Preface

This web-publication, PhD projects at DTU Aqua, presents PhD students at DTU Aqua’s PhD school as at 1 May 2023. The publication is updated twice a year.

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 in front line research, whether it is for exploring fundamental issues in aquatic sciences, 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 aquatic scientists that can face the challenges that, e.g., climate change and an increased utilization of aquatic resources present to us.

David Lusseau
Head of the PhD School at DTU Aqua

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Sei Suzuki

**Background**
The ocean hosts a great diversity of single celled microorganisms that are characterized by their flagella: a flexible fine appendix that serves for motility and for capturing and handling food particles such as bacteria and phytoplankton. These unicellular flagellates play a key role in the oceanic food chains and in the biogeochemical cycles of marine ecosystems. Despite of their importance in these marine biological processes, the mechanisms of flagellate feeding and their associated costs in mortality still remain widely unknown.

**Project**
This study will focus on heterotrophic nanoflagellates: very small flagellates (2-20µm) that exclusively feed on other organisms. At this small scale, aquatic environments become as viscous as a thick syrup and present a challenge for prey capture. First, I aim to understand how nanoflagellates overcome the impeding effects of viscosity by creating currents with their flagella to draw the prey towards them. I will describe these events and study the different types of feeding currents for several species with high-speed video recordings. I will also perform experiments to quantify the rate in which the flagellates graze upon their prey by culturing them together, and I will compare the results with the calculations of computed models of the feeding currents. And secondly, I will investigate potential defense mechanisms: how can the nanoflagellates themselves avoid or reduce the chance of being eaten while they search for food.

**Perspective**
The overarching aims of this PhD are to describe and to understand prey encounter mechanisms in important marine heterotrophic nanoflagellates. The results of my project will illustrate the evolution of different prey-capture strategies and will establish their potential trade-offs. Studying the feeding mechanisms of these small organisms is important for a better overall understanding of the predator-prey interactions that take place at the small scale.

Louise Catharina Flensborg

**Background**
Policy makers, managers and the general public are rightly concerned that marine ecosystems and the services which they supply are under threat from a range of human pressures, including overfishing and climate change. Ecological resilience is the ability of a system to remain organized around the same set of processes, structures, and functions. Resilience in a system is a measure of how much disturbance the system can buffer without moving into an alternative regime. Our knowledge of resilience and vulnerability of marine fish communities to changes are scarce. Consequently, there is an urgent need for a better understanding of the underlying process contributing to increase ecological resilience.

**Project**
In this project, we will use available data on marine fish species abundances and traits to assess, quantify and compare the resilience and stability of marine fish communities across the North Atlantic and North East Pacific following the conceptual framework provided by the cross-scale resilience model. We will investigate how key attributes of ecological resilience (i.e., functional redundancy, response diversity and evenness) vary across marine fish communities, as well as between marine ecosystems in both space and time.

**Perspective**
This will enhance our current understanding of ecosystem resilience in marine fish communities by quantifying and mapping the extent of ecological resilience in marine fish communities, and by estimating how resilience control fish biomass over time. Furthermore, we hope to help guide future research and conservation effort by providing an assessment, and ranking, of the ability of current marine protected areas to protect fish communities of low resilience.
Kristian Maar

Background
Aquatic suspension feeders span from unicellular organisms to the blue whale and are characterized by various mechanisms of filtration, which enable them to separate and retain particles of food from the water. The ocean is nutritionally dilute and marine suspension feeders must therefore be highly efficient in order to successfully capture enough food to grow and reproduce. The biomechanical adaptations suspension feeders have evolved to solve this problem are as diverse as the community of suspension feeders themselves and is fundamentally constrained by physical properties e.g. the size of the filter feeder and the type and size of particle they capture. The flow generated by active suspension feeders also affects their local environment and is theorized to facilitate the aggregation and sinking of marine snow.

Project
The first part of my project focuses on the fluid dynamics of suspension feeding in sessile barnacles. To determine the flow field generated by barnacle suspension feeding I will use high-speed video and Particle Image Velocimetry (PIV). The second part of my project focuses on the impact of colonization of microscopic suspension feeders on the formation and sinking of marine snow. I will quantify this phenomenon by conducting experiments comparing aggregation and settling of marine snow with and without active suspension feeders.

Perspective
Elucidating the mechanics of suspension feeding provides novel insight into predator-prey relationships and specific solutions to complex fluid dynamic problems. Bio-mimetic efforts inspired by marine suspension feeders have already yielded technological advancements in industrial filter technology and is currently being discussed as potential solutions to microplastic in the ocean. Understanding the processes of marine snow formation will also increase the predictive power of carbon pump models and contribute to the detailed understanding of sequestration of carbon in the deep ocean.

Amalia Papapostolou

Background
The structure of the marine food web plays a crucial role for fisheries and ocean biogeochemistry. Food webs consist of interconnected food chains and in the ocean a food chain typically follows the sequence: phytoplankton, herbivorous zooplankton, carnivorous zooplankton, upper trophic levels (i.e. forage fish). It can take a varying number of steps within a food chain for energy to transfer from phytoplankton to fish across different oceanic regions, depending on the planktonic community composition. The length of the food chain is tightly linked to the concept of "trophic efficiency", namely the efficiency with which energy flows from one trophic level to the next through predation.

Project
The aim of my PhD is to make global estimates of the 'microbial' trophic efficiency from phytoplankton to small pelagic fish; basically how does energy flow across the food chain. This is crucial to improve our estimates and predictions for fisheries yields and carbon export. To do so, I will explore the mechanisms that govern marine food web dynamics through trait-based modeling, by implementing and further developing the "NUM" model framework, created at the Center for Ocean Life. NUM is a mechanistic size- and trait-based model along the Nutrient-Unicellular-Multicellular axis, based on individual-level processes. In NUM, the multicellular component encompasses ontogeny and describes the population dynamics of key copepod groups, characterized by their adult size and feeding mode. The composition of the plankton community is an emergent property of the model, resulting from predation and competition.

Perspective
With this PhD, we expect to identify the main mechanisms linking higher trophic levels, such as fish, to primary producers, and see how trophic efficiency correlates to fisheries yields and carbon export.
Background
Flagellates represent highly relevant species among eukaryotes both from evolutionary and ecological perspectives. They are found among all the branches of the eukaryotic tree of life, with highly diverse flagellar arrangements and resource acquisition modes. Also, they play a crucial role in the biogeochemical cycles of the global ocean. Their key position in the microbial food web is governed by their feeding on bacteria and other picoplankton, by their photosynthetic activity, and by themselves being grazed by predators. Their degree of success in eating without being eaten is the key to understand the functioning of predatory flagellates. Their feeding activity dangerously exposes them to rheotactic predators that are sensitive to flow disturbances. Therefore, flagellates have evolutionarily developed singular behaviors in terms of feeding modes and predator avoidance, to find an equilibrium between resource acquisition and predation risk. These trade-offs are still largely unexplored among flagellates.

Project
During my PhD, I will study representative flagellate species belonging to different branches of the eukaryotic tree of life to look at their behaviors both as predators and prey. Firstly, I will investigate escape responses from predators feeding currents to understand their propulsion mechanism that leads to very fast and long jumps, and characterize the fluid signals that elicit them. Secondly, I will quantitatively investigate the kinematics and 3-dimensional beat patterns of diverse flagellar arrangements and use them as input to CFD models to quantify foraging-predation risk trade-offs.

Perspective
My PhD project aims at describing these trade-offs quantitatively and at understanding how they are differently optimized among flagellate species. This is crucial because the diversity of eukaryotic microbial communities is determined by such trade-offs in concert with environmental constraints and microbial diversity in turn governs the functionality and “services” of microbial communities and so their role in ocean biogeochemistry.

