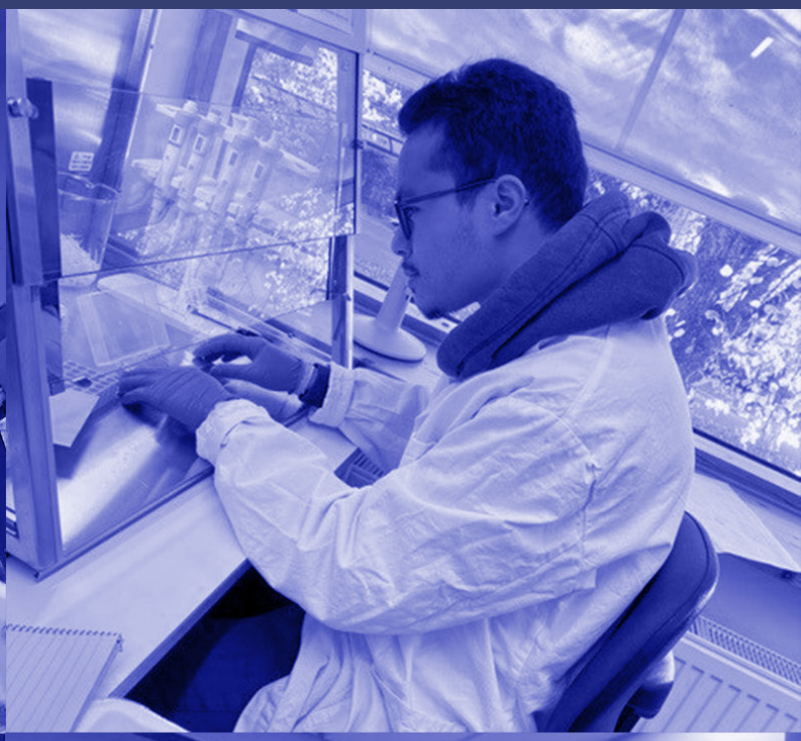
DTU

DTU Aqua
National Institute of Aquatic Resources

PhD students at DTU Aqua

Who are they, and what do they do?



Preface

This web-publication presents PhD students at DTU Aqua's PhD school.

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

Learn more about being a PhD student at DTU Aqua on our website:
aqua.dtu.dk/english/education/phd

Contents

Yixin Zhao

Background
The Earth's oceans play a crucial role in regulating the Earth's climate system, absorbing approximately 30% of anthropogenic carbon emissions through the physical and biological carbon pump. In the biological pump, carbon dioxide (CO_2) is initially fixed by phototrophic organisms, forming the foundation of the marine food webs. This fixed carbon can be transported to the deep ocean through particle sinking (e.g., aggregates, carcasses, and fecal pellets), organism vertical migration, and water movement where it can be stored for long periods, ranging from months to millennia. So far, most studies have focused on plankton's role in the biological carbon pump, while our comprehension of the contributions of fish to the biological carbon pump remains largely uncertain.

Project
This project aims to bridge this knowledge gap by applying the FishErIes Size and functional TYpe model (FEISTY) alongside earth system models to assess and quantify the role of fish in global ocean carbon cycles, as well as the effects of fishery and climate change. To accomplish the goals, the FEISTY model will be two-way, online coupled with biogeochemical models through the Framework for Aquatic Biogeochemical Models (FABM). We will utilize reconstructed global fishing data with historical fishing patterns and different emission scenarios to force the coupled models, to investigate how fish-mediated carbon fluxes and sequestration vary under various climate change scenarios and fishing scenarios from past to future.

Perspective
We expect the project to significantly improve our comprehension of fish-mediated carbon flux and sequestration in marine carbon dynamics. We will offer a novel approach to investigating and quantifying fish-mediated carbon fluxes and sequestration through coupling with earth system models. Furthermore, this research will underscore the importance of sustainable fisheries management in maintaining carbon sequestration from fish, thus contributing to climate change mitigation strategies and corresponding policy decisions.

Title:
The role of fish in carbon cycling and the impact of climate change

Principal supervisor:
Ken Haste Andersen

Section:
Centre for Ocean Life

Philip Alexander Hedlund Smith

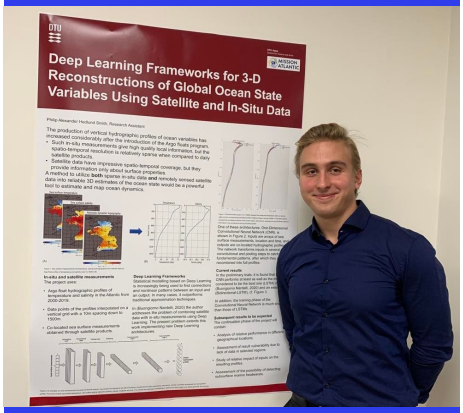
Background
Ocean dynamics are essential for the functioning of the Earth system with important effects on climate regulation and global biodiversity. Regional and global processes driving storage and transport of heat, carbon, nutrients, and marine organisms are crucial for providing many ecosystems' 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.

Title:
Big data analytics to support ecosystem-based risk management of marine ecosystems

Principal supervisor:
Patrizio Mariani



Section:
Oceans and Arctic

Costanza Cappelli

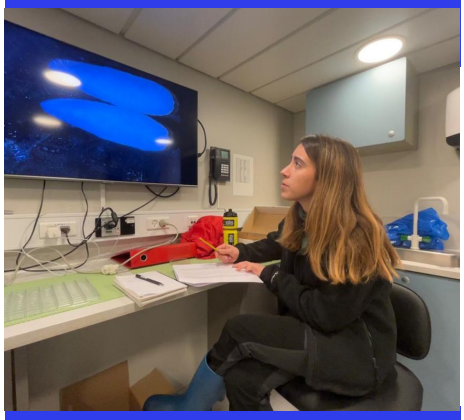
Background
Blue whiting (*Micromesistius poutassou*) is a mesopelagic gadoid species widely distributed in the northeast Atlantic Ocean, and it is commercially exploited throughout much of the region. It is both an important prey for many higher trophic level species and a zooplanktivore exerting significant 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.

Title:
Physical processes affecting stock dynamics of blue whiting in the northeast Atlantic Ocean

Principal supervisor:
Brian MacKenzie



Section:
Oceans and Arctic

Athanasios Kandylas

Background
Oceans play a crucial role in regulating and stabilizing the Earth's climate having stored nearly 40% of the anthropogenic CO_2 emissions since the industrial revolution. However, potential tipping points might lead to abrupt changes of critical physical and biological processes affecting important marine ecosystem services, such as carbon sequestration and food production. Even though the science around the physics of climate change is robust, our understanding about the response of the marine ecosystems to these changes is still incomplete.

Project
The aim of this PhD is to develop a framework through advanced ecological modelling which will be able to give an insight into the ecological state of the majority of the marine ecosystems around the world. We expect that at the end of this process, we will have gained a better understanding of two important and interrelated phenomena: Carbon Sequestration and Oxygen Minimum Zones (OMZ) in the ocean. To accomplish this, the Nutrient – Unicellular – Multicellular (NUM) framework and the SISSOMA, a specialized aggregation model, developed in the Centre for Ocean Life will be applied.

Perspective
Overall, in a fast-changing world we need to be able to make accurate predictions about the function and structure of marine ecosystems on a global scale. The tools developed in this project work on this direction and they will hopefully help us to take critical management decisions on time.

