**Marine litter in the water column of the North Sea (MARLINS) (39561)**

MARLINS (Marine litter in the water column of the North Sea) will utilize a unique collection of marine litter, sampled in connection with annual herring larvae surveys, to investigate the composition, amount, distribution and potential sources of marine litter in the North Sea. In contrast to most other investigations on marine litter which are largely focussed on beach surveys, bottom trawl surveys or sampling in surface waters, the present project will provide information about marine litter in the entire water column.

The main output of the project will be a marine litter database and a detailed description of the composition of the marine litter by different categories, colours and sizes as well as maps of the spatial distribution, amount and where applicable weight of the different litter categories in the entire North Sea area. In addition, drift model runs will be conducted to further investigate potential source and sink areas of the litter.

The knowledge gained from the project is expected to be relevant for various stakeholders and authorities such as Ministries of Environment and Fisheries, nature conservation organizations, tourism organizations as well as the International Council for the Exploration of the Sea (ICES) and the scientific community in general, in particular in relation to the Marine Strategy Framework Directive. For example, information about the most likely sources of litter and identification of potential source areas for certain litter types may allow responsible authorities and stakeholders to investigate if actions can be taken to reduce or entirely prevent the continuing, future introduction of certain types of litter into the marine environment by diminishing or completely shutting down the sources.

The project is coordinated by DTU Aqua and funded by Velux Fonden.

Huwer, B., Project Coordinator, National Institute of Aquatic Resources, Section for Marine Living Resources
Christensen, A., Project Participant, National Institute of Aquatic Resources
Eigaard, O. R., Project Participant, National Institute of Aquatic Resources
01/10/2018 → 30/09/2020

**Keywords:** Research areas: Fish Biology, Marine Living Resources & Ecosystem based Marine Management
Project: Research

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**Sand banks and fisheries impact in relation to EU fisheries and environmental policy (39519)**

Objective of the project: The project will improve the knowledge base for ongoing and upcoming Natura 2000 and MSFD implementations in the North Sea. For nature-type 'sand banks', in particular Danish sandeel and plaice fishing will be affected. Activities in the project: The key activities of the project are targeted method developments and knowledge production in relation to EU fisheries and environmental policy: 1) Development of a gear and sediment-specific model for bottom impact from all types of mobile bottom-contacting fishing gears in the North Sea. 2) Field trials to document short-term impact on sandbank fauna from demersal seine fishery. 3) Analyses of data from the seine gear field trials and of existing data for the impact of sandbanks from trawlers, including impact differences between bottom and floating trawl doors. 4) Estimation of sediment impact from natural disturbance on sand banks (e.g. tide and wave impact) as well as scaling of these in relation to physical effects of different types of gear. 5) Integrated analysis of the impact of different fisheries and other pressure factors on sand banks. 6) Dissemination. Project Expected Effects: The project's results and method developments can be used directly in the management to separate different fisheries with regard to bottom impact; e.g. by nature conservation via area restrictions. Activity 4 and 5 will generate management tools that can quantitatively address descriptor 6 under the Marine Strategy Framework Directive relative to sand banks.

The project is coordinated by DTU Aqua and is funded by the European Maritime and Fisheries Fund (EMFF) and the Danish Fisheries Agency.

Eigaard, O. R., Project Coordinator, National Institute of Aquatic Resources, Section for Ecosystem based Marine Management
Dinesen, G. E., Project Manager, National Institute of Aquatic Resources
Gislason, H., Project Participant, National Institute of Aquatic Resources
Bastardie, F., Project Participant, National Institute of Aquatic Resources
Nielsen, J. R., Project Participant, National Institute of Aquatic Resources
Egekvist, J., Project Participant, National Institute of Aquatic Resources
Pedersen, E. M., Project Participant, National Institute of Aquatic Resources
Stattrup, J. G., Project Participant, National Institute of Aquatic Resources
Nielsen, A., Project Participant, National Institute of Aquatic Resources
Hansen, F. T., Project Participant, National Institute of Aquatic Resources
O'Neill, B., Project Participant, National Institute of Aquatic Resources
Noack, T., Project Participant, National Institute of Aquatic Resources
Lundgaard, L. S., Project Participant, National Institute of Aquatic Resources
Hansen, A. D., Project Participant, National Institute of Aquatic Resources
01/02/2018 → 31/01/2020

**Keywords:** Research areas: Ecosystem based Marine Management & Coastal Ecology & Marine Living Resources & Fisheries Technology & Fisheries Management
Project: Research
Articulation and externalization of service design methods, processes and tacit knowledge for solving social challenges

This is a research collaboration project between Nippon Telegraph and Telephone Corporation (NTT) and the Technical University of Denmark (DTU). The project aims at proposing methodology of service design for the societal challenge, through articulating and externalizing service design methods and processes, especially for solving societal challenges, from Scandinavian and Japanese practices, and systematize the collection as scientific design knowledge in applicable manners. In this project, we 1) conduct a survey of existing relevant research, analyze methods and process applied for social challenges, 2) conduct workshop in Scandinavia to collect knowledge from practitioners, 3) conduct workshop in Japan to collect knowledge from practitioners, 4) systematize the collection from 1), 2), and 3), and 5) depict requirements for methods and processes particularly for societal challenge in Japan. For the years to come, the project will continuously develop service design methods applicable to different socio-cultural societies (i.e. Japan).

Yasuoka, M., Project Participant, Department of Management Engineering, Technology and Innovation Management
Akasaka, F., Project Participant, NTT Service Evolution Laboratory

01/12/2017 → 30/11/2018

Keywords: Living lab, Design, Participation, Social challenge

Collaborators: NTT Service Evolution Laboratory

Project: Research

The invasive round goby in Danish waters: Investigations of depth distributions in relation to a targeted, efficient fishery after the species for human consumption (39402)

Round goby is an invasive benthic fish, native to the Ponto-Caspian region. It has on several occasions been introduced to the Baltic region, and is now widely spread here, with established populations in many areas. In some areas it dominates the local fish fauna, having out-competed native, and often commercially important, fish species.

Round goby is generally referred to as a coastal, shallow-water species. Yet, when temperatures drop at the onset of winter, the fish disappear from the shallow, cool waters, presumably to migrate to deeper, water waters. How deep they go, and how the onset of migration to deeper waters may correlate to temperature (and hence season) however remains unknown. This information is nevertheless imperative in an evaluation of when, at what depths, and with what type of gear a potential targeted fishery after round goby should occur.

The present project will use all available national and international survey data throughout the Baltic region to map the depth distributions of round goby, and analyze the correlations between depth distributions and temperature.

The project is coordinated by DTU Aqua.

The project is funded by Direktør J.P. A. Espersen og hustru Dagny Espersens Fond.

Behrens, J., Project Coordinator, National Institute of Aquatic Resources, Section for Marine Living Resources

01/01/2017 → 31/12/2017

Keywords: Research area: Marine Living Resources

Project: Research

Brown shrimp fishery in the North Sea (39418)

The purpose of the project is to improve the possibilities for evaluating the self-management of the brown shrimp fishery and develop this through analysis of the impact of management actions on the brown shrimp stock. This objective is to be met in three work packages. Through improved monitoring and survey design (AP2) as well as model based analysis of brown shrimp dynamics and the mechanisms of stock fluctuations (AP1 and AP3) in order to calculate stock development and a number of associated parameters for current and future self-management and thereby increase opportunities for an optimal sustainable fishery on the resource.

The project further aims to build the national preparedness for advice provision on issues concerning the brown shrimp fishery. Some of the main contributions will be in preparation for international survey participation and operational stock modelling (AP3). The project will also set up systems for future fisher – researcher collaboration in management of brown shrimp fisheries and contribute to the increase and facilitating of international scientific cooperation on brown shrimp fishing through enhanced active Danish participation in relevant fora (AP4).

The project will thus

(1) collate all available information about the biology of brown shrimp and its function in the ecosystem in an easily accessible form, for the benefit of fisheries and management.

(2) Design, implement and analyse an optimized monitoring and survey system that can support stock analyses and management decisions.

(3) Analyse brown shrimp population distribution and fluctuations, and in combination with controlled growth and reproduction experiments clarify the key parameters that determine population dynamics.

(4) Develop a stock assessment model based on DTU Aquas statistical modelling framework, which, based on available data, can estimate stock development and provide the basis for international management advice.

(5) Through the results, provide input to international advisory work in ICES and STECF.

The long-term impact of the project will be a scientific contribution to sustainable self-management and utilization of an economically important resource for local fisheries.

This project is funded by the European Maritime Fisheries Fund and the Danish Fisheries Agency.

This project is coordinated by DTU Aqua.

Mosegaard, H., Project Coordinator, National Institute of Aquatic Resources, Section for Marine Living Resources
The number of grey seals has increased markedly in the Baltic Sea within recent years. Grey seal is the final host for the liver worm Contraceum osculatum, where cod is one of several transport hosts. Concurrent with the rise in number of grey seal, the prevalence (number of infected cod) and intensity of infection (number of liver worms per infected cod) with liver worm has increased, and up to 340 worms can now be found in single cod livers. Field studies have shown that intensity of infection correlates negatively with the condition of the fish, indicating that liver worm may have a negative effect on the health status of the fish. Yet, from field investigations it is difficult to separate potentially negative effects of liver worms from that of reduced food availability or poor oxygen conditions. In the present study we will perform controlled laboratory experiments to i) determine the potential costs of housing liver worm, ii) estimate the effects of liver worm on cod growth and mortality, and iii) use data generated in i) and ii) in bioenergetic modeling to calculate the effect of liver worm on the maximal food consumption and growth of individual cod. This will subsequently be scaled to the level of the population.

The project is coordinated by University of Copenhagen and is funded by the European Maritime and Fisheries Fund (EMFF) and the Danish Fisheries Agency.

**Distribution of mackerel, herring and sprat (MAKSIBRI) (39434)**

The overarching objective of the project is to increase knowledge about the spatial distribution of populations of herring, sprat and mackerel in the North Sea, Skagerrak and Kattegat. Application of new genetic marker based analyses has proven especially useful in this context and the project aims to apply newly developed markers in herring and sprat. In mackerel, the distribution of stock components in the North Sea will be examined using existing material and data. For herring, focus is on validating genetic and morphological methods and testing them to assess samples of herring bycatch from the sprat fishery. In sprat focus is on determining population components in the North Sea and Skagerrak using both genetic and modeling other types of biological data.

The project is coordinated by DTU Aqua and is funded by the European Maritime and Fisheries Fund (EMFF) and the Danish Fisheries Agency.

**Eastern Baltic cod - New knowledge of growth and mortality is the way to improved management advice (39366)**

The aim of the project is to improve the knowledge and data basis for stock assessment and management for cod in the eastern Baltic Sea. In later years, changes in growth and natural mortality of cod have presumably taken place and new knowledge on these parameters is essential for restoring analytical stock assessment for Eastern Baltic cod that is currently lacking. Improved knowledge on cod growth and mortality is therefore a prerequisite for being able to evaluate the stock status in relation to management targets and implement management plans that are built on quantitative stock assessment. Ecological situation in the Baltic Sea has changed in later years, which requires updated biological
information. This is done in the project using different approaches, bringing together expertise of different research areas. The approaches applied include molecular-genetic analyses of cod growth, bioenergetic modelling, and analyses of monitoring data on predation and condition/growth of cod. An important component of the project is cooperation with fishing industry to support tagging experiments of Baltic cod, to obtain updated estimates of cod growth. Finally, the project combines the new knowledge on cod that becomes available from this and other relevant projects to ensure that the assessment of stocks status and management advice is based on best available scientific information.

The project is coordinated by DTU Aqua and is funded by the European Maritime and Fisheries Fund (EMFF) and the Danish Fisheries Agency.

Eero, M., Project Coordinator, National Institute of Aquatic Resources, Section for Ecosystem based Marine Management
Storr-Paulsen, M., Project Participant, National Institute of Aquatic Resources
Tomkiewicz, J., Project Participant, National Institute of Aquatic Resources
Hansen, J. H., Project Participant, National Institute of Aquatic Resources
Neuenfeldt, S., Project Participant, National Institute of Aquatic Resources
Christensen, A., Project Participant, National Institute of Aquatic Resources
Kindt-Larsen, L., Project Participant, National Institute of Aquatic Resources
Berg, C. W., Project Participant, National Institute of Aquatic Resources

15/08/2016 → 15/08/2018
Keywords: Research areas: Ecosystem based Marine Management & Fish Biology & Marine Populations and Ecosystem Dynamics & Population Genetics & Marine Living Resources & Fisheries Management
Collaborators: University of Copenhagen, Danish Fishermen's Association
Project: Research

Ballast water - Tool for supporting the delimitation of a "same risk area" (39348)
A project financed by the Danish Maritime Fund via the Danish Nature Agency, to develop a decision support tool for authorities and consultants involved with the ballast water convention and measures preventing the spread of marine invasive species. The tool will support decision makers in member nations of the International Maritime Organisation (IMO) to identify and delimit marine areas with high connectivity considering hydrography and species biology. Identification of marine areas with high connectivity can provide a basis for granting exemptions in relation to the ballast water convention and the requirement for ships to treat ballast water before being discharged into the sea. The tool development is based on existing freeware including "IBM Lib" (DTU Aqua's own individual-based modeling system for linking individual-based models to hydrographical model data), Netlogo (a widely used IBM simulation system) and R (a statistical programming and data handling package).
This project is coordinated by DTU Aqua.
The project is funded by the Danish Maritime Fund via the Danish Nature Agency.
Christensen, A., Project Coordinator, National Institute of Aquatic Resources, Section for Marine Living Resources
Hansen, F. T., Project Manager, National Institute of Aquatic Resources
Mosegaard, H., Project Participant, National Institute of Aquatic Resources
Pedersen, E. M., Project Manager, National Institute of Aquatic Resources
Stage, B., Project Participant, National Institute of Aquatic Resources
Eg Nielsen, E., Project Participant, National Institute of Aquatic Resources
Worsøe Clausen, L., Project Participant, National Institute of Aquatic Resources
van Deurs, M., Project Participant, National Institute of Aquatic Resources
Andersen, N. G., Project Participant, National Institute of Aquatic Resources
01/03/2016 → 01/12/2016
Keywords: Research areas: Marine Living Resources & Observation Technology
Collaborators: Danish Meteorological Institute, Anchor-Lab
Project: Research

Sustainable management of Kattegat cod; Improved knowledge about stock components and migration (39346)
The Kattegat cod has been categorized as a data limited stock, mainly due to a large unallocated mortality, which may be caused by migration between Kattegat and neighbouring areas. In this project, we aim to improve our understanding of migration patterns and mixing of different stock components within the Kattegat through a novel combination of genetic and micro-chemical signatures for individual fish. Results from the project will feed directly into the ICES advisory process, including a scheduled benchmark meeting in early 2017 where new procedures for stock assessment will be discussed. As cod are also caught as bycatch in other fisheries, a more robust stock assessment for cod will also be important to fisheries for other species under the landing obligation, which is scheduled for implementation in the Kattegat in 2017.
The project is coordinated by DTU Aqua and is funded by the European Maritime and Fisheries Fund (EMFF) and the Danish Fisheries Agency.
Hansen, J. H., Project Coordinator, National Institute of Aquatic Resources, Section for Marine Living Resources
Hüsey, K., Project Participant, National Institute of Aquatic Resources
Eero, M., Project Participant, National Institute of Aquatic Resources
Thygesen, U. H., Project Participant, National Institute of Aquatic Resources
Storr-Paulsen, M., Project Participant, National Institute of Aquatic Resources
Meldrup, D., Project Participant, National Institute of Aquatic Resources
Levinsky, S., Project Participant, National Institute of Aquatic Resources
01/03/2016 → 28/02/2018
Keywords: Research areas: Population Genetics & Marine Living Resources & Fisheries Management
Collaborators: Danish Fishermen's Association
Project: Research

Sustainable use of the invasive round goby in favour for the fishery and the environment (SORTMUND) (39336)
The overarching aim of SORTMUND is to establish a profitable and environmentally sustainable fishery after the invasive round goby in inner Danish waters. Round goby was first seen in south-eastern Danish waters in 2008 and have since then increased rapidly in abundance along the coastline where it has severe negative effects on local biodiversity and the traditional coastal fishery. We aim to launch the fish as a high-quality Nordic product for human consumption, in addition to fur animal feed. The project covers the entire value chain, and has broad participation, ranging from local fishermen and their trade organization, the processing industry, university institutes and a Michelin restaurant. Specific activities will be estimations of stock sizes, investigations of seasonal migrations of the fish, development of seal-safe of gear to avoid damages to the catch, test of methods to fillet the fish for human consumption, documentation of nutritional quality of the fish, development of a fermented fish sauce to add umami to the food, and optimization of logistics in relation to collection, cooling and transportation of fish from small harbors to processing.
This project is coordinated by DTU Aqua.
The project is funded by the Ministry of Environment and Food of Denmark through the Green Development and Demonstration Program (GUDP).