Marcel Montanyès Solé

Background
Marine ecosystems and the services they provide are nowadays threatened by several pressures such as climate change, overexploitation of species, habitat destruction, and invasion of alien species. These pressures are likely to negatively affect taxonomic and functional diversity of marine habitats. Failing to identify future biodiversity trends and thus, to tackle the necessary management and conservation actions, will most likely lead to important biodiversity losses.

Project
This project aims to study the effects of climate change and other human activities (e.g., fishing) on the past, present and future distribution, composition, and diversity of marine fish communities throughout the North Atlantic and North-east Pacific oceans. To achieve this overall aim, we also need to better understand the underlying responses of species to drivers and to key the assembly processes that shape the taxonomic and functional structure and composition of communities at different spatio-temporal scales. We will use available data on marine fish species occurrences and traits and environmental variables to build models that will allow us to study the above-mentioned subjects.

Perspective
This project will improve our understanding on the relative importance of the assembly processes and human activities in defining the fish community. Moreover, the study of biodiversity patterns and drivers will allow us to better understand how they will be affected by climate change, so knowledge can be translated into effective management and conservation measures that seek to preserve biodiversity and hence, human well-being.
**Toni Vivó Pons**

**Background**
The spread of non-indigenous marine species has been increasing over the last decades, having severe effects on the functioning of recipient ecosystems as well as a socio-economic impact. Studying biological invasions from a trait-based approach is really interesting to start addressing interactions between introduced and native species from recipient communities, as the functional similarity between non-indigenous and native species coupled with the community assembly rules (environmentally or biologically filtered) play a major role on the invasion success. As a quick example, within an invasion scenario, a greater trait similarity could imply stronger competitive interactions between natives and invaders that could either difficult the invader establishment or be detrimental for native species.

**Project**
As a starting point the functional similarity between native and non-native organisms will be assessed, observing if the patterns of similarity are conditioned by the spatial scale, environmental or biotic conditions. This will be done by applying novel techniques for species modeling, which could allow to observe how species are associated by their traits or given certain environmental conditions. Then, the potential consequences derived from the differences in functionality between natives and non-natives will be addressed for recipient communities, e.g. the displacement or enhancing of certain native species, changes in ecosystem functionality or naturalization of the non-indigenous species.

**Perspective**
The main goal of this project is to propose a trait-based framework to study and better understand how native and non-indigenous species interact and which consequences these interactions could have on recipient communities. The results obtained could be really useful to expand knowledge about biological invasions in marine environments, and then transferred to policy makers to enhance the conservation efforts towards ecosystems under a biological invasion or more susceptible to be invaded in the future.

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**Gunaalan Kuddithamby**

**Background**
Microplastics (1 μm-5 mm size) are ubiquitous in the marine environment, making them a major environmental concern. Despite of the increased scientific interest in microplastics pollution, many questions on their fate and toxicity remain and their ecological impact is still under debate. Therefore, comprehensive research studies need to fill the gaps in our scientific knowledge on distribution of microplastics in the marine environment. It is essential to understand the distribution of microplastics since they play a crucial role as vectors of different potential contaminants to enter the marine food web. Microplastics can be accidently ingested by zooplankton and egested as part of their fecal pellets.

**Project**
My PhD project aims on the ecological risk of microplastics pollution on the marine environment and understand the links between oceanographic processes, environmental distribution of microplastics, and their impacts. This project comprises three major interconnected work packages to assess the “risks” of microplastics pollution, investigate the “abundance” of microplastics and their characterization; the “fate” of microplastics and assess the “impacts” of weathered plastic, plastic leachates and additives by examining ecological and physiological changes in marine copepods at different spheres along a gradient of marine environment from water column to seafloor.

**Perspective**
The project will assess the abundance, composition and sizes of microplastics in Danish fjords and coastal waters (Kattegat strait) in relation to hydrography. The outcomes of work packages probably lead to develop a model for risk assessment for microplastics in Danish waters.
### Magnus Heide Andreasen

**Background**
Gelatinous zooplankton organisms are a diverse group of soft bodied, transparent organisms that comprise members from diverse phyla in the animal tree of life. They comdynamics, partly due to their interference with human activities especially in coastal waters. It has been suggested that their abundances are on a rise due to global change induced stressors. However, the data and experimental basis to support this hypothesis remains inconclusive. monly attract large public attention partly due to their bloom and bust population.

**Project**
The aim of this PhD project is to address the hypothesis that gelatinous zooplankton biomass is increasing due to global change induced stressors from a time series as well as experimental perspective. The project will combine statistical modelling with laboratory-controlled experiments.

**Perspective**
The results are expected to further our understanding about gelatinous zooplankton’s long-term abundance fluctuations, their underlying population dynamics and the response of certain sub-populations to global change induced stressors.

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### Delove Abraham Asiedu

**Background**
Recent reports suggest that marine ecosystems worldwide are increasingly exposed to overexploitation and pollution from heavy metals, petroleum, plastics and persistent organic pollutants. In addition, the UN's Intergovernmental Panel on Climate Change has reported that the temperature of the ocean is likely to increase by ~1-6°C by the end of this century, with fastest-warming occurring in the Arctic areas. We, however, lack understanding of how key organisms (both native and non-native), from primary producers to higher trophic levels, are impacted by climatic and non-climatic changes and how the individual responses of species influence trophic interactions and community structure. This is particularly urgent for Arctic marine ecosystems because they are highly vulnerable to warming due to ice acting as the vital ecosystem element.

**Project**
This PhD project will combine field and experimental studies to quantify the zooplankton community composition and production in the Arctic and their sensitivity to the combined effects of climate change (e.g., increasing sea surface temperature, decreasing salinity and turbidity) and pollution. The zooplankton will consist of both native and non-native species, thus including aspects of the potentially different environmental tolerance of these groups. Also, special focus will be on small ($\leq 1$ mm) under-studied copepod species that dominate the abundance of Arctic zooplankton at many locations and seasons.

**Perspective**
The project will provide novel knowledge on the mechanistic impacts of stressor combinations on native, non-native and small under-studied zooplankton species at different ontogenic stages of development. This will contribute to the general understanding of how individual tolerances accumulate to community-level stressor responses, which is essential knowledge to be able to predict the effects of environmental change in the vulnerable Arctic ecosystem.
Aurelia Pereira Gabellini

Background
Interactions between ocean currents and life history traits can regulate fundamental processes in marine ecosystems including spatial segregation, speciation and meta-population structures. These processes can act across several temporal and spatial scales altering the response of ecosystems to multiple pressures including climate change. It is therefore relevant to develop methods to assess the marine connectivity across distant biogeographic regions to support the identification of management strategies for the sustainable exploitation of ocean resources.

Project
My PhD project aims to better understand dispersion and connectivity patterns across biogeographic regions in the Atlantic Ocean, by combining trait-based modeling description of marine organisms to high resolution ocean circulation models. General circulation models for the Atlantic Ocean will be coupled to a Lagrangian particle tracking algorithm simulating dispersion of numerical particles with properties defined by specific traits. The analyses will include a wide range of movement strategies from passive transport to more directed movements (e.g. migrations). The resulting connectivity matrices will be investigated to assess the importance of specific traits and the importance of transport across specific regions. The model will be used to assess past and present conditions as well as to provide scenarios of future connectivity patterns in the Atlantic Ocean.

Perspective
This thesis is part of Mission Atlantic project which aim is to map and assess the present and future status of Atlantic marine ecosystems. The results are expected to contribute to further our knowledge about connectivity in the Atlantic Ocean and possible consequences in the recruitment of some selected groups due to climate change.

Title: Marine Connectivity across the Atlantic Ocean—past, present and future
Principal supervisor: Patrizio Mariani
Section: Oceans and Arctic

Caroline Gjelstrup

Background
Knowledge of oceanographic conditions and their variability is essential for assessment of environmental impacts on biological communities, ecosystem services and regional climate variability. East Greenland is a region of both climatic and ecological importance, providing a connection between the Arctic and Atlantic oceans as well as eco-system services such as carbon sequestration and fisheries production. The region is influenced by cold fresh waters from the Arctic and warm saline waters from the Atlantic divided by a continuous front extending along the shelf-break. Oceanographic fronts are often associated with elevated plankton production due to entrainment of nutrients enhancing phytoplankton growth and zooplankton grazing, which supports pelagic and demersal fish. Ongoing Arctic climate change, including diminishing sea-ice cover, increasing discharge from the Greenland ice sheet and anomalous warm water pulses of subtropical origin propagating through the region, alter the physical environment.