Title:
Carbon sequestration and oxygen minimum zones

Principal supervisor:
Andre Visser

Section:
Oceans and Arctic

Thøger Engelund Knudsen

Background
Seasonal migration can serve as a strong advantage for many species across large scales of the animal kingdom. The Atlantic bluefin tuna is one such species, and travels vast distances, presumably in search for abundant prey resources. This tuna is of special interest in Denmark, as parts of its population have recently started consistently making the journey from the Mediterranean all the way to Skagerrak and Øresund.

Project
The general objective of this PhD project is to create one or more models that are able to mathematically describe the existence and evolution of migratory routes in pelagic fish populations. It is possible to mathematically show how migration and its benefits can manifest in the evolution of a species due to natural selection. An individual will to an extent remember successful journeys it has undergone during its lifetime. However, it is poorly understood how this knowledge accumulates and persist, transcending through generations, especially for species without means of explicitly communicating this information. I seek to develop a novel framework that explains the existence and creation of migratory routes in social memory so that we can understand the spatio-temporal dynamics of populations of fish like the Atlantic bluefin tuna.

Perspective
This project will help determine the key aspects for local populations of Atlantic bluefin tuna, hopefully ensuring that they have come to stay. Furthermore, the existence of a framework that describes the creation of migratory routes through collective behaviour will advance our ability to understand and predict changes in migrational patterns in a changing world.

Title:
Fish migration and ecosystem processes

Principal supervisor:
Brian MacKenzie

Section:
Oceans and Arctic

Themistoklis Konstantinopoulos

Background
The shipping industry is shifting to greener fuels, like ammonia (NH_3) and methanol (MeOH), following the instructions of the International Maritime Organization (IMO) to substantially reduce greenhouse gas (GHG) emissions. This shift imposes the risk of spilling these substances into the marine environment. The effects of NH_3 and MeOH on marine microbial life are not yet fully understood. Existing literature indicates potential adverse effects on marine food webs. However, plankton communities, especially in areas like the Baltic and North Seas, are not sufficiently studied. Given the significance of zooplankton in energy transfer within marine food webs, it is crucial to study their response to NH_3 and MeOH under different environmental conditions.

Project
During my PhD, I will collaborate with experts from Danish and Swedish universities. We will conduct sampling surveys to assess current conditions in the Baltic and North Seas, focusing on environmental parameters and zooplankton community composition. Subsequently, I will perform ecotoxicology experiments by introducing ammonia and methanol under various environmental gradients to simulate changing conditions in these areas. Finally, I will implement the results to create computational numerical models to be used in environmental impact and risk assessments.

Perspective
Copepods play a crucial role in energy transfer and greatly contribute to ecosystem services. My project aims to understand and explain the toxicity mechanisms of ammonia and methanol on copepods under different environmental conditions. The knowledge produced by this PhD will help us understand the ecosystem effects of the energy transition in the shipping industry. Additionally, I will develop numerical tools that can be used in future ecotoxicology studies.

Title:
Ecosystem effects of maritime activities

Principal supervisor:
Marja Koski

Section:
Oceans and Arctic

Emilie Skrubbeltrang Thomsen

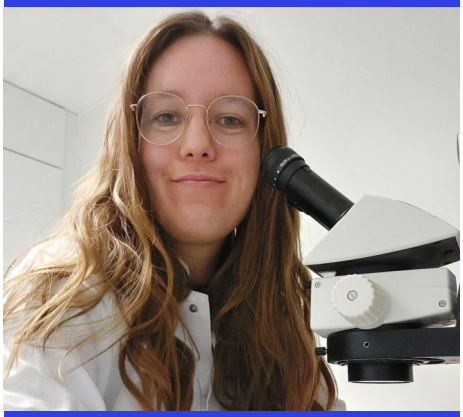
Background
Ships produce various types of waste water from the machinery, fuel, showers, dishwater etc. The waste water is often released into the ocean and can contain excess nutrients, heavy metals, polycyclic aromatic hydrocarbons (PAHs) among other things. These contaminants can alter the marine ecosystem by affecting the species involved by reducing reproduction and survival. Worldwide, research has mainly focused on understanding the impacts of individual contaminants with occasional studies on two pollutants, but studies on multiple contaminants are scarce. Furthermore, climate change is also considered a stressor that can potentially influence the effects and toxicity of pollutants; therefore, it should also be considered in the context of multiple stressors. The current challenge lies in developing a realistic method to determine the impacts of multiple stressors, which can then guide management decisions.

Project
During this PhD project, I aim to contribute to improved understanding of how shipping discharges impact marine biodiversity at the base of the food web through mixture toxicity. The main focus will be on assessing the cumulative effects of contaminants and their interactions with climate change through a combination of multiple stressor experiments, chemical analysis of contaminants and damage modeling. The PhD aims to create a damage modeling framework that quantifies the environmental effects of shipping activities on marine environments.

Perspective
My project aims to understand the environmental impacts of shipping discharges by conducting ecotoxicological experiments on copepods using multiple stressors. These results will be used in a damage modeling framework used to model the impact of shipping on marine ecosystems and their services. This can hopefully be used in maritime spatial planning and promote sustainable shipping practices.

Title:
Linking pressure from mixture toxicity of shipping discharges to loss of biodiversity in the marine environment

Principal supervisor:
Marja Koski



Section:
Oceans and Arctic

David Dylan O'Brien-Møller

Background
Argo floats are autonomous, freely drifting profiling instruments capable of adjusting their buoyancy to move vertically in the water column. Typically deployed in open ocean environments for periods of 4-6 years, Argo floats operate by drifting at approximately 1000 meters depth for about 10 days before descending to 2000 meters. From there, they ascend toward the surface, collecting vital oceanographic data such as temperature and salinity. Upon surfacing, they transmit collected data via satellite. Over the past two decades, thousands of Argo floats have revolutionized ocean data collection, significantly enhancing our understanding of ocean dynamics and climate processes.

Project
Despite their widespread use and success, Argo floats face limitations in specific marine environments. In areas with strong currents, Argo floats are quickly displaced from regions of scientific interest. Additionally, in shallow coastal areas, these floats risk being driven ashore or are unable to perform their standard deep-water profiling cycles. This project aims to develop technology to enable Argo floats to operate in coastal areas through developing methods for Argo floats to control their position. To take advantage of the new areas open to Argo floats, novel sensor technology will be integrated into Argo floats, enabling collection of new types of oceanographic data previously unavailable in these regions.

Perspective
Increasing the types of data that can be collected by Argo floats and increasing the area in which they can operate in, especially in coastal areas, will yield critical data from currently under-sampled coastal regions. Ultimately, these advancements will improve our understanding of coastal marine ecosystems, ocean processes, and human impacts on these vital environments.

Title:
Building the coastal ARGO (ARGO+)

Principal supervisor:
Patrizio Mariani

Section:
Oceans and Arctic

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.

Title:
Growth and metabolic scaling of fish: unravelling how variation in growth affects metabolic scaling

Principal supervisor:
Tommy Norin

Section:
Marine Living Resources

Daniel Anthony Hancock

Background
A rapidly changing climate will have a major impact on the distribution, evolution and persistence of species, with marine ecosystems being particularly vulnerable, facing gradual threats like ocean acidification, temperature shifts, and alterations in currents, as well as immediate crises such as marine heatwaves. Considering these challenges, climate vulnerability assessments that account for nuanced, population-specific responses such as divergent range shifts and local adaptation, as well as highlighting potential maladaptation to future environments are becoming increasingly important. Such assessments are crucial for proper evaluation and mitigation of the impacts of climate change on the persistence of species of economic and ecological importance.