Behrens, J., Project Manager, National Institute of Aquatic Resources, Section for Marine Living Resources
Christoffersen, M., Project Participant, National Institute of Aquatic Resources
Kindt-Larsen, L., Project Participant, National Institute of Aquatic Resources
van Deurs, M., Project Participant, National Institute of Aquatic Resources
01/03/2016 → 28/02/2019
Keywords: Research areas: Fish Biology & Marine Living Resources
Collaborators: Enspire, NF340 Lasse III, Gilleleje Fillet Factory, National Food Institute, Danish Fishermen's Association, Gemba Seafood Consulting
Project: Research

Sound herding system for sustainable fisheries (GUDP-SHS) (39365)
The purpose of the project is to develop a new type of fishing gear, Sound Herding System (SHS), which applies sound to influence fish swimming direction and thereby herding them into a trawl. The sounders are mounted on the trawl boards, so as to create a wall of sound on both sides of the trawl opening. This increases the effective width and height of the trawl opening, resulting in higher catch rates. The frequency of the sounders is selected to be 4 kHz, which can be used to affect the clupeoid species herring, sprat and anchovy. Most other relevant species are not sound sensitive at this frequency.
The system can be used to avoid by-catches of herring in the mackerel fishery by closing trawl opening for herring with sound. Customers receive economic gains from higher catch rates and smaller by catch. The gain for the environment is a reduction in CO2 emissions and improved resource utilization.
The central work in the project is the development of trawl doors equipped with sounders as tested by exploratory scare effect measurements and mapping of sound fields. Fish response to sound is studied experimentally and finally the sounders' impact on the environment is examined.
This project is coordinated by Sonus Aqua Aps, Denmark.
The project is funded by the Ministry of Environment and Food of Denmark through the Green Development and Demonstration Program (GUDP).
Stage, B., Project Manager, National Institute of Aquatic Resources, Section for Marine Living Resources
Mosegaard, H., Project Participant, National Institute of Aquatic Resources
Pedersen, E. M., Project Participant, National Institute of Aquatic Resources
01/01/2016 → 31/12/2018
Keywords: Research areas: Observation Technology & Marine Living Resources
Collaborators: Sonus Aqua Aps, Aalborg University
Project: Research

Study on approaches to management for data-poor stocks in mixed fisheries (MIXDLS) (39342)
The tender requires advancement of methods for advice on the status and management of data-poor stocks in mixed fisheries. In order to meet this requirement, we will undertake a detailed review of assessment and management approaches for data-poor stocks and identify relevant approaches for application in the case studies and wider EU fisheries.
The approaches should be compatible with the Common Fisheries Policy (CFP; EU 2013) in terms of (i) fishing mortality ranges compatible with Maximum Sustainable Yield (MSY), (ii) fish caught to be landed, and (iii) addressing uncertainty in significant components of the marine fish ecosystem.
The most promising methods will be tested through simulation to ensure robustness to uncertainties and to deliver confidence in methods for future operational use. The suite of identified, assured methods will then be used to develop an
objective framework to apply the most relevant assessment or management methods to each stock in each of the case study areas. Based on the output of these assessments of data-poor stocks, and where relevant, the existing assessments of data rich stocks, a mixed fisheries simulation framework will be developed to assess the performance of candidate management strategies.

Adaptation of the existing mixed fisheries tools will be required in order to incorporate data-poor stocks in the simulation framework.

This project is coordinated by DTU Aqua & IMARES, Netherlands.

The project is funded by EU, Calls for proposals/tenders (EU DG Mare).

Ulrich, C., Project Coordinator, National Institute of Aquatic Resources, Section for Ecosystem based Marine Management

Nielsen, J. R., Project Participant, National Institute of Aquatic Resources

Worsae Clausen, L., Contact Person, National Institute of Aquatic Resources

01/01/2016 → 31/12/2017

Keywords: Research areas: Fisheries Management & Marine Living Resources

Collaborators: French Research Institute for Exploitation of the Sea, Hellenic Centre for Marine Research, IMARES, Italian National Research Council, Cefas Weymouth Laboratory, AZTI-Tecnalia, Galway - Mayo Institute of Technology, Thuenen-Institut

Project: Research

**Tagging Baltic cod (TABACOD) (39333)**

The aim of this project is to improve the management of eastern Baltic cod by 1) providing new information on growth and mortality patterns, and 2) develop a validated method for deriving this information from historic and future samples.

In recent years, the traditional age-based stock assessment had to be abandoned owing to extensive uncertainties in stock trends. These uncertainties were to a large extent attributable to inconsistencies in age estimation. As a consequence thereof, the current stock status is unknown.

Estimates of growth and mortality rely on unbiased age information. TABACOD will provide this information through a large scale tagging experiment, where 20,000 cod are tagged with and externally visible tag as well as with an internal tag on their otoliths. This experiment will also provide the samples for the development and validation of a new age estimation method based on the chemical composition of the cod's otoliths.

The knowledge gained will be incorporated in length-based assessment models and their performance compared to the traditional methods evaluated in order to provide the ICES stock assessment group with the relevant tools to provide a reliable advice and to improve stock exploitation.

This project is coordinated by DTU Aqua.

The project is funded by BalticSea2020.

Hüssy, K., Project Coordinator, National Institute of Aquatic Resources, Section for Oceans and Arctic

Olesen, H. J., Project Participant, National Institute of Aquatic Resources

Andersen, N. G., Project Participant, National Institute of Aquatic Resources

Størr-Paulsen, M., Project Participant, National Institute of Aquatic Resources

Thygesen, U. H., Project Participant, National Institute of Aquatic Resources

Berg, C. W., Project Participant, National Institute of Aquatic Resources

Nielsen, K. E., PhD Student, National Institute of Aquatic Resources

01/01/2016 → 31/12/2019

Keywords: Research areas: Marine Populations and Ecosystem Dynamics & Fish Biology & Marine Living Resources

Collaborators: Swedish University of Agricultural Sciences, National Marine Fisheries Research Institute, Thuenen-Institut

Project: Research

**Assessment and management of linked stocks (39325)**

The purpose of this project is to develop operational models for linked stocks. Fish stocks are not isolated units. Fish eat, and are eaten, by fish from other stocks. The definition of fish stocks is often arbitrary or determined by management considerations. The bottom line is that some linkage must be expected between the defined stocks. For some stocks these effects are essential to give reliable assessment and management. Single species assessment and management does not include effects from linked stocks. Ecosystem and multi-species assessment models are not practically operational for assessment and management. These models are designed to describe all interactions between all important species in an ecosystem. These models often attempt to estimate detailed effects between all length- or age groups. These models often require data, which are not routinely available. This project will develop models, which are directly applicable in the scientific advice. The aim is not to describe all interactions, but simply to harvest the main benefits of considering two or more stocks in a joint model. The aim is to identify few links between the stocks, which describes the main part of the interaction, and to base the models only on standard data sources. The models will be developed to be generally applicable, but applied to two important cases (Cod EB and WB, and Cod stocks around Kattegat). Final tool will be available via stockassessment.org, so it can easily be applied to any stocks defined there.

The project is coordinated by DTU Aqua and is funded by the European Maritime and Fisheries Fund (EMFF) and the Danish Fisheries Agency.

Nielsen, A., Project Coordinator, National Institute of Aquatic Resources, Section for Marine Living Resources

Albertsen, C. M., PhD Student, National Institute of Aquatic Resources

Berg, C. W., Project Participant, National Institute of Aquatic Resources
Forward management of sandeel in the North Sea (39316)
The project will define and align the management of sandeel considering the goals and desires of the fishing industry, administration and science while taking the biology and importance of the sandeel in the ecosystem into account. The project is structured by several work-packages, each dealing with specific aspects of sandeel biology and/or fishery relevant for management. Among these will the sandeel population structure and its influence on stock assessment, CPUE and counselling be discussed. Analyses of fisheries development and sandeel availability over the fishing season will enable a more accurate calculation of fishing mortality. Furthermore, it is examined whether the increasing concentration of fishing effort on certain banks potentially causes an error in the stock assessment in relation to recruitment from unfished banks. The project will perform a statistical evaluation of fisheries-independent data for sandeel in the North Sea and evaluate existing and alternative methods of stock assessment for sandeel in the North Sea with current and alternative management areas, including implementing an analytical stock assessment of sandeel in sandeel area 4. Finally the project will evaluate existing biological and management reference points, and discuss these in relation to ecosystem reference points. Throughout the project period, a series of workshops and meetings will be held in order to discuss possible management strategies for sandeel in the North Sea. These discussions will imply a number of fundamental prerequisites defined in collaboration between management, fisheries and science in order to form the basis for an optimal management of sandeel.

The project is coordinated by DTU Aqua and is funded by the European Maritime and Fisheries Fund (EMFF) and the Danish Fisheries Agency.

Danish Fisher-Researcher Network (39315)
The project aims to bring the active Danish fishing sector and operational fisheries research closer together through “fisher- researcher” networking activities. The project will contribute to the collection and exchange of information and knowledge on fisheries and research herein across sectors and generations. This knowledge exchange will take place at several levels of education (secondary schools, university studies and training of working fishermen). The project will support innovation and development of sustainable fisheries through collation of ideas as well as preparation and planning of project cooperation for the solution of current and future challenges about fisheries, fish stocks and management. Bringing the primary fishing industries in direct contact with research and management in a network will support local skills in fishing ports to serve the development and succession in the coastal communities. Workshops and demonstrations of novel development are intended to direct technology transfer, innovative collaborative proliferation of businesses and recruitment of newly qualified academic staff. In addition, Danish fishing industry participation at the international level will be strengthened through increased technical scientific support from DTU Aqua before and under meetings in e.g. Thematic and Regional Advisory Councils.

The project is coordinated by DTU Aqua and is funded by the European Maritime and Fisheries Fund (EMFF) and the Danish Fisheries Agency.

Baltic Sea Check Point (BSCP) (39294)
The overall aim of this project is to examine the current data collection, observation, surveying, sampling and data assembly programs in the Baltic Sea basin, assess and demonstrate how they can fit into purpose in the 11 challenge
areas in terms of data uncertainty, availability, accessibility and adequacy, and deliver the findings to stakeholders through an internet portal with dynamic mapping features and a stakeholder workshop. The Baltic Sea region is as defined by the Marine Strategy Framework Directive, i.e., the semi-enclose sea bounded by the parallel of the Skaw in the Skagerrak at 57°44.43.

The project is coordinated by the Danish Meteorological Institute and is funded by the EU Executive Agency for Small and Medium-sized Enterprises (EASME), the European Maritime and Fisheries Fund (EMFF) and the Danish Fisheries Agency.

Christensen, A., Project Coordinator, National Institute of Aquatic Resources, Section for Marine Living Resources
Dinesen, G. E., Project Participant, National Institute of Aquatic Resources
Eero, M., Project Participant, National Institute of Aquatic Resources

17/09/2015 – 16/06/2018

Keywords: Research areas: Marine Living Resources & Coastal Ecology & Ecosystem based Marine Management
Collaborators: Klaipeda University, Swedish Maritime Administration, Grontmij A/S, ETT S.p.A, Danish Meteorological Institute, Finnish Meteorological Institute, European Global Ocean Observing System, Tshwane University of Technology

Project: Research

Implementing robot and drone technology in fisheries (39303)

The project aims to provide proof of concept for the use of robots in the fishery, focusing on three specific types for three different implementations. One will be used to determine the species and size composition of fish in the catch to prevent discards, the other to search for fish optically with a drone (capelin in Greenland) and the third a sailing robot to search for fish using sonar. The robots/drones to be employed are available on the marked. A development project must subsequently design software etc. to produce marketable products. It is estimated that there is a great potential in Denmark and a huge world market for these technologies that presently are not employed in fishery.

This project is coordinated by DTU Aqua.

The project is funded by the Ministry of Environment and Food of Denmark through the Green Development and Demonstration Program (GUDP).

Stage, B., Project Participant, National Institute of Aquatic Resources, Arctic Section
Mosegaard, H., Project Participant, National Institute of Aquatic Resources

01/07/2015 – 01/12/2016

Keywords: Research areas: Marine Living Resources & Observation Technology
Collaborators: Blue Ocean Robotics, Partrederiet M/S Isold HG 333, Aquamind A/S, Danish Pelagic Producers

Organisation

Project: Research

Improvement of the foundation for stock assessment for data limited stocks with importance for Danish fishery (39310)

Objectives

The aim of this project is to improve the knowledge basis, data, and methodology for providing robust stock assessment and short term forecast according to MSY for data limited fish stocks with importance for Danish commercial fishery.

