Preface

This web-publication “PhD projects at DTU Aqua” presents the 46 PhD students enrolled at DTU Aqua’s PhD school as of 1 April 2017.

Each PhD project is described by the PhD student in terms of background, project contents and perspectives, and 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, utilizing new technological approaches in their data collection and processing as well as new concepts for data treatment and evaluation. Our ambition is to contribute to securing 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.

Fritz W. Köster
Director and Head of the PhD School at DTU Aqua

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Hans van Someren Gréve

Background
As primary grazers of phytoplankton, zooplankton plays an important role in biochemical cycles and holds a key position in the marine food web. An emerging approach to understand zooplankton ecology and trophic interaction is to investigate essential traits and associated tradeoffs. Zooplankton has to move through the water column in order to find prey and encounter mates. However, moving also comes at a cost: swimming increases the chance of encountering or being detected by predators and has certain metabolic expenses. Thus, efficient feeding and mate searching trade off against survival and energetic costs. Zooplankton has developed three different strategies to collect food, each predicting a different balance between the costs and benefits.

Project
The aim of this project is to predict and experimentally quantify trade-offs related to feeding and mate searching behavior. We use different developmental stages and adult males and females of copepod species exhibiting the three main zooplankton feeding strategies. The focus of our research will be on motility patterns, feeding efficiency and prey selection, susceptibility to predation by tactile predators and metabolic expenses.

Perspective
The results of this project will provide a stage and gender specific quantification of trade-offs associated with the main zooplankton feeding mechanisms. It may help explain observed field population dynamics and distribution and improve our overall understanding of zooplankton mediated fluxes.

Jiayi Xu

Background
Copepods are an important link between ocean primary production and higher trophic levels. They may concentrate and transport algal toxins to higher-trophic-level pelagic consumers (fish and marine mammals), serving as an important entry point of phytoplankton toxins to pelagic food webs. The ability of copepods to select between toxic and non-toxic algae, potential mechanisms for prey selection, and the effect on prey selection of different types of toxic algae are poorly understood and the overarching topic of the proposed work.

Project
My PhD work aims at investigating the behavior and prey selection of copepods fed on different toxic or nontoxic algae, the potential mechanisms of prey selection and how different types of algae affect prey selection. The experimental work will focus on the copepods Temora longicornis, and Oithona davisae and will use high-speed video microscopy to observe the feeding behavior.

Perspective
The results of my project will provide a mechanistic understanding of how different feeding modes respond to toxins and the optimal feeding strategy of copepods to toxic and nontoxic algae.
Marina Pancic

**Background**
Phytoplankton is a highly diverse group of photosynthetic organisms, which contributes to approximately half of the global CO₂ fixation, and concomitantly affects the biogeochemical cycles in the ocean due to their requirements for nutrients. The fact that many phytoplankton species coexist in the same space and at the same time on few resources, together with the strong top-down selective pressure, demands for identification of the traits that determine their ecological niche. In order to reduce predation from higher trophic levels, phytoplankton has developed a variety of physical and chemical defense mechanisms, and has additionally been found to be highly flexible in traits which affect their edibility.

**Project**
My PhD work aims at identifying and quantifying the trade-offs of defense mechanisms in phytoplankton. These competition-defense trade-offs are as of yet poorly described and quantified, yet such trade-offs are required – and, hence, arbitrarily assumed – in many models to allow the coexistence of many phytoplankton species. The initial focus of the project will be on the thickness of the silica walls in diatoms, as this morphological trait is known to vary widely among diatom species. The fact that the thickness of the silica shells is a plastic trait and can be induced by the presence of herbivores, allows us to directly quantify associated benefit and cost to organisms’ fitness by comparing induced and non-induced individuals.

**Perspective**
The results of this project will provide important insights into predator-prey interactions at the lowest levels of marine food web. While prey organisms develop various defense mechanisms to avoid predation, predators evolve strategies to overcome these defenses, resulting in an evolutionary “arms race” of adaptation and counter-adaptation. A well-established benefit of defense mechanisms in phytoplankton is reduced mortality to grazing zooplankton; however, physiological cost of these mechanisms is yet to be explored.

Tim Spaanheden Dencker

**Title:**
Functional diversity and marine ecosystem functioning

**Supervisor:**
Martin Lindegren

**Section:**
Centre for Ocean Life

**Background**
The effect of biodiversity on ecosystem functioning has been a field of research over several centuries; yet has, for the majority of this time, had a species-centric focus. While species form the biotic fabric of ecosystems, it is not the mere presence of a species that is important, but rather its ecological role and functional interactions with both the biotic and abiotic components, which alter and effect the ecosystems. By shifting the focus from the species to functional traits describing these roles and interactions, it is possible to elucidate the links between biodiversity and ecosystem functioning.

