the project can provide support to fisheries management by identifying marine populations at both fine and large geographical scales, and by providing practical tools for the traceability of fish and fish products.

**Alice Manuzzi**

**Background**
Natural history collections are repositories of an immense record about changes in environmental conditions over historical time. In the last century, most of the species across the globe have experienced the effects of global change in the environment and genetic analyses of archived specimens represent a unique resource for tracking demographic and evolutionary effects, in response to climate changes and other human-induced stressors. The application of recent high-throughput technologies on archived fish samples has made the assessment of adaptive evolution feasible, as well promoting the acquisition of good sequencing data from highly fragmented and degraded DNA templates. Nonetheless, few studies have tried to extend genomic analysis back in time.

**Project**
The aim of the project is to conduct spatiotemporal genomic analysis of contemporary and archived tiger shark (*Galeocerdo cuvier*) samples to test for historical changes in distribution, abundance and evolutionary responses to environmental changes and exploitation. For the project, an exome sequencing approach will be used.

**Perspective**
Even if population genomics studies have been recognized as valuable in fisheries management, their application to sharks species is still very limited. Thus, the use of genomic data from the past will be of great help to inform decisions for a proper management and protection of the current population of tiger sharks.

**Title:**
Genomic patterns and processes of population divergence in marine fishes

**Supervisor:**
Jakob Hemmer Hansen

**Section:**
Marine Living Resources

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**Title:**
Genomic analysis of DNA from archived shark jaws

**Supervisor:**
Einar Eg Nielsen

**Section:**
Marine Living Resources
Michelle Grace Pinto Jørgensen

Background
Most cultured fish species encounter problems producing eggs with high and consistent embryonic viability and developmental potential. European eel Anguilla anguilla is a high value species in aquaculture. Production and markets for this species have been reduced due to stock depletion, leading to low abundance of juvenile glass eels used as basis in eel aquaculture. Recently, methodologies to breed eels using assisted reproduction have been developed by DTU Aqua, leading to production of viable offspring of European eel and establishment of larval culture. Nevertheless, egg quality remains low and variable.

Project
The overarching goal of this PhD project is to elucidate aspects of the reproductive physiology of female European eel, which affect female responsiveness and egg quality as a step in completing the life cycle of this species in aquaculture. Specifically, the objective of the project is to study characteristics of hormonally induced ovarian development, with particular focus on vitellogenesis, through histological and molecular analyses.

Perspective
The planned studies will provide basic scientific results and a substantiated knowledge base, which will fill gaps in the knowledge about European eel reproduction. Novel techniques will be presented to improve reproduction success, viable egg production and enhanced offspring performance of farmed eels, in order to close the life cycle of European eels in aquaculture.

This is a joint degree PhD with Norwegian University of Science and Technology.

Ole Henriksen

Background
The lesser sandeel (Ammodytes marinus) support a large fishery in the North Sea. Within the fishery, Denmark is the main contributor to the sandeel landings (~73%). However, the stock is difficult to assess and manage owing to the short life cycle, strong site fidelity, and a fishery that relies on the recruitment success in the stock. Sandeels are also a key prey species and are consumed by fish, seabirds and marine mammals. The Danish fishing industry has recently presented a proposal for an alternative model for managing the sandeel fishery in the North Sea. Also, the fisheries have highlighted that division-based management (preventing the fishermen from moving freely) and the dramatic fluctuations in quotas constitute major obstacles to an economically sustainable sandeel fishery.

Project
Project objectives are to establish a scientific basis that can support the development and evaluation of a management model like the one proposed by the fishery, in accordance with ICES sustainability principles. The study will: 1) Review living resource management approaches (worldwide), and 2) investigate spatial population dynamics by exploring the connectivity patterns and spatial differences in mortality rates induced by predators and the fishery, respectively. More specifically, the work will include mathematical modelling and exploration of spatial patterns in existing data sources. Finally, in collaboration with the industry, a working group should be established that will try and incorporate findings, approaches and methods in the development of a management strategy for sandeel in the North Sea.