Background

A number of fish stocks in the Baltic, Skagerrak-Kattegat and North Sea area with importance for Danish commercial fishery either as target species, commercially important by-catch species, or as unintended by-catch species are data limited stocks with no analytical stock assessment. More than 60% of fish stocks that ICES gives advice on are category 3 and 4. These categories include stocks for which the data and knowledge are insufficient to conduct a full analytical assessment of their state and exploitation. Until now, ICES has not been able to assess their state relative to the objective of achieving MSY (Maximum Sustainable Yield) sustainability. A major task of fisheries management is broadening from the narrow analysis of few main commercial species toward accounting for by-catches, i.e. the great range of species and sizes of lesser importance caught at the same time in non-selective fisheries (mixed-fisheries). This unwanted part of catches is becoming politically important because it may trigger restrictive management decisions for the commercial fisheries, both as part of the ecosystem-based marine management (EU MSFD), and because of the potential of these species to become limiting for some fleets in the frame of the landing obligation (=discard ban) of the EU CFP, i.e. when a fishery can be closed because it has reached the authorized catch quantity (quota) of a low-value species even though it still has some quota left for more valuable commercial species (so-called “choke species” effect).

Tasks and Deliverables

- Develop assessment and forecast models and methods for stocks in the categories 3-4 and integrate them as standard models and software in the ICES advisory framework in relation to method development and assessing data poor stocks in special working groups (ICES WKLIFE V-VI, ICES WKPROXY) and in standard stock assessment working groups covering the Skagerrak-Kattegat, Baltic Sea and North Sea areas (ICES WGNSSK, ICES WGBFAS).
- Apply the models to selected fish stocks with importance for Danish fishery with the aim of promoting analytical and benchmark assessments to assess stock status relative to MSY objectives. Application of these methods mean that the status of those category 3 and 4 stocks can be classified as desirable or undesirable in relation to MSY objectives, and the stocks can be lifted to category 2 or 1 stocks with analytical assessments. The stocks are selected in close collaboration and agreement with the Ministry of Environment and Food (several directorates), the fishing industry and associations (DF), NGO environmental stakeholders and Science (DTU Aqua).

- The work includes estimation of fish stock growth parameters, performing yield per recruit analyses, and conducting stock assessments with application of a stochastic stock production model and/or a length based stochastic assessment model, as well as where possible a stochastic age based VPA stochastic assessment model.
- Management Strategy Evaluation (MSE) for selected stocks: Establishment of biological (biomass- or fishing mortality based) reference points for each of the selected stocks involving growth models and logistic models (ogives). MSE for establishing output-based harvest control rules according to short to medium term forecasts for the selected stocks. This includes provision and further development of model software to carry out MSE of the selected stocks.
This project is coordinated by DTU Aqua.
The project is funded by the Danish Ministry og Environment and Food (under Framework Contract with DTU).
Nielsen, J. R., Project Coordinator, National Institute of Aquatic Resources, Section for Ecosystem based Marine Management
Pedersen, M. W., Project Participant, National Institute of Aquatic Resources
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01/07/2015 → 01/03/2017
Keywords: Research areas: Fisheries Management & Marine Living Resources
Project: Research

A systems approach framework for coastal research and management in the Baltic (BaltCoast) (39201)
The ultimate objective of this project is a coherent and systematic management approach that encompasses multiple impacts in a spatially heterogeneous context.
In BaltCoast we tackle this complex task using the Systems Approach Framework (SAF). The SAF is an issue oriented investigation and methodology that applies a holistic perspective. It investigates and quantifies the functions of systems in order to simulate specific questions concerning their functions or policies. It comprises the process from issue identification through system analyses to policy implementation.
This Systems Approach can, hence, competently address implementation of international directives (e.g. Water Framework Directive (WFD), Marine Strategy Framework Directive (MSFD)). In BaltCoast we address multiple issues through case studies that reflect current regional management challenges and develop a generic tool for integrated system assessment.
This project is coordinated by Leibniz-Institute for Baltic Sea Research (IOW).
The project is funded by EU, BONUS (Science for a Better Future of the Baltic Sea Region), ERA-NET.
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01/04/2015 → 31/03/2018
Keywords: Research areas: Coastal Ecology & Marine Populations and Ecosystem Dynamics & Marine Living Resources & Ecosystem based Marine Management
Collaborators: Swedish University of Agricultural Sciences, Leibniz Institute for Baltic Sea Research, Klaipeda University, University of Latvia, Tallinn University, Polish Academy of Sciences
Project: Research

Intelligent oceanographically-based short-term fishery forecasting applications (GOFORIT) (39270)
Fisheries for short lived species are highly variable because they primarily target a low number of age groups within stocks as well as irregularly recruiting year-classes. As a result, environmental fluctuations (e.g., temperature, food abundance), which cause major changes in fish productivity, can lead to rapid fluctuations in fishing opportunities and stock declines if fishing effort is not reduced accordingly. Such fluctuations are not foreseen or accommodated by management advisory frameworks for short-lived species, which generally assume environmental stability and constant productivity. The GOFORIT project will use climatic and oceanographic process knowledge with the goal to improve short-term fishery forecasts.
The project is coordinated by DTU Aqua.
Funding
The project is funded by EU, COFASP, ERA-NET.
MacKenzie, B., Project Coordinator, National Institute of Aquatic Resources, Section for Oceans and Arctic
van Deurs, M., Project Participant, National Institute of Aquatic Resources
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01/04/2015 → 01/04/2018
Keywords: Research areas: Oceanography & Marine Populations and Ecosystem Dynamics & Marine Living Resources
Collaborators: National Institute for Marine Research and Development, Marine Research Institute Reykjavik, Institute of Marine Sciences, Central Fisheries Research Institute
Project: Research
Dynamic user-driven marine e-maps for the advancement of Danish industrial fisheries (GUPD-VIND) (39246)
This project aims at strengthening Danish industrial fisheries development in order to (i) reduce the search time and fuel consumption per ton of fish caught (revenues: 16 million DKK/year), (ii) make better use of the sprat quota (revenues: 15 million DKK/year, by a full quota uptake), (iii) pave the way for sustainable self-management of resources in the industrial fisheries sector and (iv) contribute to creating and maintaining jobs in the local fishing community. The specific objectives of the project: Development of an IT tool that will contain (i) a platform to improve sharing of knowledge and registration of observable and derived variables (data), and (ii) user-defined and user-controlled digital Marine Maps with those specific data that fishermen consider important as background information in the planning and implementation of fishing trips. These marine data include (but are not limited to) a portfolio of Marine Maps spanning from the North Sea hydrography and bottom conditions over distribution of plankton and fish to water-DNA. The needs for a technological development of this fishery comes from increasing average vessel size, while the number of large vessels is reduced to about 1/8 of what it was in the past. The immediate consequence is a reduction in the collective search performance and knowledge sharing. In addition, the area based management of the sandeel fishery introduced in 2011 has contributed to a reduction of fishermen’s opportunities to diversify fishing and explore a wider variety of fishing grounds. Finally, the sprat fishery is uncertain because of by-catch limits and a very variable CPUE driven by wind and weather. This has led to a underutilization of the sprat quota by around 100,000 tons per year. Fisherman knowledge of good fishing opportunities is based on the correspondence between historical catches and observable variables at the time of capture, such as the seasons, wind, waves and tides, and it is precisely this kind of knowledge that the project wants to combine with a technological solution, so that all relevant data is made widely available to the fishermen by developing user-controlled dynamic digital Marine Maps. The project includes a business plan for the IT company Anchor Lab, which develops the user-controlled Marine Maps, and plans for derived effects in terms of better utilization of the sprat quota and fuel savings through the use of the Marine Maps. Besides the economic effects, the project contributes to CO2 reduction, and supports the technological development of a modern industrial fishery sector, based on a natural resource to be managed by the EU in accordance with ICES’ advice. This project is coordinated by DTU Aqua.

EnergyLab Nordhavn
The objective of this project it to develop new methods and solutions for design and dimensioning of the future cost-effective multi-carrier energy system (electricity, thermal, transport) based on Nordhavn as a globally visible real-life laboratory.

Investigation of causes for declines in fish abundance in coastal areas (Kystfisk 2) (39164)
The project aims to describe changes in distribution of different age groups of cod and plaice in coastal areas. Changes in the distribution of plaice off the Danish west coast were documented and correlated to changes in nutrient loadings. These results were submitted for peer review. Potential changes in the distribution of cod of different size classes in inner Danish waters are being modelled to see if there are any consistent patterns. Datamining has been undertaken to provide environmental data to conduct analyses of potential causes for changes observed.

This project is coordinated by DTU Aqua and is funded by the Danish Ministry of Food, Agriculture and Fisheries through a special governmental Funding for sustainable fisheries ("Baeredygtighedspuljen").
Minimising discards in Danish fisheries (MINIDISC) (39020)

The landings obligation, currently being implemented in the new CFP, puts major constraints on fishers, by making the landing of unwanted catch mandatory. Less restrictive technical rules (TR) in a results-based management frame under Catch Quota Management (CQM) have been suggested as a mechanism to release some of these constraints. To investigate the effects of the existing TR, some fishers were relaxed from TR during the trial and could freely choose and develop alternative gears, aiming to optimize annual catch value, while reducing discards. The study included 14 demersal fishing vessels, operating in the North Sea, Skagerrak and the Baltic Sea.

Fishers used test and control gears interchangeably or in pairs during up to 6 months and were required to sort and weigh all discard of seven common target species on a haul by haul basis. All vessels were equipped for Fully Documented Fisheries (FDF), including cameras. Collected data were analyzed to investigate differences in landings, discards, discard ratio, CPUE, VPUE and DPUE, between conventional (control) and new gears (test). The results showed a varying degree of success, depending both on area and on choices made by the individual fisher. The best results were observed in the Baltic Sea, where relaxing technical rules led to major improvements in fishing patterns. But gear changes did not contribute much in fisheries where initial discard rates were already low. Interviews realized with the skippers around the end of the trial were performed and analyzed to investigate (i) their experiences with “free” choice of gear, (ii) the processes that they followed for developing their gears and (iii) their tools for evaluating the efficiency and selectivity of their trial.

In addition to the trial, a number of other activities were performed under the MINIDISC project, including (i) the publishing of a catalogue (in Danish) of the selectivity devices experimented in Danish fisheries, (ii) a scientific selectivity trial on Danish seines fisheries in Skagerrak and (iii) a review of international experiences in the uptake of selective devices. The project has been disseminated through several meetings and conferences. A number of scientific publications are in review or close to submission.

This project was coordinated by DTU Aqua.

The project was funded by the Danish Ministry of Food, Agriculture and the Fisheries and the European Fisheries Fund (EFF).

New methods and models for population estimates of mussels with the use of GPS data (39088)

Based on the new management requirements from authorities and industry, the access to new data collection and the desire for more mussel fishing areas, there is a need for the development of new tools for monitoring and managing shellfish stocks.

The aim of the project was to develop new methods and models for estimating shellfish stocks in Denmark that may include several types of information to the management. The project worked with stratified extensive sampling strategies such as sidescan sonar, video recordings, data from automated GPS loggers from industry's own data and classical biomass collection.

Based on the data collected different types modeling tools was developed. The project has resulted in a new management tools for population estimation with different degrees of detail and types of information.

This project was coordinated by DTU Aqua.

The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).
**Starfish - power and management (Søstjerner) (39087)**
The overall objective of the project was to provide the scientific basis for management that can lead to the establishment of a commercial fishery of starfish (Asterias rubens) in primarily the Limfjorden, including Natura 2000 areas. The project background was the increasing prevalence of starfish that is both a threat to the mussel fishing and a potential source of income for fishing. In the project, the population of starfish and production was determined and analyzed and based on population stock estimates and stock modeling a total allowable quota of 10,000 tonnes annually was estimated as a conservative annual catch, which is considered sufficient to maintain a potential starfish meal industry. Effect of fishing was determined both for the population of starfish, the stock of mussels and benthic components like infauna and macroalgae. It was shown that using the starfish purse seine will have no or negligible effects on infauna and blue mussels. In terms of biodiversity and biomass of macro algae, no significant effects of the purse seine, including a load of 300 tonnes of starfish in the net, could be detected. Torn of macro algae leaves were however detected in the purse seine after fishery over macro algae habitats and this was included in management advise on effects of starfish fisheries. A guide for management including recommendations on environmental impact and starfish populations were developed. This project was coordinated by DTU Aqua.
The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).

**Boulder reefs as spawning and nursery areas for fish (RevFisk) (39144)**
The project aimed to build knowledge about marine boulder reefs and their biological function for fish as spawning and nursery areas.
The field work was conducted on a stone reef, Hatter Barn at two depths 6-12 m and 13-17 m. These two depths were chosen to provide information on fauna and flora in the upper photic zone and a deeper zone. The dominant fish were labrids, which also spawned in the area and juvenile cod. Acoustic tagged cod provided information on their presence around the reef. Many exhibited a diurnal rhythm, concentrating on the reef during nighttime, although some cod were stationary on the reef the whole time. The deeper reef was more frequently visited (fourfold) by cod than the shallower reef.

Experimental work conducted at the Blue Planet aquarium revealed that corkwing wrasse are highly territorial and able to prevent juvenile cod from occupying their crevices. Goldsinny wrasse showed little interaction with cod and generally utilized very small crevices. Both labrids and cod utilized shelter from current flows provided by the structures and cod were often seen in high concentrations near the bottom where the current flows were laminar.

The results are useful for further developing models that quantify boulder reefs impact on fish (larvae, juvenile, adult) as a function of the reefs condition, size and depth location. The results are useful in helping plan and design the restoration of destroyed boulder reefs but also to manage existing boulder reefs.
The project was coordinated by DTU Aqua.
The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).
**Ecosystem based method for impact assessment (39142)**

The project aimed to develop a methodology for impact assessment and measures to support the implementation of the Marine Strategy Framework and Natura 2000.

The project included:

- Development of an approach to impact assessment and step by step guide for management actions to ensure biodiversity, marine food webs and seabed integrity.
- A Case Study on the Dogger Bank to support the implementation of the Natura 2000 processes was evaluated and best practice identified.
- A Case study in the Kattegat with monitoring and ecosystem analysis of muddy habitats to optimize nature conservation and fisheries management under the Marine Strategy was evaluated and best practice identified.
- Development of cost-effective methods for management, monitoring and control in a report that describes the best practices in the subareas and the related costs.

The project was coordinated by DTU Aqua.

The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).

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23/07/2013 → 01/05/2015

Keywords: Research areas: Observation Technology & Marine Living Resources & Coastal Ecology
Collaborators: Dalsgaard Data A/S, Danish Anglers Association, Silkeborg Fiskeriforening

Project: Research

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**Initiative to improve mackerel assessment via tagging data (39080)**

The assessment of NEA mackerel had issues with this assessment related to the data. The most problematic data issue for NEA mackerel is the unknown amount of unreported catches in the past. The single index was available only every third year, which caused substantial revision of the perceived stock each time a new survey point was incorporated. Furthermore, the uncertainty in the stock estimate in the terminal assessment year increased as one moved away from the last available egg survey point.