**Project**
The PhD will focus on functional trait-based approaches to marine biodiversity in order to create a better understanding and prediction capabilities of ecosystem functioning. The main focus will be the functional diversity (i.e. the range of functional traits present in the system) of the demersal fish community in the North Sea. The North Sea represents a heavily exploited ecosystem, under multiple stressors, yet with a high temporal and spatial data cover. This offers a unique opportunity to study an ecosystem, where the effects of direct and indirect anthropogenic stressors (e.g. fishing and climate change) can be incorporated into the functional trait-analysis.

**Perspective**
A trait-based approach to understanding the effects of biodiversity and stressors in ecosystems can potentially lead to improved management schemes, be incorporated directly into strategy directives, and can form the basis of better prediction-capabilities of ecosystem functioning in a changing environment.
Rob van Gemert

Background
Density dependence is an important factor in shaping population structure and dynamics by affecting vital rates such as growth, reproduction, and survival. However, in almost all current fisheries models and stock assessments, density dependence is taken into account only during the larval stage of the fish. This is contrasting with empirical observations, which have shown that many fish species are subject to density-dependent processes throughout their lives. When calculating reference points for fisheries management of these species, it is therefore important to include all density-dependent processes that are present within the stock.

Project
My PhD aims to understand how density dependence manifests itself in fish populations, and to describe how fisheries reference points depend on the type of density dependence and when in life this occurs. This will be achieved by incorporating density-dependent processes into dynamic size-based models for fish stocks, and comparing the model outcome to empirical observations and current fisheries reference points.

Perspective
Fisheries management relies on fisheries models to set reference points for exploitation. This study will allow for the improvement of those models, by providing insight into how density dependence in fish stocks can influence fisheries reference points. In doing so, this study will point out both risks and missed opportunities in current fishing strategies.

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.
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 institution 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.

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.
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.

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Aurore Maureaud

Title:
Understanding the biodiversity-ecosystem functioning relationship through large scale observations and modelling

Supervisor:
Martin Lindegren

Section:
Centre for Ocean Life

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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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Peter Søndergaard Schmedes

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

Supervisor:
Jens Kjerulf Pedersen

Section:
Danish Shellfish Centre
Paula Andrea Rojas Tirado

**Background**
Aquaculture production is increasing worldwide. At the same time, environmental restrictions and claims on water sources are increasing. Recirculating aquaculture systems (RAS) is one way to solve these conflicting interests, by developing and implementing rearing systems that allow high degree of water reuse. The degree of reuse is dictated by available treatment technologies and the requirements of the rearing organism. Common for all RAS is an accumulation of waste products which causes changes in nutrient flows and carbon sources when they are not properly removed. These disturbances enhance the proliferation of microorganisms, which have caused near-catastrophic events in Danish RAS producing pikeperch, trout and salmon and shown to be a common problem independently from the type of RAS. Only recently, development of microbial population in RAS and its management strategies have received attention. This is partly due to the lack of simple and reliable monitoring systems to detect it and follow upon on daily basis and thus give the possibility to re-establish the optimal water quality or treatment within short time laps.

**Project**
The purpose of this study is to gain more knowledge and information regarding chemical-microbial cause-relationship in RAS water and how it is affected by physical and chemical treatments. The project will address microbial response to application of chemical therapeutants used nowadays in aquaculture. It will also test the effect of operational parameters (i.e. hydraulic retention time and/or feed loading) and management practices (i.e. foam fractionation), on microbial water quality in RAS.

**Perspective**
The new information on biotic and abiotic factors affecting chemical and microbial water quality in RAS will accelerate better management practices and allow a better establishment of guidelines. New types of measurements will be tested to predict deteriorating water quality conditions and hence prevent system to collapse. This will lead to more proper and stable water quality which is central for successful operation in recirculating aquaculture systems.

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Joao 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; 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.
**Esther Savina**

**Background**
The European Union is moving towards a sustainable fisheries management framework called the Ecosystem Approach to Fisheries. It aims at maintaining ecosystem health and productivity to sustain fisheries production for present and future generations. As fishing can affect other components and not just targeted species, with for example physical damage to habitats or discards, the ecosystem as a whole must be considered. There is limited knowledge about these impacts, and their minimization requires development of alternative practices. Gear technological considerations are therefore necessary to fully implement an Ecosystem Approach to Fisheries.

Although the fleet has reduced since the mid-1990s, Danish gill- and trammel nets are still of importance and are likely to gain increasing interest as environmentally friendly practices. However, such a development may only happen if the ecosystem approach is guaranteed.