Project
The objective of this project is to evaluate the risks associated with climate change to marine species in the Kattegat-Skagerrak transition zone. To achieve this, genomic and climatic data will be integrated in a comparative approach across multiple aquatic taxa to make predictions about evolutionary responses to climate change. This will involve spatial and evolutionary modelling to predict the connectivity, future distribution and adaptive capacity of populations, as well as investigating genetic vulnerability metrics such as mutational load, genetic diversity and inbreeding.

Perspective
This PhD is part of the Interreg Øresund-Kattegat-Skagerrak BlueBioClimate project, which aims to facilitate cross-border co-operation for climate-adapted management of aquatic biodiversity. Through collaboration with project partners across the region and national and regional resource management practitioners, it aims to provide guidance for the prioritization of effective conservation strategies in aquatic ecosystems, to ensure ecosystem resilience and safeguard natural resources.

Title:
Climate change population genomics

Principal supervisor:
Jakob Hemmer-Hansen

Section:
Marine Living Resources

Nina Strand

Background
Inadequate bycatch assessment in fisheries can lead to declining spawning stock biomass and reduced recruitment, impacting both target and non-target species. In Denmark, the "bucket method" is currently used to document by-catch in pelagic fisheries, which typically have landings over 500 tons. This method involves sampling 10 kg of fish for every 25 tons at fish factories, with species composition determined manually by third-party observers. It is expensive, time-consuming, and requires taxonomic expertise, creating challenges in accuracy and cost-effectiveness. Environmental DNA (eDNA) analysis, which detects genetic material from organisms in environmental samples, offers a promising alternative. It can reduce time, costs, and workload, while eliminating the need for taxonomic expertise. Despite its potential, eDNA's widespread adoption in large-scale monitoring remains limited.

Project
The DNAcatch project aims to develop, evaluate, and implement eDNA-based methods for biomass quantification of bycatch in pelagic fisheries, enhancing fisheries management. Building on the pilot study DNAmix, which showed the feasibility of using eDNA for quantifying catch composition, this PhD project will focus on comparing molecular methods (dPCR vs. qPCR) for their impact on biomass estimations, developing eDNA-based methods for several target fisheries, and comparing these results with traditional methods.

Perspective
Implementing eDNA-based methods for bycatch quantification in pelagic fisheries could improve fisheries management by providing more accurate, cost-effective, and scalable monitoring tools. By optimizing molecular techniques such as dPCR and metabarcoding, the project aims to improve the precision and sensitivity of bycatch detection, especially for rare species. The findings could lead to more effective management strategies, particularly for multi-species fisheries like sandeel. Ultimately, this research could support sustainable fisheries practices by enabling more accurate stock assessments.

Title:
DNA based catch quantification for pelagic fisheries (DNAcatch)

Principal supervisor:
Einar Eg Nielsen

Section:
Marine Living Resources

Karoline Bruun Degn

Background
The transition to sustainable energy is a crucial part of global efforts to combat climate change. Offshore wind farms are set to expand significantly as part of this green transition. For instance, the Esbjerg Declaration by Danish authorities aim to increase wind power production in the North Sea by tenfold by 2050. However, this expansion raises concerns about potential disruptions to marine ecosystems. To address these concerns, political goals have shifted from “No Net Loss” to “Marine Net Gain” in biodiversity, meaning offshore wind farms should enhance rather than harm marine ecosystems.

Project
This PhD project focuses on using environmental DNA (eDNA) metabarcoding techniques to monitor marine biodiversity around offshore wind farms. By employing advanced autonomous robotic instruments for in situ eDNA sampling and DNA analysis, the project aims to achieve high spatial and temporal resolution. Techniques such as 3rd generation sequencing, digital PCR (dPCR), and oceanographic modeling will be applied. Sampling will primarily take place around the offshore wind farm Horns Rev II located in the North Sea and at the Ørsted windfarm off the coast of Anholt. The overarching goal is to develop a robust, cost-efficient eDNA-based tool for offshore biodiversity monitoring and marine environmental impact assessment.

Perspective
We hope to transform eDNA from a basic science concept into a practical monitoring tool that can be adopted by the industry and national authorities. In that way we can ensure that the establishment of wind farms contributes positively to marine biodiversity and supports nature-based solutions for artificial reef structures.

Title:
Assessing biodiversity at offshore wind farms using eDNA (WINDDNA)

Principal supervisor:
Einar Eg Nielsen

Section:
Marine Living Resources

Magnus Højen Husen

Background
Decreased frequencies of major inflow events of oxygenated water, together with increasing sea surface temperatures and immense anthropogenic pressures, have intensified the extent and severity of hypoxia in the Baltic Sea. These factors have in recent decades negatively affected key physiological and ecological parameters of cod (*Gadus morhua*) in this region. Notably however, recent reports from the Åland Sea in the northern Baltic have shown noticeably larger and healthier cod, compared to cod from the southwestern and central Baltic. The reasons for this difference have been hypothesized to be better oxygen conditions in these northerly areas, in addition to higher availability of *Saduria entomon*, a key prey item in the diet of cod which in recent times has decreased in the central parts of the Baltic.

Project
Combining controlled experiments with information derived from the field, the aim of this study is to investigate the physiological changes that occur when Baltic cod is exposed to prolonged moderate hypoxia. In addition, the project will include historical analysis of Saduria distributions coupled to environmental data of oxygen conditions across the Baltic, and stomach content analysis of the Åland cod, to test the hypothesis of Saduria as a key determinant of the health status of the Baltic cod.

Perspective
Findings from this study will provide important insights for fisheries management and conservation efforts in the Baltic. Understanding the link between environmental stressors, such as hypoxia, and food quality can inform strategies to protect and restore Baltic cod populations. Moreover, recognizing the importance of Saduria as essential prey could lead targeted efforts to preserve or its populations in the central Baltic, potentially improving the resilience of Baltic cod.

Title:
Effects of moderate hypoxia and food quality on growth of Baltic cod

Principal supervisor:
Jane W. Behrens

Section:
Marine Living Resources

Tunca Deniz Yazici

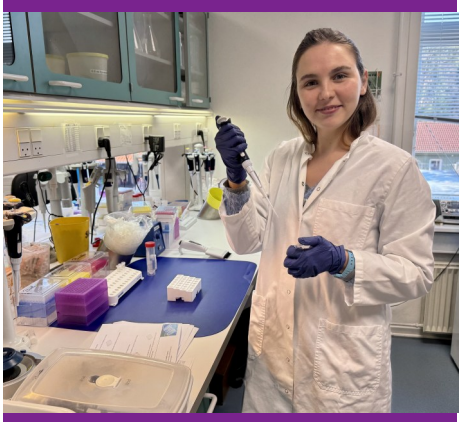
Background
Climate change is a significant driver of global environmental change. Rising temperatures, ocean acidification, deoxygenation, and changing sea levels severely affect biodiversity and ecosystem functions. Further anthropogenic activities such as pollution, habitat destruction, and overfishing profoundly affect biodiversity and ecosystem health at both temporal and spatial scales. While conservation of biodiversity and habitat restoration are highlighted by management authorities, determining which areas and species to prioritize for protection and restoration presents a significant challenge. To ease and enhance management strategies, it is crucial to understand climate change vulnerability for species and community-level impacts in marine ecosystems.