This project extended the state-space assessment model SAM (developed at DTU-Aqua) to use tag-recapture information. This was done in order to correctly propagate uncertainties associated with the tag-recapture data. In preparation of the benchmark two meetings were held with the objective to analyze the information given by the tagging data and write the code for the model extension. The model was extended and accepted as the primary model for NEA mackerel at the following benchmark assessment meeting.

This project was coordinated by Danish Pelagic Producer Organization.

The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).

Nielsen, A., Project Participant, National Institute of Aquatic Resources, Section for Marine Living Resources

23/07/2013 → 01/05/2015

Keywords: Research area: Marine Living Resources
Collaborators: Danish Pelagic Producer Organization

Project: Research

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**Short-term projections for short-lived species managed under MSY: Management of the sandeel stock in the North Sea (39148)**

The industrial fishery for small short-lived species represents the economically most important fishery in Denmark, and traditionally the North Sea sandeel (Ammodites marinus) has played a key role in this fishery.

Currently, quota advice for sandeel is based on the so-called B-escapement strategy, the purposes of which is to ensure that the spawning stock biomass remains large enough to maintain the survival of the population even after fish-eating fish, birds, and mammals have taken their share; and whatever is left is made available to the fishery. This type of management strategy relies on accurate predictions about the size of the incoming year class (the recruitment), if the criteria of MSY are to be fulfilled.

The aim of the project was therefore to ensure that the short-term prognosis reflects current knowledge about the biology of sandeels in the North Sea and applies all relevant data time-series. A new recruitment index was introduced. Seasonal and spatial patterns in log-book based catch rates of age-1 fish were analysed and compared to recruitment indices from the year before. Spatial differences in local larval retention strength were found.

A genetic tool that allowed us to distinguish between different sandeel species in a quick and accurate way was developed. Lastly, development of a state based assessment model that can handle seasonal data (something which is necessary for sandeel) and estimate shifting selection patterns was initiated.

All of this work is currently contributing significantly to the preparation of the coming North Sea sandeel benchmark assessment in ICES to be held in the fall of 2016.

This project was coordinated by DTU Aqua.

The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).

van Deurs, M., Project Coordinator, National Institute of Aquatic Resources, Section for Marine Living Resources
Optimal sustainable use of cod stocks accessible for Danish fisheries (DEL-TORSK) (39147)
Optimal sustainable utilization of cod stocks that contain several biological sub-populations requires taking population structure into account in stock assessment and management. The aim of this project was to develop scientific basis for cod management decisions in the North Sea and the Baltic that takes biological units of cod and their dynamics into account.
Methodological challenges concerning advising on stocks that contain sub-populations with differences in dynamics and biological parameters are common for North Sea and the Baltic. Therefore, the project considered both seas, in terms of developing methodological basis for addressing population structure in management advice. The results were presented at ICES benchmarks for North Sea and Baltic Sea cod in 2015, and used to develop further the management basis for optimal use of cod stocks.
The project included mapping of distribution of sub-populations using genetic analyses and modelling of transport of early life stages. These results were combined with existing knowledge on cod population structure both in the Baltic and North Sea, to identify distribution areas of sub populations. This information was then incorporated in area-specific stock assessment analyses.
This project was coordinated by DTU Aqua.
The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).

Changes in marine resources in Skagerrak and Kattegat 1946-2012 – Catch and revenue in the post war fishery and transformation of the fleet (DIGIFISH) (39103)
The project has compiled catch and economic data from fisheries in Skagerrak and Kattegat since 1946. The aim of the project was to establish a common database for future utilization in the research of development of fisheries and socio-economics in the specific area.
Research institutes from Sweden (Swedish University of Agricultural Sciences), Norway (Oxford Research) and Denmark (DTU Aqua) participated in the project. Data has been extracted from various national statistical databases and logbooks/landing slips from the fishery. The output from the project is a database with landings and economic values of fish landed in Skagerrak and Kattegat, comprising all commercial species and thereby valuable for historic studies of the species and their utilization.
There is a pressure from consumers on the fishing industry to legitimate sustainability in the fisheries, which normally requires assessments and advice consistent with international criteria on sustainability. A prerequisite for such an approach is complete catch data back in time. Therefore, the present project provides important data to base assessments on and to perspective recent fisheries with historic data.
Economic data in the database will enable socio-economic analyses of the different fisheries, including changes on structure of society and fishery.
This project was coordinated by DTU Aqua.
The project was funded by the AG Fisk (Working Group for Fisheries), Nordic Council of Ministers.
**Analysis of measures for increased stability in the industrial fisheries (39027)**

The objective of the project "Analysis of measures for increased stability in the industrial fisheries" has been to improve fisheries advice to ensure more stable quotas for the three main industrial species in the North Sea; sandeel, sprat and Norway pout. The means to get there was to improve data, calculation procedure and management plans by taking into account the special conditions that exist for each species.

Through an industry-scientist-manager collaboration platform initiatives were taken to a theoretically and practical cooperation, where collection and analysis of biological and fishery-based data and knowledge sharing between fisheries, bio-economy, management and research has supported development of robust management strategies that may increase economic stability in the industry if implemented in the future.

The project is coordinated by DTU Aqua.

The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF). Mosegaard, H., Project Coordinator, National Institute of Aquatic Resources, Section for Marine Living Resources Pedersen, E. M., Project Manager, National Institute of Aquatic Resources van Deurs, M., Project Participant, National Institute of Aquatic Resources Worsøe Clausen, L., Project Participant, National Institute of Aquatic Resources Rindorf, A., Project Participant, National Institute of Aquatic Resources Christensen, A., Project Participant, National Institute of Aquatic Resources

**Keywords:** Research areas: Marine Living Resources & Ecosystem based Marine Management

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**MSC certification of the plaice fishery in area IIIa – basic investigations and development of a management model (39025)**

A management plan is an important requirement for MSC certification of specific fisheries. However, prior to this project, reliable stock assessments, which are necessary for amangement plan for plaice (Pleuronectes platessa) in area IIIa (Kattegat/Skagerrak), had not been available. These problems most likely originated from insufficient knowledge about the geographical distribution of populations as well as the interactions between populations in Kattegat/Skagerrak and neighbouring areas. Through a mapping of the distribution and dynamics of populations, this project aimed at providing missing data that would ultimately allow for the development of an management plan for the plaice fishery in area IIIa. The work included information from genetics, tagging, otolith based growth estimation, oceanographic modelling and analyses of survey and fisheries data.

Results from the project showed evidence of both local population components in the Kattegat/Skagerrak as well as substantial mixing between North Sea populations and these local components, and consequences of lumping or splitting the populations for stock assessment and management were discussed.

The outcomes of the work directly influenced the policy decisions since 2015. Decision was finally made to proceed with the lumping option, thus allowing a quantitative analysis, assessment and management advice for the area. However, because of the differences in size between the two populations, there is a risk of depletion of the local Skagerrak population if the fisheries on it increase as a consequence of the increase in the North Sea stock. In terms of management, some mechanisms already exist for reducing the fishing pressure in the Skagerrak if deemed necessary, as plaice in the North Sea and in the Skagerrak are managed by two different Total Allowable Catches (TACs). It has therefore been suggested that routine monitoring of the survey and fisheries patterns would allow detecting any departures from the current situation, i.e. decoupling of trends in the different areas and the different seasons that could indicate a reduced productivity of the local stock.

In the longer-term, the current progresses on the biological knowledge of the stock in Skagerrak should be sustained. Additional genetic allocation of individual fish to the different populations should be performed to obtain a better quantification of the mixing different areas and seasons, and the survey coverage should be improved in the Skagerrak.

The project was coordinated by DTU Aqua.

The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).


**Keywords:** Research areas: Population Genetics & Fisheries Management & Marine Living Resources

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**Collaborators:** Danish Fishermen's Producers Organization, Danish Fishermen's Association
Restoration and management of cod in the Skagerrak/Kattegat (CodS) (38969)

The project had two main aims:
- To develop plans for ecosystem based and sustainable management of coastal stocks of cod in Skagerrak/Kattegat.
- To develop necessary scientific knowledge needed for a first pilot restoration of a locally extinct stock of cod.

The work in the project was highly multi-disciplinary and included aspects of law, policies and institutional rules, socioeconomy, genetics, ecology, physiology and behavioural ecology. The work was divided into 10 work packages and one work package responsible for coordination.

The different WPs addressed the following tasks:
- WP1: Genetic mapping of potential donor stocks of cod.
- WP2: Genetic characterization of extinct cod stocks in fjord areas of Skagerrak.
- WP3: Ecological inventory of fjords with and without cod, to establish the effect of local cod stocks on fjord ecosystems.
- WP4: Risk assessment in particular focusing on the risk of contamination of released cod larvae or juveniles that migrate into nearby stocks.
- WP5: Legal and institutional aspects of restoring fjord stocks of fish.
- WP6: Societal costs and values of cod restoration.
- WP7: Establishing production of cod juveniles, for tests of feeding and migration behaviours in relation to individual genotype.
- WP8: Developing a step-by-step plan for starting a pilot restoration, including applications for necessary permissions.
- WP9: Development of suggestions of management plans for existing or restored fjord stocks of cod.
- WP10: Synthesis and final report to stakeholders. (Scientific reports will be submitted for publication in scientific journals, in addition).
- WP11: Coordination, internal and external communication including project meetings.

The main results of the project were:
- Cod was present in very small stocks in fjords in eastern Skagerrak, as found from trawling of fish eggs during spawning period. The eggs found were identified as cod from genetic markers. Thus restoration should wait and instead all possible protection should be applied so that these tiny small groups of local spawning cod can increase in numbers over the years to come.
- Several of the fjords in Skagerrak/Kattegat have cod that genetically is a mix of North Sea cod and Kattegat cod. Some fjords along the Norwegian coast have genetically unique elements in the cod stocks.
- The Kattegat spawning stock should be a very important source for eastern Skagerrak cod populations, according to our oceanographic models.

The project was coordinated by Department of Biological and Environmental Science, University of Gothenburg. This project was funded by EU, InterReg (regional collaboration).
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01/07/2012 → 31/12/2014
Keywords: Research areas: Population Genetics & Marine Living Resources & Fisheries Management
Collaborators: Lund University, Institute of Marine Research, University of Gothenburg
Project: Research

Sustainable bycatch in Danish fishery - Reasonable management under the landing obligation (39028)

The project facilitated a more robust advice of by-catch species in the Danish fishery in the Skagerrak by suggesting and testing stock assessment approaches for data poor stocks as well as providing guidance for various options to reduce by-catch without limiting the target fishery.

The approach applied in the projects was suggested to be adopted for other areas where the landing obligation potentially can be restrictive for target fisheries (mixed-fish cases). Through thorough exploration of existing data in survey time-series it was possible to provide size-based life-history models to gauge the sensitivity of stocks in relation to fishing pressure.

The models were used to determine relevant biological reference points for the most relevant by-catch species and the resulting assessment and stock status was then compared to the prevailing ICES/RGLIFE classification. Finally, the project suggested upgrading the stocks to a higher and less restrictive ICES category for management purposes where possible.

This project was coordinated by DTU Aqua.
The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).
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Gislason, H., Project Participant, National Institute of Aquatic Resources
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Jørgensen, O. A., Project Participant, National Institute of Aquatic Resources
Kokkalis, A., PhD Student, National Institute of Aquatic Resources
01/06/2012 → 31/01/2014
Keywords: Research areas: Marine Living Resources & Fisheries Management & Marine Populations and Ecosystem Dynamics
A coast to coast network of protected areas: From the shore to the deep sea (CoCoNet) (38863)
The project targeted design and implementation of marine protected areas, as well as advancement of the scientific basis for optimal design and implementation. The project focused on two pilot studies in the Mediterranean and Black Sea for establishing a network of MPAs. DTU Aqua participated in developing the scientific basis for optimal design of MPA networks by developing spatial size-based models to describe biodiversity as appropriate scales, as well as habitat connectivity from trait-based modelling, and procedures for analyzing habitat connectivity. DTU Aqua also contributed to governance issues relating to establishment of MPA networks.
The project had 39 partners from the EU and Eastern Europe and Near Asia. The project was coordinated by Universita del Salento, Italy. The project was funded by EU, Framework Programme 7.

Center for Ocean Life (COOL) - a Villum-Kahn Rasmussen Centre of excellence for the study of life in a changing ocean (38960)
Our goal is to develop a fundamental understanding and predictive capability of marine ecosystems through the use of novel trait-based approaches and models. The Centre is organized around three main research activities:
- Identification and mechanistic description of the traits and trade-offs required to characterize the main Darwinian missions (feed, survive, reproduce) of the various life forms in the ocean through experimental and theoretical work, as well as analysis of literature data.
- Models: scaling of individual behavior to population and ecosystem dynamics through the development of trait-based models.
- Testing model prediction by comparing to observed trait patterns in the ocean.
The Centre involves biologists, physicists, chemists, and mathematicians and has a very strong training component through the supervision of master students, and about 30 PhD and postdoctoral fellows as well as by offering PhD summer schools and organizing international workshops. The Centre in addition host many visiting students and scientists.
The Centre is lead by DTU Aqua.
The project is funded by the Villum Kahn-Rasmussen Foundation (Velux Foundations) as well as through various national and European fellowship programs (Research Council, H.C. Ørsted Fellowship programme, Marie Curie, Carlsberg Foundation, etc).

Efficient and low impact gear in the Danish fishery for industrial species (GUDP Tobis) (38849)
The aim of the project was to ensure the future of the Danish industrial fisheries in the increasing demands for reduced environmental impact. The Danish industrial fisheries amount to around 800 million DKK a year in first value. The industrial fishing for sandeel, was seen threatened by a potential ban against bottom trawling in the main fishing areas at Dogger Bank in the North Sea, due to appointment of a large Natura 2000 area by UK, the Netherlands and Germany were bottom trawl could be considered to affect the conservation status of the sand habitat negatively. In addition profitability was threatened by the high vessel operating cost, considering fuel prices at the time.
The objective was to develop and document a fishing method for industrial fisheries (sandeel, Norway pout and sprat)
where the trawl doors don’t have bottom contact and where modern materials are used in the gear and for the wire. Thus, compared to traditional gear, an overall energy saving of minimum 30% on each kg fish caught was expected, and also the damages on the benthic fauna was expected to be reduced or eliminated.

The new pelagic gear was constructed according to specifications. It behaved as intended and could easily be operated on Dogger Bank. The new gear consisting of pelagic doors and Dynema equipped trawl has attracted considerable attention among fishers and can be considered a business success. Catch volumes (tons/hour) did not differ between the experimental and standard trawl under parallel fishing. Sandeel behavioral differences could not be identified from sonar and UV-camera recordings, and size and oil content of sandeels was not systematically different between the two gears. Calibration experiments demonstrated 24 % lower fuel consumption in the new trawl.

