NorMER

NORDIC CENTRE FOR RESEARCH ON MARINE ECOSYSTEMS AND RESOURCES UNDER CLIMATE CHANGE — 2012

OVERVIEW: *NorMER in brief*

NorMER *(Nordic Centre for Research on Marine Ecosystems and Resources under Climate Change; www.normer.org)* is a Nordic Centre of Excellence that brings together the expertise of leading research groups from all Nordic countries, and several North American institutions, to implement a collective and multidisciplinary research strategy to explore the biological, economic, and management consequences of global climate change on fisheries resources. It will achieve this through a unique program of primary research, implemented by PhDs and Postdocs in a system of collaborative projects, with a focus on the Atlantic cod *(Gadus morhua)*. Though our Nordic focus is on cod, this research is intended to be a platform to extend this knowledge to other marine systems.

The aims and corresponding actions of NorMER are:

1 Perform effect studies to: *(1)* evaluate climate effects on Nordic marine ecosystems, *(2)* Build new tools for predicting biological consequences of climate change, and *(3)* quantify impacts on profit, employment, and harvesting.
➟ **Actions:** PhDs are co-supervised internationally. Postdocs collaborate internationally. Leading senior scientists and climate researchers provide expert input.

2 Create an effective training environment for young researchers.
➟ **Actions:** Annual meetings, graduate courses, and special workshops focus on transferable and interdisciplinary skills. Regular interaction between students and international experts in climate- and marine ecosystem-related fields further strengthen the training program in NorMER.

3 Develop a team of outstanding global quality.
➟ **Actions:** Research institutions from every Nordic country are partners. International researchers and industry representatives are invited to annual meetings. A 7-member Centre Advisory Panel (CAP), consisting of an interdisciplinary mix of globally leading researchers participate at all annual meetings. Annually, one internationally distinguished researcher is selected as the honored Johan Hjort Chair to participate at the annual meeting to share expertise with NorMER partners and students.

4 Link to industry and policy managers.
➟ **Actions:** Industry and Policy representatives from each of the Nordic countries are encouraged to attend annual meetings for discussing societal/economic effects of climate change, and to learn more about NorMER work. PhD students will be encouraged to visit marine industries or participate in commercial fishing. A strong bio-economic focus within NorMER will facilitate transference of results to fisheries managers.

5 Update marine ecosystem management policies to sustain healthy fisheries.
➟ **Actions:** NorMER is a research based program to evaluate the effects of climate variability on marine ecosystems and how fisheries management can be adapted to maintain sustainable harvest levels. We hope to produce strong results, built on solid fundamental science, that will be applied to real systems in the Nordic region.

NorMER is primarily supported with funding from Nordforsk, on behalf of the Top-level Research Initiative (TRI), and from each of the main partners. The Centre is administered by the CEES in the Department of Biology at the University of Oslo, but this is a pan-Nordic collaborative project, which includes research teams led by Nils Chr. Stenseth at the University of Oslo, Carl Folke of the Stockholm Resilience Centre in Sweden, Erik Bonsdorff at Åbo Adakemi University in Finland, Marko Lindroos at the University of Helsinki in Finland, Markus Meier at the Swedish Meteorological and Hydrological Institute in Sweden, Guðrún Marteinsdóttir at Marine Academic Research in Iceland, Eyðfinn Magnussen at the University of Faroe Islands, Helle Siegstad at the Greenland Institute of Natural Resources, Øyvind Fiksen at the University of Bergen in Norway, and Thomas Kiørboe at the Technical University of Denmark.

Credits

Art direction and design by Jostein Strand Henriksen.
Organization and content by Jason D. Whittington.
Front cover photograph by Ruben A. Pettersen.
This report was printed November 2012 by printbox.no.

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The eye of a monkfish *(Lophius piscatorius)* taken under water close to Kristiansund, Norway.

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Photography: Ruben A. Pettersen

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SECTION ONE:
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The eggs of salmon *(Salmo salar)* from an experiment conducted by the Norwegian National Veterinary Institue (NVI).

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Photography: Ruben A. Pettersen

Comments from the Chair of NorMER

PROF. NILS CHR. STENSETH
Centre for Ecological and Evolutionary Synthesis (CEES)

We have been through our first full year as a 'Nordic Centre for Research on Marine Ecosystems and Resources under Climate Change' (NorMER), a Nordic Centre of Excellence focusing on training Young Researchers (PhDs and Postdocs) within the topic of how climate change is affecting marine systems – from ecology and evolution, to economics and management. Although our perspective is general, we are focusing on cod *(Gadus morhua)* as our model organism because we believe this will make it easier to integrate the different disciplines involved within NorMER: all NorMER members will have one common marine system over which they can combine and apply their diverse expertise.

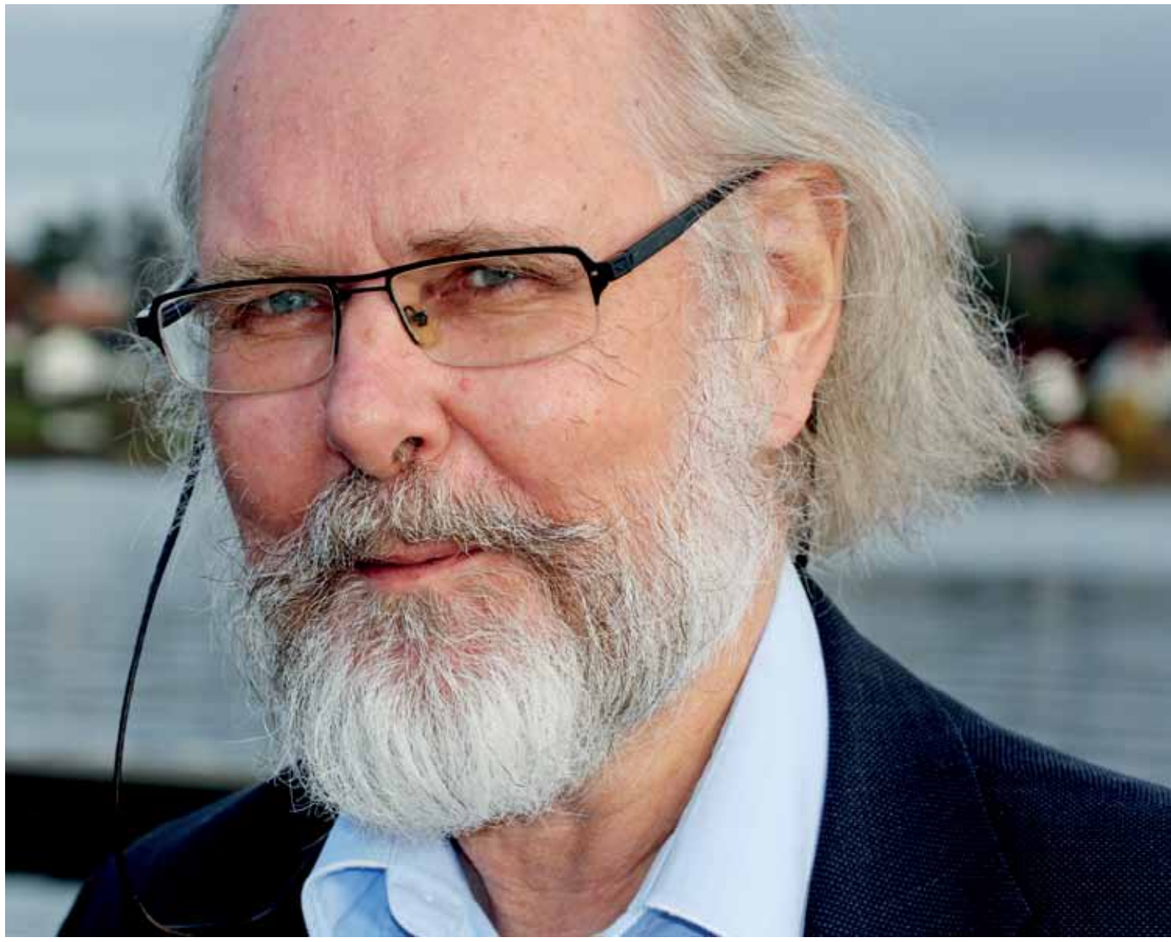
Having observed the developments during the first year, I feel confident that we are on the right track relative to our ambitions of being a truly Nordic Centre of Excellence. First of all, we have secured good funding. Second, we have established an excellent team of Young Researchers (YR) – both PhDs and Postdocs. Third, there is an excellent interdisciplinary interaction among the YR. Fourth, the 10 core partner nodes work well together to develop a well-integrated virtual centre. Fifth, we are being provided with good feedback from our Centre Advisory Panel (CAP). NorMER is indeed developing into a successful, fully integrated pan-Nordic centre. Already after only one year, we see clearly how NorMER creates a platform for growing a new generation of interdisciplinary Young Researchers with experience in combining physical, biological, social and economic aspects of marine ecosystem science and management. These interdisciplinary Young Researchers are being trained by specialists of various disciplines in a collaborative environment. This is being achieved, in part, through visits lasting for several months at partner institutions. Besides providing PhD students and Postdocs with valuable interdisciplinary training, this shared exchange with scientists from the collaborating institutions in the Nordic countries will contribute to bringing our various scientific groups closer together. In addition, the Young Researchers are organizing activities among themselves – activities which will further develop their interdisciplinary training and their scientific collaboration skills. Altogether, this will lead to, I am confident, a stronger Nordic position on leading scientific endeavors both in Europe and globally.

NorMER is designed so that each of the PhD and Postdoc projects has a strong 'curiosity-driven' scientific element: our overall ambition is to provide solid and high-quality science. In addition to the 'curiosity-driven' elements, the entire NorMER program has been designed so that our center will address many important 'problem-solving' and 'challenge-driven' issues raised by scientists, politicians and managers in response to ongoing changes in climate. This means that the new insight obtained within NorMER will ideally be applied in order to improve our management of marine ecosystems under climate change. Such emerging effects of NorMER focusing on the 'problem-solving' and 'challenge-driven' issues will for sure not come by itself. The NorMER leadership – and each of the supervisors – will have to pay particular attention to this aspect of NorMER. The joint YR activities will certainly help in this respect. I suggest that we should aim at producing some good review/perspective papers addressing the overall focus of NorMER: *what will the effect of climate change be on the marine system – and how should we humans best adapt to it so as to reduce the damaging effect of climate change.*

Communicating our perspectives and results to a broad spectrum of people, not the least to politicians, is an important part of NorMER. In order to facilitate such a dialogue with politicians and managers about the science we are doing within NorMER, we organized – just as we did the year before – an open session at the University of Helsinki in connection with our second NorMER annual meeting. At that opening session, both the Finnish Minister of Environment, Ville Niinistö, and the Vice Rector of the University of Helsinki, Jukka Kola, participated – as did the former Norwegian Minister of Research and Higher Education, Tora Aasland. This opening session was a great success – as was the annual meeting that immediately followed.

Beside communicating the ambitions and objectives of NorMER at such formal sessions like the opening session of the annual meeting, we aim at developing a rather proactive communication strategy. The Young Researchers' blog (www.normer.uio.no/blog) is part of such a strategy. In addition we will in the coming year aim at being far more visible in national and international general media.

In short, NorMER is growing as a Nordic Centre of Excellence fostering high international visibility of science carried out within the Nordic countries. NorMER shall foster,
— Excellence in Ecological Sciences: *we aim at producing scientific papers to be published in the best possible international journals within the field of ecology;*
— Excellence in Evolutionary Sciences: *we aim at producing scientific papers to be published in the best possible international journals within the field of evolution;*
— Excellence in Economic Sciences: *we aim at producing scientific papers to be published in the best possible international journals within the fields of economy and management;*
— Excellence in Interdisciplinary Sciences: *we aim at producing scientific papers to be published in the best possible international journals with a broad interdisciplinary focus and readership.*



Photography: Eva C. Simensen

The Young Researchers are playing key roles within NorMER: they are the new generation who will play leading roles in marine research and management programs in the future. Recruiting PhDs and Postdocs is therefore of utmost importance to the success of NorMER. I am pleased to observe that we, in the second round of recruiting new members, got many more than the average number of – very good – applicants; observing the great interest from young people all over the world who want to come and work with us is indeed both promising and stimulating. We have now appointed most of the PhD and Postdoc positions that were originally planned: we have altogether appointed 14 PhDs and 8 Postdocs, with 2 PhDs and 1 Postdoc still pending. Altogether we are now 22 Young Researchers. Here are some of the highlights from the students work:

NorMER PhD Ana Sofia Ferreira has been assessing how ocean circulation influences the match-mismatch of phytoplankton bloom timing and spatial orientation relative to the timing of fish spawning (see page 26). NorMER PhD Rebecca Holt has been modelling the effects of changes in temperature on the physiological performance and life history strategies in teleost fish such as cod (see page 29). NorMER PhD William Butler has been mapping the spawning and nursery grounds of Atlantic cod along the Icelandic coast (see page 27). NorMER Postdoc Lauren Rogers has been using state-space models to assess the dynamics of spatially-structured populations of cod in the Skagarrak region (see page 28). NorMER PhD Emmi Nieminen has applied Game Theory approaches to Baltic Sea fisheries to develop more optimal bioeconomic multispecies fisheries management (see page 30). Finally, you can read about a Young Researcher initiative, involving all of the PhDs and Postdocs in NorMER, to objectively assess the current state of climate change research in the Nordic region, to identify both trends and gaps in knowledge (see page 32). These are only an overview of a few of the many great projects we are developing within NorMER, projects which are 'curiosity-driven' in their nature, but which will contribute to the 'problem-solving' mission of NorMER.

