**Preface**

This web-publication “PhD projects at DTU Aqua” presents PhD students enrolled at DTU Aqua’s PhD school as of 1 October 2020.

Each PhD project is described by the PhD student. You will additionally find information on research section affiliation and supervisor. Most PhD students at DTU Aqua have co-supervisors as well. However, for the sake of simplicity we have not provided the entire list in this publication.

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

Ken H Andersen  
Head of the PhD School at DTU Aqua

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Josephine Grønning

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

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

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

Fredrik Ryderheim

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

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

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

Renata Goncalves

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

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

Perspective
Generated knowledge from this project will provide valuable insight for the formulation of nutritionally balanced dry feeds specifically designed for the species at each developmental stage. Ultimately, a species-specific formulated diet will contribute to an improvement of growth and survival rates in lobster production units.
Background
The continuous growth of the aquaculture sector puts pressure on finite marine ingredients such as fishmeal and fish oil. These ingredients are bottlenecks in the feed production for aquaculture, necessitating the full or partial substitution of these ingredients with land-based alternatives. Currently, vegetable oils are already used to provide large parts of the lipid fraction in fish feed. High inclusion rates of terrestrial lipids, however, may result in decreased production efficiency and exert a limitation on the physiological and metabolic performance in salmonids.

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

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

**Background**
The increase in human population and a larger middle class are drivers of the growth of the aquaculture sector. To be able to keep up with this growth, resources need to be used efficiently and in a sustainable way. Current feed ingredients such as fishmeal and soybean meal are associated with overfishing and deforestation, respectively. Therefore, current research is investigating alternative protein and lipid sources. One of the most promising sources are insects. Insects provide high-quality proteins and lipids with low requirements of water and land use.

**Project**
The main focus of this PhD project is to identify possible fish feed ingredients obtained from insects, in this project specifically black soldier fly larvae. Black soldier fly can be reared on biological waste streams, converting low-value organic waste into high-quality macronutrients. In the project, the influence of the rearing substrate on the nutritional composition of the larvae will be investigated. Additionally, the optimal inclusion levels of black soldier fly meal will be determined in feed for rainbow trout and Nile tilapia, to test its effect on carnivorous and omnivorous species.

**Perspective**
Knowledge generated by this project will provide valuable information on the use of insect-based ingredients in aquafeed, its effect on performance and physiology. Ultimately, the project will contribute to making the aquaculture sector more sustainable by the use of waste streams for rearing insects.

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**Julie Hansen**

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

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

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

Isabella Kratzer

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

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

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

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

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

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

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**Maria Sokolova**

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

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

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

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

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

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

Daniel Patrick Taylor

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

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

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

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 commonly attract large public attention partly due to their bloom and bust population dynamics, 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.

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

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

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

Casper Gundelund Jørgensen

Title:
Citizen science as a method to collect recreational fisheries data; strengths and limitations

Supervisor:
Christian Skov

Section:
Freshwater Fisheries and Ecology

Kristi Källö

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 bottle neck 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.

Kristi Källö

Title:
Tracking the untrackable – following behavior and migration of important marine fishes

Supervisor:
Kim Aarestrup

Section:
Freshwater Fisheries and Ecology
Marie Plambech Ryberg

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

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

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

Camilla Christensen

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

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

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

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

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

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**Homère Alves Monteiro**

**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.
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 achieve this, on the one hand I will develop methods for eDNA-based quantitative assessment of species assemblages that could be used for bycatch 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.

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 trophic position and interaction with other pelagic species, zooplankton and stomach content analyses are used in combination with hydro acoustic measurements describing vertical migration and distribution in relation to prey and environmental variability.

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

This is an industrial PhD in cooperation with Greenland Institute of Natural Resources.
Peter Fink-Jensen

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

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

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

Rocío Rodríguez Torres

Background
Marine plastic pollution is currently one of the most concerning environmental problems. In the recent years, research in this topic has increased but there is still a lack of knowledge about the consequences of plastic pollution on marine plankton under realistic environmental conditions. Zooplankton (copepods) is the most abundant group of marine animals on Earth; they play key roles in the transfer of matter in food webs, biogeochemical cycles, and recruitment of benthic invertebrate and fish populations. Since microplastics are frequently in the prey size spectra of zooplankton, ingestion of microplastics by zooplankton is likely the main route by which small plastics enter and are transferred in marine food webs.