Project
This PhD project focusses on various biodiversity metrics using sugar kelp in Danish waters. We will analyze genetic diversity through integrated genomic, environmental, and ecological analyses. We tackle the question of how diversity can be preserved in a changing climate through spatial planning and habitat restoration. Using sugar kelp both as a target species, and as an ecosystem indicator, we will investigate biodiversity and ecosystem health.

Perspective
This PhD is part of a larger project funded by Aage V. Jensen Naturfond titled as “Integrated ecological, genomic and oceanographic analysis for planning marine habitat protection”. In collaboration with Aarhus University, Aalborg University, Havsamarbejdet i Østjylland, and The Institute of Marine Research, we seek to answer the question: “how can connectivity among Danish marine habitats be preserved and strengthened to secure marine biodiversity and ecosystem functioning under future climate change?”. We gather expertise to develop predictive tools aimed at enhancing assessments and strategies for conserving and managing biodiversity amid climate change. By fostering robust and resilient marine ecosystems in Danish waters, these predictive tools will help us to achieve the ambitious goals of protecting and restoring large proportions of our marine areas.

Title:
Integrating ecological and genomic diversity for climate resilient marine spatial planning

Principal supervisor:
Jakob Hemmer-Hansen



Section:
Marine Living Resources

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.

Title:
Using computational human ecology approaches to understand the role of cultural ecosystem services to trade-offs between human well-being and biodiversity conservation

Principal supervisor:
David Lusseau

Section:
Ecosystem based Marine Management

Daniel Rooth

Background
Anthropologically induced effects such as eutrophication and hypoxia in marine coastal environments are today widespread and often severe, resulting in habitat loss, reduced biodiversity and trophic cascades. Loss of important habitats can delay or hinder the recovery and integration of fish populations into the ecosystem. Restoration and transplantation of habitats such as eelgrass meadows have proven successful in terms of promoting taxonomic biodiversity and abundance of slow-moving marine fauna. By reintroducing these habitat types to the ecosystem, complex three-dimensional structures may provide refuge as well as foraging opportunities for invertebrates, fish and other organisms, forming biodiversity hotspots. However, knowledge of the effect on community dynamics, behaviour and biodiversity of fish in these environments, remain insufficient.

Project
The objective of this PhD project is to study the fish community dynamics in relation to the coastal habitats such as transplanted and naturally occurring eelgrass. The potential re-colonisation of fish communities associated with the transplantation of eelgrass will be investigated with a strong emphasis on the roles of top- and mesopredators. With public collaboration together with recreational anglers, continuous monitoring of degraded areas is carried out whilst evaluating ecosystem function of eelgrass- and stony reef habitats.

Perspective
The PhD project contributes to a deeper understanding of the biodiversity and community dynamics, including predator-prey interactions and habitat preferences, of marine fish in shallow coastal waters, with the hopes of contribute to improving rewilding efforts in restored marine areas. The project will also critically assess various underwater monitoring methodologies commonly used to assess fish, in a complex coastal ecosystem, as well as involving local anglers and volunteers.

Title:
Rewilding marine coastal ecosystems - fish community dynamics in transplanted eelgrass habitats

Principal supervisor:
Mikael van Deurs

Section:
Ecosystem based Marine Management

Markus Varlund Strange

Background
Many species are struggling in the inner Danish waters compared just 50 years ago, and some of our previously most important fisheries there have declined or even closed. These fish stocks have been subject to several different stressors, i.e., overfishing, food scarcity, parasites, oxygen depletion, predation, etc. For mitigation efforts to be successful, it is essential to disentangle the effects of the stressors, and especially understand the natural components. One of these is predation from seals and cormorants, which have both increased dramatically since the 1970's.

Project
My project aims to quantify the natural mortality of cod, herring, and various flatfish due to seals and cormorants, both in the current situation and historically. This is achieved through a combination of empirical diet data from the predators, and modelling approaches. The diet data are acquired from otoliths in seal scats and cormorant pellets, and the modelling framework includes a stochastic stock assessment model, and a spatiotemporal species distribution model. The culmination of the project is a management strategy evaluation, where I will investigate the effects of different seal and cormorant management scenarios.

Perspective
This project will increase our understanding of predators' role in the recovery process of deteriorated fish stocks, and enable informed decision-making on management of conflict species. Furthermore, as numerous fish stocks worldwide are in poor condition and human-wildlife conflicts occur everywhere, results from this project can inspire managers all over the world. Lastly, the project will also contribute to the ongoing efforts of developing methods for including good estimates of natural mortality in fish stock assessments.

Title:
Cormorant and seal predation on fish in inner Danish waters

Principal supervisor:
Nis Sand Jacobsen

Section:
Ecosystem based Marine Management

Zita Bak-Georgsen

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.

Title:
Shifting from single to multi-species methods when evaluating fishing gear performance

Principal supervisor:
Bent Herrmann

Section:
Fisheries Technology

Laura Diernæs

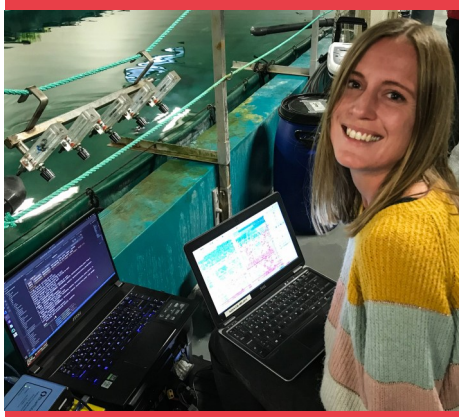
Background
Trawl gears are responsible for a large portion of unwanted catches, globally. Consequently, there is a large focus on improving their environmental sustainability while ensuring that the fisheries remain economically viable. Animal behaviour is one of few main components that are decisive 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.

Title:
Observing and quantifying fish behaviour in relation to active fishing gear

Principal supervisor:
Junita Diana Karlsen



Section:
Fisheries Technology

Nurul Huda

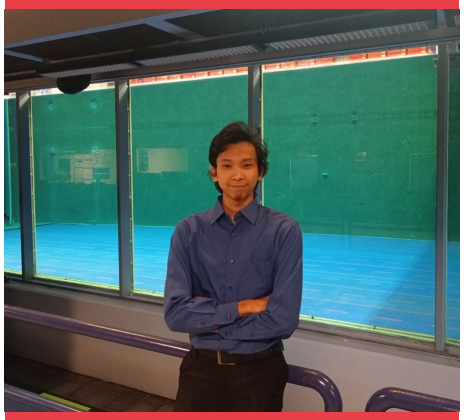
Background
In recent years there have been increasing concerns regarding demersal trawl physical impacts on the seabed, which can give rise to (i) increased fuel consumption, (ii) the release of carbon sequestered in the seabed, (iii) habitat modification and (iv) benthic mortality. In order to promote 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.