I am convinced that these Young Researchers will be able to produce good papers to be published in the very best journals within the respective fields as well as in the more general journals, taking advantage of the guidance – and encouragement – they will get from the senior members of the NorMER team.

The international links to research groups outside the Nordic countries have been an important part of NorMER. I am therefore pleased to acknowledge additional funding we received from Nordforsk to appoint two additional Postdocs, which provide strong links to respected international groups (Bodega Marine Lab at UC Davis, Northwest Fisheries Science Center, and University of Washington in Seattle). We also received funding from the Research Council of Norway for an additional Postdoc and PhD linked with the University of British Columbia Fisheries Centre. These links further broaden the already extensive network brought to NorMER by the senior members. Such an extensive network will surely benefit the YR during their training periods within NorMER, and continue to benefit them throughout their careers.

The added value of being part of a network like NorMER derives from this extensive Nordic – and increasingly global – network. Furthermore, the fact that each of the Young Researchers is participating in joint work within NorMER means that they will be involved in more – and better – papers than they otherwise would. The YR-organized workshops within NorMER have contributed greatly to strengthening this Nordic network, as well as giving the Young Researchers practical experience in collaborative, interdisciplinary research (see page 32). Also, the joint courses being organized contribute to this added value: we might want in the coming years to further develop this, e.g., through bringing in additional experts.

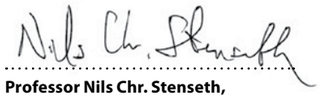
One feature we have not yet taken full advantage of is the fact that we have competence on most of the key components of the marine ecosystem – without bringing in more ecosystem modelling aspects. We will aim at doing this in the next year or so – possibly though specially organized courses or workshops. Indeed such ecosystem modelling might help us to even better integrate the various components of NorMER.

Once again, observing the initial development of NorMER leaves me with great optimism. I am eagerly looking forward to the years to come – I am sure that much exciting science of great value to scientists, politicians and managers will come out of NorMER.

We will, with the able help of Bob Dickson, honor the achievement of the creation of NorMER, and commemorate the inspiration behind NorMER into the future, with the establishment of University of Oslo Inspiration Awards (see page 38). The first two, in the form of two historically valuable scientific texts, were handed out by Bob Dickson at the NorMER 2011 Annual Meeting to Jim Hurrell and myself to honor our inspiring contributions to science – two awards we both humbly received with great appreciation. The third and fourth awards were handed out at the recent NorMER 2012 Annual Meeting to Tora Aasland, and Gregory Beaugrand and Martin Edwards. These same awards will be re-awarded to new inspiring awardees every few years into the future.

We certainly aim at continuing our work – within the NorMER platform – beyond 2015. We have already started to think about our strategy for the continuation of NorMER. I'm convinced that the current good work carried out by the YR – both alone and together with the senior members of NorMER – will help in this respect. I personally see that there is a need for such a research and training platform beyond 2016. One way to secure a continued existence is to link up with the larger European and international networks. However, without a longer term commitment from the involved partner institutions, such a continued existence will be difficult.

Many colleagues have contributed to the very good development of NorMER. First of all, I am sincerely thankful to the Young Researchers for their enthusiasm and dedication to make NorMER a true centre of excellence – excellence in ecological science, in evolutionary science, in economic science and in interdisciplinary science. Secondly, I am thankful to our Johan Hjort Chairs (Bob Dickson and Rashid Sumaila) for their inspiration and guidance. Thirdly I am very thankful to the group leaders of the 10 collaborating institutions in the Nordic countries; in particular I would like to thank my co-chair, Carl Folke, for helping us develop NorMER as a proper interdisciplinary Nordic Centre of Excellence and the Center Advisory Panel (CAP), chaired by Philippe Cury and consisting of top-level scientists within the broad spectrum of fields covered by NorMER. Finally it is a great pleasure to thank Jason D. Whittington for his very talented and great assistance in developing NorMER; together with Gry Gundersen, he helps Carl and myself with all aspects of chairing NorMER – assistance spanning all sort of issues from the very small details to the larger strategic scientific and management decisions. Indeed, it would be hard to think of how to further develop the scientific platform of NorMER without the able help of Jason; it would be equally difficult to think of how to administrate NorMER with its complicated consortium agreement without the able help of Gry: thanks Jason and Gry.



Professor Nils Chr. Stenseth,
Chair of NorMER

Comments from the Centre Advisory Panel (CAP) Chair

PHILIPPE CURY
Institut de Recherche pour le Développement, France

Before closing, and on behalf of the CAP, I would like to congratulate each of you for the quality of your research and for your involvement in NorMER. The CAP was extremely pleased to appreciate the great progress you made during the last year and today. Your presentations illustrated the immense scientific progress that was made.

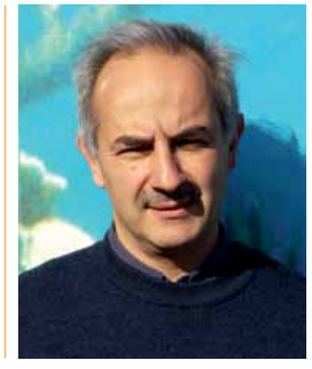
This is a critical time for NorMER, as you will start to deliver during this year the scientific results that constitute the core of NorMER. This is also an important time, as we need to construct a global strategy for NorMER and its future.

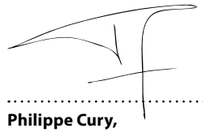
In 2015, you should have an excellent thesis of which you can be proud, but you should also be proud for having the priviledge of participating in this incredible multidisciplinary adventure initiated by NorMER.

The future of our marine ecosystems deserve our attention collectively as their importance and scientific value are immense. The major objectives NorMER hopes to achieve can be met through cooperation between scientists, as collaboration is key to sharing the scientific experience *(science is fun: particularly when made with good friends!)*

Be curious, be creative, but also do not forget to put your research project into a broader NorMER context (i.e. the such as within both global change and the future ecosystem dynamics).

Rashid Sumaila tells his students that he wants to help them develop a 'trained mind' and I would like to add also a 'committed mind!' **Congratulations for your work and see you all in one year.**





Philippe Cury,
Chair of CAP

SECTION TWO:
New faces

Historical Atlantic cod specimen. DNA retrieved from historic samples may reveal patterns of recent adaptive evolution driven by climatic changes or human impacts.

Photography: Bastiaan Star

PhDs and Postdocs

PHD

POSTDOC

KRISTINA KVILE

KRISTINA KVILE

Project title: Climatic influences on zooplankton dynamics in Lofoten and the Barents Sea.

→ Zooplankton constitute the primary grazers in ocean foodwebs and form an important link between the primary production and higher trophic levels. In the Atlantic waters of the Norwegian and Barents Seas the copepod *Calanus finmarchicus* is of particular importance as food source for many fish species of commercial interest, including cod larvae. Zooplankton are also, due to their short time-span and high sensitivity to temperature, ideal indicators of climatic variation in marine environments. Climate change processes are therefore likely to generate a strong impact on zooplankton species distribution.

This projects will analyse Norwegian and Russian data with high spatial and temporal resolution and extent to increase our knowledge on zooplankton dynamics in the Norwegian (Lofoten) and Barents Sea. I will apply modern statistical analyses combined with hydrodynamic models in order to assess how climatic factors and advection shape the variation in zooplankton biomass and phenology of *C. finmarchicus*.

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Supervisor: Leif Chr. Stige, Centre for Ecological and Evolutionary Synthesis (CEES), Department of Biology, University of Oslo, Norway.
Co-supervisor: Uffe Høgsbro Thygesen, National Institute for Aquatic Resources, Technical University of Denmark (DTU Aqua), Denmark.

JOHANNA YLETYINEN

JOHANNA YLETYINEN

Project title: *The effect of network properties on the dynamics of social-ecological systems and their response to multiple drivers.*

→ The goal of my project is to achieve a better understanding of the impact of climate on the Nordic marine resources by doing a social-ecological network analysis of the Baltic Sea and other Nordic marine systems. I will use different tools of ecological and social network analyses to test how network structures and their properties affect the dynamics of social-ecological systems, i.e. marine food webs with institutional, economic and societal dynamics. Besides this, a significant part of my study focuses on the application of new methodological approaches to analyze the structural patterns of interactions in social-ecological systems.

As a first step I will apply the ecological network approach to study the past Central Baltic Sea food web reorganizations (regime shifts). Furthermore, the plan is to test the effect of fishing behaviour, in the context of institutional regulations, on the food-web structure in the Baltic Sea and other marine areas within NorMER. I will also include the potential effects of different climate scenarios on these social-ecological systems.

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Supervisor: Dr. Thorsten Blenckner, Baltic Nest Institute / Stockholm Resilience Centre, Sweden.
Co-supervisor: Prof. Erik Bonsdorff, Åbo Akademi University, Finland.

NADIA FOUZAI

NADIA FOUZAI

Project title: *Larval cod in environmental gradients: How do recruitment success relate to oceanographic conditions?*

→ This project will develop theoretical models of larval cod growth and survival in scenarios of future oceanographic conditions. The key research question is how recruitment success of larval cod will depend upon changes in environmental and ecological gradients such as ocean temperature, alkalinity, primary production, optics and prey availability. Particular attention will be given to changes in vertical environmental gradients and behavioural strategies, but horizontal patterns and drift may also be explored. The research strategy is to apply optimality modelling and individual-based models to integrate from physiological processes to ecological and evolutionary mechanisms involved in long-term changes of the environment. Processes of feeding, growth and predation risk is coupled mechanistically to the environmental drivers – and the predictive ability of these models will first be applied on existing empirical studies of particular field data covering both environment, prey and larval fish growth and distribution.

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Supervisor: Øyvind Fiksen, Department of Biology, University of Bergen, Norway.
Co-supervisor: Andy Visser, DTU Aqua, Technical University of Denmark, Denmark.

ALEXANDROS KOKKALIS

ALEXANDROS KOKKALIS

Project title: *Grey-box methods for size-based estimation of fish stocks.*

→ In this project size will be used as the structuring parameter of the fish population, instead of the commonly used age. Size data are easily gathered and far more accurate than information about age. Furthermore, survival, reproduction and growth depend less on the age of an individual than on its physiological characteristics, like its length or weight.

Grey-box statistical models for assessment of Atlantic cod *(Gadus morhua)* based on catch and survey data will be developed. Grey-box methods combine models based on biological knowledge (white-box) with stochastic models (black-box). Environmental covariates will be included into the model and situations where data availability is limited will be considered.

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Supervisor: Ken Haste Andersen, National Institute of Aquatic Resources, Technical University of Denmark (DTU Aqua), Denmark
Co-supervisor: Anne Maria Eikeset, CEES, University of Oslo, Norway.

BENJAMIN WEIGEL

BENJAMIN WEIGEL

Project title: *The role of benthic fauna in the coastal food web under environmental stress.*

→ Benthic fauna plays an indispensable role in various processes of a healthy and functioning coastal ecosystem. It influences major biogeochemical processes in the sediments and serves as an essential food source for higher trophic levels. Eutrophication has become a severe ecological threat in coastal areas and together with rising temperature and decreasing salinity this forces a reorganization of benthic habitats and communities. I'm interested in the consequences those changes have on benthic fauna, their habitats, their predators, and ultimately on the whole coastal ecosystem depending on it. My main goal is to evaluate the role of benthic fauna as food for fish, with a focus on cod, under environmental stressors in the Baltic Sea. We want to link the effects of climate change, eutrophication, as well as the influence of non-native species to the food web structure of coastal regions.

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Supervisor: Erik Bonsdorff, Åbo Akademi University, Finland.
Co-supervisor: Thorsten Blenckner, Stockholm Resilience Centre, Sweden.

KATHARINA OTTOSEN

KATHARINA OTTOSEN

Project title: *Spatial distribution of cod on the Faroe Plateau in relation to climate and other environmental conditions.*

→ Rather than displaying the typical (weak) relationship with spawning stock biomass, recruitment of cod on the Faroe Plateau is instead controlled by cannibalism (at age 1) and the abundance of cod at age 2. Cannibalism in the stock is enhanced when adult (age 3+) cod move into the near-shore nursery areas of age 1 cod. This phenomenon occurs when food availability on the Faroe Plateau is low, but is probably enhanced by higher than average temperatures. This indicates that spawning success/larval survival might be negatively affected if the temperature exceeds 6°C. The Faroe Shelf now has an annual average of 8.4°C as of 2008. During these years of elevated temperatures, the spawning centre has moved easterly toward colder water masses, but the mass centre seams not to be unaffected in autumn. This project will explain these spatial changes in cod distribution and determine how those changes affect recruitment in the stock. The spatial distribution of cod will be compared to hydrographical data, such as bottom temperature from the trawl, vertical temperature and salinity profiles from the CDT, and nutrient and plankton data. In addition, logbook data from the fishery are available.

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Supervisors: Eyðfinn Magnusson, University of the Faroe Islands, Faroe Islands. Petur Steingrund, Havstovan, Faroe Islands.
Co-supervisors: Guðrun Marteinsdóttir, Marice, Iceland Henrik Gislason, DTU-Aqua, Denmark.

MARTIN SNICKARS

MARTIN SNICKARS

Project title: *Habitat distribution under climate change scenarios – impacts on benthos and fish.*

→ My research focuses on a set of benthic habitats that are important for the link between benthos (prey) and fish (consumers), using the coastal waters of the Åland Islands, northern Baltic Sea as a case study area. This trophic link is primarily studied by comparing time-series of benthic feeding fish species and their prey. The aim is to estimate the strength of this link in different habitat types, how this has changed over time, and to predict how the different feeding habitats of fish is and can be affected by climate change. This is done by analyzing how both the benthic macrofauna and the benthic feeding fishes are affected by changes in environmental variables over decades, and by modelling future scenarios modifying salinity and temperature.