Project
The general objective of this project is to investigate the interactions between microplastic (plastic < 5mm) and plankton at individual and community levels to evaluate the impact of microplastic pollution on marine food webs. This PhD is part of the Ve-lux project, Danish Center for Research in Marine Plastic Pollution "MarinePlastic" that aims to understand the sources, fate and consequences of plastic pollution in the marine environment to support societal solutions and sustainable policies.

Perspective
This project will show the impact of MPs under realistic conditions, using existent microplastic concentrations and real environmental conditions. Based on incubations and video observations we will be able to explain the importance of plankton feeding behavior in the entrance of MPs to the marine food webs. In addition, we will assess the impact of the combination of MPs with other pollutants.
Regitze Lundgreen

Background
Atlantic cod (Gadus morhua) is one of the most important commercial fishes and has seen an overall decline in stock size recently. This is especially evident in the Baltic Sea which has been characterized by declining oxygen concentrations and increased temperatures throughout the last decades, resulting in a decrease in the extent of cod nursery areas. However, it is unknown how changing environmental and biological conditions might affect migration patterns in eastern Atlantic cod. In order to ensure efficient management of cod populations in the future, it is necessary to understand the temporal and spatial variation in cod migration patterns.

Project
The main aims of the project are to 1) map migration patterns through time, 2) determine which environmental and biological factors affect migration patterns, and 3) identify how individual cod migrate between locations. In order to resolve this, the project will utilize conventional archival tagging data with information on release and recapture of tagged cod from the 1950-1980s covering the Baltic and the North Sea, and more recent data from DST’s (2000-2010s) covering the Øresund to the eastern Baltic Sea. The environment experienced by individual fish will be examined using otolith microchemistry to study individual migrations. By combining these data sources with environmental and biological databases, migration patterns can be studied in great detail using state-space models and geostatistical methods.

Perspective
The results of this project will improve our understanding of how environmental drivers affect cod migration patterns which is especially important in light of the changing climate. Furthermore, information on the spatial distribution of cod is invaluable for proper management of stocks.

Title: Spatial and temporal dynamics of migrations in eastern Atlantic cod
Supervisor: Karin Hüssy

Kjetil Thorvaldsen

Background
Mesopelagic fishes are ubiquitous to all world oceans and have been estimated to hold an enormous potential biomass. These fishes have a low trophic level, which makes them a potential sustainable source for protein. But the knowledge on these layers of organisms is limited due to inefficient sampling methods. Mesopelagic fish have been observed to be inefficiently sampled with midwater trawls. There are also several challenges with traditional acoustic observation technologies. Problems such as swim-bladder resonance during acoustic surveys, inclusion of gelatinous zooplankton with similar acoustic properties. With new technologies, such as acoustic wideband systems and optics, there is great potential to learn more about these organisms.

Project
In this project, different types of state of the art hydro acoustic and video equipment will be used to observe mesopelagic fishes and other components in the mesopelagic layers. The frequency spectrum of single targets will be used to identify different acoustic classes in scattering layers. Small and large scale behavior will be observed to learn more about the components of the layers, the movement of mesopelagic fish, and interactions with other trophic levels.

Perspective
This study will highlight the importance of using wideband acoustics on resolved single targets to identify and learn more about the small fishes at great depths. An effort will be made to find a way to separate between mesopelagic fishes and other scatterers. This project will look at different individual fish behaviors. By using target tracking, this study will explore the spatial behavior of mesopelagic fishes and observe interactions with other trophic levels. Mesopelagic fishes are important in the marine foodweb, and such small scale interactions are the basis to understanding the formation of meso- to large scale patterns.

Title: Improved Methods for detecting population dynamics of mesopelagic fishes using advanced hydro-acoustic methods
Supervisor: Stefan Neuenfeldt
### Christian Mathias Rohde Kjær

**Background**

Due to recent advances in ocean observations and modelling, today it is possible to make forecasts of the physical variables in the ocean on seasonal to decadal time scales. Using better observational data and more skilful forecasts of the physical environment can improve our understanding of the biological environment, leading to models predicting and forecasting ecological changes. Forecasting ecological changes, from productivity to distribution, can provide valuable information for stakeholders and decision makers and developing these so-called “climate services” for marine ecosystems represents one of the new challenges in marine science. However, current marine ecological forecast products are limited to predictions of phenology or distributions: There are currently no marine fish productivity forecasts.