Title:
The scale modelling of towed demersal fishing gears

Principal supervisor:
Barry O'Neill



Section:
Fisheries Technology

Sissel Kolls Bertelsen

Background
The Common Fisheries Policy (CFP) aims to ensure sustainable fish stock exploitation and eliminate discards. To achieve this, the EU has implemented the Technical Measures Regulation, outlining complex restrictions to e.g. fishing gear and area. The complexity and prescriptiveness of the Technical Measures Regulation restricts fishers' ability to adapt their fishing practices according to changes in the fishery. Presently, however, emerging technologies such as electronic monitoring can potentially facilitate automatic catch registration, and thereby provide fully documented fisheries. Thus, by providing fully documented fisheries, electronic monitoring could increase the data input to stock assessments, enhance enforcement of regulations, replace time consuming control procedures, and potentially render large parts of the Technical Measures Regulation redundant.

Project
The overall aim of this PhD is to understand whether the implementation of new technologies for catch monitoring and reporting can facilitate a simpler and more flexible management framework, while ensuring improvements in the environmental and economic performance of fisheries. The project will be made in close collaboration with the fishing industry and the Danish Fisheries Agency and contribute to the EU Horizon project EveryFish.

Perspective
Simplifying the management framework may act as an incentive for the fishing industry to adopt electronic monitoring. Additionally, this project will explore fisher's perceptions of electronic monitoring, to understand challenges and advantages related to this from a fisher's perspective. Finally, the project will investigate how information from electronic monitoring data can be made useful for fishers to increase the efficiency of the fishing process. Hence both management, technical, and social aspects related to the implementation of electronic monitoring are considered in this project.

Title:
Electronic monitoring and new management structures for facilitating innovation within fisheries

Principal supervisor:
Jordan Feekings

Section:
Fisheries Technology

Cristina Fernández García

Background
Demersal fishing gears, particularly beam trawls, lead to significant negative impacts on the seabed and benthic communities. Heavy gear components are used to mechanically lift target catches into the net, damaging benthic habitats, causing alterations in sediment composition and disrupting marine ecosystems. Overall, these effects contribute to reduced biodiversity, altered species composition, resuspend sediments, and nutrients, and release CO_2 that was sequestered in the seabed, compromising the overall marine ecosystem health. With increased awareness towards sustainability in recent years, there is significant demand for innovative technologies that can be both less aggressive towards the seabed and selective for the target species with high commercial value, thereby reducing bycatch. Fishing gear development, specifically the modification of towed gear design to enhance fisheries sustainability and optimize fishing performance, therefore, has great potential for mitigating environmental impacts.

Project
This PhD project will start building on the results of a recent study in the Limfjord sea star fishery, where it was demonstrated that the turbulence in the wake of a beam towed close to the seabed can replace the mechanical gear components to raise sea stars from the seabed. This new data constitutes the foundation to investigate further modifications of the beam design and the project will shed light on the understudied behavioral responses of several demersal target and bycatch species in response to hydrodynamic flow.

Perspective
By leveraging this innovative gear modification, this project aims to explore new possibilities for sustainable fishing practices which, in turn, strive to make cost-effective technology readily available to fishers enhancing their efficiency and sustainability practices, with a focus on minimizing environmental impacts and reducing bycatch in various highly impactful fisheries.

Title:
Using hydrodynamics to modify the performance of towed fishing gears

Principal supervisor:
Barry O'Neill

Section:
Fisheries Technology

Satish Pawar

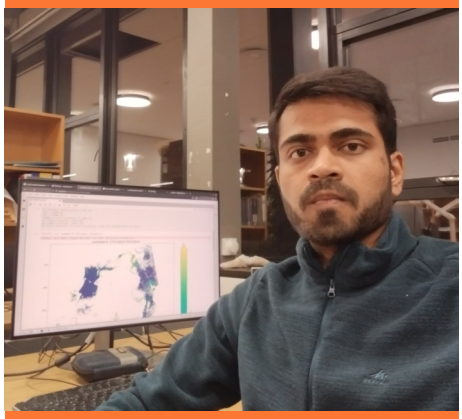
Background
Eelgrass is one of the common aquatic vegetation in the northern temperate coastal regions. It provides valuable ecosystem services like nursery grounds to juvenile fish, improve water quality and sequester carbon as green biomass. The eelgrass meadows in Danish coastal waters were damaged 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.

Title:
Habitat suitability and potential recovery of eelgrass

Principal supervisor:
Karen Timmermann



Section:
Coastal Ecology

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.

Title:
Stability of subtidal blue mussel bed in coastal areas

Principal supervisor:
Pernille Nielsen

Section:
Coastal Ecology

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.

Title:
Disease-free production of European flat oysters

Principal supervisor:
Camille Saurel

Section:
Coastal Ecology

Ana Lilia Tovar Aguirre

Background
Aquaculture, a rapidly growing sector of food production, is crucial for meeting the global demand for seafood. The European flat oyster (*Ostrea edulis*) is of significant ecological and economic importance. A critical factor in the success of oyster hatcheries is the quality of microalgal feed, which must meet the nutritional needs of oysters at various life stages. While monocultures of microalgae have been the traditional choice, studies highlight the advantages of using mixed microalgae cultures. Native, local, undefined poly microalgae cultures may offer cost-effectiveness, and high-quality nutritional profiles, making them a promising alternative for sustainable oyster farming.

Project
This PhD project focuses on using local, undefined poly microalgal cultures as a sustainable and effective feed source for *Ostrea edulis* in hatcheries. The research will explore the potential of these natural microalgal communities by adapting them to controlled hatchery environments. By examining different factors, the project aims to optimize the cultivation of these polycultures to enhance their suitability as oyster feed. Additionally, the study will investigate the scalability of these cultures from lab-scale to larger production systems, assessing their impact on oyster growth, tissue composition, and overall health.

Perspective
The findings from this project will advance sustainable aquaculture practices by demonstrating the viability of local, native, microalgal polycultures as a high-quality feed option for oyster hatcheries. This approach could lead to reduced feed costs and improved oyster productivity, contributing to the long-term sustainability of the aquaculture industry. Beyond aquaculture, the insights gained could have broader applications in different areas where polycultures could be suitable.

Title:
Microalgae production for shellfish hatchery

Principal supervisor:
Camille Saurel

Section:
Coastal Ecology

Morten Højen Kristiansen

Background
Horse mussel beds are marine formations consisting of dense congregations of living mussels, empty shells, and various substrates, all held together by the mussels' byssus threads. High densities of mussels are vital for their function as ecosystem engineers that stabilize sediment and create habitats, promoting a rich biodiversity and high biological productivity. In addition, horse mussels provide regulating ecosystem services through suspension feeding, removing phytoplankton and particles from the water column, thereby improving water quality. However, historical records reveal a significant decline in the spatial extent of horse mussel beds, mainly driven by physical disturbances from human activities. The management of threatened horse mussel beds can be supported through targeted restoration efforts, with a promising approach being the deployment of cultured juvenile mussels (spat) to boost recruitment.

Project
Horse mussel spat has been produced in hatcheries before, but not in quantities that are sufficient to meet the demand for horse mussel reef restoration projects. A limitation in production is largely due to a significant lack of research on horse mussel biology and behaviour. Therefore, to close the knowledge gaps, this PhD project will focus on investigating the life-stage-specific demands of horse mussels in aquaculture. This requires refinement of feeding procedures and control of environmental parameters to create an ideal environment in a hatchery that can help maximize reproductive potential and offspring survival and growth. Additionally, the project will explore biological mechanisms or conditions that trigger spawning and larvae settlement.