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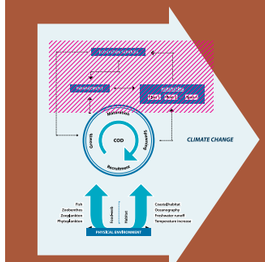
Home institution: Åbo Akademi University, Finland

Linked programmes on Adaptation to Climate Change

FOCUS AREA OF THESE PROJECTS*



* refer to page 23 for a bigger version of the figure

STRENGTHENING THE ADAPTIVE CAPACITY OF INSTITUTIONS IN FISHERIES

FUNDED BY THE RESEARCH COUNCIL NORWAY UNDER THE CALL *'NORKLIMA'*

Globally, marine ecosystems are under pressure from high exploitation and climatic changes. Some regions in the world are especially vulnerable, because ecosystem resilience is low, or their institutions are ill-equipped to adapt to a changing climate, for example because communities rely largely on fishing as a source of income. Thus, there is a pressing need to analyze how climate change alters marine ecosystem functioning, the fishing sector, and communities in areas that are particular at risk. The main focus of the proposed project is the complex system of the Barents Sea / Lofoten fishery, taking into account the multiple feedbacks between climate, marine ecosystems, and institutions ***to understand and disentangle the various aspects of societal adaptation to climate change***. The aim is to strengthen the adaptive capacity of institutions that govern marine ecosystems. In particular, we propose to analyze:

- How adaptive action by fishermen is influenced by informal institutions, such as social norms, peer behavior, cultural identity, and social status.
- How quickly formal institutions respond to environmental change, and how this affects coastal communities and interacts with adaptive action taken by individual users.
- How biological complexity may hinder efforts to adapt, taking into account the risk and uncertainty of a stock collapse or the possibility that users can switch to other species.
- How the adaptive capacity of institutions can be strengthened to respond adequately and efficiently to climate change, providing valuable management lessons for the Arctic regions.

The proposed project is complementary to NorMER, which investigates the effects on climate change on marine ecosystems in the Nordic regions with a focus on Atlantic cod. While ecosystem complexity is important, this research proposal fills an important gap by addressing institutional and social complexity. The proposed project takes a global perspective with the aim to learn from fisheries around the world, which will be combined with valuable expertise from NorMER to meet Nordic challenges.

Our main international partner, the Fisheries Centre of the University of British Columbia, has expertise on global and regional analysis on climate change effects on marine biodiversity and fisheries and hosts a database comprising distribution maps, and ecosystem and catch data for more than 1,000 species. Thus, this project combines global insights from fisheries around the world with valuable Nordic expertise to meet challenges posed by a changing climate.

We will achieve our research goals by using a unique mix of theoretical modeling and empirical analysis, and benefiting from extensive experience with developing interdisciplinary bioeconomic models among all partners. The proposed project will disentangle the various aspects of adaptation to climate change by analyzing the multiple feedbacks between climate, formal and informal institutions, and ecological complexity, to strengthen the adaptive capacity of institutions that govern marine ecosystems. It will thus clarify the role of risk and uncertainty of climate change, both for managers and stakeholders, and will reveal how management could affect coastal communities, including important equity considerations.

ANDRIES RICHTER

Andries Richter is a postdoctoral researcher at the University of Oslo, Norway, where he is working on social complexity in resource management. He holds a PhD from Wageningen University, the Netherlands, on the multiple feedbacks between natural renewable resources and institutions governing those resources. His main field of scientific interest includes the evolution of social norms and cooperation, but also the governance of marine ecosystems.

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Collaborators:

Claire Armstrong, Professor, University of Tromsø. Working on the economics of Arcto-Norwegian cod, marine protected areas, and cold-water coral reefs.

William Cheung and Rashid Sumaila, Fisheries Centre, University of British Columbia, Vancouver, Canada.

Carl Folke and Thorsten Blenckner, Stockholm Resilience Centre.

Guðrún Marteinsdóttir, MARICE, University of Iceland.

Jeffrey Hutchings, Dalhousie University, Halifax, Canada.

BOTTOM-UP CONTROLS IN FISHERIES MANAGEMENT AND ADAPTATION TO CLIMATE CHANGE

Nordic countries are particularly dependent on their marine resources which holde exceptional national, cultural, and economic significance. However, the Nordic region is also particularly vulnerable to climate change and high fish stock exploitation. Thus, understanding methods of adaptation within fisheries management systems that preemptively address both biological and human responses to these pressures are urgently needed. Of the fisheries management systems, those that employ individual transferable quotas (ITQs) may be especially valuable: the total allowable catch (TAC) of a stock for the year is divided into individual quota shares, which are traded as property by individuals. However, despite preventing the race for fish that have led to past fisheries collapses, the tradable aspect of ITQs has often been avoided due to criticism for detrimental socioeconomic effects. This problem illustrates how the success of any fisheries management system relies heavily on both biological and social aspects. In this context, biological aspects and policy and regulations can be thought of as top-down controls in the setting and enforcement of TACs, whereas social aspects are bottom-up controls that can undermine biological goals if adherence to fisheries regulations is ignored. This latter aspect underscores how the human dimension of resource management can have unintended consequences if incentives are improperly designed.

In multi-species fisheries, species are rarely caught by a fisherman in proportion to the his own array of quotas. Thus, it may be profitable to discard one species if its quota fills up more quickly than a more valuable species, thereby avoiding the necessity to stop fishing. Alternatively, if regulations allow, fishermen may instead be able to trade quota or modify the species mixture by adjusting fishing effort allocation or fishing gear. Although the first behavior is negative and unintended, the latter two yield benfits directly in line with ecosystem management (i.e., reductions in bycatch and habitat destruction).

To reduce the incentive to discard, some nations have enacted regulations that increase flexibility in quota usage in multi-species fisheries, which allow fishermen to account for overages through these catch-balancing mechanisms. My project focuses on profitability & sustainability of the multi-species ITQ system Icelandic fisheries, which is unique because *1)* fishermen can not only trade quota, but convert it between species and transfer it between years (under certain restrictions) and *2)* this system has been in place for ~20 years for most species. Therefore, the dynamic interactions expected to develop in such a system between relative abundances, relative profitability, and relative fishing pressure of target species have been recorded in Icelandic trade, transfer, and catch records. This bottom-up component of the Icelandic management system, which is not normally considered within more traditional top-down forms of adaptive management, may be beneficial to the ecosystem by allowing response to occur on a much faster time scale and with less top-down investment. However, it may also be detrimental by consistently allowing a legal route for fishing over individual species TACs. This project aims to *1)* analyze past trends in how environmental trends, relative abundance, and relative profitability have caused differential use by fishermen of individual quota trade, species conversions, and yearly transfers to effect fishing pressure, and *2)* use this information to parameterize a simulation model in which the fishing regulations will be improved to effect long-term sustainability and profitability.

PAMELLA WOODS

Pamela Woods is a postdoctoral researcher at the University of Iceland, where she is working on bottom-up control strategies for fisheries management. This project continues a partnership between the University of Iceland and the University of Washington and Northwest Fisheries Science Center, USA, that was established during her PhD work. She completed her PhD studies in December 2011 on the ecological variation in a species that exhibits high intraspecific diversity (Arctic char Salvelinus alpinus) across lakes in Iceland and Alaska.

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Dr. Daniel Holland, Northwest Fisheries Science Center, NOAA Fisheries, Seattle, USA.

Dr. André Punt, School of Aquatic and Fishery Sciences, University of Washington, Seattle, USA.

Dr. Andries Richter, CEES, University of Oslo

New partnerships

UBC FISHERIES CENTRE

Our planet's fisheries have reached their ecological limits. As benefits from fisheries decrease, pressure grows to develop other sources of revenue, not necessarily compatible with ecosystem health. Policy and planning for ecosystem-based management must then be informed by knowledge of the interplay of human, biotic and environmental factors that affect ecosystem structure and function. Key requirements are sufficient time-depth to capture biodiversity, abundance and trophic structure prior to depletion, identification of the full range of benefits that healthy ecosystems provide to present and future generations and integration of the fine-scale knowledge of the maritime community with large-scale national and international fisheries management.

The Fisheries Centre promotes multidisciplinary study of aquatic ecosystems and broad-based collaboration with maritime communities, government, NGOs and other partners. We believe that the social capital developed through collaboration and the intellectual capital that increased knowledge of ecosystem function and values represents can lead to the re-investment in natural capital necessary to conserve and restore aquatic systems.

The Fisheries Centre is characterized by an exceptional degree of cooperation among its research units. In particular, the Fisheries Economics Research Unit (FERU) and the Sea Around Us research units are relevant to NorMER interests.

The Fisheries Economics Research Unit (FERU) studies the economics of capture and aquaculture fishery resources. Under the guidance of Rashid Sumaila, the unit explores how ecosystems can provide sustainable and equitable economic and social benefits to both present and future generations, while maintaining biodiversity and ecosystem services.

The Sea Around Us Project was established by Daniel Pauly to document large-scale impacts on marine ecosystems and find solutions to the challenges they pose. Its work is cataloged and accessible on the web, offering ecosystem data, distribution maps and catch data for more than 1,000 species, historical trends and peer-reviewed publications. We are currently working with William Cheung to add to and make use of this excellent database of knowledge.

Daniel Pauly

Dr. Daniel Pauly is a French citizen who completed his high school and university studies in Germany; his doctorate (1979) is in Fisheries Biology, from the University of Kiel. After many years at the International Center for Living Aquatic Resources Management (ICLARM), in Manila, Philippines, Daniel Pauly became in 1994 Professor at the Fisheries Centre of the University of British Columbia, Vancouver, Canada, and from 2003 to 2008, its Director. Since 1999, he is also Principal Investigator of the Sea Around Us Project, funded by the Pew Charitable Trusts, and devoted to studying, documenting and promoting policies to mitigate the impact of fisheries on the world's marine ecosystems. The concepts, methods and software Daniel Pauly (co-) developed, documented in over 500 publications, are used throughout the world – especially the Ecopath modeling approach and software and FishBase, the online encyclopedia of fishes. This work, which increasingly includes climate change issues, covered in close collaboration with his colleague William W.W.L. Cheung, is recognized in various profiles, notably Science, April, 2002; Nature, Jan. 2003; New York Times, Jan, 2003, and by numerous awards, among them the International Cosmos Prize, Japan (2005), the Volvo Environmental Prize, Sweden (2006), the Excellence in Ecology Prize, Germany (2007), the Ramon Margalef Prize from the Government of Catalonia (Spain, 2008), the Grand Prix 2011 of the French Ecological Society (2012), and the Nierenberg Award for Science in the Public Interest for the Scripps Institution for Oceanography, California (2012).

William Cheung

William is an Assistant Professor at the UBC Fisheries Centre since 2011, and is head of the Changing Ocean Research Unit (CORU). William obtained a BSc. (Biology) in 1998, and subsequently a M.Phil. in 2001 from the University of Hong Kong. After working in WWF Hong Kong for two years, he completed his PhD in Resource Management and Environmental Studies in the UBC Fisheries Centre in 2007. He then worked as a postdoctoral fellow in the Sea Around Us project for two years. From 2009 to 2011, he was Lecturer in Marine Ecosystem Services in the School of Environmental Sciences, University of East Anglia in the UK.

His main research is assessing the impacts of fishing and climate change on marine ecosystems and their goods and services, and studying ways to reconcile trade-offs in their management. He works on various interdisciplinary research projects with global collaboration networks in the U.K., China, Australia, Africa, USA and Canada. He has been a member of the IUCN Groupers and Wrasses Species Specialist Group since 2005 and serves on the editorial board of Fish and Fisheries and International Journal of Sustainable Society.

Rashid Sumaila

As the 2012 NorMER Johan Hjort Chair, his bio can be seen on page 37 of this report.

DANIEL PAULY

WILLIAM CHEUNG

RASHID SUMAILA

NORTHWEST FISHERIES SCIENCE CENTER (NWFSC)

DAN HOLLAND

The Northwest Fisheries Science Center studies living marine resources (e.g., salmon, groundfish, and killer whales) and their habitats in the Northeast Pacific Ocean-primarily off the coasts of Washington and Oregon and in freshwater rivers and streams in Washington, Oregon, Idaho, and Montana. The Center seeks to better understand living marine resources and their ecosystems to assist resource managers in making sound decisions that build sustainable fisheries, recover endangered and threatened species, and sustain healthy ecosystems, and reduce human health risks. The Center's 500 scientists and staff conduct research in 5 primary areas:

Status of Stocks. Center scientists conduct and coordinate stock assessments for West Coast groundfish and salmon stocks in the Pacific Northwest by taking a variety of measurements (e.g., data from fishing vessel catch or landings, scientific surveys, observers stationed on fishing vessels, and life history studies), analyzing the data, and using mathematical models to draw conclusions from the results.

Human Caused Stress/Risks. Center scientists are conducting research to better understand how salmon, marine fish, and marine mammals react to the stresses of human impacts on the environment and to quantify, assess, and minimize these risks.

Ecosystem Observations and Climate Variability. Center scientists are conducting research on physical and biological processes that influence aquatic, marine and estuarine ecosystems in the Pacific Northwest, including sediment delivery, upwelling and tidal processes, and nutrient inputs and cycles, as well as the effects of invasive species, toxic phytoplankton, climate change, and natural environmental fluctuations.