Project
This PhD project aims to improve our understanding of variability in oceanographic conditions in East Greenland, and how this relates to ecosystem change and fisheries productivity. A combination of in-situ and remotely sensed observational data will be used to characterize oceanographic conditions and resolve underlying mechanisms responsible for variability herein. Eventually, a trait-based model will be applied to understand how changes in environmental conditions influence ecosystem function.

Perspective
By gaining insights as to how the spatiotemporal distribution of water masses in the East Greenland region are changing, and what that change implies for nutrient availability and plankton dynamics we can begin to foresee how East Greenland will respond to future change.

Title: Changing oceanographic conditions of East Greenland and its link to regional fisheries
Principal supervisor: Colin Stedmon
Section: Oceans and Arctic
**Anshul Chauhan**

**Background**
Understanding ocean dynamics is vital to interpreting marine ecosystems functioning and determining key processes affecting global climate and biodiversity. Changes in chemical composition, warming of the ocean, loss of biodiversity, and several climate interactions alter the dynamic equilibrium between ocean, land, atmosphere, and between biotic and abiotic components in the Earth System. Such interactions can operate across multiple temporal and spatial scales and generate extreme conditions that significantly alter ocean dynamics and ecosystem functioning. The complexity of these processes is high and many uncertainties still exist on physical, biological, and chemical mechanisms regulating them.

**Project**
The aim of my PhD is to focus on advancing state-of-the-art processing and interpretation of big ocean data introducing deep learning methods and hybrid-modeling approaches (statistical and process based) for understanding marine ecosystems. This research project is primarily concerned with critical oceanic variables like sea surface temperature (SST), sea surface salinity (SSS), ocean currents, and phytoplankton groups as well as other ocean variables valuable in assessing present and future ecosystem states.

**Perspective**
With this PhD, we expect to develop indicators for ecosystem state, understand the correlation between extreme events, detect abrupt transitions in ecological states across regions, and simulate possible future outcomes in the spatio-temporal domain.

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**Philip Alexander Hedlund Smith**

**Background**
Ocean dynamics are essential for the functioning of the Earth system with important effects on climate regulation and global biodiversity. Regional and global processes driving storage and transport of heat, carbon, nutrients, and marine organisms are crucial for providing many ecosystems’ goods and services that enable life on Earth. These processes are driven by mechanisms interacting and operating over wide ranges of spatial and temporal scales, and inherently involve both horizontal and vertical dimensions, making them exceedingly difficult to monitor and to understand fully.

**Project**
The general objective is to determine and understand spatio-temporal dependencies, relations, and mutual effects in the abundant climate and biogeochemical data. The goal is to understand these relationships as well as constructing frameworks for predicting future behavior. Moreover, to establish systems where ocean and ecosystem dynamics are learned and can be emulated for different initial state values. Neural networks and deep learning approaches in particular display major advantages in exploiting spatio-temporal data and capturing nonlinear relations in data compared to classical approaches.

**Perspective**
Generating deep learning frameworks to combine remotely sensed and in situ observations may improve estimates and models of subsurface ocean state variables, which presently can be difficult to monitor due to the scarcity of local measurements. Furthermore, predictive data-driven models that accurately reproduce simulation data may facilitate comprehensive risk analyses and assessments, as changes in simulation data for varying driver inputs may be considerably less time consuming.

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**Title:** Resolving marine ecosystem dynamics in time and space with machine learning approaches  
**Principal supervisor:** Patrizio Mariani  
**Section:** Oceans and Arctic

**Title:** Big data analytics to support ecosystem-based risk management of marine ecosystems  
**Principal supervisor:** Patrizio Mariani  
**Section:** Oceans and Arctic
Costanza Cappelli

Background
Blue whiting (Micromesistius poutassou) is a mesopelagic gadoid species widely distributed in the northeast Atlantic Ocean, and it is commercially exploited throughout much of the region. It is both an important prey for many higher trophic level species and a zooplanktivore exerting significant top-down pressures. In the last 15 years, blue whiting has experienced considerable swings in abundance and recruitment. Despite its commercial and ecological importance, little is known about blue whiting stock dynamics in relation to atmosphere-ocean variability, constituting a major source of uncertainty for the management of this species.

Project
In this PhD project, I will examine how large-scale changes in the ocean-climate conditions affect blue whiting recruitment and distribution in the North Atlantic Ridge area. Using statistical tools and agent-based particle tracking modelling approaches, I will provide a quantitative analysis of the relationship between large-scale oceanographic features in the North East Atlantic (e.g., subpolar gyre dynamics, wind stress curl) and the early life history of blue whiting (larval drift patterns, growth, and survival rates).

Perspective
This project will assess factors shaping temporal and spatial dynamics of blue whiting populations in relation to variable marine climate conditions in the North East Atlantic Ocean. The purpose is to develop models to understand the reproductive variability of blue whiting, as well as to improve stock assessments and fishery-related forecasts for this species. This knowledge will contribute to new ecosystem-based approaches to the management of blue whiting, UN Sustainability Development Goals related to Life Below Water, and an increased understanding of how climate change might impact productivity and biomass of this species.

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 evaluating 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.
Background
The flat oyster *Ostrea edulis* represents a valued food source since the Romans, and a luxury good nowadays. It has been overfished and heavily impacted by disease outbreaks. In contrast with the pacific oyster *Crassostrea gigas*, where the whole genome sequencing enabled novel and more powerful genetic population studies of the species, the flat oyster has not got the same consideration yet. In Denmark, the current distribution is confined to the Limfjorden. In Norway, records have been reported as far north as the Nordland region, which likely represents the northernmost distribution limit of the species. In Sweden, flat oysters are observable in the north of the Swedish Skagerrak coast and show sustainable populations in relatively good health in contrast with other European flat oyster’s locations.

Project
We aim to gain insights into the European flat oyster natural genomic diversity, with a particular focus on the Scandinavian populations, and to develop genetic knowledge of the species as a practical tool to inform aquaculture production and restoration projects. To achieve these goals we will perform an analysis of genome-wide markers at an unparalleled level of geographical and genomic detail. Expected results are knowledge on 1) Genetic diversity of the Scandinavian natural flat oyster, with comparison among populations from the species’ entire distribution range, and 2) Genetic practical tools applicable to aquaculture and restoration programs.

Perspective
This large sampling campaign and subsequent genetic diversity analysis will permit an assessment of the putative population structure, local adaptation, and effects from translocations of *O. edulis* in Scandinavia. As well as providing genetic input resulting in a set of recommendations/guidelines for the flat oyster aquaculture and restoration.

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Homère Alves Monteiro

**Title:**
Applied population genomics in European flat oyster (*Ostrea edulis*)

**Principal supervisor:**
Jakob Hemmer-Hansen

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Paulina Urban

**Background**
Environmental DNA (eDNA) describes all DNA molecules found in an environmental sample, e.g. water, soil or air, that originated from organisms present in that environment. Consequently, analysis of eDNA can be used for monitoring of species or species assemblages. This would likely save time, costs, and workload for such procedures. So far, eDNA implementations for large scale monitoring projects conducted by management institutions, such as fisheries institutes, are limited. This includes both single species monitoring, of e.g. invasive species, and monitoring of species assemblages, e.g. for bycatch estimations. One of the reasons for this might be the need for quantitative estimates for such applications. In order to use eDNA for quantitative estimates, eDNA behavior needs to be better understood, and the molecular methods applied need to be calibrated and validated.