**Project**
With regard to the upcoming challenges of an Ecosystem Approach to Fisheries, the project aims at (1) studying the sweeping behaviour of nets and their effect on the seabed; (2) quantifying invertebrates and fish discards and understanding how the capture process can influence discard behaviour; (3) developing technical innovation that could improve catch quality and therefore maximize the production. Trials are conducted on gill- and trammel nets within the Danish coastal waters.

**Perspective**
Information on gear interactions with the marine environment will provide for a better implementation of an ecosystem approach to the commercial set nets fisheries including proposals of appropriate management regulations and a better viability of the Danish fisheries.

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**Elliot Brown**

**Background**
The coastal zone sees a disproportionately large amount of human development. This narrow area therefore warrants increased attention from environmental managers and policy-makers, whom require accurate and up-to-date scientific advice in order to make informed decisions. In Denmark, with a high coast to land area ratio, the need for focus on the coastal zone becomes even greater. One area of focus is the contribution that the coastal zone makes to natural resources; fisheries are one such resource. The harvesting of flatfish is important throughout the Baltic and although the target species may vary, the majority of exploited species have an important developmental stage closely linked with shallow coastal marine habitats.

**Project**
This PhD project aims to quantify the importance of different environmental parameters for the growth and production of juvenile recreationally and commercially important flatfish of the Inner Danish Waters. This will be achieved through the construction of habitat suitability models from direct field observation of flatfish abundance and growth in different shallow, soft-sediment habitats. These models will then be reapplied and evaluated in different areas of the Inner Danish Waters.

**Perspective**
The resulting models from this study will help inform policy regarding marine spatial planning by identifying what factors contribute to essential fish habitat. The re-application of the habitat suitability models will investigate their relevance in different areas than the original study site.
**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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**Valentina Melli**

**Background**
A new Common Fisheries Policy (CFP) has been introduced in EU waters as of the 1st January 2016. One of the major changes introduced is a landing obligation system where all sizes of listed species have to be landed and the catch of such species will be counted against quota. Catch of unwanted sizes and species can thereby no longer be thrown back overboard at no economical cost. This shift in fisheries policy will therefore require the development of simple, robust, and flexible gear solutions which individual vessels can use to enhance their size and species selectivity throughout the year to optimize the economy in their fisheries.

**Project**
The project is focused on the Danish mixed species demersal trawl fishery, a poorly selective technique that will be strongly affected by the new CFP. The idea is to develop simple and flexible gear solutions that will improve the sizes and/or species selectivity in the gears and will be constructed to facilitate fast mounting and de-mounting of systems in the trawl to allow a very flexible use on a haul by haul level.

**Perspective**
By comparing the efficacy of different gear solutions that use species ecology and behavior to implement gears selectivity, and analyzing their interaction with environmental factors, we hope to offer fishermen the opportunity to adapt their gear to specific and individual catch goals.
**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.

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**Gildas Glemarec**

**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 (a) to provide reliable estimates of the levels of seabird bycatch in Danish gillnet fisheries, and (b) 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.
**Sieme Bossier**

**Title:**
Evaluation of sustainable exploitation of major Baltic fish stocks

**Supervisor:**
J. Rasmus Nielsen

**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 RCO-SCOBi 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.

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**Kristian Schreiber Plet-Hansen**

**Title:**
Integration of bycatch in sustainable mixed fisheries management

**Supervisor:**
Clara Ulrich

**Section:**
Ecosystem based Marine Management

**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 bio-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 providing scientific advice for approaches to the sustainability objectives listed in the CFP and MSFP while supporting the economic sustainability of the commercial fisheries.
**Joan Holst Hansen**

**Background**
Migration is a common and widespread behavior in many animal populations. In recent years it has become increasingly clear that several lacustrine fish population, including keystone species such as roach (*Rutilus rutilus*) and bream (*Abramis brama*), are not static populations within single lakes. However, up to 80% of the population migrate from the lake in autumn and overwinter in connected streams.

**Project**
Fish densities and species composition has a great impact on lake ecosystem functioning through top-down trophic interactions. Partial migration of fish species may vary significantly between lake types, resulting in fluctuating fish densities in the lakes. Therefore, knowledge on behavior and feeding biology of lacustrine fish species is central in order to understand and manage freshwater systems. The main objectives in the project are: 1) Do predators suffer from food shortage in lakes were prey densities fluctuate? 2) Do interspecific differences in migration behavior of lacustrine fish result in seasonal differences in competition regimes between fish species, in closed and open lakes? 3) Are there species specific differences in migrations between neighboring lakes? 4) Do migration of zooplanktivorous fish influence lower trophic levels within lakes? 5) Can biomanipulation in lakes with inlets and outlets be done more cost effective during winter, where migrating fish aggregate in the streams?