Recovery & Rebuilding Species. The Center studies genetic variation and conducts research on the population structure of salmon, marine fish, and killer whales. The Center also develops innovative recovery tools like captive breeding or broodstock programs to propagate salmon species, new techniques for rearing hatchery fish, and culture techniques to rear marine fish in captivity.

Innovation & Technology. Center scientists are taking a lead role in developing and applying technologies, techniques, and tools to support conservation and recovery of the Pacific Northwest's living marine resources.

Dan Holland. Dan Holland is an economist with the Northwest Fishery Science Center. He earned a Ph.D. in environmental and natural resource economics at the University of Rhode Island in 1998 and has since worked for government, academia, and industry in different parts of the US and in New Zealand. Dan is President Elect of the International Institute for Fisheries Economics and Trade, serves on the board the North American Association of Fisheries Economists, and is an associate editor of Marine Resource Economics. Dan's research is focused on design and evaluation of fishery management tools and strategies that will lead to profitable and sustainable fisheries and a healthy marine ecosystem. He has a long standing interest in spatial aspects of fishery management such as marine reserves and area management.

UNIVERSITY OF WASHINGTON

The University of Washington (UW) School of Aquatic and Fishery Sciences (SAFS) is one of the largest graduate-degree awarding institutions focusing on problems revolving around fisheries science and natural resource management in both marine and freshwater systems. The school is composed of 30 faculty, 125 graduate students, and 100 undergraduate students, and is fueled by high success rates at obtaining research grants, and by many partnerships with local federal agencies (e.g., Northwest Fisheries Science Center, Alaska Fisheries Science Center, United States Geological Survey), as well as local programs (e.g., Washington Sea Grant). The quality of the research and graduate programs are visible in the high number of graduate fellowships awarded to SAFS doctoral students in 2012, such as those awarded by the Pew Foundation and the Ecological Society of America. Members of the school community also actively participate in multi-disciplinary research via past and present IGERT programs, and co-funded faculty positions teach in both SAFS and social science departments. SAFS has also carried forward long-term ecological monitoring and fisheries assessment programs both as educational tools and extremely useful data source for analyzing long-term environmental change (e.g., UW Teaching and Research Hatchery & research on Lake Washington, Washington; research on Lake Fisheries Research Institute, Alaska). Faculty members have also begun a collaborative project with national and industry partners to compile the Global Fisheries Database Project, which includes global catches, indicators of stock status, and attributes of the fisheries management systems.

André Punt

Dr. André Punt is one of the SAFS faculty involved in the Global Fisheries Database Project, for which he became the Director in 2012. His research interests are focused on evaluating current methods, and developing new methods, to assess renewable resources. These generally focus on fish and marine mammal populations, but are tailored to fit the species biology and individual situation. Current areas of interest include spatial models, individual-based models and stage-structured models. His lab group has also worked extensively on applying Bayesian methods to stock assessment, risk analysis and stock identity problems.

Dr. Punt is a native of South Africa who did his graduate studies at the University of Cape Town (UCT) and went on to study issues of African and Australian fisheries management as a resource modeller at UCT and CSIRO in Australia before joining SAFS in 2001. Beyond performing a wide range of urgent and innovative research, Dr. Punt has collaborated extensively with ecologists and economists, gained multiple student-nominated awards in teaching, and served on numerous panels, councils, and committees for management of ocean resources spanning the globe and ranging in scale from invertebrates to whales (e.g., IUCN, IWC).

ANDRÉ PUNT

The Atlantic cod (Gadus morhua) is one of the most important fishery species in the Nordic region. They average 26 cm by the end of their first year. Most reach sexual maturity at 1.7–2.3 years and are harvested at ages 2–5.

Photography: Øyvind Paulsen

SECTION THREE: *Scientific activity*

Organization of the research

→ SCIENTIFIC FRAMEWORK

NorMER will evaluate the risks and opportunities of the effects of climate change on fisheries in the Nordic region, with a particular focus on the Atlantic cod (Gadus morhua), a species of ecological and economic importance throughout our region. The individual projects are designed to fit within (for PhDs) or between (for Postdocs) four Thematic clusters within our scientific framework.

Purse seine fishing for herring *(Clupea harengus)* in the North Sea with the fishing vessel Libas

Photography: Ruben A. Pettersen

→ NORMER'S GRAND CHALLENGES: COD AS A MODEL OF CLIMATE CHANGE IMPACTS

1. Develop a comprehensive model of physical processes and their interactions with marine food webs.
2. Define the importance of lower trophic levels and their influence on harvested species.
3. Detail the drivers, patterns, and trends of harvested populations.
4. Create guidelines for optimal management of marine resources to maximize profit and yield, now and in the future.

This will be done for all northern seas.

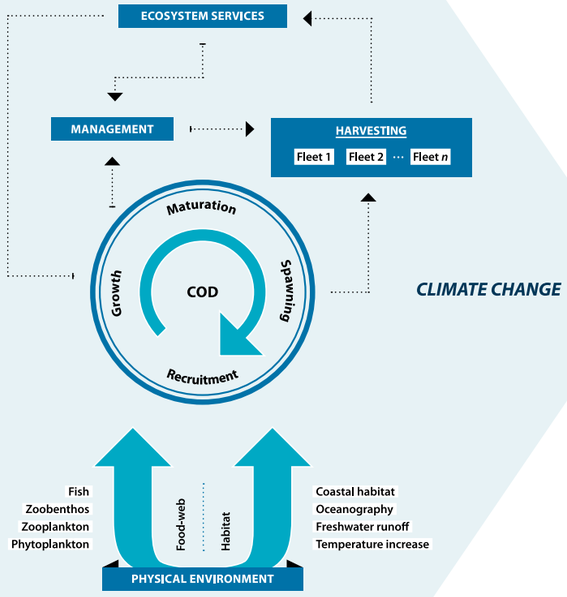
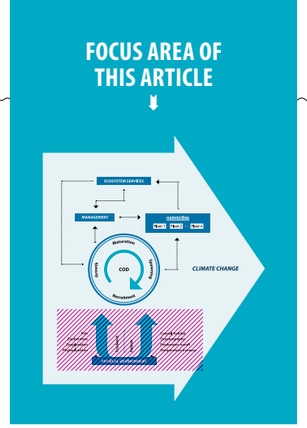


Illustration: Jostein Strand Henriksen

Scientific highlights



SCENARIOS OF CLIMATE CHANGE FOR THE BALTIC SEA

By Helén C. Andersson, Swedish Meteorological and Hydrological Institute, Sweden.

HELÉN C. ANDERSSON

Climate model results for the Baltic Sea, based on IPCC scenarios, indicate that a significant warming of the region can be reality before the end of the 21st century. The warming is projected to be most pronounced during the winter season and in the north-eastern part of the region, where the change in mean winter air temperatures at 2 m above the sea surface in some scenarios is more than 6°C.

The global warming will hence have large impact on the marine environment of the Baltic Sea, with resulting increase of water temperatures and reduced sea-ice cover. The warming will also affect the hydrological cycle and model results show a likely increase in river runoff in the northern areas which will reduce the over-all salinity of the Baltic Sea.

The Baltic Sea is a sensitive sea. It is one of the World's largest estuaries ant its semi-enclosed location, with the only exchange with the open sea through the narrow and shallow straits between Sweden and Denmark, means restricted deep-water renewal and long residence times. In combination with high nutrient loads to the basin, this results in severe eutrophication and large hypoxic areas.

The low-salinity setting, with surface salinity ranging from about 9 psu in the south west to about 2 psu in the north, gives that relatively few species are adapted to this rather special environment. Changing conditions due to climate change might have significant impact on all levels of the ecosystem and can affect distribution, population size, growth and reproduction. This may particularly influence reproduction of cod, since this has been linked to temperature, salinity and oxygen conditions at the spawning grounds.

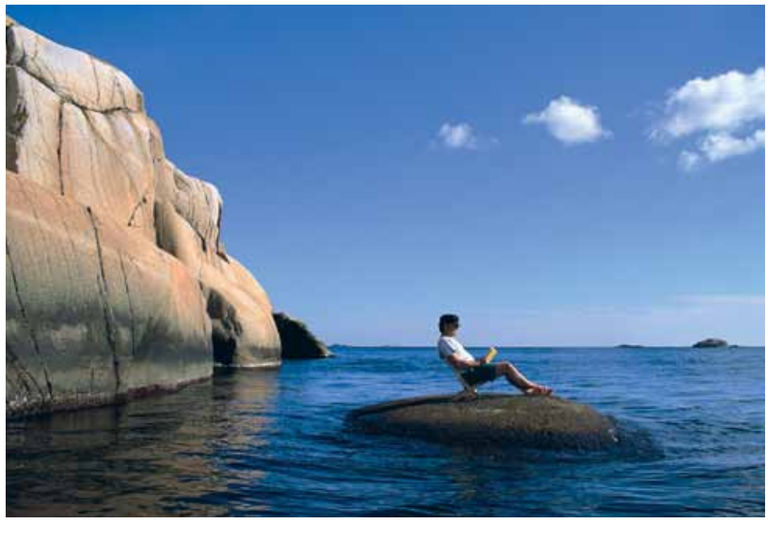


Fig. 1: Summer in the Baltic Sea *(Source: SMHI)*

Ensemble modeling of the marine environment of the Baltic Sea has been used to reduce uncertainties of the scenarios due to model deficiencies, scenario formulation and initial-condition dependence. Although there are differences between scenarios and model outputs, the state-of-the-art models used also give common, and thereby with present knowledge of future developments, robust results.

As a response to global climate change, the ocean temperature of the Baltic Sea is expected to increase in all areas and throughout the whole water column. The climate-induced warming is modeled to be significant by midcentury. By the end of the century the volume averaged mean temperature is projected to have increased with about 2.5°C *(Fig. 2, upper panel)*. The volume averaged mean salinity responds to the increased precipitation and river runoff by a decrease of about 2 psu *(Fig. 2, lower panel)* – a decrease that means that the salinity conditions presently found in the Bothnian Sea can in the future be the state of the Baltic proper.

The models suggest that due to increased water temperatures, oxygen saturation concentrations will decrease and turnover rates of biogeochemical processes will increase. Due to increased river flows eventually larger amounts of nutrients may also be flushed out from land. The low bottom oxygen levels in large parts of the Baltic are of present concern and intensive abatements for the whole Baltic Sea region are introduced through the HELCOM convention's Baltic Sea Action Plan (BSAP). However, the scenarios indicate that these efforts are less effective for the marine environment in future compared to present climate. Future bottom oxygen levels under the BSAP scenario will not increase significantly and will even be reduced assuming present loads *(Fig. 3)*. Hence, Nutrient load reductions are even more important in future climate and Baltic Sea management has to consider the impact of climate change in addition to eutrophication and other human induced threats.

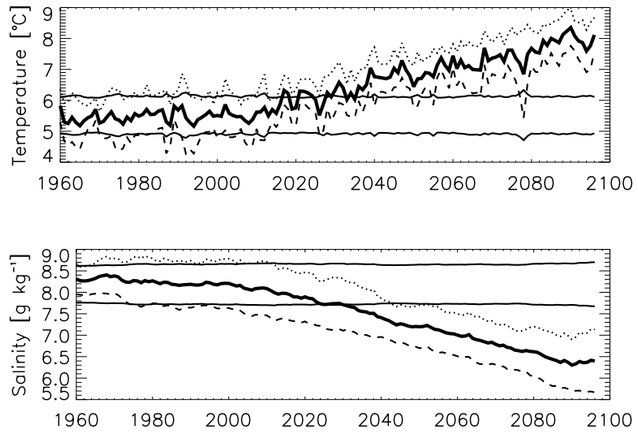


Fig. 2: Volume integrated water temperature and salinity and hypoxic area (with bottom oxygen concentrations below 2 ml/l) in the Baltic Sea (solid lines). The ranges of plus/minus one standard deviation around the ensemble means are depicted by dotted and dashed lines, respectively. Straight lines indicate the 99% confidence interval for significant changes from present climate variability during 1978-2007. *(From Meier et al 2012[1])*.

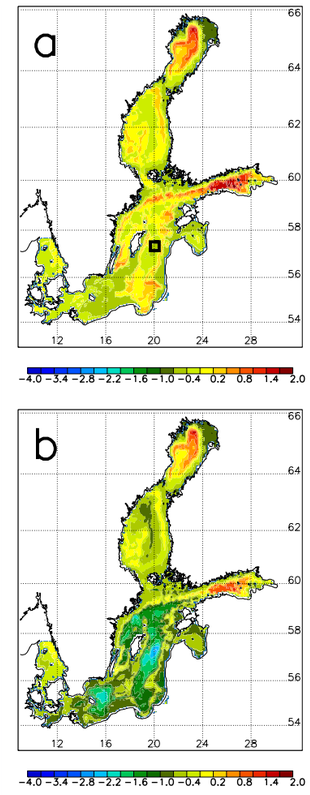


Fig. 3: Summer-time (June-August) changes of oxygen content (ml/l) in future (2069–2098) relative to present climate (1978–2007). The left panel *(a)* assuems reductions in nutrient loads according to HELCOM Baltic Sea Action Plan and the right panel *(b)* a continuation in future of present nutrient loads *(from Meier et al, 2011[2])*. The location of the monitoring station at Gotland Deep (BY15) is denoted by a black square, and the vertical profiles are further analysed for variability of the cange with depth in the reference above.

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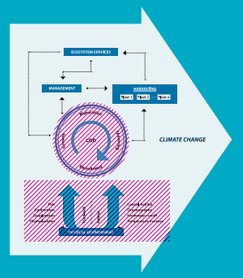
FOCUS AREA OF THESE ARTICLES



HOW IS A WARMER NORTH ATLANTIC AFFECTING PRIMARY PRODUCTIVITY?