**Project**
My PhD project aims at facilitating practical implementations of eDNA based methods for monitoring of single species and species assemblages in management and industry. To archive this, on the one hand I will develop methods for eDNA-based quantitative assessment of species assemblages that could be used for by-catch estimations in fisheries. On the other, I will assess and advance methods for monitoring single species, e.g. invasive species that would enable fast monitoring of their spread in ecosystems.

**Perspective**
Results gained from this PhD project will improve the understanding of eDNA ecology and behavior, and improve the molecular methods applied on eDNA for different monitoring goals. If successful, the methods developed throughout the PhD will come at hand to applied areas such as management, and industry, which need frequent species monitoring.
Kasun Anuruddha Bandara

**Background**
Eels, although being a targeted high value fish in aquaculture, their production is based on wild capture of juveniles. As the natural stock of European eel has declined sharply and is ranked as critically endangered on the IUCN red-list, there is an urge developing hatchery technology for a sustainable aquaculture and assisting management and conservation plans. Recent research conducted at the prototype hatchery, EEL-HATCH located at DTU Aqua in Hirtshals, has led to a stable production of larvae entering the feeding stage. Establishing feeding in larval culture entails increased bacterial load in the water leading to detrimental effects on the larvae. Therefore, research addressing microbial management and immune system ontogeny is essential to progress hatchery technology for European eel.

**Project**
The aim of this PhD project is to fill gaps in knowledge about impacts of microbial interactions on offspring survival and developmental success in culture of European eel larvae. We study the effect of stocking density at different developmental phases (embryonic, yolk-sac and feeding stages) on microbiome composition and on embryonic and larval health. Additionally, we explore how gut-priming/immuno-stimulation, dietary composition, and feeding regime drive the microbiome in culture water and larvae, and we identify if and how the shift in microbiome affects larval development. Finally, the data on microbial communities of larvae and the environment, generated from the above studies will be used as input to conclude on community assembly and succession of the microbiome in European eel larvae.

**Perspective**
This project will expand our knowledge on the importance of microbial management in enhancing offspring survival and developmental success in marine fish larval culture, using European eel culture as a model.

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

Alexander Rosén

**Background**
Metabolic rate scales with body size, but usually out of proportion, meaning that for a given increase in body mass, metabolic rate usually increases less. This means that larger animals are more efficient, and 1 kg of mouse thus uses magnitudes more energy than 1 kg elephant. This scaling is not constant and there is substantial variation among taxa and taxonomic level. Precisely why it is so, and particularly why there is variation in this metabolic scaling relationship between individual, species and groups of species are some of the biggest unanswered questions in biology.

**Project**
The goal of the project is to test a novel hypothesis that metabolic scaling is governed by growth and that variation in selection pressures on fast early-life growth courses the variation in metabolic scaling. This will be tested using both a multigenerational selection study where zebrafish will be breed for high or low growth rates and during a comparative study examining different fish species with varying levels of early growth rates. Metabolic rate will be measured with respirometry.

**Perspective**
This project is expected to produce new and fundamental knowledge about metabolic scaling and why it varies both in individuals, between individual, between species and species groups. These findings would translate into a better understanding of the energetics of animals and low evolution affects this. In addition, it can help predict how animals will be respond to new selection pressures such as climate change and over-harvesting.
**Background**
This PhD project is part of the Horizon 2020 WaSeaBi project, which aims to bring the state-of-the-art in solving the barriers to sound exploitation of the aquatic resources with focus on the optimal utilization of seafood side-stream through development of storage solutions, sorting technologies and decision tools to secure an efficient, sustainable supply system for by-catches and side-stream from aquaculture, fisheries and the aquatic processing industries.

**Project**
The focus of the PhD project is to illustrate how the companies in the WaSeaBi project can optimize their decision-making processes to improve the sustainability and economic utilization of the aquatic side-streams by using decision making tools. This will mainly be explored through the development and application of a new decision support tool to the already existing Analytic Hierarchy Process (AHP) methodology, that accounts for different decision-making biases and the decision makers’ dominant logic, which are rarely studied or accounted for in this methodology. By using the psychological technique of cognitive mapping to map out a decision makers decision paths on sustainable development it will be identified which biases and components of dominant logic are causing barriers to the sound exploitation of the aquatic resources and side-streams.

**Perspective**
The insights gained from this PhD project will be used to formulate the support tool’s methodology and create a new AHP support tool that to greater degree can account for biases and dominant logic components in its calculations, in order to support decision makers in making unbiased decisions about sustainable optimization of aquatic resources and side-streams.

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**Søren Espersen Schrøder**

**Title:**
Decision tools and management in the fish sector

**Principal supervisor:**
J. Rasmus Nielsen

**Section:**
Ecosystem based Marine Management

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**Berthe Vastenhoud**

**Background**
The mesopelagic zone of the ocean is located in pelagic water masses from 200m to 1000m depth, between the euphotic zone, where light is available, and the bathy-pelagic zone, where no light is visible. Global survey estimates of the mesopelagic fish biomass are large but remain uncertain, with estimates ranging between 1 and 20 Gt. There is increased interest from commercial fisheries to exploit these species for the use for fishmeal, fish oil and nutraceuticals, but the question is whether such potential exploitation is sustainable or not.

**Project**
This project evaluates the sustainability of potential exploitation of two key meso-pelagic fish species, *Maurolicus muelleri* and *Benthosema glaciale*, in the North-East Atlantic Ocean, both in terms of ecological sustainability and economic viability. Length-based statistical methods for data-limited stock assessments are used to estimate demographic parameters related to growth, mortality, stock size and production of the stocks according to Maximum Sustainable Yield. The economic sustainability of a mesopelagic fishery and different management strategies will be evaluated using the DISPLACE individual vessel based bio-economic model for Danish large scale pelagic fisheries.

**Perspective**
Alongside with the global human population growth, the demand for food, including marine products, continues to increase. The sustainable exploitation of new marine resources such as mesopelagic species could complement and potentially partially relieve the fishing pressure on existing marine resources while meeting the increasing demands. It is important already in an early stage to make assessments of the long-term ecological and economic sustainability of potential exploitation, and to develop suitable management measures. This project is part of the H2020 MEESO project, which aims at filling knowledge gaps related to mesopelagic species, to assess their role in the ecosystem and the sustainability of potential mesopelagic exploitation.
Anne Cathrine Linder

Background
One of the grand challenges of sustainability science is understanding principal trade-offs between human well-being and the natural environment. Such trade-offs are dependent on how well-being benefits emerge from spending time in nature and how such use of nature may in turn threaten biodiversity. Thus, it is relevant to determine the overlap between species and habitats sensitive to tourism and recreation and ecosystem features underpinning cultural ecosystem services (CES). CES are generally defined as non-material benefits people obtain from nature and have been suggested to be important contributors to human well-being. However, we have a poor understanding of how CES are derived from human-nature interactions, with one of the key hurdles being data access.

Project
The objective of my PhD project is to utilize data from social media to understand cultural ecosystem services associated with human-nature interactions and assess trade-offs arising from these interactions. Social media sampling and text mining approaches will be used to sample the intensity of nature use and retrieve the context of human-nature interactions to identify key ecosystem features providing CES. This project will also estimate sentiment and emotions expressed in social media posts, which along with a series of controlled experiments will enable me to understand well-being emerging from CES exposure as facilitated by human-nature activities.

Perspective
This project will advance sustainability science by providing a global understanding of CES. Moreover, this project will identify nature features important for eliciting well-being benefits and determine the overlap between these key features and species and habitats sensitive to tourism and recreation. Thus, providing a framework for assessing trade-offs arising from human-nature interactions.

Morteza Eighani

Background
Towed bottom fishing gears can cause widespread disturbance to the seabed of shallow shelf seas. The physical impacts can have environmental and ecological consequences that affect primary production and threaten the biological sustainability and economic viability of fisheries, whereas the energy requirements will have global consequences associated with emissions of CO2 and NOX gases. In Denmark, demersal trawls are widely used and to ensure the long-term sustainability of these fisheries and to reduce their environmental impact there is a need to develop and design fishing gears that have a reduced impact on the seabed and that are more fuel-efficient.