**Perspective**
The project will address a number of essential questions to increase the knowledge on how migration behavior of lacustrine fish species may impact the ecosystem on both higher and lower trophic levels. Furthermore it will contribute to a new conceptual understanding of spatial and temporal trophic dynamics not only in lakes, but in freshwater ecosystems in general.

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**Michael Schwinn**

**Background**
Anadromy is a feature of many species in the family of Salmonids and is in general interpreted as a trade-off between the advantages of richer feeding resources at the sea that can lead to superior fitness of the individuals on the one hand and higher energetic costs as well increased risk of predation on the other. This life history strategy is often connected with high mortality in the juvenile stage. It can be extraordinary high if smolts face obstacles of anthropogenic origin, for example if they have to pass artificial lakes during their seaward migration.

**Project**
In this PhD project the effects of a newly established lake, Egå Engsø, on the migration and mortality of juvenile trout (*Salmo trutta*) are investigated. This so called VMP - Lake (Actionplan/Vandmiljøplanen) was created in 2006 in order to reduce the nitrogen load to the marine environment. Preliminary studies have shown an extraordinary high mortality of smolts during their passage. The aim of this research is to investigate the causes and effects of this increased mortality. In particular the effect of predation by other fish, birds and mammals will be focussed on as well as the impact of the reduced current in the lake on the ability of the smolts to navigate through the lake.

**Perspective**
The current situation does most likely not allow a self-sustaining population of sea trout in the River Egå. Considering that trout is a keystone species in its ecosystem and also carries a very high recreational value, strong efforts should be made in order to improve the situation. It is expected that the scientific results from the project will be used in the advisory and management tasks of the institute. Currently other countries than Denmark are establishing similar lakes in order to reduce nitrogen intake to the sea, so the results and experiences from this project are expected to be a good reference for future planning and managing, both in Denmark and internationally.
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.
Filipa da Silva

**Background**
The reproduction of European eel in captivity is an important research topic since the stock has dramatically declined in recent decades and the demand for wild glass eels for use in aquaculture is increasing. Research on captive breeding is in progress however, eel reproductive biology is complex. Firstly, eels kept in captivity do not sexually mature and oogenesis needs to be induced artificially usually by chronic injection of hormones. DTU Aqua is leading in experimental research on reproduction of European eel and mass production of viable eggs and yolksac larvae has been successfully achieved. Still, the underlying mechanisms presently limiting a stable egg production have not yet been identified.

**Project**
The PhD project is related to an EU FP7 project PRO-EEL Reproduction of European eel in captivity – towards a sustainable Aquaculture. The aim of this PhD project is to determine the influence of female condition and hormonal treatments on female fecundity, follicle maturation and finally, on egg and larval quality. Stereological methods will be used to quantify female fecundity and to assess the developmental pattern of the oocytes during vitellogenesis and final maturation. Fecundity and follicular maturation pattern will then be correlated with treatment, female characteristics, ovulation success and embryonic/larval developmental competence.

**Perspective**
Results from this PhD project will increase knowledge on the oocyte recruitment processes and help optimizing the present methods used to induce oogenesis and follicular maturation of female European eel leading to an enhanced production of high quality eggs and embryos. A stable production of viable eggs in captive breeding is an essential starting point for a self-sustained eel aquaculture.

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

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Helle Jørgensby

**Background**
During the last years the scientific and environmental community has focused on the damage being done to benthic organisms by destructive human practices. Green organizations are exerting a growing pressure on the sea food industry, oil industry and other users of the ocean, to use more sustainable methods. This new paradigm is visible in new international regulations by the UN and the requirements that must be fulfilled to achieve eco-certification for fishery products by e.g. MSC and KRAV. The term vulnerable marine ecosystem (VME) covers these sensitive organisms.

**Project**
Despite this growing interest very few studies have taken place in Greenlandic waters. This study is pioneering in Greenland and a necessary building block in Greenland’s international responsibilities. The growing interest in VME’s by the international community, have a real economic effect for the Greenlandic fishing industry. To achieve eco-certification of the fishery it is necessary to initiate scientific studies of sea floor communities and the impacts on them. These impacts include fishery, oil exploration and cable laying. This study will add important knowledge to the distribution of VME organisms in Greenlandic waters in a form directly useful for the industry and for managers and advisors.

**Perspective**
The results of this industrial PhD project will provide information about VME organisms and their distribution in Greenland. This broadened knowledge base will be of importance for Greenland (to fulfill international obligations) and for the Greenlandic fishing industry as a basis for the MSC process. Other industries, e.g. the oil industry also need information about VME’s to conduct the environmental impact assessments (EIA) that are required by Greenlandic law.