By Ana Sofia Ferreira, NorMER PhD student, DTU Aqua, Denmark

ANA SOFIA FERREIRA

When the available concentration of nutrients and light match phytoplankton demands, the basis of aquatic life, blooms occur. Increased mixing of water masses has been linked to an increase in nutrient supply, but may also act as a light-limiting factor[1]. Phytoplankton will then have a cascading effect on zooplankton production and, subsequently, on fish survival[2,3]. Thus, ocean circulation is a key factor influencing access to light and nutrients for phytoplankton[4-10].

In the North Atlantic, the subpolar gyre (SPG) can be used as a proxy for the marine climate in the North East Atlantic (NEA) *(Fig. 1)*. A weak SPG allows salty, warm, and stratified eastern waters to dominate in the European continental slope[11] *(Fig. 1b)*. Previous studies have reported the influence of SPG in phytoplankton abundance and changes in the zooplankton community structure in the NEA using data from the continuous plankton recorder[2,12].

Satellites are a powerful source of data, for they provide highly resolved temporal and spatial products. These products are extremely valuable when one aims at assessing spatial patterns. From the Globcolour Project, one can obtain long time series of consistently calibrated global ocean color information as a proxy for chlorophyll concentration.

With the first signs of spring, phytoplankton blooms flourish in the NEA, which can be observed in the phenology of chlorophyll concentration *(Fig. 2)*. The higher the latitude, the later the bloom occurs. But how does this relate to climate?

In years with a strong SPG (negative index), average chlorophyll *a* concentrations are lower. This is expected, for a strong SPG means fresh, cold waters over the region. However, bloom initiation appears to behave differently. A strong SPG, thus a strong atmospheric forcing, seems to affect the timing of phytoplankton increase according to its latitude *(Fig. 3a)*. Years with a weak SPG, thus a saltier and warmer scenario, show a more stable timing across latitudes *(Fig. 3b)*. These findings may have implications in the recruitment of fish species that spawn within and outside of the SPG region, such as blue whiting[2,12] North Atlantic cod[19], haddock[3], Atlantic salmon[20,21], Northern shrimp[22], Norwegian spring-spawning herring[23], and possibly Bluefin tuna[24].

The earlier the bloom initiates, and the longer it lasts, the higher the probability the timing of copepod blooms will match the timing of fish spawning[3]. If a warmer NEA would mean a somewhat late bloom, my question is: *how big would the impact on commercial fish species be?*

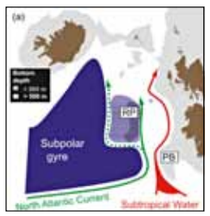


Fig. 1: Illustration of (a) a strong and (b) a weak subpolar gyre (SPG) [11]. *Abbreviations: RP, Rockall Plateau; PB, Porcupine Bank. Adapted from Hátún et al [12].*

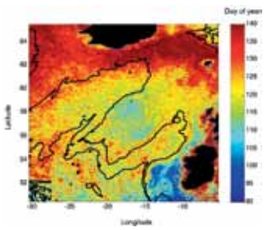


Fig. 2: Map of initiation of average of phytoplankton blooms from 1998 to 2010 in day of year. Bloom initiation was defined as the day when chlorophyll a concentrarion was above 5 % of median value [5,12] after fitting a Generalized Additive Model on the annual data for each pixel.

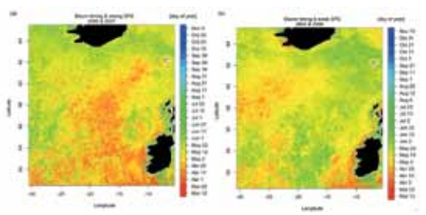


Fig. 3: Map of initiation of average of phytoplankton blooms in day of year, for years (a) 2000 and 2007 (strong SPG), and (b) 2004 and 2006 (weak SPG).

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MAPPING THE SPAWNING GROUNDS OF ATLANTIC COD (GADUS MORHUA) IN ICELANDIC WATERS

By William Butler, University of Iceland

Historically, the main spawning grounds around Iceland were considered to be along the south coast [1], from where eggs and larvae are transported to nursery grounds in the north via the coastal and Irminger currents. Recent studies based on back-calculated hatch dates of 0-group cod have indicated that other areas located within fjords of the West, North and East coasts appear to contribute significantly, at least in some years, to the surviving pelagic juvenile population[2, 3]. Still, further work is required to elucidate the finer-scale spatial structure of the main spawning grounds and the relative importance of other spawning areas around Iceland.

To achieve this, we explored the distribution of fisheries during the spawning season and occurrences of spawning cod confirmed by Marine Research Institute (MRI) samples. Data were considered from 1991 to present as logbook records have been mandatory for all vessels with gross tonnage exceeding 9.9 tonnes for this timespan *(Fig. 1)*. As fishermen have been known to target spawning aggregations in the past, the spatial distribution of fisheries during the spawning season is a suitable proxy for spawning locations. By setting a series of rules as to what constitutes a spawning site (e.g. > 60% target species in catch), we were able to identify 55 potential spawning regions which could be confirmed with survey samples. These are grouped into 6 larger spawning areas according to proximity and hydrography. Fish length within each area was treated as a response variable to test the appropriateness of this spatial stucture with year, sex and region as explanatory variables (i.e. the goal was to define areas with no significant difference in length between regions). Once the optimal spatial structure was identified, maturity ogives and sex ratios were used to generate an abundance index of spawning females, which when multiplied by the size of each region gives the relative distribution of spawning females per region per year. This was then used to split each years VPA to estimate the abundance of spawning females per region per year.

The results, seen in figure 2, demonstrate that areas outside of the main spawning ground also contribute to the spawning female population. Greatest abundance is found in the southwest (Selvogsbanki) and up the west coast (Faxaflói and Breiðafjörður). Within these larger areas, there is a finer-scale structure (i.e. spawning cod are not distributed uniformly within these areas) with steep gradients in abundance between adjacent regions particularly evident in Selvogsbanki. Along the northern coast abundance is generally smaller than elsewhere with the exception of an offshore area located around Grimsey Island and Þistilfjörður in the northeast. The results highlight that spawning is a location-specific event and further work is required to elucidate the physical structures and processes that influence spawning site selectivity in these areas.

Two of the largest rivers in Iceland, the Ölfusá and Þjórsá, flow into Selvogsbanki. The freshwater is entrained in the coastal current and periodically transported around Reykjanes peninsula into Faxaflói Bay leading to distinctive peaks in freshwater thickness during late spring and summer[4]. By providing resources and physical conditions necessary to optimise growth and survival, stratification dynamics may be one of the main factors influencing the early survival of cod and other fish species in these waters. Using a similar methodology as described above, work is underway mapping the spawning grounds of haddock *(Melangrammus aeglefinus)* and saithe *(Pollachius virens)*, as well as looking at temporal trends in spawning period. A finer-scale understanding of the spawning grounds of these three species, together with information on spawning periodicity, will highlight key areas and timings to examine stratification dynamics and dispersal pathways of eggs and larvae in forthcoming work. This will help elucidate our understanding of the physical processes operating at the same time as major spawning events and the influence they have on recruitment variability.

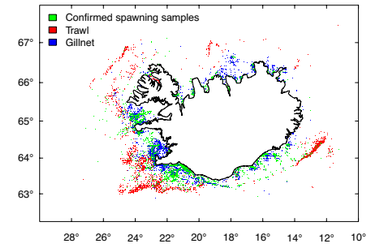


Fig. 1: Each red and blue square (demersal trawl and gillnet respectively) is a minute by minute gridcell that was fished > 2 times during a single spawning season (15th March–15th May). Green squares represent confimed occurences of spaw-ning cod obtained from MRI surveys. Data is shown for years 1991-2010.

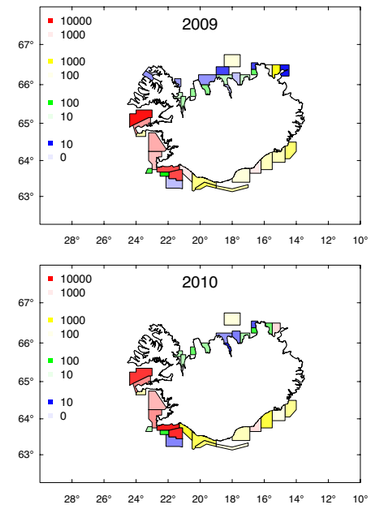


Fig. 2: The abundance of spawning females (in thousands) per region for 2009 and 2010. The legend shows the maximum and minimum for each colour band, the depth of shading gives an indication of the abundance within these limits.

References: [1] Sæmundsson B. 1924 Fiskarnir *(Pisces Islandiae)*. Felgasprentsmidjan, Reykjavik. [2] Marteinsdottir, G., Gunnarsson, B. and Suthers, I. M. 2000. Spatial variation in hatch date distributions and origin of pelagic juvenile cod in Icelandic waters. ICES J. Mar. Sci. 57:1184–1197. [3] Begg, G.A., Marteinsdottir. G. 2000. Spawning origins of pelagic juvenile cod Gadus morhua inferred from spatially explicit age distributions: potential influences on year-class strength and recruitment. Mar. Ecol. Prog. Ser. 202: 193–217. [4] Logemann, K., Ólafsson, J., Marteinsdottir, G. 2010. The ocean model CODE and its application to Icelandic waters. MARICE E-report MER-10-2010.

WILLIAM BUTLER

USING STATE-SPACE MODELS TO ASSESS HOW CLIMATE AFFECTS THE DYNAMICS OF SPATIALLY-STRUCTURED COD STOCKS

By Lauren Rogers, NorMER postdoc, University of Oslo

LAUREN ROGERS

Assessing the sensitivity of fish stocks to current and future climate change remains an important but challenging goal. Fish population dynamics are notoriously 'noisy', and distinguishing the effects of climate from intrinsic population processes can be difficult. Atlantic cod *(Gadus morhua)* are known to exhibit strong cohort interactions due to competition and cannibalism, and combined with stochastic recruitment processes this can lead to both high- and low-frequency variation in abundance[1]. Furthermore, evidence suggests that many marine fish stocks consist of multiple subpopulations characterized by differences in genetics and/or life histories[2, 3], yet most studies fail to incorporate this sub-stock complexity, potentially affecting the ability to detect important ecological processes. In this project, we developed a dynamic state-space model that accounts for spatial structure in order to study how changes in climate have affected recruitment and survival in Skagerrak coastal cod.

The historical (1919–present) Flødevigen beach seine survey along the Skagerrak coast of Norway presents a unique opportunity for studying the effects of changes in climate on Atlantic cod population dynamics. Every year, juvenile (age 0 and 1) cod have been sampled at >100 sites distributed among several fjords along the coast *(Fig 1)*. These cod are non-migratory, and genetic population structure has been detected at the scale of individual fjords[2]. Temperature in the Skagerrak has increased during the past two decades *(Fig 2)*, and summer temperatures have often exceeded the optimum for juvenile cod growth[4]. Using this 93-year time series, we asked whether changes in temperature have affected the population dynamics of Skagerrak coastal cod.

In this state-space modeling framework, the system is modeled according to two sets of equations. The first describes the biological dynamics and the second describes the sampling (or observation) process. The biological dynamics of cod were described by age-structured models, which incorporated cohort interactions and spawner-recruit relationships. Populations were modeled at the fjord level and fjords were linked through covariation in recruitment. The observations (survey catches) were modeled according to an overdispersed Poisson distribution. Parameters were estimated in a Bayesian framework using JAGS.

In general, we found that warmer temperatures were associated with lower recruitment and reduced survival in Skagerrak coastal cod. Temperatures experienced during the larval stage were found to have the strongest effect, but temperatures during the first and second summers also had negative effects on survival. Residual recruitment variability was correlated among fjords, likely due to common environmental influences not included in the model. A test based on simulated data showed that this method can estimate the 'true' parameters even in the presence of strong stochasticity and large observation errors, suggesting that this modeling framework is a valid and powerful tool for studying how climate affects the dynamics of age- and spatially-structured fish stocks.

While we cannot directly identify the mechanism linking warmer temperatures to reduced survival in Skagerrak coastal cod, both direct effects on physiology as well as indirect effects via the planktonic prey community are likely[5]. These results are supported by other studies that have found negative effects of warming on cod at the warmer edge of their species distribution[6], and suggest that coastal cod in the Skagerrak will face an increasingly challenging environment if climate continues to warm.

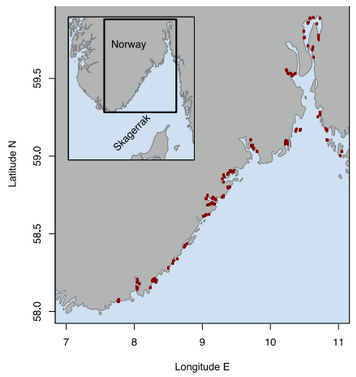


Fig. 1: During the Flødevigen beach seine survey (1919–present), juvenile cod are sampled cod at over 100 stations (red dots) along the Norwegian Skagerrak coast.

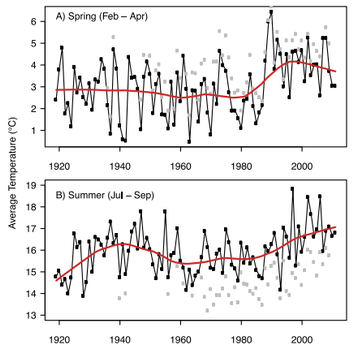


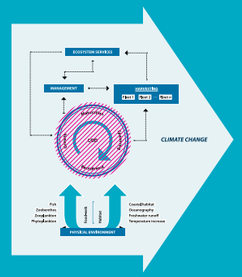
Fig. 2: Average spring (A) and summer (B) sea temperatures recorded near Flødevigen Research Station at 1m (black circles and lines) and 19m (gray circles) depths. Temperatures are only shown if data exist at that depth for at least 80% of the days during the given period. The temporal trend in 1m temperatures is illustrated in red by a loess smoother (span = 0.3).