Perspective
The project will provide valuable knowledge on the spatial population dynamics of sandeel in the North Sea, which will be of pivotal importance in relation to fisheries stock assessment, evaluation and management. If successful, then a suitable and applicable model which is evaluated against the ICES sustainability criteria could have great significance for future collaborations with the industry.
Marie Plambech Ryberg

Background
Failure of the analytical stock assessment in 2014 of Eastern Baltic cod (Gadus morhua), left the present stock status unclear due to missing biological information and difficulties in age reading. The nutritional status (i.e. condition) of Eastern Baltic cod is unexpectedly low combined with low number of large individuals. Many different reasons for this trend have been debated, including an increase in infestation rate with the parasite liver worm (Contracaecum osculatum) to which cod is a transport host, where fish with many parasites in the liver have lower condition. This possibly because of malfunctioning of the liver that negatively affects energy metabolism.

Project
The aim of this PhD is to identify and quantify potential pathophysiological effects of liver worm infestation on growth and condition of Eastern Baltic cod. Controlled in vivo experiments on live fish where the influence of other variables are negated and in vitro investigations of cod liver structure and gene expression, would be carried out to investigate potential pathophysiological effects of liver worm infestation on the health status of Eastern Baltic cod.

Perspective
The results from this study can improve our understanding of how growth and condition in Eastern Baltic cod may change in relation to parasite infection. Subsequently this knowledge can be scaled to the level of the population, allowing the information to be implemented into bioenergetics models contributing with new biological information to assessment models in order to help managers towards better prediction of Eastern Baltic cod in the future.

Camilla Christensen

Background
Archived specimens held in museums and other natural history collections can provide a population genetic baseline, against which to assess potential negative consequences of recent changes in the environment. Thereby, offering an opportunity to track demographic and evolutionary consequences of climate change and other human-induced pressures. The recent advances in molecular genomics has made it possible to investigate genetic changes in many individuals sampled more than a century ago. However, few retrospective genomic analyses has comprised sharks.

Project
This PhD project is part of an international collaborative project, GenoJaws, involving the University of Queensland, Technical University of Denmark and Flinders University. The ambition of the project is to gain knowledge about population genetic parameters of the vulnerable sand tiger shark (Carcharias taurus) on a spatial and temporal scale. Performing genomic analysis on contemporary and historical samples will allow us to test for changes in abundance, effective population size, distribution and connectivity and ultimately make us capable of understanding adaptive responses to environmental change and exploitation.

Perspective
By tracking changes in genetic composition on a temporal scale, it is possible to find evidence of both distributional shifts and responses to selection. Ultimately, analysis of such records, taken over several years, can help us understand micro evolutionary processes. In addition, retrospective analysis can help making informed decisions for the protection and management of the current populations of sand tiger sharks.
Elisa Benini

Background
Self sustainable aquaculture and conservation efforts are needed to restore the critically endangered European eel, *Anguilla anguilla* stock. Its life cycle has not been closed in captivity yet although laboratory studies have identified optimal environmental conditions for improved early offspring performances. However, there is still paucity in knowledge about nutrition and mechanisms regulating digestion of European eel larvae.

Project
The objectives of my PhD project is to investigate aspects of digestive physiology and nutrition of *A. anguilla* as a step forward in closing its life cycle in aquaculture. A multidisciplinary approach will be used to assess and describe different aspects of the digestive capacity of eel larvae. The first step will focus on the biochemical composition of larvae to define which components are essential for growth and survival. The second study will assess the impact of exogenous feeding on the ontogeny of the digestive tract during early development. The third study will focus on larval nutritional requirements and digestion capacity.

Perspective
The knowledge gained during this project will help us to enhance larval survival and growth under controlled conditions. Based on my research outputs regarding larval digestive physiology and nutrition, we will be able to grow larvae until the juvenile stage.

Dionysis Krekoukiotis

Background
Macro and microplastics created by anthropogenic activities are widely considered as emerging marine pollutants, found in almost every marine habitat around the world, with plastic composition and environmental conditions significantly affecting their distribution. Recent studies have demonstrated that a wide range of zooplankton can ingest microplastics, influencing vital rates negatively and possibly affecting, through the trophic link, quality of habitats, dynamics of commercially exploited species and other services derived from aquatic systems. However, these complex interactions remain poorly constrained in the natural environment and their ecosystem-wide implications remain to be tested with respect to projected sources and pathways of pollutants.

Project
The overarching goal of this project is to generate ecologically consistent estimates of zooplankton trait distributions and the ecosystem impacts of their changes in response to pressure from marine plastics contamination. Thus, the project will meet the following objectives: 1) to characterize the trait distribution of zooplankton as a function of environmental/habitat variables including microplastics as a pressure, 2) to project the impact of microplastic sources and pathways on zooplankton community and ecosystem states by combining a trait based zooplankton model with a physical drift model, 3) to develop a general modeling framework suitable to identifying ecosystem services under pressure from marine plastic pollution in different environmental settings.