*This is an industrial PhD in cooperation with Sustainable Fisheries Greenland.*
Johannes Nduvudi Kathena

**Background**
The Namibian hake fishery is a mixed fishery which targets two species, *Merluccius capensis* and *M. paradoxus*. It is the largest commercial fishery in Namibia, contributing to half of all fishery products. It is difficult to distinguish between the two species - until 1960 they were classified as one species – so catches of hake in the commercial fishery are not recorded by species. Scientific surveys, and observer samples taken from some commercial hake catches, distinguish between the two species. However, hake stock assessment relies largely on commercial catch data, which are not separated by species. Consequently, any difference in the population dynamics between the species is ignored in the hake assessment and therefore also in the subsequent management decisions. Given that the stock dynamics vary with species, it is crucial to do a split species assessment to achieve a more realistic hake assessment.

**Project**
The aim of this PhD is to improve reliability of stock assessment by using alternative models for processes, such as selectivity and growth, and by considering species and stock structure. This implies setting up of a state space assessment model (SAM) for hake. Focus is also on improving the understanding of hake spatial dynamics and to establish transboundary assessment models for hake that could provide a basis for regional management advice.

**Perspective**
The knowledge obtained from the study will provide new dimension to stock assessment in the region. It will improve our understanding on stock compositions, abundance and fishing mortality within the mixing area and trans-boundary, hence improving the regional assessment of the hake stock. The results are expected to shed more light on the hake species in different depth strata and hake stock of the same species in different areas.

Thomas Frank-Gopolos

**Background**
There is increased concern about the perspectives of maintaining the genetic (and thus evolutionary) integrity of wild fish populations in the face of human impacts - as a general conservation objective as well as in relation to the principles and policy context of the Marine Strategy Framework Directive. A specific concern relates to the potentially detrimental effects of released and escaped fish of aquaculture origin, which through hybridization and introgression impact on the gene pools and fitness of their wild counterparts. However, knowledge about direct effects of introgression with genes of aquaculture origin on fitness traits in the wild is at best scarce.

**Project**
The project will focus on identifying key life-history differences in brown trout of wild, hatchery and admixed background and linking observed trait variation to genomic variation, using quantitative genetic modeling. Life-history traits such as growth, maturation and survival are determined under natural and controlled experimental conditions using a ‘common garden’ approach. Subsequently, links between genotype and phenotype are identified using e.g. family-based association tests and linkage mapping.

**Perspective**
The project is expected to evaluate how the introduction of foreign, non-adapted genotypes in natural systems (e.g. through aquaculture escapes) affect fitness and adaptive potential of natural salmonid populations through interbreeding. The project is envisaged to produce valuable scientific knowledge as well as contribute to the development of sustainable management practices.
Sebastian Nikitas Politis

**Background**
European eel, Anguilla anguilla, is categorized as a critically endangered species and has increasingly attracted scientific inquiry towards improving our knowledge relevant to species conservation and sustainable aquaculture. Eel research has advanced, enabling a steady production of gametes, embryos, and yolk-sac larvae, expanding the focus to larval rearing performance, as well as emerging first-feeding trials, leading to the leptocephalus stages. The PhD is integrated into the DTU Aqua coordinated EEL-HATCH project.

**Project**
This PhD will investigate how and which extrinsic factors influence cultured European eels from embryogenesis to the first-feeding larval stages. More specifically, different temperature, salinity, light, green water, and feeding regimes will identify tolerance ranges and limits for optimal development and growth during early life history. Additionally, gene expression of targeted genes associated with early life development will be investigated within the different environmental conditions and linked to morphogenesis, survival, and phenotypic variability during development. Moreover, studies will relate to larval feeding and behavior trials with focus on nutritional requirements, digestive system development and corresponding histology as well as gene expression.

**Perspective**
The aim is to assess optimal ranges of biophysical conditions in cultured European eel early life stages and thus enhance knowledge on their ontogeny and physiological requirements. Understanding the relationship between environmental factors and early ontogenesis will help establishing suitable conditions for a feeding larval culture, an important next step towards a sustainable aquaculture of this species.

Christoffer Moesgaard Albertsen

**Background**
In marine biology there is often an interest in complex systems that can not be controlled or monitored completely. Two examples are tracking animal movement, and stock assessment models. To track the movement of an animal a tag is mounted on the animal. Information from the tags can then be converted to a more or less precise location. In stock assessment models the goal is to count the number of fish in the ocean and to measure the mortality induced by fisheries, to avoid overfishing. Since it is not practically possible to count all the fish, the models have to rely only on the numbers caught each year by fishermen along with a sample of fish counted by researchers. In both cases the actual process of interest is only observed through noisy measurements and special care has to be taken when analyzing the data.