Bottom surveys were carried out annually from 2012 to 2014 in the North-eastern part of Dogger Bank (in the Dutch/NL EEZ) at approximately 35 meters depth. Sediment analyses showed a grain size composition dominated by fine sand mixed with small amounts of gravel, whereas fine particles comprises 1 % maximum ideal as a sandeel habitat. Grain size composition was not altered by trawling or time.

Bottom impact with new gear is estimated to be 30 % reduced compared to a similar trawl using conventional doors. Based on the side-scan sonar recordings it was not possible to distinguish differences between the two trawl types in sediment depth penetration. The foot prints left by both sandeel trawls in one year were not discernible in subsequent years. Results from the video record analyses showed especially conch and hermit crabs were more abundant soon after trawling compared to before impact. The sediment analyses revealed nearly 100 different invertebrate species many of which lives burrowed or tube building in the sand. Overall diversity did not differ significantly between transects trawled by the two gears and the non-trawled transect. Detailed analyses showed, however, that some species (fragile sea anemones, polychaetes and echinoderms) were less abundant after impact from the conventional trawl compared with the newly-designed trawl and the control transect. A few species were more abundant in the transect trawled by the conventional trawl, including some smaller crustaceans. These results suggest the newly-designed sand eel trawl has a lower impact on benthic fauna than the conventional trawl and we expect the final analyses will support these results.

The project is coordinated by DTU Aqua.

The project was funded by the Danish Ministry of Food, Agriculture and Fisheries through the Green Development and Demonstration Program (GUDP).

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01/01/2012 → 05/01/2015

Keywords: Research areas: Marine Living Resources & Fisheries Management & Observation Technology
Collaborators: Thyborøn Harbours Fishermen’s Association, Northsea Trawl, Thyborøn Trawldoor.dk
Project: Research

Maximizing yield of fisheries while balancing ecosystem, economic and social concerns (MYFISH) (38850)

The European Common Fisheries Policy has made a commitment to direct management of fish stocks towards achieving Maximum Sustainable Yield (MSY) by 2015 (or no later than 2020 in special cases). Attaining this goal is complicated by lack of common agreement on the interpretation of both ‘sustainability’ and ‘yield’, and because achieving MSY for one stock may affect the possibility of achieving MSY for other stocks and compromise ecological, environmental, economic, or social aims.

The objective of MYFISH was to face these difficulties and provide definitions of MSY variants, evaluations of the effect on ecosystems, economy and social aspects of attaining these variants, their social desirability and an operational framework for their implementation.

This was achieved through cases addressing a range of fisheries in all European regional areas. The cases cover situations ranging from data-poor to the most studied and well-understood marine ecosystems in EU waters. The suggested implementation of MSY builds on the existing ecosystem and fisheries models in the cases, modified to perform the maximization of the relevant yield measure operationally. Social aspects were integrated throughout the project by active involvement of stakeholders in the definition and evaluation of MSY variants. Global experience was engaged through associated partners and communication of results was enhanced through two major events, a dedicated MYFISH/ICES symposium in 2015 and a targeted policy meeting in 2016. More details can be found at www.myfishproject.eu.

The project was coordinated by DTU Aqua.

The project was funded by EU, Framework Programme 7.

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MyOcean 2 (38862)

The project advanced and coordinated European scientific and technical infrastructure in the European operational oceanography community, for collecting and distributing ocean observations and ocean forecasts, being a continuation of MyOcean. DTU Aqua was reference intermediate user (RIU) in WP3 aimed at integrating MyOcean products into national systems and services and foster downstream exploitation of MyOcean information especially at a regional level.

The project had 61 partners from the EU and was coordinated by Mercator Ocean, France.

The project was funded by EU, Framework Programme 7.

Operational ecology: Ecosystem forecast products to enhance marine GMES applications (OPEC) (38864)

The primary goal of OPEC was to improve the quality of operational services for biogeochemical and ecological parameters and hence, improve our ability to project the future status of European marine ecosystems, by delivering a suite of error quantified indicators which describe changes in ecosystem function suitable for implementation in operational centers.

In order to advance our understanding and predictive capacities for the response of marine ecosystems to global change, OPEC employed a combination of numerical simulations, data assimilation of satellite and in situ data, observational strategy evaluation and cross-disciplinary synthesis. The MSFD takes a regional approach to the development of strategies for environmental status, identifying four main regions: NE Atlantic, Baltic, Mediterranean and Black Seas. The MSFD also identifies a number of high level descriptors of environmental status (e.g. biodiversity, commercial fish, eutrophication, food webs, and invasive species) each of which has a defined set of indicators. Using the regional approach as framework we implemented and tested a suite of indicators in each region. These descriptors along with the ECVs provided a framework for the definition of new environmental applications (e.g. habitat for biodiversity, oxygen depletion/eutrophication, fisheries and marine climate change research).

A common set of descriptors with associated GES indicators and ECVs were defined across the four regions, to ensure a commonality of approach and the development of a consistent capacity across Europe. Auditable quality is essential for GMES environmental applications, and OPEC emphasized the assessment of predictability of key indicators. The R&D of the project included development of coupled end to end ecosystem models, where DTU Aqua implemented the coupling between the SMS model for higher trophic levels and HBM-ERGOM for physics and biogeochemistry.

The project had nine partners from the EU and was coordinated by Plymouth Marine Laboratory, UK.

The project was funded by EU. Framework Programme 7.

Eastern-western Baltic cod: Improved management based on stock discrimination of eastern and western Baltic cod (Øst-Vesttorsk) (38989)

The aim of this project was to improve the management of western Baltic cod by incorporating stock identification routines in order to discriminate between eastern and western Baltic cod stocks.

In recent years evidence from fishery patterns and otolith structures have indicated an increasing degree of mixing between the two cod stocks which until 2013 were managed as two separate stocks. Changes in fishing pressure and patterns would therefore result in a risk for local depletion of the smaller western stock.

Stock identification methods were based on established approaches using genetic discrimination and otolith shape analysis, and improved by linking theses methods. This method provides a tool to estimate the degree of stock mixing using the existing otolith archives. This approach documented an increase of eastern Baltic cod from 30% to > 80% in the eastern part of the western Baltic Sea management area. As a consequence of this stock mixing, a new procedure incorporating stock mixing on an annual basis was set in place which aimed to improve stock exploitation and reduce the risk of local depletion. The knowledge gained also influenced recent management regulations, particularly a prolongation of spawning closer of the fishery in 2016.

The project was coordinated by Centre for Environment, Fisheries & Aquaculture Science, UK.

The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).
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27/06/2011 → 29/03/2013
Keywords: Research areas: Marine Populations and Ecosystem Dynamics & Marine Living Resources & Population Genetics & Fisheries Management
Collaborators: Cefas Weymouth Laboratory
Project: Research

Development of ecological sustainable fisheries practices in the Benguela Current Large Marine Ecosystem (EcoFish) (38847)

EcoFish promotes the ecosystem approach to fisheries (EAF) and is conducted in the Benguela Current Large Marine Ecosystem (BCLME), encompassing fish stocks from Angola, Namibia and South Africa.

The project represents a paradigm shift compared to DTU Aqua 20 years of FAO/Danida courses in the 80's and 90's, where fish stock assessment was taught in 85 countries by using comparative simple techniques. In contrast EcoFish applies advance stock assessment methodology based on open access, web-based state space (SAM) and geostatistical (GeoPop) tools. Thus the capacity building involved also includes a focus on DTU Aqua because of similar ongoing challenges in the Nordic seas, and two DTU Aqua PhD projects are integrated in EcoFish.

Focus in EcoFish is on hake, horse mackerel and sardinella, coordination to important donor projects in the area such as the Norwegian climate project NansClim and EAF-Nansen is ensured through the leadership of Benguela Current Commission. There are potential synergies to several EU projects (FP6 IMAGE, FP7 MEECE and FP7 FACTS) as well as national projects such as Sunfish (Description of the life cycle and recruitment of cod) and REX/RESOURCE (fishermen-science collaboration on cod in the North Sea). The potential database for BCLME is unique and EcoFish offers the possibility for developing a master example to be used as a generic tool in African Large Marine Ecosystems as well as the large lakes.

The project is coordinated by Benguela Current Commission, Namibia.

The project is funded by EuropeAid.

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01/01/2011 → 31/12/2015
Keywords: Research areas: Marine Living Resources & Marine Population and Ecosystem Dynamics
Collaborators: National Marine Information and Research Centre, Department of Environmental Affairs: Oceans and Coasts, Benguela Current Commission, University of Cape Town, Institute National Investigacao Pescas, University of Stellenbosch
Project: Research

Flatfish nursery grounds (38176)

The aim of the project is to determine what constitutes a good nursery area for specific flatfish in coastal soft bottom areas in the inner Danish waters using a combination of empirical and theoretical approaches. Field studies on juvenile flatfish feeding, growth and condition use both wild and released fish. One approach is to explore different statistical methods to determine potential nursery grounds for different flatfish based on physical parameters such as wave exposure, sediment type and abiotic variables such as temperature, salinity and depth. This research coupled with the development of tools to map different coastal habitats will provide the basis for advice on management of coastal fish nursery areas.

Implementation of PIT-tag technology in coastal marine waters will be developed in order to build up expertise to sample...
released individuals in different habitats.

The project was coordinated by DTU Aqua.

The project is funded by the Danish Rod and Net Fishing License Funds.

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01/01/2011 → 31/12/2013

Keywords: Research areas: Coastal Ecology & Freshwater Fisheries and Ecology & Marine Living Resources

Collaborators: Aarhus University, Danish Organization for Amateur Fishermen

Project: Research

North Atlantic - Arctic coupling in a changing climate: Impacts on ocean circulation, carbon cycling and sea-ice (NAACOS) (38888)

Climate change is most pronounced at high latitudes, with rapid and dramatic changes observed in sea-ice coverage, circulation and the ecosystem. These changes have profound effects both at the regional scale as well as globally. The North Atlantic and Arctic Ocean are the headwaters of the thermohaline circulation (THC), the global heat engine responsible, amongst other things, for the relatively mild climate we experience in Denmark. Subtle change in sea-ice formation, deep water circulation, and freshwater supply on a relatively local scale will have repercussions around the world. More subtle still are the feedback controls these processes have on climate change. Sea-ice coverage and the earth's albedo is one feedback, but there is also the draw down and sequestration of atmospheric CO2 in deep waters by physical and biological processes. The whole is an intricate weave of interrelated mechanisms: the scientific challenge to draw together expertise across disciplines to address these issues was accomplished; the strategic outcome was a suite of knowledge-based tools designed to reduce the uncertainty and contribute to climate policies. The NAACOS team comprised a number of well-recognized scientists with profound experience and a significant international collaboration. NAACOS developed and refined oceanographic models using remote sensing and observations to evaluate the impact of high latitude climate change on circulation, deep water formation, sea-ice and carbon flux, and their implications at regional scales.

The project was coordinated by DTU Aqua.

The project was funded by the Danish Council for Strategic Research and a DHI student stipend.

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01/01/2011 → 31/12/2014

Keywords: Research areas: Oceanography & Marine Populations and Ecosystem Dynamics & Marine Living Resources

Collaborators: Aarhus University, Danish Meteorological Institute, DHI Water - Environment - Health, University of Copenhagen, Faroe Research Institute

Project: Research

Optimal sustainable exploitation of Nephrops norvegicus in Kattegat and Skagerrak (38909)

The scientific advice on management of fisheries is primarily aiming at avoiding overfishing of the fish and shellfish stocks and only to a very limited extend addresses how the utilisation of the resources can be optimised within a sustainable ecosystem framework. An example is the regulation of the demersal trawl fisheries in the Skagerrak and the Kattegat which to protect the cod stock is sub-optimal in relation to the utilisation of the Norway lobster (Nephrops) stocks. The project takes a new approach to the management and aims at optimising the utilisation of Nephrops stocks without compromising the protection of cod.

The Nephrops fishery is one of the economically most important fisheries in Denmark. In the Kattegat and Skagerrak, Nephrops catches accounted in 2010 for 53 % and 25 % of the total value of fish and shellfish, respectively, landed by Danish fishermen. Cod is taken as by-catch in the Nephrops fishery and it has been necessary to introduce measures to limit the by-catches of cod, which is currently below agreed reference points for stock size. These measures have had a negative impact on Nephrops catches.

The project addressed four objectives: (i) development of advice on the fishing mortality for the Nephrops stocks, which is consistent with maximum sustainable yield; (ii) mapping of the distribution of Nephrops in Skagerrak and Kattegat; (iii) development of a new trawl concept optimising the catchability on Nephrops while limiting the by-catches of cod and impact on the sea bed; and (iv) evaluating alternative fishing methods for Nephrops including fishing with pots.

The project was coordinated by DTU Aqua.

The project was funded by the Danish Ministry of Food, Agriculture and Fisheries through the Green Development and Demonstration Program (GUDP).

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01/01/2011 → 31/12/2014

Keywords: Research areas: Fisheries Management & Fisheries Technology & Marine Living Resources
Collaborators: Danish Fishermen's Association
Project: Research

Statistical aspects of heterogeneous population dynamics (38102)

A variety of 'indices' of distribution are often considered: occurrence, aggregation and geographical range. However, the estimators of these indices are frequently biased and the results often do not reflect changes in distribution, often due to effects of non-random sampling in space and time. Another type of bias in many existing methods results from the assumption that the individual observations of abundance in an area are all independent and spatial correlation is ignored. Methods that do take spatial correlation into account, such as kriging, are often inappropriate because they do not handle the high frequency of zero observations, which are typical of survey data. During this task we will develop new types of models using the so-called "Log Gaussian Cox Process" (e.g. Lewy and Kristensen 2009; Kristensen 2008), which account for spatial correlation and better involve the information from zero observations. These models will further strengthen our ability to detect changes in distribution and provide useful indices of biological aggregation or ‘clumping’ based on the degree of spatial correlation.

24 research institutes and 14 universities are partners in the project.

The project is coordinated by Plymouth Marine Laboratory, UK.

The project was funded by EU, Framework Programme 7.

Gislason, H., Project Manager, National Institute of Aquatic Resources
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01/01/2011 → 31/12/2011

Keywords: Research area: Marine Living Resources
Project: Research

Vectors of change (VECTORS) (38907)

Marine life makes a substantial contribution to the economy and society of Europe. VECTORS aimed at elucidating the drivers, pressures and vectors that cause change in marine life, the mechanisms by which they do so, the impacts that they have on ecosystem structures and functioning, and on the economics of associated marine sectors and society. VECTORS particularly focused on causes and consequences of invasive alien species, outbreak forming species, and changes in fish distribution and productivity. New and existing knowledge and insight was synthesized and integrated to project changes in marine life, ecosystems and economies under future scenarios for adaptation and mitigation in the light of new technologies, fishing strategies and policy needs. VECTORS also evaluated current forms and mechanisms of marine governance in relation to the vectors of change. Based on its findings, VECTORS outlined solutions and tools for relevant stakeholders and policymakers during the lifetime of the project. The VECTORS consortium included a mixture of natural scientists with knowledge of socio-economic aspects, and social scientists (environmental economists, policy and governance analysts and environmental law specialists) with interests in natural system functioning.