Perspective
This project will contribute with new insights into the biology of the horse mussel and the biological responses that aquaculture conditions impose on the species. The development of a novel horse mussel hatchery will provide the means to restore degraded horse mussel beds and potentially establish new ones, contributing to global efforts to enhance biodiversity and ecological health of marine ecosystems. This project has the potential to drive innovation in ecological restoration techniques and set new standards for sustainable marine conservation.

Title:
Horse mussel, *Modiolus modiolus*, production for restoration

Principal supervisor:
Camille Saurel

Section:
Coastal Ecology

Anna Steinmann

Background
Coastal ecosystems depend on bivalves for several ecosystem services (ES), including the improvement of water clarity and the formation of long-lasting, complex habitat structures to promote biodiversity. However, human activities such as overfishing and climate change have led to a decline of the populations, thereby threatening these ES. While restoration efforts have been made, they often lack standardized monitoring methodologies or monitoring all together. Consequently, it is challenging to evaluate restoration impacts and identify potential issues that require adaptations to the restoration strategy.

Project
The objective of this project is to assess the impact of restoration efforts, while considering biotic and abiotic pressure factors that shape and determine the evolution and stability of restored bivalve habitats. Thus, different methods for a standardized monitoring will be developed and compared. A combination of imaging-based techniques, side-scan sonar, and traditional physical sampling will be applied to assess metrics such as the footprint area, sediment coverage, and patterns of self-organization. Alongside those assessments, water clarity as an important ES will be investigated. In-situ sensors will be utilized to monitor particle depletion, which will be linked to relevant abiotic factors. This aims at establishing a monitoring protocol for the assessment of water clarity in and around bivalve beds, with considerations of spatialtemporal changes.

Perspective
A key outcome will be a detailed assessment of the advantages and limitations of different monitoring methods. This will provide an evaluation of their applicability and thereby support the identification of appropriate techniques for assessing restoration impacts. Ultimately, protocols for standardized monitoring across different restoration projects and studies will be proposed. The implementation of the developed methods will provide a detailed understanding of short-term trends, and the ES provided. It should also provide a perspective on assessment metrics and the expected effort required to implement long-term monitoring.

Title:
Evolution, stability and ecosystem services provided by restoration of marine bivalve habitats

Principal supervisor:
Pedro Seabra de Freitas

Section:
Coastal Ecology

Lene K. Sortland

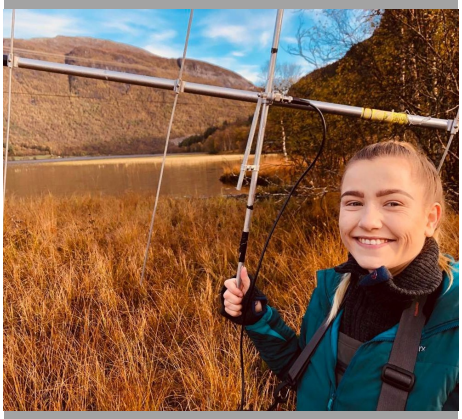
Background
Salmon and sea trout are iconic salmonids that migrate between the freshwater and marine environments. Salmonids reproduce in rivers, where they spend their juvenile phase before migrating to sea as “smolts” for feeding and growth. During their seaward migration smolts can experience high 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.

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

Principal supervisor:
Kim Aarestrup



Section:
Freshwater Fisheries and Ecology

Benedikt Merk

Background
The eutrophication of lakes can alter aquatic ecosystems, by creating algal blooms and anoxic conditions, often resulting in reduced water quality and a loss of biodiversity. Zooplanktivorous fish like roach (*Rutilus rutilus*) reduce the predation of phytoplanktonic algae increasing their abundance. Thus, water turbidity increases and growth of benthic macrophytes that provide valuable micro-habitats for zooplankton and piscivores, e.g., pike (*Esox lucius*) is hindered. Alteration of the fish composition, in combination with reduction of nutrient influx, can minimize the effect of eutrophication on the lake, and lakes can even be restored to their mesotrophic origin. However, alterations in fish biomass (e.g., by removing roach from lakes) and environmental changes (e.g., water clarity and lake stratification) likely have various effects on the ecology, behaviour, inter- and intraspecific interactions of the remaining fish community.

Project
This PhD project is centred around a eutrophicated lake undergoing restoration efforts through first biomanipulation and next sediment-removal with the aim to improve water quality and biodiversity. The project utilizes high-resolution acoustic telemetry allowing for fine scale 3D-postioning of tagged fish in combination with continuous measurements of several biotic (e.g., growth, fecundity, density) and abiotic parameters (e.g., water temperature, oxygen). Thus, detailed behavioural and ecological analyses of roach and pike before, during and after lake restauration measures can be conducted.

Perspective
The project contributes to expanding our knowledge regarding fish behaviour in a changing environment by exploring novel aspects of fish behaviour relating to inter- as well as intraspecific interactions which can be of relevance for future management of other eutrophic lakes. Additionally, biomanipulation and fish observation methods are assessed, aiming to increase their effectiveness. All in all, a wider understanding of the impacts lake restoration methods have on fish behaviour and lake ecology can be generated.

Title:
Lake restauration and its effects on fish behaviour

Principal supervisor:
Christian Skov

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.

Title:
Documenting the effects of coastal habitat improvements and marine protected areas on the presence of anadromous brown trout and Atlantic cod

Principal supervisor:
Jon C. Svendsen

Section:
Freshwater Fisheries and Ecology

Marie Pedaccini

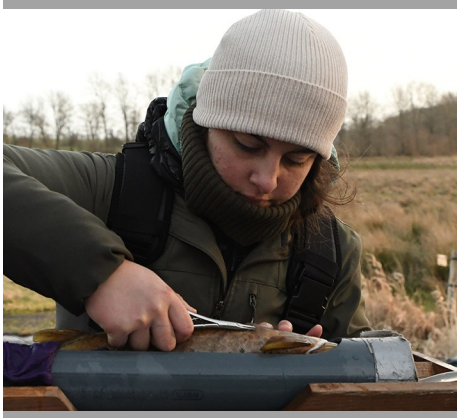
Background
Fish must cope with numerous stressors and threats, including pollution, habitat destruction, overfishing, fisheries interactions, and climate changes. Understanding when and why fish are vulnerable is crucial for conservation, especially for migratory species, facing energy-intensive migrations and relying on specific environmental conditions. Although previous studies have assessed the vulnerability of salmonids and tunas under some circumstances, many knowledge gaps on the threats they face remain. Understanding the behaviour and threats of brown trouts (*Salmo trutta*) in direct sea systems (without fjords) and the impact of increasing temperatures on their behaviour, activities and performance remains unclear. Additionally, crucial information is lacking regarding how catch-and-release interactions affect the behaviour and survival of Atlantic bluefin tuna (*Thunnus thynnus).*

Project
The main goal of this PhD project is to assess the underlying mechanisms that determine when and why migratory fish are vulnerable to stressors in the marine and freshwater regions of the Skagerrak-Kattegat-Øresund region, using brown trout and Atlantic bluefin tuna as model species. Biotelemetry and physiological data help assess vulnerability by tracking movements and analyzing fitness, offering insights into critical instances and factors influencing vulnerability.

Perspective
This PhD project will strengthen our understanding of the critical instances or circumstances under which fish are most vulnerable, as well as the factors that may modulate this vulnerability. Those findings should enable adaptative handling practices and the development of conservation measures for brown trout and Atlantic bluefin tuna, but the findings are expected to be transferable to similar species.