**Project**
State-space models can handle this kind of data by having two layers - one that models the process of interest, and one that models the additional noise added by the measuring method. This project will extend and develop state-space models for the above applications using recent developments in computational statistics. The aim of this project is to provide more realistic movement and measurement models in tracking problems, and to develop stock assessment models which can account for migration of fish and predator-prey interactions.

**Perspective**
The models developed in this project can provide insight in marine animal behaviour that can be used to improve management of fish stocks and fishing quotas.
Brian Klitgaard Hansen

**Background**
Monitoring programs targeting commercial fish species and other key aquatic organisms are an important element in understanding the ecosystem dynamics and for implementing an effective management policy. The traditional marine monitoring programs targeting these organisms are highly labor intensive, invasive and costly to implement across large geographic regions. The application of environmental DNA (eDNA) analysis is an emerging, promising and a relatively unexplored path forward in marine monitoring. The method reduces many of the drawbacks of the conventional monitoring methods and relies only on the genetic material left behind by the targeted organisms.

**Project**
The overarching aim of this project is to explore and develop molecular detection techniques relevant for fisheries and marine ecological monitoring. The study will use cutting edge platforms and methods to determine important ecological parameters from the retrieved DNA. The project will mainly focus on commercial fish species, but will also include case studies on invasive and rare marine species.

**Perspective**
To become a valid and reliable tool, it is crucial that eDNA analysis reflects the present state of the targeted organisms in the marine environment. Therefore the project aims to refine and evaluate the method for different fisheries monitoring applications.

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.
Alan Le Moan

Background
Studies have shown that 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 funded 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 (Platychthys 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.
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.

**Project**
The overarching goal of this PhD project is to elucidate aspects of the reproductive physiology of female European eel, which affect female responsiveness, egg and embryonic quality as a step in completing the life cycle of eel in aquaculture. Specifically, the objectives of the project are to study characteristics of hormonally induced ovarian development including vitellogenesis and physiological regulation mechanisms, considering expression of genes involved in oocyte development, as well as incorporation of cytoplasmic factors, such as mRNA, that plays an important role in the early cell cleavages and influence embryonic developmental success and larval survival of the European eel.

**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.*

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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.
Paulus I. Kainge

Background
Studies have shown that variability in environmental conditions (including oxygen, temperature, wind and time of day) during trawling may result in differences in the catchability of the trawl gear, which affects estimation of stock abundance. This is even complicated in the case of Namibian hake stocks (*Merluccius capensis* and *M. paradoxus*), which are known to perform diurnal vertical migration in search of food. These abundance estimations, together with commercial catch-at-age and catch per unit effort (CPUE) indices, are key input data into the stock assessment model that guides scientific TAC recommendations and other management measure advices, for the Namibian hake stocks.

Project
This PhD study aims at studying the effects of such environmental parameters on the availability of hakes to the demersal trawl gear. It will then attempt to correct the abundance estimations accordingly in order to improve the reliability of data input into the stock assessment model. This will be achieved through survey time-series data analysis to study the effect of time of day on catchability, field work with a CTD instrument package attached to the trawl to study environmental parameters, quantifying stomach evacuation rates through modelling to study feeding biology, an geographic population modelling.

Perspective
The knowledge obtained from the study will provide a new dimension to monitoring stock assessment surveys in the Benguela Current region. It will improve the reliability of abundance estimates and also understanding of stock behaviour, which will in turn result in an improved modelling assessment of the hake resource and better management measures advices for the sustainable utilisation.

Title: Environmental effects on the availability of hakes to the demersal trawl gear in the Namibian waters
Supervisor: Kai Wieland

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: Monitoring and Data
Anette Maria Christensen

Background
The Baltic Sea region is one of the largest brackish water areas in the world and is characterized by strong vertical and horizontal salinity gradients. In this environment the hydrographical conditions, especially salinity, determine biodiversity, distribution and population dynamics of the species, including zooplankton. However, the Baltic Sea is becoming less saline due to less frequent saline inflows from the North Sea and increased precipitation and river run-off as an effect of climate change, along with an increase in temperature. These trends are likely to have a strong influence on distribution, abundance and community composition of zooplankton, which ultimately could cause alterations in food web dynamics and ecosystem function in the Baltic Sea.

Project
The responses to future climate change and the potential for evolutionary adaptation in Baltic zooplankton will be investigated using three different approaches: 1) experimental investigations of tolerance and physiological performance of Baltic populations of the marine species *Temora longicornis* and the brackish species *Acartia bifilosa* with regard to salinity and temperature; 2) the assessment of genetic and physiological basis of plasticity in these populations, evaluated in common garden experiments; and 3) investigation of local adaptation of traits using different populations of *T. longicornis* (Baltic vs. Kattegat) isolated along a salinity gradient, and of potential implications of shifts in the contribution of genetic and physiological plasticity to total plasticity (with regard to salinity) for the tolerance of increasing temperature.