Project
This project will focus on developing methods for the assessment of the physical impact and drag of demersal trawls and the evaluation of low impact gears that are being developed by the fishing gear manufacturing industry. A specially designed sledge that tows individual gear components will be used to investigate the depth to which these components penetrate the seabed, the hydrodynamic turbulence they create and the associated quantity of sediment they mobilise into the water column. Small-scale modelling trials in a flume tank will be used to get a better understanding of the hydrodynamics of the trawl gear components and to extend the results of the sledge trials. Additionally, there will be full-scale trials to assess and compare the physical impact and fishing gear performance of a conventional otterboard with a remotely controllable otterboard that is being developed by a commercial trawl door company.

Perspective
This project will ensure that towed gear fisheries will be biologically sustainable, environmentally friendly and economically viable. It will allow policy makers and fishery managers to implement the EU Common Fisheries Policy (CFP) and contribute to the Danish Government’s sustainability target or reducing CO2 emissions by 70% by 2030.
**Zita Bak-Jensen**

**Background**
Several demersal fisheries are by nature mixed species fisheries because of abundance of several species simultaneously in the fishing ground. In the capture some species are target species while others should be avoided or at least minimized as much as possible. Therefore, there has been focus on developing gear solutions that can address the mixed-species challenge. In the Baltic Sea the challenge is having an effective fishery targeting flatfish species while avoiding or at least minimizing the capture of cod. Traditionally, the approach of dealing with gear development has typically been towards single species, where the selectivity for each species is evaluated individually, but is in this PhD project shifting to a multi-species approach.

**Project**
With the demersal trawl fisheries being used as case studies, this PhD project will focus on developing and testing new approaches and data frameworks that bring the currently used method from single to multi-species assessments in evaluating fishing gear performance. A special focus will be on cod avoidance in the demersal trawl fishery in the Baltic Sea targeting flatfish species such as plaice and flounder.

**Perspective**
The aim is to develop a new approach and data framework for evaluating the performance of the selectivity in multi-species fisheries making selection and selectivity models more adequate when dealing with multi-species fisheries. Even though this PhD project will focus on cod in the Baltic Sea the method will be extrapolatable to much larger scaled mixed-species fisheries.

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**Mette Svantemann Lyngby**

**Background**
Today's limited insight into what is occurring throughout fishing processes means that commercial fishing is still mainly undertaken in the blind. Consequently, current commercial fishing practices result in unnecessary bycatch and environmental impacts, carbon dioxide outputs, all while reducing the economic competitiveness of the sector. DTU Aqua has developed a cable-based real-time camera to be applied in fishing operations such as bottom trawling. The camera will provide the fishermen with a stable real-time video of the process and enable them to observe catch items that enter the trawl. DTU Aqua has undertaken development work to improve the camera observation scene in the trawl to accurately monitor the entire catch and the species composition passing towards the codend.

**Project**
This PhD project will use the established data stream from the newly developed and installed real-time trawl camera system. The focus of the PhD project will be to quantify the system's performance and its overall effect on both the ecological and economic sustainability in selected trawl fisheries. The project will further develop new AI-based solutions to automate the extraction of important information from the real-time UW observations to improve catch efficiency and specific bycatch avoidance.

**Perspective**
Such real-time catch descriptions will allow fishermen, for the first time, to continuously monitor catch volumes and compositions and actively improve the catch composition in the ongoing fishing process. This new technology has significant news value, both nationally and internationally, and will contribute to the development of a technology-based fishery where fishermen in real-time will know what is being caught and have the opportunity to direct the ongoing catch compositions towards the quotas available.
**Martin Mathias Nielsen**

**Background**
Electronic monitoring (EM) was introduced into demersal fisheries in Europe in 2008. The EM cameras were installed to produce video footage of the fishing operations on-board with the objective to verify declared catches to attain a fully documented fishery. Since then, it has become clear that these data have much wider applications than merely control and enforcement. A key challenge in utilizing these data has been the reliance on manual reviews for analyzing the EM footage, which today is processed on land by trained humans. This procedure severely limits the application of the data as only a fraction of the collected data is getting analyzed due to the workload involved, and since the analysis is not conducted in real-time.

**Project**
In this PhD project, the application of new computer vision methods is investigated to address some of the existing challenges in automatically documenting catch compositions in terms of species identification and length distributions. This new data can potentially challenge conventional fisheries management practices, provide fishers more insight into their fisheries, and change the way fishing gears are developed, tested, controlled and monitored – which will be investigated to further incentivize the adoption of EM.

**Perspective**
Besides being a control and enforcement tool to verify declared catches, this new data has the potential to significantly increase the 1% catch coverage from observer programs today. This data can, among others, support more accurate stock assessments, identify bycatch hotspots, help fishers avoid choke situations, and provide insights into interactions with protected species, mammals, and birds.

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**Laura Diernæs**

**Background**
Trawl gears are responsible for a large portion of unwanted catches, globally. Consequently, there is a large focus on improving their environmental sustainability while ensuring that the fisheries remain economically viable. Animal behaviour is one of few main components that are decisive for the efficiency and selectivity of commercial trawl gears and so, the amount of unwanted catches retained. Behaviour of marine animals is typically studied using underwater cameras attached to the fishing gear. This technology has however limitations in the operational conditions during which observations can be obtained.

**Project**
Recent technological developments, such as high frequency acoustics, as well as alternative platforms for collecting data, such as remotely operated vehicles, provide new ways to quantitatively study fish behaviour in relation to fishing gear. This project focuses on using hydroacoustic to develop methods for optimal identification and tracking of individuals. Such tracking enables detailed observations of animal behaviour during the capture process with trawls.

**Perspective**
Using hydroacoustic techniques to observe detailed animal behaviour facilitates the understanding of the behavioural mechanisms involved when animals respond to fishing gears. This information will reduce the huge knowledge gap found for many commercial species and has the potential to support the development of more sustainable trawl designs.
Nurul Huda

**Background**
In recent years there have been increasing concerns regarding demersal trawl physical impacts on the seabed, which can give rise to (i) increased fuel consumption, (ii) the release of carbon sequestered in the seabed, (iii) habitat modification and (iv) benthic mortality. In order to promote the environmental and economic sustainability of towed demersal fisheries, we must reduce the physical impacts of these gears when they are towed across the seabed. One of the main approaches in the design and development of fishing gears is small scale model testing in recirculating flume tanks. These approaches are based on maintaining the ratio of the gravitational and hydrodynamic drag forces, (characterised by the Froude and Reynolds numbers) so that the observations at the small scale can be extrapolated to the full scale. The current approaches do not account for bottom contact forces, and hence are not particularly suitable for designing demersal gear which are towed across the seabed.

**Project**
This project will focus on developing generic scale-modelling rules for demersal trawls that balance the gravitational, hydrodynamic drag and contact forces acting on a trawl gear. The theoretical framework will be established based on the fundamental relationships between these forces. This will be done by analysing the geometry and force measurements on different scale representations of a given trawl gear. Small scale trials will take place in a flume tank and full-scale trials will take place at sea, using a research vessel.

**Perspective**
The resulting scale modelling criteria will allow small-scale experiments on demersal fishing gear, which are carried out in flume and towing tanks, to be scaled up and extrapolated accurately to full scale. This will permit the design and development of low impact, fuel efficient fishing gears that will help ensure the environmental and economic sustainability of towed demersal fisheries.

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Aris Thomasberger

**Background**
Eelgrass is a key element and indicator species for water quality in the European Union Water Framework Directive. To ensure that the Danish shellfish fishery complies with EU environmental directives, eelgrass is fully protected within Natura 2000 areas under the Danish Mussel Policy and environmental impact assessments have to be carried out before fishing activity can commence. Consequently, detailed knowledge on eelgrass distribution is of high importance.