Perspective
This project will respond to the urgent need to estimate the currently unknown potential ecosystem-wide implications of changes in zooplankton vital rates under additional anthropogenic pressures from plastic pollution.
**Søren Lorenzen Post**

**Background**
Blue whiting (Micromesistius poutassou) is a gadoid species, widely distributed in the North-Atlantic. The fishery has been one of the largest in the world in the 2000s. However, the stock size and fishery have fluctuated greatly throughout the latest decades. Greenland waters are generally considered as a fringe area of blue whiting distribution and it is only caught sporadically within the Greenland exclusive economic zone. In the most recent years it has been a more frequent bycatch in research surveys and the commercial fishery, similar to several other pelagic species in Greenland waters (e.g. mackerel and bluefin tuna). Blue whiting could therefore become an additional target species for the growing pelagic fleet in Greenland.

**Project**
This project aims at generating life history information concerning blue whiting in Greenland waters and to obtain information on its role for the pelagic ecosystem as a whole. To resolve the questions, the distribution will be mapped using historical trawl survey data and data from newer acoustic surveys. Potential drivers affecting the presence will subsequently be modelled to test the significances of various environmental parameters. For revealing questions regarding trophic position and interaction with other pelagic species, zooplankton and stomach content analyses are used in combination with hydro acoustic measurements describing vertical migration and distribution in relation to prey and environmental variability.

**Perspective**
A robust stock assessment relies on thorough understanding of the species life cycle. This project aims at clarifying the reasons for stock size fluctuations of blue whiting in Greenland and hence improve the short term forecasts for management advice. It will moreover contribute with knowledge about interactions between pelagic key species in East Greenland.

*This is an industrial PhD in cooperation with Greenland Institute of Natural Resources.*

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**Peter Fink-Jensen**

**Background**
Capelin (Mallotus villosus) is essential as trophic link between plankton and larger predators in the arctic marine ecosystem around Greenland. Multiple species including fish, birds and marine mammals depend on healthy capelin stocks for successful growth and reproduction. During late spring and most of the summer, large schools of capelin gather at shallow waters in Greenland’s fjords to spawn. However, very little is known about their migration and stock structure through the remainder of their lives.

**Project**
In this project, stock discrimination and the migratory behavior of capelin will be examined on the basis of earstone (otolith) microchemistry using state-of-the-art trace element analysis. The primary contributor to chemical fingerprints in otoliths is ambient water chemistry, while factors such as food intake, temperature and salinity are secondary factors. As otoliths grow incrementally as a fish grows, without physical or chemical post-depositional alteration, their chemical composition can provide chronological records of e.g. fish growth, migration patterns and environmental exposure. I will use this to track the movement of individual capelin between different marine environments and stocks, based on otoliths from more than 1200 spawning capelin from 18 different localities along Greenland’s coast.

**Perspective**
The results of this project will lead to a greater understanding of the movement and behavior of capelin and possible separation into multiple stocks. Such knowledge is crucial for proper scientific advice, which enables local authorities to manage ecosystem services, including fisheries and ecosystem functioning, related to capelin sustainably and optimally. This information is essential for sustainable fisheries of this species – a natural resource that the industry is looking to utilize.

*Title: Capelin migration and stock structure using otolith microchemistry*

*Supervisor: Karin Hüsey*

*Section: Oceans and Arctic*
Background
Diel Vertical Migration (DVM) is one of the most impressive features of the marine ecosystems. In short, grazers migrate to a certain depth during daytime to avoid visual predation, but have to return to the surface at night to feed on phytoplankton. This can trigger the same migration pattern for their predators, resulting in what is believed to be the biggest movement of biomass of the planet.

Project
Firstly, the goal of my PhD project is to use a trait-based approach to model these migrations, which can be justified with notions from game theories such as Nash equilibrium. Secondly, once these migration patterns are understood, I will look at the consequences of DVMs for ecosystem functions, in particular the trophic transfer efficiency of a food-web with organisms undertaking DVMs, and the role of DVMs in long-term carbon storage of the oceans.

Perspective
Even though DVM is a well-known phenomenon, it is not well understood and quantified. The original approach of game theory applied to this phenomenon will help us addressing this knowledge gap. This will permit us to assess how marine food webs can help counter climate change as well as to better understand the cascading consequences of climate change on pelagic and mesopelagic ecosystems.