Perspective
Many model predictions on the effects of future environmental changes are based on typical physiological measurements that do not take evolutionary adaptation into account. This research aims to provide us with a somewhat pioneering knowledge on the evolutionary adaptation potential in zooplankton communities on both local and regional scales.

Nicolas Azaña Schnedler-Meyer

Background
In recent decades, reports of a supposed anthropogenic global increase in jellyfish abundances, and in the frequency and magnitude of blooms have been a subject of strong debate, reflecting a general lack of knowledge about jellyfish population dynamics and their role and significance in marine food webs. This debate has sparked an increase in jellyfish research, but in spite of this, the importance of jellyfish predation and competition impacts on ecosystem dynamics is still poorly understood, mainly because jellyfish populations are hard to study in the field.

Project
The aim of this project is to investigate the importance of competition between jellyfish and fish for the dynamics of their populations, across different types of jellyfish and along different gradients of environmental conditions. The lack of good jellyfish time series promotes a mechanistic, trait-based approach, using population models based on rates and processes at the level of the individual. I will be working with a four-species food web model which can be calibrated to investigate how system dynamics depend on organism traits such as life histories, size and feeding mode. The model can also be adapted to investigate the effects of varies environmental conditions such as advection, light regime and seasonality.

Perspective
Marine ecosystems and environments are currently undergoing major changes due to anthropogenic impacts such as overfishing, eutrophication and climate change. It has been proposed that this may promote jellyfish to the detriment of fish and fisheries, but improved understanding of how traits and environment in combination affect the balance between these two groups is crucial, if we are to manage ecosystems in a changing ocean.
Background
Arctic sea ice is melting creating new opportunities for Arctic shipping routes and marine oil and gas exploration. Increased activities increase the risk of accidental oil spills. The Arctic climate increases potential effects of contaminants, through prolonging exposure time for affected organisms. Arctic copepods *Calanus spp.* play a key role in the energy transfer in the Arctic marine food web. Little is known about ecotoxicological effects of oil spill response methods or long-term oil exposure on physiology of Arctic copepods.

Project
This project aims to assess effects of oil spill responses and long–term oil exposure on the physiology and survival of *Calanus glacialis* and *Calanus hyperboreus*. 1) In 2015, long-term mesocosm experiments were conducted in the sea ice on Svalbard simulating a surface oil spill. We studied impacts of natural degradation, chemical dispersion and in situ burning of crude oil on survival, egg production, pellet production and egg hatching success of the *C. glacialis*. 2) In 2016/2017, long-term oil exposure studies were conducted in the laboratory on hibernating *C. hyperboreus* and *C. glacialis* to assess combined effects of a future warmer ocean and oil exposure at the sea bottom followed by a simulated spring bloom to evaluate the impact after the exposed over-wintering.

Perspective
This project will fill a knowledge gap about long-term effects on Arctic copepods of oil spills in the sea surface and bottom, as well as effects of response methods. Results from the field experiments will be integrated into a pan-arctic research program financed by the International Association of Oil and Gas Producers aiming at developing a Net Environmental Benefit Analysis tool to help stakeholders improve future spill response actions in the Arctic.

This is an industrial PhD in cooperation with COWI.

Urban Wünsch

Background
Dissolved organic matter (DOM) is the largest active reservoir of reduced organic carbon in the world. DOM is a complex mixture of organic compounds ultimately originating from the degradation of terrestrial and aquatic plant material. The physical and chemical properties of DOM greatly influence aquatic ecosystems by providing a source of nutrients and energy for aquatic microbes, and by being a conduit of carbon in the global carbon cycle. While the direct chemical characterization remains a time consuming analytical challenge, the colored fraction of DOM (CDOM) can be analyzed much faster using absorbance and fluorescence spectroscopy.

Project
The project aims to improve our understanding of the relationship between chemical and optical properties of DOM. To achieve this, absorbance and fluorescence properties of selected organic chemicals will be studied and their optical properties will be compared to a database containing sample compounds produced by the mathematical decomposition tool PARAFAC (Parallel Factor Analysis). Secondly, we will develop a size based separation technique to allow for a comparison of physical separation and mathematical decomposition of organic matter. The analytical developments will be applied to drinking water treatment at Chalmers University (Dr. K Murphy).

Perspective
The results of this PhD project will help to increase the potential of CDOMs optical properties as a valid tool to elucidate its chemical properties. Moreover, the physical separation of DOM will provide unique opportunities to associate molecular markers of DOM with CDOM properties in DOM fractions with reduced complexity. The results will improve the potential of UV-visible spectroscopy as a tool to study DOM in natural waters and to monitor and optimize processes in drinking water facilities.