**Project**
The project will carry out extensive studies with drones in water bodies of different characteristics to explore the possibility of implementing drone technology in future mapping of subaquatic vegetation. I will focus on the development of new methods for eelgrass mapping in environmentally complicated areas with deep and/or turbid waters. Different sensor/platform combinations and new approaches to image classification processes will be tested to explore strengths and limitations of drone based mapping. The project is funded by the EMFF and will be carried out in close collaboration with other sections of DTU Aqua, the DTU Space Drone Center and SDU's drone group at the Department of Biology.

**Perspective**
The project is expected to develop new technological methods and tools that in the future can ensure an economically and professionally sound mapping of subaquatic vegetation in Danish coastal waters. Of special interest will be Natura 2000 areas where fishing with bottom trawling takes place, thus is subject to the Danish Mussel Policy. The developed methods are expected to be directly applicable in the annual impact assessments for mussel and oyster fisheries as a more accurate and cost-effective alternative to the current point specific video surveys. In addition to Natura 2000 areas, the methods developed will also be applicable within other management practice, e.g., the future third generation water plans.
**Satish Pawar**

**Background**
Eelgrass is one of the common aquatic vegetation in the northern temperate coastal regions. It provides valuable ecosystem services like nursery grounds to juvenile fish, improve water quality and sequester carbon as green biomass. The eelgrass meadows in Danish coastal waters were damaged due to stone fishing and frequent eutrophication episodes. These activities have been discontinued and water quality has improved over the last decade. However, the eelgrass has not recolonized the previously occupied habitat sites. Understanding the factors affecting eelgrass recovery is primary task in eelgrass habitat restoration and future management.

**Project**
The eelgrass growth could be affected from local disturbances along with global phenomena of climate change. This project aims to understand the combined effect of these factors affecting eelgrass recovery. This will be achieved by combining the monitoring data of eelgrass environment and habitat suitability modelling techniques. Continuous satellite data will provide spatial habitat variables like light availability, turbidity and Sea Surface Temperature (SST) of shallow waters. The habitat suitability analysis will be performed by implementing the eelgrass growth model with spatial habitat data along with correlation-based niche models to spatially map potential habitats. The growth models can simulate climate change scenarios to evaluate effect of eutrophication and increased water temperature.

**Perspective**
Combining satellite data and modeling will provide new knowledge on shallow water environment in Danish coastal waters. The project will contribute significant insight into the combined effect of eutrophication and climate change on eelgrass health. From the spatial outputs of habitat suitability, eelgrass zones for potential recovery can be identified for their management. The information obtained from spatial simulations can aid in planning restoration activities and forming policies for eelgrass conservation.

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**Isabelle Johansson**

**Background**
Blue mussels are an ecosystem engineering bivalve that enhances biodiversity by creating habitats for other species, contributes to a local particle reduction by controlling phytoplankton biomass and water clarification. Stability of blue mussel beds and factors influencing variation in populations between years is not always understood, especially in eutrophied subtidal areas. Limfjorden is the main area for both blue mussel fishery and aquaculture in Denmark and the mussel stocks are surveyed annually. However, the current large-scale mapping is resource intensive.

**Project**
This project aims to understand factors influencing development and stability of mussel bed in subtidal areas. This will be achieved by performing survival analysis on temporal mussel beds using a time series of stock assessment data, black box data from fishing vessels and environmental data. Furthermore, production efficiency for wild mussel seeds in on-bottom culture in Limfjorden will be explored, to find the optimized density of mussels to relay in culture plots. Finally side scan sonar imagery collected for various mussel beds (wild, culture plots and restored beds) will be investigate regarding the possibilities to develop automated data processing methods to optimize the mapping of areal distribution, coverage, and biomass of mussel beds.

**Perspective**
This project is expected to assess the stability and document factors affecting the stability of mussel beds in eutrophic subtidal areas. The outputs will contribute to the sustainable development of mussel production and can improve management of biogenic habitats as well as fisheries/aquaculture management. During this project existing non-invasive techniques will be optimized and developed to map areal distribution, densities, and biomass of blue mussel beds. The methodology could be applied for multiple purposes benefitting fishery management by improve methods for stock assessments, optimizing the cultivation practices of on-bottom mussel aquaculture or establishment and monitoring of restored mussel beds.
**Thiviya Nair**

**Background**
The Danish Limfjorden was once rich with European Flat Oysters (*Ostrea edulis*), treasured as a reef engineer and a nutritious source of protein by local and foreign markets. Unfortunately, the spread of the invasive micro-parasite, *Bonamia ostreae*, and overfishing for the flat oysters in Europe eventually caught up with the region, decimating their populations. In 2020, the Limfjorden lost its disease-free status and relies on the production of Bonamia-free spat to seed shellfish aquaculture and reef restoration efforts. Bonamia-free spat production relies on accurate and early detection of the parasite, as its life cycle outside of its host is unclear, and infections are often diagnosed when it is too late.

**Project**
My projects will aim to investigate the biotic and abiotic factors that contribute to the activation of bonamiosis in flat oysters and potential treatments that can be applied to limit *B. ostreae*’s infectivity. The project will also include testing early and non-destructive sampling methods for parasite detection and provide a basis for biosecurity protocols required for successful Bonamia-free oyster spat production in the Danish Shellfish Centre hatchery at Nykøbing Mors.

**Perspective**
The discoveries that will be made in this project will fill up the knowledge gaps on the life cycle and behaviour of *B. ostreae*. The disease testing methods refined in this project will also serve as a potential early alarm system for hatcheries and Bonamia-free sites. Developments from this project will enable shellfish farm managers to formulate the best mitigation strategies and avoid financial losses. The Bonamia-free spat produced through the efforts of this project can go on to seed future reefs and fisheries, thereby reviving the flat oyster populations in the Limfjorden.

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**Kristi Källo**

**Background**
Brown trout is a migratory species that may take on long seaward migrations. The extent of these migrations may vary quite a lot between populations and even among individuals within the same population, which makes brown trout a very interesting species to study. Even though, it is a highly studied species, there are still many unknowns surrounding the marine phase of the life cycle.

**Project**
The aim of my project is to combine otolith microchemistry and telemetry to extend the knowledge we have about seatrout migration in the fjords and the open ocean. Otoliths are small calcified structures in the fish’s head that have the ability to reflect water chemistry of the surrounding habitat the fish has been in and therefore could be used to back-track migratory history of individuals without disturbing the course of it. Further, during this PhD project, telemetry will be used to determine more specific migratory pathways and bottleneck areas along the way where individuals may be subject to higher rates of mortality.

**Perspective**
Combining telemetry and otolith microchemistry will give further insight into migratory behavior and habitat utilization of seatrout. Understanding where fish migrate and which factors affect them along the way is crucial knowledge to take into account when managing these important populations.
**Background**

There is growing evidence that oil and gas platforms may provide productive habitats for fish communities, partly because of reef effects associated with the foundations, but also because the areas within and surrounding the platforms may act as *de facto* marine protected areas with limited or no ongoing fishing. For example, the Atlantic cod (*Gadus morhua*), which constitutes an important target for North Sea fisheries, but its populations are considered to stand below sustainable thresholds, have been preliminarily associated with these structures. However, there is still a poor understanding of the mechanisms behind platforms’ effects and scarce assessments of the ecological outcomes in relation to fish ecology and fisheries. This makes it difficult to predict possible fisheries scenarios associated with different decommissioning and abandonment options.

**Project**

The project aims to provide an understanding of the role that platforms are playing for fish and fisheries in the Danish North Sea, using cod as a case study. The experimental approach involves estimating catch variation along distance-to-platform gradients, and spatiotemporal 3D mapping of cod individuals nearby an oil platform. This knowledge seeks to inform decision-making processes related to platform decommissioning in the North Sea by evidencing how these structures are acting as artificial reefs, potentially providing refuge and substrate to different species.