Title:
When and why are fish vulnerable?

Principal supervisor:
Kim Aarestrup



Section:
Freshwater Fisheries and Ecology

Franziska Bockelmann

Background
Freshwater fish represent one of the most threatened taxonomic groups in Europe, highlighting the urgent need for improved conservation and monitoring strategies. Despite being a significant driver of fish population declines, the extent of cormorant predation on threatened fish species remains under-explored, posing a challenge for informed conservation decision-making. Another main problem is the lack of reliability of monitoring data. EU member states are mandated to report on species listed in the Habitats Directive, yet monitoring data for riverine fish is often incomplete or absent.

Project
Through my PhD, I aim to address these challenges by investigating the relationship between cormorant predation and fish population dynamics in European rivers. Using a combination of historical data analysis, field studies, and experimental approaches, I seek to quantify the extent of predation pressure and identify key environmental factors that influence its severity. For example, I am exploring how habitat complexity may mitigate predation and assessing the effectiveness of exclusion measures in protecting fish populations.
This PhD is part of the EU-wide ProtectFish initiative and uses the European grayling (*Thymallus thymallus*) as a case study, to highlight the predator-prey dynamic of cormorants and riverine fish, and propose solutions to enhance protection measures.

Perspective
We aim to produce actionable insights that can guide policy changes, improve biodiversity monitoring systems, and enhance the conservation status of freshwater fish. Ultimately, this research aspires to contribute to a more sustainable coexistence between predator populations, and the aquatic ecosystems they share. The findings will contribute to policy updates at the EU level, fostering improved biodiversity monitoring frameworks.

Title:
Cormorant predation and river fish conservation

Principal supervisor:
Niels Jepsen

Section:
Freshwater Fisheries and Ecology

Alexandre Nguyen-tiêt

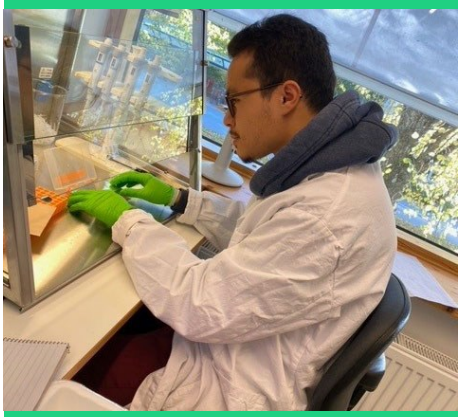
Background
Hydrogen sulfide (H2S) is an extremely toxic compound for organisms, preventing aerobic respiration. In marine land-based recirculating aquaculture systems (RAS), H2S production is a major challenge, leading to fish mortality and thus important economic consequences. Because of the high sulfate (SO42-) 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 H_2S production in RAS and especially the cysteine degrading bacteria. To do so, I will first enrich and cultivate H_2S producing bacteria from samples collected at several locations in RAS. After that, I will use metagenomic/metatran-scriptomic analysis to identify the bacteria as well as the metabolic pathways responsible of H_2S production and develop primers to examine H_2S 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 H_2S production in land-based aquaculture. With this new knowledge, I can develop ways to quantify and monitor both the traditional (SRB) and cysteine-degradation H_2S producers in RAS to avoid production losses related to H_2S exposure and to promote safe and stable fish production in the future.

Title:
Characterization of H_2S producers in recirculating aquaculture systems

Principal supervisor:
Sanni-Leea Hellevi Aalto



Section:
Aquaculture

Matthew Mainieri

Background
The global population is on the rise and with this increase comes multiple climatic as well as food security issues. Anthropogenic activity has caused a widespread increase of greenhouse gases including rising CO_2 levels. Microalgae play a crucial role in mitigating rising CO_2 levels through sequestration while also serving as a valuable resource in aquaculture. Their biochemical composition can be altered by environmental stressors such as CO_2 levels and photoperiod, impacting their nutritional value. In marine fish larviculture, microalgae enhance live feeds like rotifers and *Artemia*, improving larval growth, survival, and microbiome development. The "green water technique" further supports larval health by enriching the rearing environment. Optimizing microalgae nutrient profiles for both live feeds and water quality can significantly improve fish larval growth, survival, and long-term robustness.

Project
The project will encompass all aspects of teleost larval rearing. I will begin by applying various abiotic stressors to the microalgae culture of multiple species to manipulate the omega-3 polyunsaturated fatty acids (DHA, EPA) profile which are essential in early larval development. I will follow the microalgal culture trials by culturing and enriching live feeds (rotifers and *Artemia*) with the cultured microalgae and analyzing their nutrient retention efficiency. Lastly, I will culture finfish larvae while utilizing the results from the live feeds trial and condition the water with the cultured microalgae in an attempt to enhance larval growth, development, and survival.

Perspective
The potential gained perspectives of the PhD project are to 1) address how microalgae species respond to various stressors in terms of growth, nutrient profile, and physio-chemical interactions, 2) promote growth and survival of finfish larvae through live feed nutrition and water conditioning and to better understand the mechanisms and interactions behind the growth and survival, 3) discover the short and the long-term effects on larval growth, development, and robustness from initial early nutrition and environmental exposure.

Title:
Microalgae in fish feeds

Principal supervisor:
Ivar Lund

Section:
Aquaculture

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.

Title:
Early warning for disease: improving aquaculture monitoring with real-time microbiome sequencing.

Principal supervisor:
Argelia Cuenca

Section:
Fish and Shellfish Diseases

Alejandra Villamil Alonso

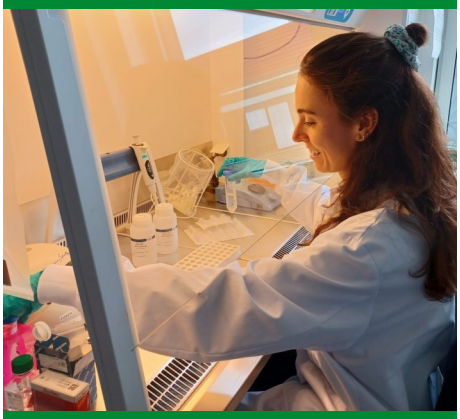
Background
Bacterial kidney disease (BKD) is a systemic infection that affects wild and farmed salmonids, compromising aquaculture systems worldwide. The causative agent of BKD is *Renibacterium salmoninarum*, a Gram-positive intracellular bacterium characterized by chronic disease progression and able 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 (*Oncor-hynchus 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

Shana Fresnido Genavia

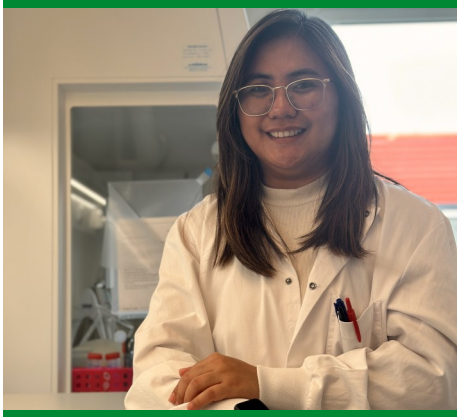
Background
The immune system in animals is a multi-faceted defense mechanism against pathogens. In vertebrates, the immune system operates through both innate and adaptive mechanisms, the latter being capable of generating immunological memory. Traditionally, invertebrates, such as shrimp, have been understood to possess only innate immune systems, devoid of any capacity for immune memory. This paradigm is being challenged as more research suggests invertebrates demonstrating a form of immunological memory, albeit not antibody-based. Understanding this could have a broad impact on industries like aquaculture, which often grapple with viral diseases that threaten shrimp populations.