References: [1] Bjørnstad O.N., Fromentin J-M., Stenseth N.C., Gjøsæter J. 1999. Cycles and trends in cod populations. Proc Natl Acad Sci USA 96:5066–5071. [2] Jorde P.E., Knutsen H., Espeland S.H., Stenseth N.C. 2007. Spatial scale of genetic structuring in coastal cod Gadus morhua and geographic extent of local populations. Mar Ecol Prog Ser 343:229–237. [3] Olsen E.M., et. al. 2008. Small-scale biocomplexity in coastal Atlantic cod supporting a Darwinian perspective on fisheries management. Evol Appl 1:524–533. [4] Rogers L.A., Stige L.C., Olsen E.M., Knutsen H., Chan K-S., Stenseth N.C. 2011. Climate and population density drive changes in cod body size throughout a century on the Norwegian coast. Proc Natl Acad Sci USA 108:1961–1966. [5] Beaugrand G., Brander K.M., Lindley J.A., Souissi S., Reid P.C. 2003. Plankton effect on cod recruitment in the North Sea. Nature 426:661–664. [6] Planque B., Fredou T. 1999. Temperature and the recruitment of Atlantic cod *(Gadus morhua)*. Can J Fish Aquat Sci 56:2069–2077.

CLIMATE RESPONSES IN FISH: TEMPERATURE DEPENDENCE OF PHYSIOLOGICAL PERFORMANCE AND CONSEQUENCES FOR ECOLOGICAL FUNCTIONS

By Rebecca Holt, Department of biology, University of Bergen

FOCUS AREA OF THESE ARTICLES



Marine ecosystems are under pressure from anthropogenic drivers such as climate change, pollution, and exploitation. Among these, climate has an uncontested influence on the marine environment, as it affects individual organisms during all stages, with consequences for populations, communities, and the functioning of marine systems.

The shift in water temperature is considered one of the main driving forces causing changes in the physiology and ecology of fish[1]. At the individual level, increasing temperature can directly influence bioenergetics and numerous physiological and life history processes. Increased temperature directly affects fish metabolism, invoking changes in physiological rates and in particular effects oxygen demand and maximum aerobic respiration, leading to a reduced metabolic scope[2].

Energetic demands placed on an organism as a result of temperature changes can place constraints on the allocation of resources to all components of fitness with consequences expected for populations, communities, and the functioning of marine ecosystems.

We develop a conceptual state-dependent model that mechanistically describes temperature-dependent physiological processes for a general teleost fish within an ecological and evolutionary setting. The focus on physiological mechanisms such as metabolic scope and oxygen budget fulfills the purpose of this model, which is to derive hypotheses for consequences of temperature induced adaptations for life histories of fish within a general conceptual model.

The model is state dependent, describing temperature-dependent energy allocation to growth and reproduction in fish, based upon a model parameterised for Northeast Arctic cod developed by Jørgensen & Fiksen (2010)[3]. A simple bioenergetics structure is used where energy is described as a restricted resource, in which the life-long pattern in allocation embodies many of the trade-offs that shape life history. The energy allocation process is modelled mechanistically while retaining flexibility in how allocation can change with state and time under varying temperature and ecological scenarios.

Within the bioenergetics framework we include a simple oxygen budget, which describes temperature dependent respiration in fish, utilizing general relationships for metabolic processes sourced within the current literature. The model is parameterized for Atlantic cod *(Gadhus morhua)*, but using relationships representative of a general teleost fish.

We use dynamic programming techniques[4, 5], to find the optimal allocation pattern under the constraints given by the realistic and detailed description of physiology and ecology to provide evolutionary predictions of temperature-dependent life history processes.

The model illustrates how climate change effects may influence the life history strategies of fish in diverse ways *(Fig. 1)*. As temperatures increase, greater energetic costs are incurred resulting from the increase in the rate of biochemical reactions, reducing the amount of metabolic scope or energy available for allocation to growth and reproduction.

Emergent patterns in foraging behaviour are observed, whereby increased temperature results in an increased rate of foraging. Fish forage harder, behaviorally compensating for changes in temperature-dependent physiological processes. Natural mortality increases due to the evolutionary life history response towards a smaller size, increased predation risk and elevated reproduction investment.

The model demonstrates that under increasing temperature scenarios fish will mature earlier and at smaller sizes. This result extends the standard expectation for life history responses as usually observed from high levels of mortality such as that caused by fishing[6].

REBECCA HOLT

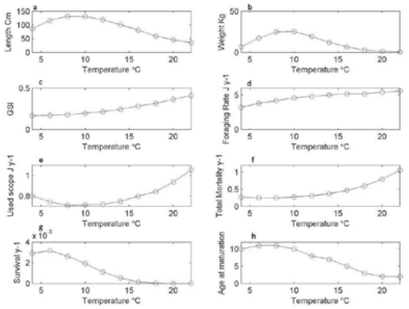
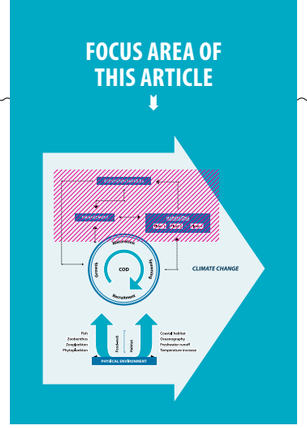


Fig. 1: Temperature dependent life history responses at age 15; growth in terms of length (a), weight (b), reproductive investment quantified as GSI (Gonad-somatic index) (c), optimized strategy of foraging behaviour (d) and age of maturation (h), amount of used metabolic scope (e), acquired total mortality found through forward simulation of state-dependent life history strategies (f) and Survival (g).

References: [1] Pörtner, H-O., Bock, C., Knust, R., Lannig, G., Lucassen, M., Mark, F.C. and Sartoris, F.J. 2008. Cod and climate in a latitudinal cline: physiological analyses of climate effects in marine fishes. Climate Research. 37: 253–270. [2] Rijnsdorp, A.D., Peck, M.A., Englehard, G.H., Möllmann, C. and Pinnegar, K. 2009. Resolving the effect of climate change on fish populations. ICES Journal of Marine Science. 66: 1570–1583. [3] Jørgensen & Fiksen. 2010. Modelling fishing induced adaptation and consequences for natural mortality. Canadian Journal of Fisheries and Aquatic Sciences. 67: 1086–1097. [4] Houston, A.I., and McNamara, J.M. 1999. Models of adaptive behaviour: an approach based on state. Cambridge University Press, Cambridge, UK. [5] Clark, C.W. and Mangel, M. 2000. Dynamic state variable models in ecology. Oxford University Press, New York. [6] Law, R. and Grey, D.R. 1989. Evolution of yields from populations with age-specific cropping. Evolutionary Ecology. 3: 343–359.



OPTIMAL BIOECONOMIC MULTISPECIES FISHERIES MANAGEMENT AND GAME THEORETICAL ANALYSIS OF THE BALTIC SEA FISHERIES

By Emmi Nieminen, NorMER PhD student, University of Helsinki, Finland

EMMI NIEMINEN

INTRODUCTION

Baltic cod *(Gadus morhua callarias)*, Baltic herring *(Clupea harengus membras)*, and sprat *(Sprattus sprattus)* are the most commercially exploited fish species in the Baltic Sea. Since 1985, cod catches have rapidly decreased, and simultaneously sprat catches – a prey species of cod – have increased remarkably[1]. The reason for lower cod catches was – in addition to high fishing pressure – the low salinity and oxygen levels for cod recruitment. Continuing climate change may have decreasing effects on the salinity level in the Baltic Sea[2,3] due to changes in the atmospheric circulation and therefore decrease in the salt water pulses from the North Sea[4,5].

The species interactions have effects on the development of the fish stocks in the Baltic Sea and an important influence on both biological and economic performance. Here we will first present our previous multispecies study, the underlying bioeconomic model and the results. Then, the upcoming research with game theoretical application will be introduced.

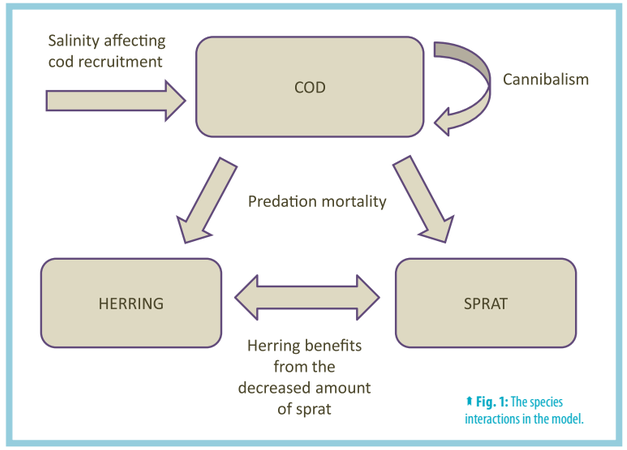


Fig. 1: The species interactions in the model.

OPTIMAL MULTISPECIES BIOECONOMIC MANAGEMENT*

We have earlier developed a deterministic, discrete, multispecies bioeconomic model for cod, herring, and sprat concerning the Baltic Sea fishery[6]. Our simulation period is 50 years with a one-year time step. To find the economically optimal fishing mortality paths for the species, we construct a numerical model combining biological and economic factors, and maximize the net present value (NPV) over the simulation period under the biological constraints. The optimization is conducted from the viewpoint of a fisheries management planner, and the aim is to maximize the social welfare of the entire fishing industry.

The biological part of the model consists of population dynamics and the biological interactions of the species. The recruitment function for herring and sprat is modeled using Ricker's density dependent formation. Cod recruitment follows a function according to Heikinheimo[7,8] with a salinity factor included. The main interaction between the species is the cod predation on herring and sprat[9] *(Fig. 1)*. We model the interaction by using a predation mortality functions based on functional response rates. In addition, herring benefits from lower sprat stock and cod cannibalism is also included. The cost function for cod follows a non-linear format as in Arnason et al.[10]. According to the function, an increase in cod biomass decreases harvesting costs because the fish are then easier to locate. For herring and sprat, the costs are linear function of fishing effort according to Gordon[11]. We assume that price is constant for each species.

We simulate the model under four different scenarios. The first scenario is the current situation with current fishing mortalities under low salinity conditions. Scenario 2 is also conducted under these conditions, but in this case we optimize the fishing mortalities. Scenarios 3 and 4 consider situations under higher salinity conditions with current and optimal fishing mortalities. All the main results are presented in Table I. The fishery of cod, herring, and sprat in the Baltic Sea is at present profitable, but the profits could be almost three times higher in the long run if fishing mortalities were optimized. A lower fishing mortality for cod allows time for individuals to grow and achieve a higher economic value and reproduction potential. This would increase the net present value due to higher catches and lower harvesting costs.

In Scenario 3 under improved salinity conditions, which leads to better conditions for cod recruitment, the net present value would be almost seven times higher than in Scenario 1 even with current fishing mortalities. Higher salinity level would increase the cod stock remarkably and furthermore affect herring and especially sprat stocks negatively, and their harvests almost disappear. When the fishing mortalities are optimized in Scenario 4, the net present value would be even higher. Still, even under higher salinity conditions the optimal fishing mortality of cod would be lower than currently.

In Scenario 2, the net present value becomes almost three times higher compared to Scenario 1, but the proportional increase is much less in Scenario 4 compared to Scenario 3. According to this, fishing regulations are relatively more important under low salinity conditions which are likely to prevail in the future due to changing climate.

TABLE I: Average steady states of the scenarios

	Nc	Nh	Ns	SSBc	SSBh	SSBs	Fc	Fh	Fs	Hc	Hh	Hs	NPV
Scenario 1	0.7	66	190	0.2	0.9	0.9	0.59	0.24	0.47	88	200	300	1.8
Scenario 2	1.5	75	240	0.5	1.6	1.3	0.28	0.21	0.05	160	310	57	5.3
Scenario 3	5.5	49	10	1.0	0.9	0.04	0.59	0.24	0.47	570	200	11	12.1
Scenario 4	5.5	51	48	1.4	1.0	0.2	0.42	0.03	0.01	570	40	0.8	15.4

N=stock size in numbers (thousands of millions), SSB=spawning stock size (millions of tonnes), F=fishing mortality rate, H=catch (thousands of tonnes), NPV=net present value (billion €); subscripts c, h, and s refer to cod, herring, and sprat, respectively.

GAME THEORY – UPCOMING RESEARCH

In our bioeconomic analysis we assumed there is a single decision maker, a sole owner, who can choose the optimal fishing mortalities for the species that maximizes the benefits. What about if we have several decision makers as it is often in the real world? There are nine countries harvesting in the Baltic Sea *(Fig. 2)*, and it is definitely not a sole owner situation. Our tool for analyzing this kind of strategic interaction of more than one rational decision maker is game theory. The decision makers, or players, affect the availability of fish stock by their own actions and thus the economic profits of other players as well. Game theory helps explaining the different actions players take in fishery. So far there exist only few economic multispecies studies that have been conducted from a game theoretical point of view.