**Perspective**

We expect to evidence the potential importance of oil and gas platforms for Atlantic cod in the Danish North Sea. Considering that fishing is banned within 500m around the platforms, these structures could be functioning as fish sanctuaries and fish hubs, supplying juvenile fish to other areas of the North Sea. Provided the intense trawling in the North Sea, platform decommissioning could contemplate a partial scheme in which some structures are left to provide refuge for fish communities. Our information will help in the design of future decommissioning and abandonment plans.

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**Bruno Ibanez Erquiaga**

**Background**

Salmon and sea trout are iconic salmonids that migrate between the freshwater and marine environments. Salmonids reproduce in rivers, where they spend their juvenile phase before migrating to sea as “smolts” for feeding and growth. During their seaward migration smolts can experience high mortality rates, both natural (e.g., predators) and human induced (e.g., hydropower regulations). Smolt survival is generally considered to be density-independent, meaning there should be a correlation between smolts leaving the river and adults returning to spawn. Thus, increasing the number of smolts leaving a river can increase the number of adult returns.

**Project**

The aim of my PhD is to use telemetry to identify bottlenecks that limit the survival of seaward migrating smolts. Telemetry involves attaching animals with electronic transmitters and tracking their movements through listening stations in the river, estuary, and fjord or with manual tracking along the river. Using telemetry and other sources of information (i.e., physiology, environmental conditions), I will investigate how migration and survival of smolts are influenced by predators, surrounding temperature, energetic status of individuals, and also look into the impacts of trapping, handling and tagging smolts with electronic transmitters.

**Perspective**

Salmonids are facing multiple threats in their marine and freshwater environments, with humans often being the source. Despite conservation efforts, the number of wild Atlantic salmon has declined during the last couple of decades. Identifying and reducing bottlenecks for smolt survival can aid management actions to optimize adult returns and aid population recoveries.

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**Lene K. Sortland**

**Background**

**Title:** The importance of oil and gas platform foundations for a key commercial species, the Atlantic cod

**Principal supervisor:** Jon C. Svendsen

**Section:** Freshwater Fisheries and Ecology

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**Lene K. Sortland**

**Title:** Increasing adult salmon recruitment via optimizing management decisions during outmigration

**Principal supervisor:** Kim Aarestrup

**Section:** Freshwater Fisheries and Ecology
Marie Hartlev Frausing

Background
Marine habitats in Denmark have undergone degradation during past decades due to factors as stone fishing and global warming. Suitable marine habitats are important for the commercially and recreationally valuable species Atlantic cod (Gadus morhua) and anadromous brown trout (Salmo trutta). Brown trout smolts are particularly dependent on suitable coastal habitats as smolts are vulnerable when they enter the marine environment and often experience severe predation. Atlantic cod populations in the Baltic Sea are currently under pressure and most cod stocks in this region have been depleted and are unable to reproduce in a stable manner. Despite various efforts to increase populations of cod and trout, only little attention has until now been put into understanding the dynamics and beneficial effects of coastal habitat improvements and marine protected areas (MPAs) for these species in the Baltic Sea.

Project
The aim of this PhD project is to examine and document the effects of coastal habitat improvements and MPAs on the presence of anadromous brown trout and Atlantic cod. Acoustic telemetry will be applied to track and examine the presence of juvenile and adult trout as well as cod at different coastal sites in Denmark. The presence of juvenile trout will be studied in association with the establishment of a coastal boulder reef. The reef is expected to provide appropriate habitats for the juvenile trout when they migrate into the marine environment. The presence of adult trout and cod will be investigated in two coastal MPAs and examined in relation to temperature.

Perspective
The results of this PhD project will strengthen our understanding of the beneficial effects that coastal habitat improvements and MPAs may have on trout and Atlantic cod. The movement patterns and presence of the tagged fish within the study areas will provide crucial information for future coastal habitat improvements and MPAs and how to use such management tools in the years to come.

Julie Hansen Bergstedt

Background
The use of recirculating aquaculture systems (RAS) in production of Atlantic salmon is continuously increasing, partly due to the technological advancement in increasing the sustainability of production. Filtration and treatment of the water is done with a limited exchange of water, which is putting less pressure on valuable resources. However, the limited water exchange poses a challenge, as the concentrations of e.g. organic matter can be high, which provides a foundation for bacteria, including sulfate reducing bacteria (SRB). SRB can affect water quality and imperil fish health, as they produce hydrogen sulfide (H₂S) as a by-product metabolizing organic matter anaerobically. Seawater consists of much higher levels of sulfate compared to freshwater, and the potential for production of H₂S is higher. Atlantic salmon smolt is produced under saline conditions, and are at risk of being exposed to dangerous concentrations, as H₂S is toxic even at very low concentrations.

Project
This project aims to understand the physiological mechanisms and behavioral response related to acute and chronic H₂S exposure. The project will examine the underlying mechanisms of how Atlantic salmon copes with H₂S, which physiological systems are the most sensitive, identify sub-lethal and lethal levels, and whether the fish to some extent are able to adapt to non-critical H₂S levels. We will determine the effects of H₂S exposure through a combination of metabolic studies, behavioral assays, and bioenergetics and welfare indicators.

Perspective
The results from this project will provide an understanding of the impact of H₂S on the physiology Atlantic salmon, and lay the foundation for a practice to best manage the toxicant in aquaculture. The information gained during this research will be used to aid land based aquaculture, by providing an array of values that are considered safe. By mitigating the effects of H₂S, fish health and welfare can be improved and mass mortalities avoided.
Background
Feed is the main input of nutrients in form of nitrogen (N), phosphorus (P) and organic matter into a recirculating aquaculture system (RAS). Ingredient composition in fish feed, and consequently the input of available nutrients and organic matter, changes continuously due to ingredient availability and market price, technological developments in feed processing, and tightened environmental regulations. There is, however, very limited information on the effects of changing feed composition on RAS water quality, treatment efficiency and accompanying effects on fish performance. Effects on chemical composition might somewhat be expected but any effects on microbial water quality remain unknown and unpredictable at present.

Project
In this project, the impacts of feed composition will be investigated in four aspects: (1) feed ingredients, (2) dietary C/N input, (3) dietary P input, and (4) particulate feed waste. Feeding trials will be conducted in RAS with rainbow trout at DTU Aqua, Hirtshals. Water analysis will reveal the changes in micro-particle conditions, chemical contents, and microbial quantities and activities. Based on the results, possible mitigation methods will be discussed to manage RAS water quality.

Perspective
The purpose of this PhD project is to systematically study the interactions between feed composition, nutrient balances and RAS water quality, with special focus on the effects and dynamics of microbial water quality. The generated knowledge will contribute to future diet evaluation, improve system compatibility between feed and RAS, and secure stable water quality and fish production in RAS.

Xiaoyu Huang
Title: Water quality in recirculating aquaculture systems and its relation to feed composition
Principal supervisor: Per Bovbjerg Pedersen

Wanhe Qi
Background
Recirculating aquaculture systems (RAS) have a high degree of water reuse, reduce environmental impacts and provide controlled rearing conditions for fish production. All RAS rely on a central biological treatment process – biofiltration. This microbial process involves nitrifying bacteria that converts toxic ammonium (excreted from the fish) to harmless nitrate. It is crucial to get more information about how water disinfection strategies affect biofilter performance. Currently, such assessment is difficult to perform, and there is limited knowledge and tools available to understand and quantify the mechanisms, activity and importance of surface attached bacteria known as biofilm.

Project
The PhD project is supported by a joint Danish-Norwegian research project “RASHealth” (nofima.no/en/project/rashealth), where assessment of disinfection strategies on water quality and biofilm activity is central. The aim of my PhD project is to develop simple, fast and practical assays to quantify biofilm activity that can be used as a tool to assess biofilter performance, disinfection efficacy and predict disinfection demand in RAS.

