Overall theme:

The role of wild-caught fish as a sustainable and nutritious food source

In the <u>Theoretical Ecology group</u> we are working with many themes related to how we can obtain food from the oceans in a sustainable manner, particularly in our project <u>How can fisheries contribute more</u> to a sustainable future?</u>. Our focus is on wild caught seafood since it has the benefits of not requiring any input of feed, water, pesticides or fertilizers. Therefore, much of wild caught seafood has a lower environmental footprint than food that is produced on land. The protein source with the lowest associated environmental impacts across land and sea is small pelagic fishes, like herring, caplin, and sprat, since these fish aggregate in schools and can therefore be caught with high fuel efficiency (low greenhouse gas emissions per unit of catch). These fishes also have a high nutrient richness, are very abundant, and are affordable for people in many low- and middle-income countries. Hence, how we harvest small pelagic fishes and use their catch has strong links to several of the *Sustainable Development Goals* and the *Paris Agreement on climate change*.

With this background we suggest **three themes for Master's projects** that each could host one or several projects. All the projects will involve searching for and retrieving data, performing analyses and visualization of data in R, and will force students to put details into a wider perspective. Such skills and knowledge are very valuable for a future career both within and outside of academia. All themes will fit students following the Marine sustainability programme and Theme 3 is also suitable for students in Fisheries or Marine biology.

Theme 1: Barriers and solutions for supplying more small pelagic fish for direct human consumption in Norway (30 p in Marine sustainability)

About 70% of the global catch of small pelagic fishes is converted into fishmeal and oil for use in animal feeds. Since about 90% of the energy is lost for every step in the food chain, more food could be gained if these fish were instead directly consumed by humans. If a larger portion of the catch is to go to direct human consumption, one needs to identify *why* this is currently not the case and then *how* change could be achieved.

Norway has a well-established fishery of several small pelagic fish species and there are good data on how much of each species has been caught over the years, how much has been exported, and what the catches have presumably been used for. Nevertheless, there are many details that need further investigation. Examples of questions that can be asked within a Master's thesis project are:

- How much of different species of small pelagic fish are caught in Norway and what is it used for?
- What is the end use of the fish that is exported from Norway?
- Why are the catches of particular species used as they are? For example, is it driven by consumer demand/price, the natural quality of the fish, harvest-induced quality reduction, the available fishing fleet, etc.?
- Which species have the potential to be used for direct human consumption and what are possible solutions to achieve such a shift?

A project within this theme could be associated with an **internship** for example at Fiskebåt (to be confirmed), an interest- and employers' organization for the majority of the Norwegian ocean-going fishing fleet working on national and global level. The member vessels include purse seiners for pelagic species, seiners and trawler for cod, net- and longline vessels as well as shrimp and industrial trawlers.

This would provide unique insight into the details that drive fishermen's decisions and into the capacity, strengths, and weaknesses of the Norwegian fleet.

Supervisors will be Gabriella Ljungström or Kim Scherrer (main supervisors) with help from Tom Langbehn with Katja Enberg or Christian Jørgensen as responsible contact at Department of Biological Sciences, UiB.

Theme 2: Environmental and nutritional consequences of replacing fish with land-based protein sources (60 p in Marine sustainability)

Over recent years, there has been a growing movement to protect the oceans and the popular Netflix movie Seaspiracy led many popular influencers to claim that they would never eat seafood again. Studies have shown that when a consumer is deprived of a food commodity that she is used to consuming, she replaces that food with alternative comparable foods. Considering that many seafoods have lower associated environmental impacts than land-based foods, and are more nutritious, what are potential consequences of such actions if for example a portion of herring is replaced by chicken, or a portion of cod by beef? Here we refer to such displaced impacts as *marginal impacts*.

Focusing on the Norwegian market (to limit complexity), we suggest two Master's projects on this theme. In Project 1, two reference species are used which provides a clear basis for the analysis. Project 2 considers alternatives to several species of small pelagic fishes and thereby offers a more complex analysis. The projects are based on the following research questions:

- 1. What are the marginal impacts associated with replacing capelin and cod with alternative comparable food sources from land and sea, in terms of greenhouse gas emissions and nutrient output?
- 2. What are the marginal impacts associated with replacing small pelagics with alternative comparable food sources from land and sea, in terms of greenhouse gas emissions and nutrient output? This analysis involves identifying comparable alternatives for several species of small pelagics, of which some may be consumed directly by humans and some may go to animal feeds.

Supervisors will be Gabriella Ljungström or Kim Scherrer (main supervisors) with help from Tom Langbehn with Katja Enberg or Christian Jørgensen as responsible contact at Department of Biological Sciences, UiB.

Theme 3: Harvesting of small pelagic fish worldwide: is there evidence for capping management strategies? (30 p or 60 p in Fisheries/Marine biology or Marine sustainability)

In 2012, the report "Little fish, big impact" was published by a group of top international scientists. The report recommends that small pelagic fishes should be harvested much below the level that is considered sustainable, the Maximum Sustainable Yield, according to the *EU's Common Fisheries Policy* and the *Johannesburg Declaration on Sustainable Development*, and similar levels have been suggested by others (hereafter referred to as capping management strategies). Their recommendation is based on two objectives: 1) to increase the likelihood of maintaining fully functioning ecosystems, and 2) to increase catches of dependent species that are commercially more valuable. In Norway, this type of strategy is implemented for the Barent's Sea capelin-cod fishery, by which the catch of capelin is capped to leave more food in the ocean for Norway's most commercially important fishery of Northeast Arctic cod, with an export value of roughly \$1 billion annually. This type of management strategy is problematic as it leads to fewer, less nutritious, and more costly fish with a higher environmental impact entering the food system.

This project will scrutinize fisheries management of small pelagics worldwide, e.g. in major systems such as Europe, North America, the high seas, upwelling systems, and systems with no management, and ask questions such as:

- What is the foundation for management strategies of small pelagics in these different systems?
- What are the total allowable catches (recommended by researchers) of small pelagics in different systems and how much is actually being caught?
- What are the actual management outcomes, i.e. how much is actually being caught?

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