Impact Objectives

- Identify and quantify multi-stressor impacts and feedbacks in ocean systems
- Assess socioeconomic vulnerabilities and adaptive capacity
- Address ocean policy and management issues

Creating certainty

***OCEAN-CERTAIN** is an ambitious collaborative project working to create more certainty about the contributions of our oceans during climate change*

Climate change poses serious risks for both natural systems and human beings, and plausible and feasible policy decisions and strategies to mitigate these risks are urgently needed. However, there are important knowledge gaps surrounding the large-scale natural processes and interactions with social-economic processes that play an important role for our oceans. The multi-disciplinary project OCEAN-CERTAIN (Ocean Food-web Patrol – Climate Effects: Reducing Targeted Uncertainties with an Interactive Network) aims to shed light on these processes. OCEAN-CERTAIN is an EU FP7 project that comprises 11 partners from eight European countries, Chile and Australia. It started in 2013 and is due for completion in 2017. It includes both natural scientists, who will work with the ecosystem and the biological pump, and social scientists who will study possible consequences for society.

Project Coordinator Professor Yngvar Olsen, based at the Department of Biology at the Norwegian University of Science and Technology (NTNU), explains that the researchers involved are 'working to identify and quantify multi-stressor impacts and feedbacks and explore how these alter the functionality and structure of the food web and the efficiency of the biological pump (BP) in different bio-geographical regions'. Scientific Coordinator Professor Murat Van Ardelan, from the Department of Chemistry at NTNU, says that using a multi-disciplinary model to accumulate knowledge and experience on climate related ocean science has been valuable for OCEAN-CERTAIN: 'Our team's experience and knowledge make us one of the pioneers in integrative multi-disciplinary climate related ocean science.' Operational Manger Rachel Tiller, from the Department of Political Science at NTNU and SINTEF Ocean expands on this and says that 'One of the pioneering activities of OCEAN-CERTAIN is precisely to integrate the natural and social sciences. This is done by holding participatory stakeholder workshops in three different regions, and translating this qualitative data into quantitative data for the decision-support modelling which in turn will be able to assist in informing decision making at national and regional levels.'

COMBINING KNOWLEDGE

The project's key goals include identifying and quantifying multi-stressor impacts on the functionalities and structure of the food web (FW) and estimating the efficiency of the biological pump (BP) in exporting and sequestering carbon as a response to these stressors. In addition, the team is working to identify the interactions between climate related oceanic processes and global climate dynamics. Olsen says another of their goals is to 'integrate marine ecosystem scenarios with probable socioeconomic scenarios to help quantify human feedback to the coupled socio-ecological system, relevant to mitigation and adaptation pathways and the development of scenario-based impact prediction capacity that is important for developing effective policy strategies'. This is critical for the Decision Support System (DSS) that is produced and tested in OCEAN-CERTAIN, where they couple findings from both qualitative and quantitative data, and assess the ability of these tools to support policy strategies for sustainable exploitation of marine resources under different climate scenarios.

To achieve these goals the work required has been broken down into seven Work Packages (WP). WP1 derives existing data from international databases as a support to the experimental and modelling work in WP2, which focuses on the natural sciences, including conceptual modelling, mesocosm and microcosm experiments, cruises to collect data from the Mediterranean Sea, and ecological modelling. WP3 explores the vulnerability and adaptive capacity of human communities in Norway, Chile and Turkey under different scenarios of instability and changes in the biological pump. WP4 synthesises the interactions between participants and WPs, bringing the work together and assessing the results holistically. W5 is responsible for the software architecture and technical implementation of the DSS, while WP6 covers the dissemination of results.WP7 is coordination of the overall project. 'We have used field studies, experimental approaches and modelling to analyse the interactions between climatic and non-climatic stressors/drivers, microbial ecosystem structure and functions and we attempt to estimate the connections between the changes in microbial food web and biological carbon pump,' explains Ardelan.