In our model the players, i.e. countries, are asymmetric as they have different harvesting costs and discount rates. These differences affect their optimal harvesting strategies. In our analysis we will first optimize the fishery from a viewpoint of all three countries. The countries will maximize their joint profits by choosing their optimal fishing mortalities each year. Why is it then difficult to attain this cooperative solution? The problem lies in the incentive to free ride. One country may leave the agreed cooperation and free ride if it benefits more by doing so. Thus, the free-rider is harvesting more than has been agreed according to quotas. Our second task is to assess the profits countries receive when instead of cooperating they decide to non-cooperate. Now each country maximizes its own profits instead of joint profits. Countries have to take into account the choices of others, since those affect the availability of fish that can be harvested. Usually non-cooperation yields lower profits and higher fishing mortalities in total than a cooperative solution. Finally, our focus is on partly cooperative games where two of the countries start harvesting together and form a coalition whereas the third country acts as a singleton. The coalition is cooperating and maximizing its joint profits, but they are playing a game against the singleton that maximizes its personal profits.

The main focus in the study will be comparing the different types of games, the profits gained from those, and the stability of the cooperation. We will also examine the effects of different discount rates between the countries. Finally all the games will be compared with the present real world situation in order to discover what kind of game structure is closest to the current one.

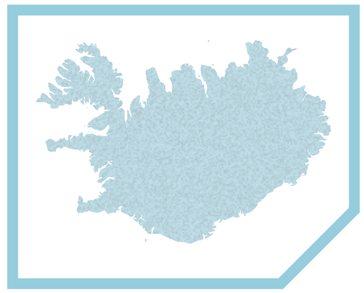
Fig. 2: Countries around the Baltic Sea.

References: [1] ICES, 2010, Report of the Baltic Fisheries Assessment Working Group (WGBFAS), 15–22 April, 2010, ICES Headquarters, Copenhagen, Denmark, ICES CM 2010/ACOM:10, 642 pp. [2] Meier, H.E.M. 2006. Baltic Sea Climate in the Late Twenty-First Century: A Dynamical Downscaling Approach Using Two Global Models and Two Emission Scenarios. Climate Dynamics, 27(1), pp. 39–68. [3] Neumann, T. 2010. Climate-Change Effects on the Baltic Sea Ecosystem: A Model Study. Journal of Marine Systems, 81(3), pp. 213–224. [4] Matthäus, W. and H. Schinke. 1994. Mean Atmospheric Circulation Patterns Associated with Major Baltic Inflows. Ocean Dynamics, 46(4), pp. 321–339. [5] Schinke, H. and W. Matthäus. 1998. On the Causes of Major Baltic Inflows – An Analysis of Long Time Series. Continental Shelf Research, 18(1), pp. 67–97. [6] Nieminen, E., M. Lindroos, and O. Heikinheimo. 2012. Optimal Bioeconomic Multispecies Fisheries Management: A Baltic Sea Case Study. Marine Resource Economics 27(2):115–136. [7] Heikinheimo, O. 2011. Interactions Between Cod, Herring and Sprat in the Changing Environment of the Baltic Sea: A Dynamic Model Analysis. Ecological Modelling, 222(10), pp. 1731–1742. [8] Heikinheimo, O. 2008. Average Salinity as an Index for Environmental Forcing on Cod Recruitment in the Baltic Sea. Boreal Environment Research, 13, pp. 457–464. [9] Sparholt, H. 1994. Fish Species Interactions in the Baltic Sea. Dana 10:131–62. [10] Arnason, R., L.K. Sandal, S.I. Steinshamn, N. Vestergaard, S. Agnarsson and F. Jensen. 2000, Comparative Evaluation of the Cod and Herring Fisheries in Denmark, Iceland and Norway. TemaNord 2000:526, Ekspressen Tryk og Kopicenter, Denmark. [11] Gordon, H.S. 1954. The Economic Theory of a Common-Property Resource: The Fishery. The Journal of Political Economy, 62(2), pp. 124–142.

* The full article from which this chapter is derived was published in Marine Resource Economics Vol. 27, No. 2, pp: 115–136, published by the Marine Resource Foundation, Inc.

Young researcher workshops

Text by Lauren Rogers



Training a new generation of researchers to tackle issues related to climate change and marine ecosystems is one of the primary goals of NorMER. This new generation should be skilled at collaborating and communicating across disciplines ranging from physical to biological to social sciences. As a geographically distributed center, developing such skills can be a challenge. Following the NorMER Annual Meeting in October 2011, the young researchers (YR) developed, on their own initiative, two activities to become a more cohesive group of collaborating researchers: the first was to start a NorMER Blog (which can be seen at http://www.normer.uio.no/blog), and the second was to organize workshops to bring the young researchers together on a regular basis to work towards a common goal. Two YR-organized workshops have followed, giving all YRs the opportunity to learn and apply real skills in collaborative, interdisciplinary research.

Photography: Kind stranger

1

12–13 MAY 2012

MARINE BIOLOGICAL STATION
DRØBAK, NORWAY

—

We first came together for two days in Drøbak, Norway. The idea was to consider proposals for a group project we could all participate in, and to subsequently embark on such a project. It quickly became clear that the Copenhagen node (led by Ana Sofia Ferreira, Martin Wæver Pedersen, and Alexandros Kokkalis) would lead the charge, having developed a clear idea for a project that would *1)* require the expertise of all YRs, *2)* increase our knowledge of climate effects on Nordic marine ecosystems, and *3)* likely result in one or more YR-authored publications of interest to other researchers and the general public (see box).

Following their lead, we embarked on our first task: *defining commonly-used terms in marine research*. This was educational for all, as we realized that we may use the same words to refer to different things, and vice versa. Despite having talked of taking a relaxed hike in the woods, we ended up working around a white board until late at night, eagerly debating definitions and developing a common language. We started again early the next morning, setting goals and a timeline for work before we would meet again. We left with a new appreciation for the challenges of interdisciplinary group work, but also with great enthusiasm for being part of such an engaged community of young researchers.

2

6–7 OCT 2012

LAMMI BIOLOGICAL STATION
LAMMI, FINLAND

—

Five months later, we met at Lammi. We had grown to 18 young researchers, comprised of 6 postdocs and 12 PhD students, representing 8 NorMER nodes and 11 nationalities. For two days, we pored over results from our pilot study, assessed our original goals, set out additional ones, and left with a concrete plan for turning ideas and analyses into manuscripts. The interactions fostered during the workshops, as well as the continuing discussions over email and Skype, have been essential for creating a cohesive community of young researchers from different countries and disciplines. It's clear that the network that we are forming now will benefit us and our science throughout out careers.

Photography: Kind stranger

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TRENDS IN NORDIC MARINE CLIMATE CHANGE RESEARCH

By Martin Wæver Pedersen

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This project is a collaboration between all young researchers (PhD students and postdocs) affiliated with NorMER and aims to address the following questions: What is the current state of climate change research within the Nordic marine regions? Specifically, what has been studied so far, what are the trends in research activity, and where are the gaps?

The approach is to create a database categorizing the literature relevant to NorMER (limited by certain criteria). The contents of the database can then be visualized and synthesized, and used to answer specific questions. For instance, which species are the most studied in the climate change research within the North Atlantic? Most people may have an opinion about this, but with the database the question can be answered using facts rather than speculation. The database will also contain information about the spatial and temporal structure of the relevant literature such that trends in climate change research can be quantified. This includes also trends in more complex aspects such as interdisciplinary approaches to research, spatial variability in research foci, or the temporal development of cod-temperature studies.

The database will serve as a valuable asset for future studies to everybody in NorMER. However, the potentially most valuable outcome of the project is the lessons learned from the exercise of constructing the database, compiling the literature, and above all coordinating and collaborating among the many international nodes and diverse backgrounds of people involved in NorMER. Currently, all NorMER young researchers are involved with creating the database.

There are currently plans of publishing a scientific paper describing the trends in the literature in relation to climate change studies in the North Atlantic using the information gathered in the database. However, the database will contain such a vast amount of information that several other papers have been discussed, such as a network analysis of collaborations between research groups in the Nordic region. Such publications, coauthored by all young researchers, would not only be of value at the individual level, but also identify NorMER as a coherent center.

A flock of Northern Gannet *(Morus bassanus)* taken on an expedition in the North Sea.

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Photography: Ruben A. Pettersen

SECTION FOUR:
Awards and honors

SECTION FOUR—AWARDS AND HONORS

Johan Hjort Chairs

An internationally distinguished researcher is invited to attend each annual meeting as Johan Hjort Chair in Marine Biology, in honor of a professor in marine biology at the University of Oslo 1921–1939, and the president of ICES 1938–1948.

This Johan Hjort Chair is intended as a position of honor to express our recognition of researchers or managers who have made an especially large contribution to a field relevant to NorMER's scientific focus. It is also a valuable opportunity for PhDs, Postdocs, and senior scientists in NorMER to interact with someone who has made a transformative contribution to research on marine ecosystems, and an invitation to the Johan Hjort invitee to become more deeply involved in NorMER research. It is our intention that the Johan Hjort chairs, both through their research and their participation in NorMER, will be a source of inspiration to all of the PhDs and Postdoc level researchers within our Nordic Centre of Excellence.

The Johan Hjort Chairs are invited to give a keystone lecture at an annual meeting and are encouraged to continue their participation in NorMER throughout and beyond the following year. With our second annual in October 2012, we have had two distinguished holders of his honorary position. The Johan Hjort Chair for 2011 was Bob Dickson from Cefas and for 2012 is Rashida Sumaila from the Fisheries Centre at the University of British Columbia.

ROBERT (BOB) BOYDS DICKSON
NORMER'S 2011 JOHAN HJORT CHAIR

Dr. Bob Dickson was educated at the University of Edinburgh in 1961–64, and gained a Ph.D in Environmental Sciences at the University of East Anglia in 1965–67. Since joining the Lowestoft Laboratory (now CEFAS) in 1964, he has maintained four main research interests: First, since the early days of the self-recording current meter, he has contributed to the available stock of direct current measurements by which the sense and variability of the deep ocean circulation has become better understood. Second, he has studied the processes that drive variations in the physical environment of the North Atlantic, including the varied ocean response to an extreme multi-decadal shift in the North Atlantic Oscillation between the 1960s and 1990s. Third he has investigated ways in which change in the ocean circulation and climate at interannual to decadal time scales have affected various components of the Atlantic ecosystem from plankton to commercial fish stocks. Fourth and most recently, he has contributed to major international research efforts aimed at understanding the role of the high latitude ocean in Global Change. This has involved (principally) the task of chairing and coordinating the international Arctic-Subarctic Ocean Flux Study (ASOF) from its inception in 2000 to becoming one of the largest ocean-observing systems in the Hemisphere, and his continuing efforts on behalf of the Arctic Ocean Sciences Board to piece-together an integrated Arctic Ocean Observing System (iAOOS) for the International Polar Year and its 'legacy phase'

In pursuing these interests in the role of the Northern Seas in climate, Bob Dickson has acted as Deputy Chairman of the Arctic Ocean Sciences Board, as a member of the WCRP-CLIVAR Atlantic Panel, as a Member of the SSC for the University of Washington Study of Environmental Arctic Change (SEARCH), as a Member of the Steering Committee for the 'RAPID Climate Change' thematic programme of UK-NERC and as a member of the Royal Society's UK National Committee for the International Polar Year 2007/8. Most recently, in March 2011, his Report defining 'An Ocean-Observing System for Northern Seas during the Legacy Phase of the International Polar Year', written at the request of the Arctic Ocean Sciences Board (now the Marine WG) of IASC, was delivered and accepted during the Arctic Science Summit Week in Seoul, South Korea. Since 2011, Bob has been a member of the Advisory Board for SIOS (Svalbard Integrated Arctic Earth Observing System), part of the international effort to define its optimal scientific profile; and from 2011–12, he was one of the 9-member international Committee under Thomas Rosswall charged with the 'Evaluation of Norwegian Climate Research' for the Research Council of Norway (submitted June 2012).

In recognition of his long-sustained efforts to measure the cold, dense Denmark Strait Overflow (his own research contribution to ASOF), he gained the prestigious Albatross Award of the American Miscellaneous Society (1998). More conventionally he was elected a Fellow of the Royal Society of Edinburgh (1995); was awarded the Plymouth Marine Sciences Silver Medal (1995) and was appointed first Fellow of the Sir Alister Hardy Foundation for Ocean Science (1997) in recognition of his role in rescuing the long-term Continuous Plankton Recorder Survey, now the World's leading index of change in the planktonic ecosystem; and was awarded the Kelvin medal of the Royal Philosophical Society of Glasgow (2004). On his retirement in 2006, Bob Dickson was appointed the first CEFAS Emeritus Research Fellow and his contribution to science was recognized in his appointment as CBE in the Queen's New Year Honours List of January 2007. Bob was invited to take part in the British library 'Life Stories' series (now on the point of completion).

In October 2011, in recognition of the broad and fundamental contributions he made to field of marine science throughout his research career, Bob was appointed to the 1st Johan Hjort Chair in Marine Biology and Management by the Nordic Centre of Excellence 'NorMER' led by the University of Oslo. As part of that contribution, he initiated the 'Inspiration Awards of the University of Oslo' endorsed enthusiastically by the University, with the first two awards made during the first annual NorMER Meeting in Oslo in Oct 2011 and the second pair awarded in Helsinki Oct 2012 during the 2nd annual NorMER meeting. A third and final pair will be awarded at the 2013 annual meeting in Reykjavik.