DTU Aqua contributed to VECTORS by developing new statistical models of fish species distributions, by further developing spatially resolved bio-economic models of fishing, and by analyzing fish species richness and distribution in the north Atlantic and the general relationship between changes in fish stock abundance and distribution area. We coordinated the Baltic WP where we implemented the ATLANTIS end-to-end model and performed initial scenario testing. We also analyzed the most important drivers of fish population dynamics in the Baltic, and contributed to the study of invasive species.

VECTORS comprised a total of 37 European Universities, research institutions and professional associations dealing with applied maritime and marine research.

The project included marine environmental scientists, fisheries scientists, conservation biologists, sociologists and economists from across the European scientific community providing expertise in marine ecosystems, management, fisheries, maritime transport, tourism and coastal development.

The project was coordinated by Plymouth Marine Laboratory, UK.

The project was funded by EU, Framework Programme 7.
EU preparatory action on maritime spatial planning in the North Sea (MASPNOSE) (38895)

Several EU member states had been working on spatial plans for their part of the North Sea. However, most marine spatial planning was carried out on a national level and largely ignored the possible benefits of cross-border cooperation. Joining forces with neighboring countries could have been an efficient way forward. A first step in this direction was the EU MASPNOSE project that brought together spatial planning practitioners, stakeholders and researchers in order to deal with these bottlenecks. MASPNOSE was an EU project on ecosystem based Maritime Spatial Planning (MSP) in the North Sea, focusing on cross-border areas. The project focused on the southern North Sea with Belgium, Denmark, Germany and the Netherlands as target countries.

To achieve this aim, MASPNOSE explored possibilities for cooperation among North Sea countries; established elements for a common agenda for cooperation of countries around the North Sea; tested the 10 key principles on Maritime Spatial Planning set up by the European Commission; and identified potential barriers and opportunities for cross border Maritime Spatial Planning.

The MASPNOSE project acknowledged the overarching importance of national authorities and other stakeholders (e.g. industries, NGO’s) in Maritime Spatial Planning. National governments had an advisory role in the project. Stakeholder participation was one of the focus points of the project and took place in the different case studies on a local scale. MASPNOSE could be seen as an experiment on how cross-border Maritime Spatial Planning could be carried out. This was based on two cross-border case studies in the North Sea: the Dutch-Belgian border and the Dogger Bank. The project was coordinated by Wageningen University, The Netherlands. The project was funded by EU, Call for tender (Preparatory Action for Maritime Spatial Planning).

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01/01/2010 → 31/05/2012

Keywords: Research areas: Ecosystem based Marine Management & Marine Living Resources & Coastal Ecology

Collaborators: Wageningen IMARES, Wageningen University & Research, Thunen-Institut, Deltares, Ghent University

Project: Research

EURO-BASIN: European basin-scale analysis, synthesis and integration (EURO-BASIN) (38899)

EURO-BASIN was designed to advance our understanding on the variability, potential impacts, and feedbacks of global change and anthropogenic forcing on the structure, function and dynamics of the North Atlantic and associated shelf sea ecosystems as well as the key species influencing carbon sequestering and ecosystem functioning. Like the entire biosphere, marine ecosystems such as the North Atlantic and its associated shelf sea ecosystems can be characterized by emergent properties controlled by a dynamic network of interactions and relationships and not static entities. This system complexity is what Martin Luther King Jr. called "an inescapable network of mutuality" scientists today define as complex adaptive systems (CASs).

EURO-BASIN has represented the first attempt of creating future prognosis of marine ecosystem states sensitive to CAS dynamics using as its test case the North Atlantic. Long-term prediction of the status of these CAS systems, population dynamics of key species and hence management of marine systems requires the implementation and advancement of an ecosystem approach for the management of marine resources sensitive to CAS dynamics. What is the ecosystem approach? Unlike a single species approach, the ecosystem approach takes into account population and ecosystem responses to changes in the Earth's climate, fisheries, and interactions between them. In EURO-BASIN not only did we monitor and assess how North Atlantic marine ecosystems behaved in the past, but also predict how they will respond under possible future climate change scenarios. Hence, the results of this project have provided important recommendations for better marine resource management in the European Union.

The project had participants from 23 European universities and research institutions as well as collaborations with key institutions and Universities in the US and Canada. The project was coordinated by DTU Aqua. The project was funded by EU, Framework Programme 7.

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01/01/2011 → 31/01/2015

Keywords: Research areas: Ecosystem based Marine Management & Fisheries Management & Marine Living Resources

Collaborators: Wageningen IMARES, Wageningen University & Research, Thunen-Institut, Deltares, Ghent University

Project: Research
**Sustainable shrimp fishery in Skagerrak (38994)**
The main objective of the Norwegian-Swedish-Danish research project "Sustainable shrimp fishery in the Skagerrak" was to clarify whether there are one or more shrimp stocks in the Skagerrak. The management of shrimp fishing in the Skagerrak and Norwegian Deep is based on the perception of the shrimp resource as one large population. However, biological differences between shrimps (e.g. the size at sex change) indicate that there may be several stocks in the area. The question of one or more stocks was answered by collecting and genetically analyzing several thousand shrimp from Skagerrak and northern Kattegat, Norwegian Channel and the Norwegian fjords. The analyzed shrimps came both from research cruises and commercial fisheries. The kinship of the collected shrimp was examined with modern DNA technique and the results compared with existing knowledge of the biology of the species. This knowledge was obtained from scientific sources as well as from the fishing industry in terms of skipper interviews. The genetic analyses revealed that shrimps in Skagerrak and Norwegian Deep all belong to the same stock, but also that some of the fjord-populations are genetically distinct (can be considered separate stocks). These results are published in ICES Journal of Marine Science in 2015.

The fisher information collected in the project was not only focused on shrimp biology but also addressed economical and technical aspects of the shrimp fishery. In this way, scientists have gained an understanding of both how shrimp populations are structured and distributed in the Skagerrak and of the economic importance. The exchange of knowledge between researchers and fishers was an important aspect of the project and was facilitated by regular meetings and interview schemes in all three countries.

Another primary objective of the project was to improve the current assessment of the Skagerrak shrimp stock by developing a new length-based analytical model. DTU Aqua was in charge of this part of the project and in an assessment benchmark in 2012 the developed model was accepted.

The project was coordinated by Institute for Marine Research, Norway. The project was funded by EU, InterReg (regional collaboration).

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01/01/2010 → 31/12/2013

**Cardio-respiratory adaptations in cod feeding under hypoxic conditions (CarlsbergTorsk) (38851)**
Employment of DataStorage Tags on individual Atlantic cod (Gadus morhua) in the Bornholm Basin has shown that some fish migrate towards the deeper basin centre, presumably to feed. During these voluntary dives, fish expose themselves to oxygen saturations as low as 10 % and many individuals spend a third of their total time at oxygensaturation.

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01/01/2009 → 31/05/2012

**Keywords:** Research areas: Marine Populations and Ecosystem Dynamics & Fish Biology & Marine Living Resources

Collaborators: University of Gothenburg
Developing fisheries management indicators and targets (DEFINEIT) (38763)
DEFINEIT constructed operational models of fish stock dynamics explicitly taking into account exploitation and climatic conditions and combine these models with basic economic models. To ensure an outstanding scientific level in each of these areas, the project brought together key competences in operational multispecies modelling, stock recruitment relationships, population dynamics of non-target fish species and economic modelling of fisheries from a wide geographic area ranging from the Barents Sea to the North Sea. The project used multispecies models to investigate changes in predation induced by differences in the distribution and the amount of alternative food. Effects of technical interactions in the fishing process were considered to avoid delivering management advice for different stocks which is mutually inconsistent. Integrating the knowledge gained, the project suggested methods for estimating reference points. The project identified the main causes of variation in recruitment patterns between stocks as well as the key processes from spawning to recruitment of selected stocks. The consequences of using proxies to describe stock reproductive potential were determined and survival during early life stages was investigated in order to identify the role of the physical and biological environment. The improved understanding of recruitment variability was used in individual stock assessment and included in multispecies models to provide reliable predictions. The maximum level of fishing effort consistent with sustainment of susceptible species was estimated along with the effect of discard of by-catch on economic yield. The project developed resource indicators that combine economic, social and biological indicators and relate directly to the benefit for the society. Future stock dynamics limits to sustainable ecosystem exploitation and the fishing levels delivering maximum sustainable economic yield under selected climatic scenarios were analyzed in unison to ensure the delivery of mutually consistent management advice. General properties of the ecosystems were used to suggest rules of thumb for management in areas where the amount of data available is insufficient to construct similar models.

The project was coordinated by DTU Aqua.
The project was funded by EU, MariFish, ERA-NET.
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01/01/2009 → 30/06/2012
Keywords: Research areas: Ecosystem based Marine Management & Marine Living Resources & Marine Populations and Ecosystem Dynamics & Population Genetics
Collaborators: Imperial College London, Marine Research Institute Reykjavik, University of Southern Denmark, Wageningen IMARES, Institute of Marine Research, Hellenic Centre for Marine Research, University of Copenhagen, Cefas Weymouth Laboratory, University of St Andrews
Project: Research

Development of a method for long term spatially resolved management of the herring fishery in the North Sea and IIIa taking the migration of the primary herring stocks, the fishery pattern and by-catch of mackerel into consideration (URSIN) (38731)
The overall objective is to develop a tool to create long-term management plans for the two main herring stocks in the North Sea and IIIa, which may allow the industry an optimum use of the population under safe conditions relating to population maintenance and catch of mackerel.

The project will further develop, test and optimize a method for the quantification and prediction of herring stock spatial distribution in relation to life stages that is based on existing methods. This quantification of the migration patterns will provide more solid understanding of population development under various conditions. Moreover, the method will include a modeling of the herring fleet behavior, allowing for merging of herring spatial distribution in relation to life stage and hence potential economic value of fishing pattern. The historical and current behavior of the herring fleets will be quantified in collaboration with the industry. Similarly, mackerel skull occurrence will be mapped as it is of great importance for the herring fleet behavior, due to the economic incentives to minimize this by-catch.

The objective of the project is to generate a scientifically based tool for prediction of utilization of herring that can be used in future scientific advice to management, and information on optimal harvest strategies for the fishery in collaboration with the fishing industry. This is partly to increase the transparency and credibility of the scientific work and increase security in the input data and thus reduce uncertainty in the advice given in the end. Collaboration with industry includes Pelagic PO, Skagen PO and Esbjerg Fishermen and covers all types of fishing for herring (both industrial and human consumption).
The project is coordinated by DTU Aqua.
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01/01/2009 → 31/12/2011
Keywords: Research area: Marine Living Resources
Collaborators: Danish Fishermen's Association, Danish Pelagic Producers Organisation
Project: Research

Development of tools for logbook and VMS data analysis (38751)

Objectives and Background
The project “Development of tools for logbook and VMS data analysis” was an EU project under studies for carrying out the common fisheries policy (No MARE/2008/10 Lot2). The aim of the project was to develop a set of standard protocols for coupling and simultaneous analyses of EU fisheries logbook and VMS satellite vessel record data.

Tasks and Deliverables
The process began with the construction of standardized data formats for logbook (EFLALO) and VMS (TACSAT). The software for analyzing the data took the form of a fully documented package called vmstools, built using the freeware package, R (http://cran.rproject.org/). Once the data have been imported into R in the correct format, a series of R programs or 'functions', linked by 'scripts' enable all tasks necessary to be completed in a single software environment. The software can ‘clean’ data and format input data, estimate distances between VMS positions, and métiers can be identified objectively from species assemblages in catch data using multivariate statistical techniques.

We have included a range of complimentary methods for determining fishing activity from VMS position registrations. Positions at sea, for example, can be distinguished from vessels in harbor or erroneous positions on land. Position registrations of vessels actually fishing can be separated from those engaged in other activities (e.g. steaming) using their speed in conjunction with other information such as vessel size and gear being used.

Logbook and VMS data can be merged such that high-resolution spatial maps of catches of various commercial species can be generated. Individual vessel tracks can be reconstructed for more realism through different interpolation techniques (both linear and non-linear, i.e. using Hermite spline functions). Further, all the fishing activity indicators required under the Data Collection Framework can be calculated using vmstools. The package can also be used to explore the impact of different spatial (grid size) and temporal aggregations (month, quarterly, annual) which need to be explicitly considered when assessing fishing impact on the sea floor. There are also scripts for displaying results using Google Earth which is a useful aid for dissemination.

The combination of all these routines ‘under one roof’ permitted and permits the construction of ‘Regional’ databases (i.e. FishFrame developed by DTU Aqua - a regional database hosted by one of the project partners) and scripts to produce output suitable for this are included with the vmstools package.

As proof of concept, all analyses performed within each work package have been tested, using the vmstools package, against national datasets with contributions from the French, Danish, Irish, UK and Dutch institutes. As an example, FishFrame has been populated with Dutch and Danish combined VMS and logbook data for 2005-2009. The project demonstrated emphatically that logbook and VMS data from disparate countries with often different data collection regimens can be combined and compared using generic tools and that the output can be sent to regional databases permitting more holistic assessments of fishing activity.

The project has built further on the networks and platforms produced under EU FP6 EFIMAS Project coordinated by DTU Aqua, and the DTU Aqua team associated with the project has produced several peer reviewed journal papers under Lot 2.

The project is coordinated by Institute for Marine Resources and Ecosystem Studies (IMARES), Wageningen UR, The Netherlands.
This project is funded by EU, Framework Programme 7.
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01/01/2009 → 31/12/2012
Keywords: Research areas: Fisheries Management & Marine Living Resources
Collaborators: Wageningen IMARES, Sea Fisheries Institute, Marine Institute, Marine Scotland, Cefas Weymouth
Laboratory, IFREMER
Project: Research

Fehmarn Belt science provision project: Fehmarn Belt fish and fisheries and related environmental investigations (38669)

Objectives and Background
The purpose of the project was to investigate current exploited fish stock and fisheries dynamics in relation to the
monitoring and evaluation of spatially managed areas (MESMA) (38871)

The MESMA project focused on marine spatial planning and aimed to produce integrated management tools (concepts, models and guidelines) for monitoring, evaluating and implementing Spatially Managed Areas (SMAs). The main tasks in the project were information analysis, the development of a generic framework, the testing and evaluation of this framework through case-studies and the development of a toolbox. A significant proportion of the effort was centered on the case studies within five geographical regions: the North Sea, Baltic, Mediterranean, Atlantic, and Black Sea. This approach made it possible to compare pressures on an inter-regional level (e.g. offshore wind farms in the North Sea, Black Sea and Baltic), or a multi-pressure level for a specific region (e.g. SMA in fishing, wind-energy, geo-hazards and tourism in the Black Sea).