**Project**

Traditionally fish recruitment modelling is stock-based, where a single stock-recruitment relationship model is fitted for each stock and rarely incorporates environmental effects. However, the main drivers behind biological processes can change on a yearly basis. Other disciplines have incorporated techniques, such as iterative updating, non-stationarity and multi-model ensemble approaches, which can be adopted by recruitment models. This project attempts to combine the above, possibly resulting in a better understanding of the drivers behind recruitment dynamics. Most importantly, it can also pave the way to operational recruitment forecasting for use in fisheries management applications.

**Perspective**

The aim of this project is to provide a better understanding of the dynamics and main drivers of fish recruitment. Furthermore, forecast products will be made available for important fish stocks, to provide advice for stakeholders and managers.

### Per Anton Vergod Almgren

**Background**

The biological pump is the vertical transport of carbon, bound in organic matter through photosynthesis, from the surface ocean to the deep ocean. Together with the solubility pump (the transfer of atmospheric CO₂ into the ocean), the biological pump play an important role in the global climate system, as it removes CO₂ from the atmosphere and transport it to the deep ocean where it stays for hundreds or thousands of years. A major part of the vertical transport of carbon happens through the sinking of marine snow (particulate organic matter), and the fraction of the marine snow that is not re-mineralized before it reaches the sequestration depth is buried in the deep ocean.

**Project**

Throughout my PhD, I will develop a model that is able to describe the degradation and remineralization, as well as the aggregation, of marine snow particles. This will be put into a global context, using trait-based models of marine ecosystems, to provide input in terms of particulate organic matter. The aim is to use this modelling approach for providing a realistic estimate of the efficiency of the biological pump on both global and regional scales.

**Perspective**

The efficiency of the biological pump in terms of carbon sequestration is difficult to estimate, and current estimates based on e.g. sediment traps, provide a wide range of carbon sequestration rates. Further, the current estimates say little about the mechanistic processes involved in the biological pump. By modelling the processes of particle degradation and sinking, we will both get a more realistic estimate of the efficiency of the biological pump, as well as a framework that may be used for future climate scenarios.
Sofie Hansen

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

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

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

Anders Dalhoff Bruhn Jensen

**Background**
Terrestrial dissolved organic matter from river upland and permafrost erosion can be found throughout the Arctic Ocean. Terrestrial dissolved organic matter can affect ocean chemistry, carbon cycling and in the end marine ecosystems. With global warming the release of terrestrial dissolved organic matter into the Arctic Ocean will increase simultaneously. It is therefore becoming more and more urgent to understand the fate of this dissolved organic matter.

**Project**
This project will study how to use lignin phenols as a terrestrial plant biomarker and thereby be able to understand and map the fate of terrestrial dissolved organic matter in the ocean, particularly the Arctic Ocean. To separate the lignin phenols I will apply reversed phase High Pressure Liquid Chromatography. Since the lignin phenols hold different spectral fingerprints, absorbance and fluorescence spectroscopy can be used for detection. Finally, chemometric decomposition methods such as Parallel Factor Analysis will be used to analyze the data. Once the method is developed, seawater across the Fram Strait will be sampled and analyzed for lignin. From these results, we can hopefully deepen our understanding of how the terrestrial dissolved organic matter is exported into the Atlantic Ocean. For the future, I hope to establish a lignin method that can be applied in situ.

**Perspective**
From understanding the fate of terrestrial dissolved organic matter in the Arctic Ocean and its export through the Fram Strait, we can hopefully begin to predict how future climate change will affect ocean chemistry and carbon cycling. Will the terrestrial dissolved organic matter be taken up by living organisms, be stored in the deep ocean for millennia or be respired into the atmosphere as carbon dioxide?
**Valentina Donati**

**Background**

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

**Project**

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

**Perspective**

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

**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 hypothesised 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 Unit 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.