This is a joint degree PhD with Chalmers University of Technology, Sweden.
**Background**

Living conditions in the oceans are changing as a response to climate change. This affects all lifeforms from the largest predators down to the simplest plankton cells. Like all other organisms a plankton cell needs to invest its energy resources in a manner to achieve the best fitness under the given environmental conditions. This raises several important questions on what traits to prioritize and fine-tune: What is an appropriate size? How efficient must light and nutrient harvesting be? Should energy be spent on rapid growth or defence mechanisms? And how does one trait exclude another; what are the trade-offs between different traits?

**Project**

The objective of this project is to investigate how in particular the traits of size, nutrient and light harvesting investment in phytoplankton develop and distribute in a changing environment. The changes considered will both be on short term as seasonal fluctuations and long term changes brought by climate change. The study will be performed as a model study, where the development of the different traits will be studied using a mechanistic trait model, forced with a physical model of the environment.

**Perspective**

Phytoplanktons are the most important primary producers of the ocean and changes in their patterns can have implications for the oceanic food chain and carbon cycle. Therefore my project aims at increasing the ability to predict how phytoplankton communities will respond to not only the seasonal fluctuations in the environment but also the long term changes caused by climate change.

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**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 has 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 tropic 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.*
**Anna Katharina Miesner**

**Background**
Tremendous advances in observing and modelling of the ocean have occurred in recent decades: today it is possible to make accurate forecasts of physical oceanographic variables, such as temperature and salinity, several years into the future. However, the next step of converting these forecasts of the physical environment into forecasts of the biological environment, and therefore into variables that are directly relevant for stakeholders and society has yet to be taken. Developing these so-called “climate services” for marine ecosystems represents one of the new challenges in marine science.

**Project**
During my PhD, I will develop seasonal-to-decadal scale forecasts of marine ecosystem variables such as the productivity or distribution of different marine species, e.g. blue whiting, based on the mechanistic understanding of the species-environment relationship. This entails, the creation of statistical models linking biological variables of interest to physical ocean models and then translating forecasts of physical oceanographic variables into forecast the biological environment.

In order to ensure that a forecast has skill, it is essential to thoroughly examine the quality of the biological model as well the physical model. Therefore, building on the knowledge of forecast validation metrics used in atmospheric science and physical oceanography, I will review and apply different statistical tools that can be valuable in assessing the quality of forecasts.

**Perspective**
By transforming climate-related data into biological variables that are of relevance to ocean users and managers, seasonal-to-decadal scale forecasts provide an early window for the implementation of strategies to minimise the impacts of climate change and are essential in proactive marine resource management. My PhD will create novel biological forecasts and give a better insight into assessing the quality of marine biological forecasts and the robustness of climate change predictions.

**Kristian Ege Nielsen**

**Background**
Fish age is traditionally estimated from reading seasonally formed rings in sagittal otoliths. In eastern Baltic cod however, this age estimation has always been problematic. In the last decade the challenges have increased considerably, and recently have culminated in contributing to ICES decision to manage the stock under a suboptimal data limited approach. This in turn has caused loss of the eastern Baltic cod fisheries MSC ecolabel. In the search for a solution, otolith microchemistry studies have indicated that the incorporation of certain elements could be associated with seasonality, thereby providing a method for deriving fish age and growth. Investigation of this relationship forms the frame of the PhD project.

**Project**
During the project we will analyse the microchemical composition of otoliths in different perspectives. To get insight into the relation between cod growth and otolith element composition, the research will examine the relation between otolith protein composition and protein bound elements and their association in different growth zones. The research will explore spatial variation in element concentrations in relation to season and otolith growth. The objective is to provide validated knowledge to develop methods for supplying reliable age and growth information based on microchemistry analysis. The analysis will be based on archived otoliths from previous tagging and age validation projects, as well as on otoliths from a concurrent large scale Baltic tagging project. The latter in particular serves as validation of potential seasonality in microchemistry signals.

**Perspective**
We will supply necessary new knowledge on seasonal microchemistry composition of otoliths especially related to growth. With this we aim at providing the data necessary for correcting the current stock assessments for the eastern Baltic cod, and to develop methods for obtaining age and growth information from historic and future samples necessary for evaluating other stock status parameters important for future management.
DTU Aqua - National Institute of Aquatic Resources - is an institute at the Technical University of Denmark (DTU).

DTU Aqua conducts research, provides advice, educates at university level and contributes to innovation in sustainable exploitation and management of aquatic resources. We have our own PhD School with around 40 PhD students enrolled. In this publication the current PhD projects are presented.