The project was coordinated by IMARES, Wageningen UR, The Netherlands.

The project was funded by EU, Framework Programme 7.
The shore crab and its parasites in Limfjorden. A model study of a marine invasive species in its home range (38870)

The purpose of the DTU Aqua part of the project is to collect and analyze data for a quantitative description of the population and parasite structure of the shore crab (Carcinus maenas) in Limfjord in Denmark. This includes quantitative information on the species’ geographical distribution in the Limfjord as well as estimates of abundance. The abundance estimates will be based on mark-recapture experiments and trawl survey data. Geographical distribution and year to year fluctuation in abundance of the shore crab will be related to key parameters such as salinity, depth and temperature.

The project is coordinated by University of Copenhagen, Denmark.

Bridging the gap between science, stakeholders and policy makers (GAP 1 & GAP 2) (38133 & 38860)

Stakeholders and scientists involved in GAP1 initiated cooperative research by making plans to combine knowledge in participatory research through a series of European and regional workshops. GAP1 represented phase 1 of a three-phase program that aimed to explore the complementary nature of alternative knowledge and investigate how to combine it in ways that will enhance understanding and management of natural resources. Tied to knowledge, GAP1 was an evidence-based approach that used participation as the vehicle to improve understanding on fisheries research and management issues of common concern to stakeholders, scientists and policy makers. Through initiation of cooperative research and facilitating the building of the capacity of stakeholders to engage in participatory research, GAP1 contributed towards the wider aspiration of the Science in Society program. In particular, enhancing the democratic debate with a more engaged and informed public, thus providing better conditions for collective choices on scientific issues relating to sustainable management, conservation of ecosystem integrity and biodiversity of the marine environment.

GAP2 was about making a difference to an issue of significance to the whole of society; the wellbeing of the marine environment and the sustainability of fisheries upon which society depends for food. It continued the relationships, processes and plans made in GAP1 by enabling Mobilization and Mutual Learning (MML) actions that promoted stakeholder participation in the debate and development of research knowledge and structures relevant to emerging policy on fisheries and the marine environment. The aims were to promote and enable processes for open and effective participation of stakeholders in research and management, demonstrate through specific examples and critical evaluation the role and value of stakeholder driven science in the governance of fisheries and the marine environment. DTU Aqua was the case study leader of one of the selected cases of GAP2.

Find full list of participants at the website of GAP2.

These projects were coordinated by the Centre for Environment, Fisheries and Aquaculture Science, UK. The projects were funded by EU, Framework Programme 7.

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01/01/2008 → 31/12/2015

Keywords: Research areas: Marine Living Resources & Population Genetics & Fisheries Management

Collaborators: Istituto Superiore per la Protezione e la Ricerca Ambientale, Pelagic Regional Advisory Council, Swedish National Board of Fisheries, Baltic Sea Regional Advisory Council, Universidade da Coruña, UiT The Arctic University of
Establishment and testing of area-based management models for North Sea sandeel fisheries (ETOMTOBIS) (38588)
The goal of this project is to investigate the effects of area-based management for sandeel stocks and the fisheries. Objectives include developing for optimal area-based management of sandeel fisheries in the North Sea. The tools will first be tested through computer simulations and the experience gained will be used to develop a revised management model at the end of the project.

The project will also help fisheries managers to act proactively to other marine management initiatives. In connection with the implementation of the EU Habitat Directive in the North Sea, EU coastal states appoint Natura 2000 areas by 2010. Area based analysis of population dynamics is therefore necessary to quantify the effect of fishing at the local level, and subsequently assess whether fisheries are affecting the habitat. Additional field-based analysis will be valuable in assessing interaction of the sandeel fishery with potential Natura 2000 areas. Spatial management is not only intended to restrict fishing. A description of the consequences for fisheries and sandeel population dynamics are important in assessing the benefits and drawbacks of introducing area-based management of sandeel fisheries in the North Sea.

Currently the sandeel fishery is managed under the assumption that there is one population of the sandeel (Ammodytes marinus) in the North Sea, in spite of this, the North Sea sandeel stock can be divided into several sub-populations. Based on recent research there is now a strong wish from ICES (see eg. ICES 2007 and 2008) and from the EU (see eg. STECF 2005), to introduce area based management of the sandeel fisheries, in order to adjust fishing to a level defined as sustainable for each of the local sub-populations.

Sandeel stocks in the North Sea will be divided into separate management units, each of which can be regarded as sub-populations who have little or no mutual exchange of both sand eel fry and adult sandeels, as presented in the final report of the project TORTN (project 38128). An assessment model will be developed to analyze sandeel population dynamics for each of the identified management units. A forecast model based on the relevant scientific surveys will predict the actual size of the sandeel recruitment in each of the management areas. Finally a tool will be developed that calculates the catch of sandeels in each of the management areas in a number of scenarios that include output of maximum sustainable yield, the most stable catches, and optimal fisheries management.

The project also includes a field sampling module, using two different methods, pelagic larval and demersal 0-group sampling, associated with a tool technological module for this collection to measure the size of the sandeel recruitment. The purpose of the field collection is to continue and analyze existing time series of field data to further develop area based recruitment indices. Field data should also be used as a fishery independent index of the sandeel stock size in the developed assessment model.

The project is coordinated by DTU Aqua.
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01/01/2008 → 31/12/2010
Keywords: Research area: Marine Living Resources
Collaborators: Danish Fishermen's Association
Project: Research

Influence of ecological dynamics and climate change on the marine environment in Danish waters (ECODYN) (38136)
The environment in the open Danish waters is controlled by a complex interplay between physical and biological processes, and it is therefore difficult to determine the exact cause of changes in the environment. This is also the situation for hypoxia, which is caused both by nutrients from sources ashore, by ecological dynamics of the waters, and by the flow in Kattegat and the Belts. This project examined the marine environment through three-dimensional numerical models which describe both physical and biological processes. In parallel, laboratory experiments clarified how temperature affects the biological rates at or near the sea floor. This was used to model the response of the ecosystem to the temperature increases which are expected as a result of climate change, and the future consequences for the marine
environment were analyzed. Through model simulations and oxygen measurements from ships and buoys, the biological processes leading to hypoxia were determined with the so far highest resolution in time and space; this contributed significantly to the understanding of the functioning of the ecosystem in this area.

The connection between the state of the marine environment and the abundance of fish was analyzed, focusing on the distribution and spawning regions of cod, in relation to the oxygen conditions in the inner Danish waters and in the Baltic Sea. Thereby, the project provided a description of interconnections between the ecosystem, the water flow, and the effects of a changing climate.

The project was coordinated by Department of Bioscience, Aarhus University, Denmark. The project was funded by the Danish Council for Strategic Research. Thysen, U. H., Project Manager, National Institute of Aquatic Resources, Section for Marine Living Resources Neuenfeldt, S., Project Participant, National Institute of Aquatic Resources Behrens, J., Project Participant, National Institute of Aquatic Resources

01/01/2008 → 01/04/2012

Keywords: Research areas: Marine Living Resources & Oceanography & Marine Populations and Ecosystem Dynamics & Fish Biology

Collaborators: Aarhus University, Danish Meteorological Institute, University of Copenhagen

Project: Research

**MEECE: Marine ecosystem evolution in a changing environment (MEECE) (38131)**

In order to advance our understanding and the predictive capacities necessary to resolve how marine ecosystems will respond to global change MEECE employed a combination of data synthesis, numerical simulation and targeted experimentation to further our knowledge of how marine ecosystems will respond to combinations of these climate change and anthropogenic drivers.

A key objective of MEECE was to advance model coupling across trophic levels and create concepts and infrastructure to enable end-to-end modeling, from physics to fish, which has empirically been difficult due to different space and time scales involved, as well as relative emphasis of statistical and mechanistic aspects. Finally MEECE integrated modeling advancements with fishery management perspectives.

The project was coordinated by Plymouth Marine Laboratory, UK, and had 21 partners from the EU.

The project was funded by EU, Framework Programme 7.


01/01/2008 → 15/10/2012

Keywords: Research areas: Marine Living Resources & Marine Populations and Ecosystem Dynamics & Fisheries Management

Project: Research

**MyOcean (38134)**

The project advanced and coordinated European scientific and technical infrastructure in the European operational oceanography community, for collecting and distributing ocean observations and ocean forecasts. DTU Aqua contributed by developing an integrated system for forecasting of sandeel fisheries in WP3 and in WP18 as reference intermediate user (RIU), for integrating operational oceanography products in marine resource management.

The project was coordinated by Mercator Ocean, France and had 52 partners from the EU.

The project was funded by EU, Framework Programme 7.

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01/01/2008 → 15/05/2012

Keywords: Research areas: Marine Living Resources & Oceanography

Project: Research

**Optimizing the exploitation of fishery resources in Skagerrak (OSKAR) (38720)**

The purpose of this project was formulated in 2008 to establish knowledge on the geographical distribution of target species in Skagerrak, which enables the fishermen to plan and execute sustainable fisheries on these species with a minimum of discard and unwanted by-catch of cod, and without drastically reductions or unjustified closure of areas.

OSKAR was a collaborative fishermen-scientist project building on the experience from the REX-project conducting small-scale scientific surveys with commercial ships.
To separate control issues of the mixed fishery of Skagerrak from the issues of using fishermen's and scientists' combined knowledge and experience to produce more selective fisheries, some of the key questions addressed were:
- Is it feasible to predict the size distribution of cod on a small spatial scale (single trawl haul) from surveys?
- How important are the seasonal changes for the spatial distribution of cod in Skagerrak?
- Can fishermen's anecdotic knowledge on the distribution of cod be used?
- Which role does mechanistic process knowledge play in determining critical spatial dynamics of cod?
- Taking also gear technology into account then how can we best produce e.g. a useful cod avoidance tool?

A new advanced geostatistical tool GeoPop was introduced in order to use all available survey data in the maximum likelihood estimation of temporal and spatial dynamics of the size distribution of the stock. Real time closures, future disallowance of discards etc. put the perspective of OSKAR into focus.

The development of GeoPop in this fishermen-scientist project has proven valuable (see Jansen et al 2016, Fish. Res. 179: 156-167 and refs herein). The method was published in 2013 (Kristensen et al 2013, Can. J. Fish. Aquat. Sci. 99: 1-19). Particular attention in GeoPop is paid to correlation between size classes within each trawl haul due to clustering of individuals with similar size. Extracting this nugget effect produces clearer population signals and allows e.g. following cohorts in space and time and determining stock structures. Although GeoPop today is fully TMB operated it is the present computer capacity which sets the limits to exploring e.g. the impacts of spatial heterogeneity on fishery stock assessment. The project was coordinated by DTU Aqua.

The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).

**Sustainable fisheries, climate change and the North Sea ecosystem (SUNFISH) (38135)**

Global climate changes will seriously challenge the governance of fisheries in the North Sea and elsewhere. Changes in temperature, wind conditions, river runoff and currents will affect primary and secondary production, the distribution, feeding, growth and survival of commercially exploited fish at all stages of life. Without improved knowledge about the effect of climate on the basic biological processes involved in fish production, it will be increasingly difficult to separate the effects of fishing from those of environmental fluctuations and change, identify biological reference points, and to develop management strategies for sustainable fisheries. By combining models of the effects of climate on the hydrographical and biological processes important for fish production with models of fish stock dynamics and fishing, the project provided a basis for improved predictions of the effects of climate change on the sustainable exploitation and maximum yield of North Sea fish stocks. The dynamics of cod (a top predator), herring and sandeel (two important prey for fish), seabirds and marine mammals were studied in detail. Their spawning, egg and larval drift, juvenile and adult distribution, growth and survival were investigated through experiments, statistical analyses of collected data and advanced bio-oceanographic models. The sustainability of exploitation under changing climate conditions were examined by modifying an existing stochastic multispecies fisheries model to make it account for climate effects on fish ecology. The project provided an integrated modelling framework for developing sustainable fisheries management strategies superior to using simple extrapolations of observed historical trends to predict the likely outcome of climate change on the North Sea ecosystem.

The project was coordinated by DTU Aqua.

The project was funded by the Danish Council for Strategic Research.

**Development and performance test of method for establishing an area based recruitment index for North Sea sandeels (TORTN) (38128)**

The project's overall objective is to establish a recruitment index for sandeel in the North Sea, for use in preparation of the scientific advice for North Sea sandeel fisheries. It is also an objective that this index should be developed in collaboration with the fishing industry. This is partly to increase the transparency and credibility of the scientific work but also to reduce the cost of setting up the necessary information to as low as possible.
It is of significant interest to be able to subdivide North Sea sandeel habitats based on well-founded biological and physical principles in order to provide spatial explicit stock assessment and advice on local fishing potential. Using hydrographic modeling and field sampling during the fishing season the coupled larval drift and population model (SPAM) will be validated.

The North Sea wide collection of winter hibernating sandeels from the seabed with the modified scallop dredges will be continued and the time series of abundance data will be analyzed. The project will further create a database of VMS, data corresponding to Danish vessels fishing for sand eels (defined by logbook database). From this data fishing effort, a fishing ground level will be estimated through the use of VMS and log book data. Using sandeel samples from the fishery area-based age-length keys will be developed using a continuation logit statistical approach. Combining recruitment data from population analysis and fisheries independent data on 0-group, the project will further develop, test and optimize a method for calculating the recruitment of 0-year-old sandeels to the North Sea stock. Real-time Monitoring of the sandeel fishery, which is the present basis for in season advice on fishing opportunities (applied 2004-2009), earliest establish the same basis by May i.e. in the middle of the fishing season. The new procedure developed in the project makes it possible to provide the scientific advice used in fisheries management in January, more than 2 months before the start of fishing season. Thus the procedure will allow the development of area based recruitment indices to manage the sandeel fishery in accordance with principles that ensure a more optimal utilization of sandeel stock and also reduces the risk of local overfishing.

The project is coordinated by DTU Aqua.

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01/01/2007 → 31/12/2008
Keywords: Research area: Marine Living Resources
Collaborators: Danish Fishermen’s Association
Project: Research

Improved methodology for cod age estimation (DECODE) (38120)
The objective of this project is to develop and implement an objective method for the age-determination of Eastern Baltic cod. The assessment for Eastern Baltic Cod (Sub-divisions 25-32) has presented a number of problems in recent years. The key problem is the severe inconsistencies in age determination which affect both the catch-at-age and the survey data. The methods to be developed within this project are based on the use of otolith biometrics. This procedure has proven successful in other stocks with age-reading problems. The data series on commercial and survey catch length distributions, otolith biometrics and biological parameters (collected for ICES Study Group on Ageing Issues in Baltic Cod (SGABC)) will be extended back as far as 2000. Mixture and conditional models to estimate age structure for a given component in stock assessment will be developed as statistically robust approaches to age-determination. Based on this new method, the historic catch and survey data will be reconstructed. The primary focus is on data for routine single-species assessments, but data for multi-species assessments will also be updated where possible.