SUCCESSFUL RESULTS

The main cruises and field experiments, as well as the first rounds of stakeholder workshops and the final version of the DSS for OCEAN-CERTAIN, are now finished. The researchers involved have discovered that the changes of the food web structure under different stressors, which can influence ecosystem functioning and carbon export, depend heavily on the spatial and temporal conditions. Olsen says that the project outcomes now have the potential to be used to support and implement participatory governance, involving scientific experts, local stakeholders and administrations.

The project has developed a network of interdisciplinary researchers that will continue using the knowledge they have accumulated during OCEAN-CERTAIN in future projects, particularly dealing with multi-stressors effects on marine ecosystem and biogeochemical processes in the changing oceans.

Climate clarity from complexity

OCEAN-CERTAIN Team members Yngvar Olsen, Murat Van Ardelan, Rachel Tiller and Jean-Luc De Kok provide insights about their work which is setting out to explore if, and how, the activity and function of the biological pump is vulnerable to climate change and human interference




Clockwise from top left: Yngvar Olsen, Murat Van Ardelan, Rachel Tiller and Jean-Luc De Kok

> *'Our team's experience and knowledge make us one of the pioneers in multi-disciplinary climate related ocean science'*

Can you explain the objectives of the OCEAN-CERTAIN project?

YO: Uncertainty on the action of the biological pump and its stability during climate change has been problematic in predicting future climate change. OCEAN-CERTAIN should address how societies and economies might be affected, to ensure that the situation can be handled in the best way for the world's population. It is important that we know about and have a sound understanding of the important natural processes that can counteract climate change, so that future climate-related predictions can be improved and the oceans can be managed in a way that strengthens, rather than weakens, the biological pump.

How did you each become involved in this project?

YO: I am the OCEAN-CERTAIN Project Coordinator. My main background is studying plankton nutrition, which includes functional groups of autotrophic phytoplankton, heterotrophic zooplankton and heterotrophic bacteria. The planktonic food webs in the ocean is a key target in studies of productivity and issues of marine environment, and it is also central for climate issues of carbon export and sequestration (processes that bring carbon out of the biological cycle, soil formation) in the ocean. My background in food web dynamics of the complete marine planktonic ecosystem and my knowledge on structure and functioning of the important functional groups of organisms brought me into this project.

MVA: I am an associate professor in the Department of Chemistry at the Norwegian University of Science and Technology (NTNU). My study area is the marine biogeochemical processes in different seas. I am the proposal initiator, and scientific manager, of OCEAN-CERTAIN.

RT: I am a Research Scientist at SINTEF Ocean at the section for Governance, Climate and Security. I have a PhD in political science with a highly interdisciplinary angle, where I explored possible geopolitical future scenarios in the High North considering changes in distribution patterns of the plankton Calanus finmarchicus. The project leader of the Calanus project, where this PhD project belonged, was Professor Yngvar Olsen. After the end of my PhD, he introduced me to Associate Professor Murat Van Ardelan and suggested the three of us work together on interdisciplinary project proposals. This we did, and we were rewarded immediately with a nationally funded research project on the effects of eutrophication changes to local coastal and marine communities and stakeholder conflicts. We became good friends and colleagues during these years, and started to work together towards developing our focus on interdisciplinarity further – when Murat Van Ardelan suggested an FP7 call that he believed we could be strong in. This was the call to which we submitted OCEAN-CERTAIN.

JLDK: I have a PhD in physics, and have been working in the field of integrated water management, applied systems modelling and science-policy exchange since 1994. As of 2008 I have worked at the Environmental Modelling Unit of the Flemish Institute for Technological Research (VITO) in Belgium. My work focuses on research related to the design of policy support tools and system dynamics modelling of integrated social-environmental and water systems. My research interests include science-policy and natural-social science integration, and the design of policy-support tools. I participated in a number of complex, integrated modelling studies of coastal zones and river basins in Indonesia, Germany, the Netherlands, and EU funded projects. Currently I coordinate the decision-support work package (WP5) in OCEAN-CERTAIN, and VITO contributed to WP3. My work tasks include research, project management, and research funding acquisition.