Perspective
The outcome from my research will provide tools to test biofilm activity under controlled lab-scale experimental conditions and pilot-scale practical situations. This will provide guidelines for improved disinfection strategies in RAS and generate theoretical and applied knowledge on biofilm formation and tolerance during disinfection practice. Ultimately, these efforts will support ongoing research and development of biofilter designs and RAS operation.

Title: Water disinfection and biofilm activity in recirculating aquaculture systems (RAS)
Principal supervisor: Lars-Flemming Pedersen
**Alexandre Nguyen-tiêt**

**Background**
Hydrogen sulfide (H2S) is an extremely toxic compound for organisms, preventing aerobic respiration. In marine land-based recirculating aquaculture systems (RAS), H2S production is a major challenge, leading to fish mortality and thus important economic consequences. Because of the high sulfate (SO4^2-) and organic matter concentration present in marine RAS, H2S production has been associated with the sulfate-reducing bacteria (SRB). However, there are also other pathways for producing H2S that could play a significant role but are currently neglected, e.g., some bacteria have the capacity to degrade the cysteine to produce pyruvate, ammonia and H2S. In both marine and freshwater RAS, cysteine is present, originating from the uneaten feed and feces of fish, suggesting that cysteine degradation could be an important H2S source in aquaculture environment.

**Project**
The main goal of this PhD project is to gain knowledge on the bacterial communities responsible of H2S production in RAS and especially the cysteine degrading bacteria. To do so, I will first enrich and cultivate H2S producing bacteria from samples collected at several locations in RAS. After that, I will use metagenomic/metatranscriptomic analysis to identify the bacteria as well as the metabolic pathways responsible of H2S production and develop primers to examine H2S production dynamics and microbiology in aquaculture biofilms.

**Perspective**
The results obtained through this project will give a better understanding of the microbial community responsible of H2S production in land-based aquaculture. With this new knowledge, I can develop ways to quantify and monitor both the traditional (SRB) and cysteine-degradation H2S producers in RAS to avoid production losses related to H2S exposure and to promote safe and stable fish production in the future.

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**Godwin Abakari**

**Background**
Recirculating aquaculture systems (RAS), which involve the reuse of water while removing fish excretions from the rearing water through a series of mechanical, chemical, and biological treatments, has been under rapid development in recent years. While the processes in the internal recirculation loop is generally well controlled, still challenges exist with respect to the management of both liquid (nitrogen) and solid (phosphorous and organic matter) waste streams from such systems. Therefore, research focusing on exploring cost-effective, sustainable and innovative end-of-pipe treatment technologies for the recovery and valorization of nutrients are needed.

**Project**
The study will focus on the use of different cost-effective technologies for valorizing and down-streaming waste from RAS. Specifically, innovative methods for phosphorous and nitrogen recovery, organic coagulants, and dewatering technologies for organic matter treatment and transport. The recovered resources will be evaluated for their potential commercial use e.g., as fertilizer. The environmental credentials of these innovative methods will be assessed via life cycle assessment programmes.

**Perspective**
The knowledge generated from this study will help enhance the design of RAS, ensuring efficient resource utilization and reducing environmental impact. The transition of RAS into an even more sustainable and circular economy strategy where waste is considered a residual resource will be supported by the development of cost-efficient end-of-pipe treatment technologies.
### Juliane Sørensen

**Background**
Since late 2017, a novel subtype of *Piscine orthoreovirus* (subtype 3, PRV-3) has been associated with disease and increased mortality in Danish rainbow trout (*Oncorhynchus mykiss*) farming. A surveillance study conducted in 2018 revealed that the majority of Danish rainbow trout farms are infected with PRV-3, although only some farms experience disease in relation to the infection. However, the farms that do experience disease and increased mortality are subject to major economic losses. Additionally, PRV has recently been hypothesized to be involved in discoloration in the fillet.

**Project**
The aim for this project is to develop and implement two high throughput diagnostic tools: 1) Fluidigm assay for detection of PRV-3 virus along with other pathogens and host immune gene expression in samples from fish, which will enhance the predictive value of disease outbreaks. 2) Luminex assay for detection of antibodies directed against PRV-3, which will enable mitigation of disease by introducing immune-competent fish into PRV-3 infected facilities.

**Perspective**
Overall the tools developed within this project will advance the diagnostic capacity of the Section of Fish and Shellfish Diseases at DTU Aqua. Furthermore, this project will generate relevant knowledge to explain host-pathogen interactions once environmental changes occur, and will help the industry in mitigating the impact of this disease in RAS.

### Giulia Zarantonello

**Background**
The aquaculture microbiome balance is crucial for the health status of the system, such that dysbiosis has been reported when a stressor, such as a pathogen, is introduced. Current farmed fish diagnostics methods consist in infection event monitoring and imply histopathology, culture isolation, and targeted molecular diagnostics for the suspected pathogen. However, this approach comes with drawbacks: action is only taken after manifestation of clinical signs or increased mortality, and standard diagnostics are targeted towards known pathogens, which impairs new pathogen discovery, especially when the microorganisms are unculturable.

**Project**
My PhD project aims to develop a rapid, untargeted NGS-mediated workflow for early detection of declining health conditions and microbial disease for farmed animals in aquaculture, by exploiting the microbiome as an indicator for the state of the system. First, I will implement a microbiome sequencing protocol with Oxford Nanopore Technology from various aquaculture-relevant samples, both environmental (eDNA) and host-associated. Then, I will test the protocol in stress-induced conditions (pathogen, organic waste) in experimental RAS facilities, to detect possible changes in the healthy microbiome associated with fish health. The protocol will then be translated to detect distress-correlated dysbiosis in industry samples. Finally, I will apply metagenomics sequencing for pathogen discovery for a salmonid skin disease, whose unculturable disease-causing agent is still unknown.

**Perspective**
My project aims to exploit aquaculture-related microbiome sequencing to integrate current diagnostics with a non-lethal, fast and untargeted community surveillance method. If successful, the outcome of my PhD could represent the first steps towards the development of a novel indicator of fish health, such as microbiome risk scores for disease prediction. Early detection of distress could favour preventive strategies to minimize the impact on aquaculture production.
**Alejandra Villamil Alonso**

**Background**
Bacterial kidney disease (BKD) is a systemic infection that affects wild and farmed salmonids, compromising aquaculture systems worldwide. The causative agent of BKD is *Renibacterium salmoninarum*, a Gram-positive intracellular bacterium characterized by chronic disease progression and able to spread both horizontally and vertically. Although efforts have been made to characterize the bacteria mechanisms of transmission, pathogenesis, and immune evasion, they remain poorly understood. Moreover, no knowledge is available on the introduction and molecular evolution of the pathogen in Denmark, which is of foremost importance for understanding the current and past movements of *R. salmoninarum*.

**Project**
My PhD project seeks to elucidate the interplay between host-pathogen-environment by first establishing a challenge model of *R. salmoninarum* in rainbow trout (*Oncorhynchus mykiss*), the predominant fish species farmed in Denmark. Bacteria route and persistence inside the fish will be studied, as well as the influence of different environmental stressors such as water temperature and water quality in BKD development. I will also work on the development of improved diagnostics methods for *R. salmoninarum*, focusing on qPCR and targeted detection of eDNA on water systems. Eventually, I will study the origin and molecular evolution of *R. salmoninarum* in Denmark by genome sequencing of a collection of historical and new isolates originated in Danish farms for phylogeographic and molecular analyses.

**Perspective**
With this project, we expect to gain knowledge on BKD transmission and progression in rainbow trout, as well as to build a deeper understanding on the virulence mechanisms of the pathogen and the subsequent host immune response. Together with the planned genomic studies, this research will facilitate the development of novel diagnostic methods and contribute to the identification of improved prevention and treatment measures for BKD.

**Title:**
Bacterial kidney disease in rainbow trout, with focus in infection kinetics and molecular tracing of *Renibacterium salmoninarum* in Denmark.

**Principal supervisor:**
Argelia Cuenca

**Section:**
Fish and Shellfish Diseases