The project is coordinated by DTU Aqua.
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01/01/2007 → 31/12/2009
Keywords: Research area: Marine Living Resources
Collaborators: Federal Research Centre for Fisheries, Morski Instytut Rybacki w Gdynia, Latvian Fish Resources Agency, Swedish National Board of Fisheries, Cefas Weymouth Laboratory
Project: Research

Spatially-explicit management methods for North Sea cod – a Danish fishermen-science collaboration (REX, REX II, REX III) (38430, 38431, 38541)
The REX project started in 2006 as a protest from the Danish Fishermen Association because fishers had a less pessimistic perception of the status of the cod stock in the North Sea than ICES, and they considered the agreed TAC levels far too low. In particular the fishermen considered the scientific surveys as inappropriate due to extremely low catches of large cod because of wrong gear and fishing on smooth bottom only. This seemed to call for more spatially-
explicit oriented approaches and REX was born with an aim of getting closer to a common understanding of the true number of adult cod in the North Sea by focusing on communication and collaboration in developing and implementing a scientifically sound and robust survey strategy with commercial ships in a north-eastern area selected by the Danish Fishermen Association using three vessels presenting different fishing methods (flyshooter, trawler and gillnetter).

The development of the fishermen-scientists collaboration with mutual respect has increased the understanding on both sides. In particular the emphasis on defining common goals, facing and solving conflicts immediately and extending thorough collaboration from survey planning, conducting of field work to interpretation of results during workshops have contributed to bridging the communication gab.

A better understanding of cod biology has also been a focal point in these projects through the new field studies incorporating fishermen’s knowledge. This includes distribution and migration, feeding behavior and importance of Hot-Spots (e.g. ship wrecks). Electronic tags were applied to learn about migration also in the Baltic. Together with the aim of continuing to obtain better assessments of the stocks such more mechanistically oriented studies are needed to answer two apparently simple questions “Where are the cod and why?”

The REX projects have strengthened the scientific collaboration with fishermen and produced several results and types of knowledge that will influence future work on developing spatial explicit management tools. REX also represents capacity building for DTU Aqua’s interdisciplinary field research and monitoring towards the spatial dynamics of cod.

The project is coordinated by DTU Aqua.
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01/01/2006 → 31/01/2010
Keywords: Research area: Marine Living Resources
Collaborators: Danish Fishermen's Association
Project: Research

Understanding the mechanisms of stock recovery (UNCOVER) (38104)
The UNCOVER project has produced a rational scientific basis for developing Long-Term Management Plans (LTMP) and recovery strategies for 11 of the ecologically and socioeconomically most important fish stocks/fisheries in the Norwegian and Barents Seas, the North Sea, the Baltic Sea and the Bay of Biscay and Iberian Peninsula.

UNCOVER’s objectives were to:

(i) identify changes experienced during stock depletion/collapses,

(ii) to understand prospects for recovery,

(iii) to enhance the scientific understanding of the mechanisms of fish stock/fishery recovery, and

(iv) to formulate recommendations how best to implement LTMPs/recovery plans.
The project recommends that such plans ideally should include:

(i) Consideration of stock-regulating environmental processes,
(ii) Incorporation of fisheries effects on stock structure and reproductive potential,
(iii) Consideration of changes in habitat dynamics due to global change,
(iv) Incorporation of biological and technological multispecies interactions,
(v) Integration of economically optimized harvesting,
(vi) Exploration of the socio-economic implications and political constraints from existing and alternative recovery plans,
(vii) Investigations on the acceptance of plans by stakeholders and specifically incentives for compliance by the fishery,
(viii) Agreements with and among stakeholders.

UNCOVER has provided imperative policy support underpinning the following fundamental areas:

(i) Evolution of the Common Fisheries Policy with respect to several aims of the ‘Green Paper’;
(ii) Contributing to the Marine Strategy Framework Directive with respect to fish stocks/communities;
(iii) achieving Maximum Sustainable Yield (MSY) for depleted fish stocks. This has been done by contributing to
LTMPs/recovery plans for fish stocks/fisheries, demonstrating how to shift from scientific advice based on limit reference
points towards setting and attaining targets such as MSY, and furthering ecosystem-based management through
incorporating multispecies, environmental and habitat, climate variability/change, and human dimensions into these plans.

The project was coordinated by Institut für Ostseefischerei, Bundesforschungsanstalt für Fischerei, Germany.
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01/01/2006 → 31/12/2010

Keywords: Research areas: Marine Living Resources & Fish Biology
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Laboratory, Marine Research Unit, Marine and Food Technological Centre, University of Hamburg
Project: Research

Bank resolved prognoses of sandeel fishing potential in the North Sea (38563)
Sandeel stocks in the North Sea have experienced successive recruitment failures within the last 5 years. There is an
urgent need to develop management tools that may contribute near and long term planning of the sandeel fishery and
understand the reasons behind recent recruitment failures.
The project has three main goals:

(i) To fill some of the current knowledge gaps in the biology of North Sea sandeels and evaluate the North Sea sandeel stock via monitoring programs;

(ii) To demonstrate by combining advanced modelling with biological knowledge, that it is possible to generate fishing potential prognoses for sandeel spatially resolved at bank levels, just like ubiquitous whether forecasts, which at sight may be incorporated in the fishery management process;

(iii) To develop the collaboration with the Danish Fishermen's Association (DF) and foster a sustainable sandeel fishery based on increased self regulation within the fishery.

The scientific activities in this project relate developing the necessary components, which are a premise for generating fishing potential forecasts. This encompasses computer model code writing and data collection. The efforts have been very successful and a first generation fishing potential forecast has been generated as final products of this project. On the modelling side two model components has been developed. The first is the larval module that describes hydrodynamical transport of sandeel larvae which is determining next year's recruitment. The second component is the population model which combines the hydrodynamical transport output with available biological data and knowledge into a spatially explicit sandeel stock model. Two fishing vessels take part in the project.

The project is coordinated by DTU Aqua.

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01/01/2005 → 31/12/2007

Collaborators: Danish Meteorological Institute, Danish Fishermen's Association

Keywords: Research area: Marine Living Resources

Project: Research

BLUE REEF (38179)
The overall project objective was to restore a rare marine habitat at a strategically important locality (Læsø Trindel) with the purpose of conservation of marine biodiversity.

The more specific objectives include:
- Stabilization and restoration of a cave-forming stone reef to favorable conservation status.
- Conservation and proper management of a reef donor area (larval dispersal) for the oxygen depleted inner Danish waters.
- Implementation through dissemination and cross-sectoral co-operation among authorities and local stakeholders.

Offshore boulder reefs have a high biodiversity and are a biologically important reef type at national and European level. At national levels these reef types are rare and Læsø Trindel constitutes one of 51 reef areas included in the Danish Natura 2000 network. In Denmark, shallow water boulder reefs have been extensively exploited for about a century, targeted for their easily accessible large boulders for constructing sea defenses and harbor jetties. A cautious estimate is that at least 34 km² of boulders from predominantly shallow cavernous reefs have been extracted from Danish waters and national monitoring programs indicate that only around 5 ha of the total original cavernous reefs have been left untouched.

The field experimental work was based on baseline surveys to be followed up by a survey 4 years after the deployment of the boulders; i.e. a "Before-After" approach. One role that DTU Aqua had in the project was to participate in the design of the restoration together with the other project partners. Based on the results from the multi-beam echo-sounder survey of the area conducted by GEUS in 2005, the reef restoration design was developed through several meetings between engineers and biologists/ecologists (Støttrup et al. in prep.). DTU Aqua’s main role in the project, however, was to document the ecology and biodiversity status of Læsø Trindel with focus on fish and shellfish assemblages before and after the restoration (Støttrup et al. 2014; Kristensen et al. 2 papers close to submission). This work was carried out in close collaboration with Aarhus University who is responsible for monitoring bottom fauna and flora. The baseline study has been carried out in 2007, just before the deployment of the boulders that should stabilize the remains of the original reef and restore its earlier shallow-water cavernous reef function. In 2012 the area was revisited using the same methodology and sampling program as in the baseline study.

The project was coordinated by Danish Nature Agency.

The project was funded by EU LIFE.

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01/01/2005 → 01/07/2012

Keywords: Research areas: Coastal Ecology & Marine Living Resources
Improved advice for the mixed herring stocks in the Skagerrak and Kattegat (ICES area IIIa) (2011)

The ICES working group on Herring Assessment for the Area South of 62°N (HAWG) has not been able to provide an advice applicable for the stock components in area IIIa due to limited resources to explore on the matter intersessionally. In previous years, the TAC for the fleets fishing herring in area IIIa have been decided by managers according to recommendations for the North Sea Autumn Spawners (NSAS), raised according to the historical fraction of NSAS in the catches by these fleets. The recommendation for the NSAS was guided by the need to rebuild that stock. By now, the NSAS stock has recovered and the main concern is for the Western Baltic Spring Spawners (WBSS) stock. The HAWG used a simple procedure in 2004 to find the highest total catch by fleet in area IIIa that would be compatible with a precautionary exploitation of WBSS. This procedure used two kinds of information about the fishery, the fraction of WBSS that is caught in area IIIa, and the fraction of the catches by the area IIIa fleets that consist of WBSS based on recent historic data. This very crude procedure can be refined with more detailed information on how the stocks on one hand and the fisheries on the other hand are distributed geographically and seasonally. Furthermore, the differences in both distribution and fishing pattern both in terms of season and stock components suggest a scope for a fishery management that is more fishery and stock oriented, allowing for more directed stock-wise exploitation. The primary goal of the project is to improve the assessment and advice of the mixed stock in area IIIa by elaborating fleet- and stock-based disaggregation on the existing projection method. The advice would so take into account both stocks and all fleet components in area IIIa. Temporal and spatial distribution of the different stock components and fleet exploitation patterns will form the basis for the elaboration.

The project was coordinated by DTU Aqua.

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Keywords: Research area: Marine Living Resources

Critical interactions between species and their implications for a precautionary fisheries management in a variable environment – a modeling approach (BECAUSE) (38613)

Across Europe, the population of predatory fish has fallen dramatically in recent years. This has reduced the predation rate and the prey species has remained fairly stable. Therefore the balance between predators and prey species has been radically changed. No accurate scientific picture of the exact interactions between these species and their effects on non-commercial top predators is available. To maintain biodiversity and make recovery plans more effective, such an understanding is vital.

The sustainable management of European fisheries requires an adaptive approach that takes into account the long term dynamics of the entire marine ecosystem so as to protect the biodiversity of our seas. BECAUSE investigated the interaction between predator and prey, and the shifts in their relative populations and looked into how fishing affects the balance of the marine food chain. The interactions targeted for investigation included sandeel/predator fish, predators and prey of cod, and hake/prey fish.

Contributions to the policy development aimed at integrating a sustainable ecosystem approach into the EU’s Common Fisheries Policy (CFP) thereby helping the EU to meet its global fishing commitments and underwrite the sustainability of ecosystem services. Multi-species fisheries assessment were improved and enhanced policy and management measures to replenish fish stocks and ensure high yields were proposed.

The was coordinated by Universität Hamburg, Germany.
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Analysis of biological key parameters, population structure and population dynamics of the lesser sandeel (Ammodytes marinus) in the North Sea, based on detailed information about the sandeel fishery (AHA.DOT) (2167)

The overall goal is to establish the scientific basis for a management system for the North Sea sandeel fishery that will prevent local depletion of sandeels due to fishing and improve the yield of the fishery.

Stock assessment of sandeels in the North Sea is based on the assumption that there is one stock of sandeels in the North Sea and one stock in the Shetland area. However, recent investigations suggest that sandeels in the North Sea can be divided into several stock components or sub-stocks. Further, growth and fecundity seem to vary significantly between the different stock components. This project will analyse spatial trends in key biological parameters (emergence behaviour, growth and fecundity) and the distribution of the lesser sandeel Ammodytes marinus in the North Sea. Additionally the drift pattern of sandeels larvae between the spawning areas will be analysed by use of a hydrographical model. Information about distribution, biological parameters and the drift of larvae will be used to define the stock components of sandeels to be assessed as separate population units.

Besides the lack of information about the spatial heterogeneity on the biology of sandeels, the possibility to carry out regional assessments is hindered by a lack of information about the sandeel fishery and the catches of sandeels, where the main problem being the level of aggregation of the data. To carry out assessments for each of the stock components separately, more detailed information about the fishery and the catches of sandeels is needed. The data available about the fishery can only be allocated to ICES rectangles. However, data will have to be allocated to fishing grounds. Effort and catch data as well as biological samples has since 1999 been collected on a by haul basis for 15-20 Danish vessels representing the existing vessel categories and fishing pattern in the Danish North Sea sandeel fishery. During this project satellite data for all Danish vessels fishing sandeels in the North Sea will together with the detailed data from the 15-20 vessels, be used to disaggregate data on effort and catches of sandeels, from being on a trip and ICES rectangle level to being on a haul and fishing ground level.

The information about the biology and population structure of sandeels and the detailed data about catches and effort will be used to carry out separate assessments of each of the stock components of sandeels. Furthermore, a model that was developed at DTU Aqua (THEMAS) will be used to simulate the effect of different management scenarios on the fishing fleet and the sandeel populations.

The project was coordinated by DTU Aqua.

Keywords: Research area: Marine Living Resources
Collaborators: Krog Consult ApS, Marine Scotland Science, Danish Fishermen's Association, University of Hamburg
Project: Research

Cooperative agreement between Greenland Institute of Natural Resources and DTU Aqua (38085)

DTU Aqua supports the Greenland Institute of Natural Resources (GINR) within general fisheries biology, assessment, survey planning and evaluation and education and support of young scientists. The scientists are also engaged in formulation of advice to the Greenland Government in several ICES Expert Groups such as North Western Working Group (NWWG) and Working Group for Widely Distributed Stocks (WGWIDE), North East Atlantic Fisheries Commission (NEAFC) and North West Atlantic Fisheries Organization (NAFO). ICES and NAFO are
further the platforms where important assessment issues such as stock ID, assessment methods and survey techniques are discussed and applied in the advisory service.
Further scientists acts as appointed experts at the Self-Governments bilateral fisheries meetings and costal state meetings.
During the years DTU has recruited eight scientists from GINR while one scientist has been recruited from DTU Aqua to GINR.
The project is coordinated by DTU Aqua.
The project is funded by the Greenland Institute of Natural Resources.
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01/01/2001 → …
Keywords: Research areas: Fisheries Management & Marine Living Resources
Collaborators: Greenland Institute of Natural Resources
Project: Research