In what ways will this research fill gaps in knowledge?

MVA: The ambition is to come through with the information that normal biogeochemical processes in the sea sequester carbon and mitigates CO_2 accumulation in the atmosphere and that we must take care not to disturb these processes negatively in our use of the ocean and as a consequence of global change. The development of a decision support system (DSS) will allow us a closer look at the complex human and natural science interactions.

How are you going about working out a DSS and can you explain why this is important?

JLDK: The design of the DSS is strongly problem- and end-user driven. The choice was made not to integrate scientific models and data directly but use so-called 'metamodels' to represent these, using a generic, modular design that will make it easier to maintain the DSS and apply in new projects. We have also developed a system dynamics model for the socio-economics. The latter has been fully integrated with the food-web submodel of the DSS without compromising the nature of the underlying concepts and models used. The design trajectory of the DSS has been an iterative process, in which local stakeholders, social and natural scientists and software developers interacted throughout the project.

What are the socio-economic analyses you are performing?

RT: We use a mix of methods for our socio-economic analysis. These include cognitive maps (systems thinking), backcasting and the development of stakeholder driven future scenarios (Bayesian Belief Networks) and quantifying this data into weighted variables in so-called Fuzzy Cognitive Maps (FCMs) to analyse system feedback in an intuitive manner. The FCMs were then translated for use in the DSS. For example, if a commercial fisher said that an increase in the key fish species would have a +3 (strong) effect on his income, we used our own expertise and 'local knowledge' of stakeholders to make a qualitative assessment of the impacts on other variables. For the final version of the DSS a detailed analysis was made of the common social and economic processes for the three case studies. The results were translated into a fully quantitative, 'stock-and-flow' model, which was integrated with the ecological and physical models.

Have you unearthed any important findings to date?

MVA: Our experimental results in conjunction with modelling activities show that the changes of the food web structure under the different stressors, which can influence ecosystem functioning and carbon export, depend heavily on the spatial and temporal conditions. These natural variabilities in the responses of the marine ecosystem to multi stressors should carefully be differentiated from the term of 'uncertainty'.

Can you talk about the project's possible impacts on society?

RT: We have developed a DSS combining social science data (qualitative) with natural science data (modelling) to compare different policy options. This has often been suggested as an optimal solution for extracting stakeholder (local) knowledge and legitimacy, but is seldom implemented or tested with full feedback between the natural and social subsystem. In addition, the generic toolkit of the project and DSS will have been tested on three different case areas, allowing for similar studies to be done in other regions, using the similar or even new principles and assumptions.

How are you disseminating the project results?

MVA: Knowledge transfer in the scientific communities has been performed through scientific publications, participations of conferences, meetings and workshops. For cross-sectoral dissemination, we have chosen the World Ocean Council meetings to interact and disseminate our results to industrial stakeholders. The Ocean Certain project is one of the pioneers in using artificial intelligent techniques for extraction of information from scientific literature. It aims to support the scientists in linking the findings reported by researchers across multiple, related disciplines.

Project Insights

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Professor Yngvar Olsen is a full Professor at the Norwegian University of Science and Technology (NTNU), from 1995 until present. He was Director of the Strategic Marine Focus Area at NTNU, responsible for facilitating and coordinating interdiciplinary marine research at the universty from 2006 until 2013. Olsen has 30 years experience within the main research field of plankton ecology and environmental interactions of aquaculture. He has published 160 papers in peer-reviewed journals, educated 19 PhD students, and been a member of many international boards and committees. Relevant scientific intererests are structure and function of plankton communities, plankton nutrition, food web dynamics, trophic cascades, biochemical composition, and nutrient cycling.

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