Project
This PhD project aims to explore the role of circular viral DNA (cvDNA) in the immune response mechanism of shrimps against invading viruses. Utilizing *Penaeus vannamei* (Pacific whiteleg shrimp) as a model organism, the project will investigate whether cvDNA molecules are produced during viral infections and if these molecules serve as templates for RNAi-induced antiviral immune response. The project aims to address the biological aspects of cvDNA as well as its potential for conferring viral resistance and longevity of immunity. Methodologically, the study will employ a combination of molecular techniques, sequencing, and bioinformatics analysis to examine cvDNA and its implications.

Perspective
The implications of this research extend beyond shrimp aquaculture. If shrimp do possess a form of immune memory mediated by cvDNA, this could revolutionize our understanding of invertebrate immunity and even have repercussions for vertebrate immune systems. Moreover, it could open up new avenues for combating viral diseases in commercial aquaculture. The robust nature of cvDNA may offer innovative methods for studying virus-host interactions, both in contemporary and historical contexts. This has implications not only for animal husbandry but also for broader public health policies, especially considering the emerging evidence that vertebrates may utilize similar pathways.

Title:
Potential role of circular viral DNA in the shrimp immune system

Principal supervisor:
Niels Lorenzen



Section:
Fish and Shellfish Diseases

Chiara Cialini

Background
Rearing fish at high densities increases the risk of spreading pathogenic viruses and bacteria, particularly in larvae and fry. An important fish pathogen in aquaculture is *Flavobacterium psychrophilum*, the etiological agent of Rainbow Trout Fry Syndrome (RTFS), that causes significant economic losses in hatcheries worldwide. Cases of reduced susceptibility to antibiotics underline the need for alternative and more sustainable methods for the treatment of this bacterial infection, such as bacteriophage-based therapy. Bacteriophages (also called phages) are host-specific viruses of bacteria. Their use has recently demonstrated promising results in controlling various infectious fish diseases. However, further development is needed for the commercialization of this solution as a novel prophylactic product.

Project
Besides investigating the efficiency of phage administration in controlling RTFS by performing in vivo experimental infection trials, this PhD project will specifically target rainbow trout (*Oncorhynchus mykiss*) health status and host-pathogen interactions. In particular, the host immune response to phages will be assessed through gene expression analyses using qPCR, while the effects on fish microbiota and tissues development will be evaluated through sequencing and histological techniques, respectively. Once considered as safe, the most efficient phage preparations will be administered to fish/tanks using different strategies (feed pellets, liquid solution, coating on elements of the filtration system of tanks) to establish the best delivery method, before testing this disease control strategy under farming conditions.

Perspective
The final goal of this PhD project is to perform an efficiency and risk assessment of the phage-based solutions. This represents one of the tasks of a larger IFD research project, AQUAPHAGE whose final aim is to develop bacteriophage-based products that target specifically the bacterium *F. psychrophilum,* and to bring these solutions to a commercially viable stage. This new sustainable and innovative method can increase production efficiency and reduce the environmental burden of aquaculture.

Title:
Prophylactic measures against disease with *Flavobacterium psychrophilum* in rainbow trout; effect on pathogen as well as host

Principal supervisor:
Lone Madsen

Section:
Fish and Shellfish Diseases

Joyce Arguelles Hilario

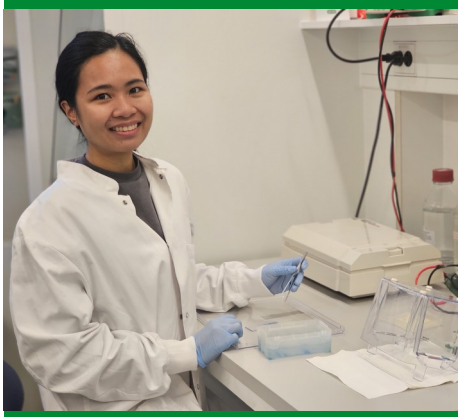
Background
Aquaculture is the most sustainable form of animal husbandry in terms of environmental impact, but infectious diseases cause significant losses, often requiring antibiotics. Lost production as well as use of antibiotics compromise both financial and environmental sustainability of aquaculture. The key to overcoming these problems is improved disease prophylaxis, with vaccination being one of the most effective tools. While injection vaccination is well established for larger-sized fish, early vaccination of smaller fish is less developed due to the lack of efficient vaccines delivered by mucosal routes. The mechanisms of immune activation and protection remain to be fully understood.

Project
The project aims to develop and test formulation strategies for mucosal delivery of recombinant viral vaccines based on DNA and/or recombinant proteins in rainbow trout (*Oncorhynchus mykiss*), targeting diseases that infect early life stages. First, I will optimize the vaccine formulation by incorporating mucosal adjuvants and explore different delivery methods, including inactivated transformed bacterial cells. Next, I will test vaccination strategies, focusing on dose, delivery, and adjuvant aspects under laboratory conditions. Finally, I will evaluate the protective immunity in vaccinated fish through infection trials and identify immune response elements correlating with protection, providing insights into immune mechanisms and ensuring long-term vaccine efficacy.

Perspective
Optimized mucosal vaccines that enhance uptake and stimulate both mucosal and systemic immune responses could address disease problems in small-sized fish. These vaccines would be easier to administer, reduce labor costs, and ultimately contribute to the overall health and welfare of fish population. This approach will not only improve aquaculture productivity and sustainability but also offer valuable insights into the mechanisms of fish mucosal immunity, thus, contributing to the broader field of immunology and vaccine development.

Title:
Development of mucosal vaccine delivery strategies for farmed rainbow trout.

Principal supervisor:
Niels Lorenzen



Section:
Fish and Shellfish Diseases

Caitlin Yoo

Background
Danish aquaculture is a relatively small but stable food production sector, with a strong emphasis on sustainability. However, disease outbreaks pose a significant threat to productivity and profitability. While economic evaluations of aquaculture diseases exist in other regions, there is limited research specifically addressing the economic impact of diseases in Denmark's aquaculture sector.

Project
The first part of this project aims to assess the economic burden of the fish disease IHN in Danish aquaculture, with the potential to expand its scope to other diseases in later project segments. A combination of economic evaluation methods, including cost-benefit analysis, modeling, and case studies, will be applied. The research will utilize a range of data sources, including industry reports, farm-level data, and government statistics, to provide a comprehensive analysis. Additionally, this work is being conducted as part of the EUPAHW partnership, which facilitates collaboration on animal health and welfare issues at a broader European level.

Perspective
The findings of this research are expected to support key stakeholders—such as farm owners, managers, and policymakers—in making informed decisions regarding disease management. By quantifying the economic impact, the study can contribute to more effective planning for disease surveillance, eradication, and control programs. However, a key challenge may arise if the results suggest increased investment in prevention and eradication efforts, as there could be resistance from those bearing the financial burden. Addressing these concerns through well-informed policy recommendations will be crucial for the practical application of the research outcomes.

Title:
Economic evaluation of diseases in Danish aquaculture

Principal supervisor:
Britt Bang Jensen

Section:
Fish and Shellfish Diseases

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