RASHID SUMAILA
NORMER'S 2012 JOHAN HJORT CHAIR

Dr. Ussif Rashid Sumaila is Professor and Director of the Fisheries Economics Research Unit at UBC Fisheries Centre. He specializes in bioeconomics, marine ecosystem valuation and the analysis of global issues such as fisheries subsidies, IUU (illegal, unreported and unregulated) fishing and the economics of high and deep seas fisheries. He is deeply interested in how economics, through integration with ecology and other disciplines, can be used to help ensure that environmental resources are sustainably managed for the benefit of all generations. Sumaila has experience working in fisheries and natural resource projects in Norway, Canada and the North Atlantic region, Namibia and the Southern African region, Ghana and the West African region and Hong Kong and the South China Sea.

He has published articles in several journals including appearances in Science, Nature and the Journal of Environmental Economics and Management. Sumaila's work has generated a great deal of interest, and his work has been cited by media such the Economist, the Boston Globe, the International Herald Tribune, Maine Sunday Telegram, the Financial Times, the Globe and Mail, VOA, CBC News and the Vancouver Sun.

The recognition of Sumaila's contribution to the global debate on achieving sustainable ocean fisheries has won him awards, including, the Leopold Leadership Fellowship, the Pew Fellowship for Marine Conservation; Craigdarroch Award for Societal Contribution; the Zayed International Price for the Environment and the Peter Wall Institute Senior Early Career Scholar Award.

The evidence of his policy influence can be judged by the many high-level invited talks he has given over the years including at the UN Rio + 20 Ocean Dialogue, the White House, the U.S. Congress, the Canadian Parliament, the House of Lord, UK and the WTO. Indeed, Sumaila got an audience with Prince Charles at the St James Palace in London in 2010, where they discussed how to achieve sustainable ocean fisheries worldwide.

In October 2011, in recognition of Sumaila's contributions to the field of ocean and fisheries economics, management and policy, he was appointed to the 2nd Johan Hjort Chair in Marine Economics and Management by the Nordic Centre of Excellence 'NorMER' led by the University of Oslo. As part of that contribution, Sumaila gave a keynote speech in Helsinki Oct 2012 during the 2nd annual NorMER meeting.

For more information, see Professor Sumaila's homepage:
http://www.fisheries.ubc.ca/faculty-staff/rashid-sumaila

The University of Oslo 'Inspiration' Awards

A BRIEF EXPLANATION AND NOTES FOR RECIPIENTS

In 2011, a new Nordic Centre of Excellence NorMER (Nordic Centre for Research on Marine Ecosystems and Resources under Climate Change) was established to combine the expertise of internationally recognized research teams from all the Nordic countries in order to explore the biological, economic, and societal consequences of global climate change on fisheries resources in the Nordic region. The programme is administered within the Department of Biology at the University of Oslo.

As part of the new programme, a 'Johan Hjort Professorship' was also instigated, with the aim of inspiring the multidisciplinary research teams of NorMER in some clear and focused way, and the 'Inspiration Awards' described here are one direct result.

The idea for these awards stems from a rather plain volume sent to me out of the blue in the late 1980s by Henry Stommel, carrying his brief inscription on the flyleaf *(award #6)*. As Jim Luyten and Nelson Hogg of Woods Hole wrote in 1992 (special Stommel issue of Oceanus magazine), *«For most of the past 50 years, Henry Melson Stommel was the most influential figure in oceanography. Through his simple brilliance, his personal magnetism, and his great zest for life, he inspired legions of oceanographers».* And his gift with its simple inscription certainly inspired me for decades. With this example in mind, a total of six equally-inspirational award-volumes have been brought together, roughly corresponding to the subjects of meteorology, marine biology, the marine ecosystem, science administration, physical oceanography and numerical climate studies, all of fundamental interest to NorMER; each of the six award volumes is as special as we could make it, having been inscribed by six of the great leaders of these subjects, namely Fridtjof Nansen, Sheina Marshall and Andrew P. Orr, Sir Maurice Yonge, C.T.R. Wilson, Henry Stommel and Lewis Fry Richardson. Each is described in a little more detail on the next few pages.

The proposal for these Inspiration Awards has been enthusiastically endorsed and adopted by the Rector of the University of Oslo, Professor Ole Petter Ottersen, the university's highest official representative, whose own duties place emphasis on *«...serving as an inspirer, a cultural bridge-builder and an initiator»*. While the Award is intended to confer Distinction, it does also place a couple of important obligations on the recipient. First, within a few years (~5) of receiving an award, each recipient is asked to pass his or her award volume on to someone who has inspired them in their subject together with a copy of this 'explanation', and to arrange to tool the leather slip case of the volume with the year, name, and affiliation of the new recipient. At the same time, they are asked to notify the Library of the University of Oslo* of the contact details of the new recipient so that they might keep track: in this simple way, the hope is that the Inspiration Awards scheme may be self-perpetuating.

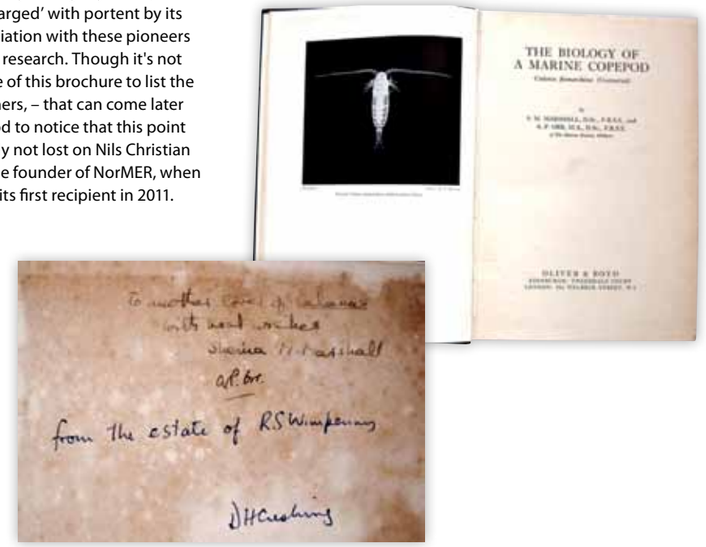
In *«The Collected Works of Henry M. Stommel»* edited by Nelson Hogg and Rui Xin Huang, his unpublished autobiography includes these words: *«The freedom to work in science on one's own, with congenial colleagues, unfettered by supervision, with a scientific problem in one's mind when he goes to bed and awakes next morning, to be able to give undivided attention to unraveling some puzzle of nature is a privilege beyond compare»*. If you have received one of these awards, it is because, in someone's considered opinion, a significant step in that 'unraveling' process has been down to you!

Bob Dickson, Cefas, NorMER,
Johan Hjort Professor, 2011–12

**The contact information for the University of Oslo Science library is: Science Library, Niels Henrik Abels hus, first floor, Moltke Moes vei 35, P. O. Box 1063 Blindern, 0316 Oslo, Norway. Phone: +47-22855400. E-mail: realfagsbiblioteket@ub.uio.no*

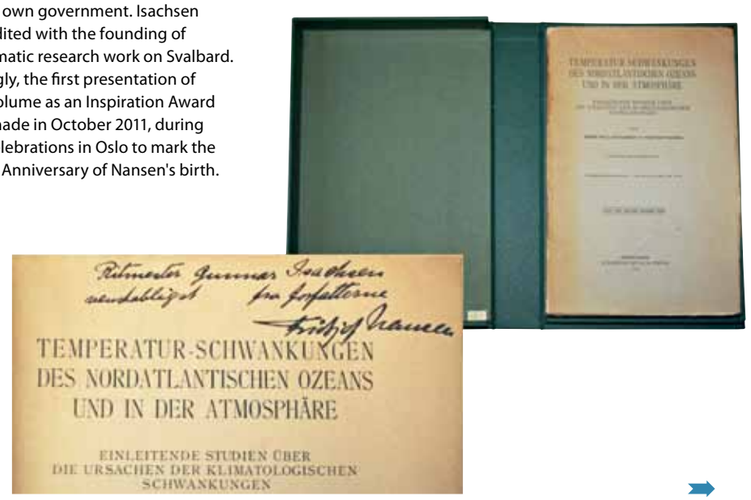
1 Award for Marine Biology

At first sight this may seem a strange choice for an Award Volume. Rather scruffy and lacking a dust jacket, it may seem an unlikely candidate for a green leather slip case and gold tooling. But quite the reverse is the case. In one of these winter evenings over a bottle of wine at the home of the great Lowestoft marine ecologist David Henry Cushing, when Cush was intent on showing me his treasures, this plain slim volume was one he returned to time and again and was plainly something special to him. The inscriptions make it so. This monograph on *«The Biology of a Marine Copepod»*, printed in 1955, summed up much of the life's work of two marine biologists from the Millport Marine Station on the Isle of Cumbrae, Sheina M. Marshall and A.P. Orr, and was inscribed by them both to R.S. Wimpenny of the Lowestoft Laboratory *«...another lover of Calanus»*. David Cushing later obtained the volume from Wimpenny's estate and his ownership signature completes a flyleaf that may be slightly foxed, but which is 'charged' with portent by its direct association with these pioneers of plankton research. Though it's not the purpose of this brochure to list the award-winners, – that can come later – it was good to notice that this point was certainly not lost on Nils Christian Stenseth, the founder of NorMER, when he became its first recipient in 2011.



2 Award for Meteorology

This delicate but early and influential account of the temperature changes in the North Atlantic Ocean and atmosphere was presented to me in his usual quiet way, *«Here. I'd like you to have this. You like these things»*, by Odd Henrik Saelen who had been Professor of Physical Oceanography at both the University of Oslo (from 1965) and University of Bergen (from 1978) and whose great specialism was the hydrography of the Norwegian Sea. When Harald Sverdrup wrote his famous work *«On conditions for the vernal blooming of phytoplankton»* in 1953, it was based on the comprehensive data set collected at Ocean Weather Station Mike by Odd Saelen. Though this presentation copy was written by Bjorn Helland-Hansen and Fridtjof Nansen, its exciting feature is the inscription to *«Captain Gunnar Isachsen from the authors, (signed) Fridtjof Nansen»*. Isachsen had been topographer on Otto Sverdrup's Fram Expedition to the Arctic Archipelago from 1898 to 1902, mapping large areas of Northern Canada in the course of long sledge journeys. He was promoted 'Rittmeister' (~Captain) in 1899 and led topographic and bathymetric expeditions to Svalbard from 1906 to 1910, funded both by Prince Albert of Monaco and by his own government. Isachsen is credited with the founding of systematic research work on Svalbard. Fittingly, the first presentation of this volume as an Inspiration Award was made in October 2011, during the celebrations in Oslo to mark the 150th Anniversary of Nansen's birth.



3 Award for the Administration

This award is directed towards those who have inspired, argued for and driven the progress of science through one or other aspect of its administration – for example in their role within Government, Funding Agency, Science Evaluation Group (an increasingly large and complex task) or as Institute Director. While we would readily accept that a sympathetic and supportive administration is crucial in advancing our science, it is a role we only rarely acknowledge, hence this award. The Award is appropriately 'special' too. Simply inscribed *«To W. Dickson (my father) from CTR Wilson»*, it is the Nobel Lecture that CTR delivered in Stockholm in 1927 describing his discovery of the cloud chamber, a device described by Ernest Rutherford as *«the most original and wonderful instrument in scientific history*»*, and used in many of the discoveries that led to the development of particle physics. Wilson was also deeply interested in atmospheric electricity and his ideas about thunderstorms are at the heart of modern theories. My father and CTR developed their close friendship after finding themselves sitting together at a lecture in Edinburgh by the great Danish physicist Niels Bohr, and as Head of the Science Department at George Watsons College in Edinburgh, my father would annually insist that the Science 6th should send Birthday and Christmas greetings to the great man at his retirement home in Carlops until his death in 1959. Some of his replies are tipped in. Simple stuff maybe, but direct 'touches' nonetheless of what I find 'inspirational' about this volume.

**Source: Royal Society of Edinburgh.*

4 Award for Ecosystem Science

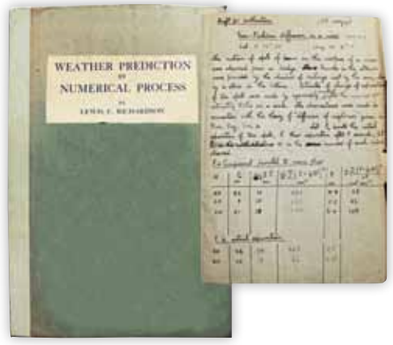
This award is a 1930 first edition of Sir Maurice Yonge's *«A Year on the Great Barrier Reef»*, inscribed by him on behalf of the Great Barrier Reef Expedition to Prof. J.H. Ashworth FRS, and including The Expedition Christmas Card of 1928–29 sent from Low Isles North Queensland, signed by *«C.M. Yonge and Party»*. The flyleaf also carries the ownership signature of David Cushing, who presented the volume to me towards the end of his life.

With the consent and enthusiastic support of the Team that operates the Continuous Plankton Recorder (CPR) Survey out of Plymouth, this Award has been designated the *«Michael Colebrook Memorial Volume»*, and its slipcase is labelled to this effect so that people will continue to ask who Michael was, and what he did that was so special in leading the Survey to achieve so many of Sir Alister Hardy's original scientific aims.

Michael's principal contribution – one that underpinned the work of the Survey for so many years – was bringing statistical rigour to the analysis of the large and complex CPR data set, and the methods of counting phytoplankton were changed early on to allow these more rigorous analyses to be applied (COLEBROOK, J.M., 1960). From the early 1960s, his were the three main lines of work by which the plankton became understood: – principal components analysis to describe the geographical distribution of zooplankton (COLEBROOK, J.M., 1964); parametric analysis to describe the abundance, timing and season length of phytoplankton and copepods in the north-eastern Atlantic and the North Sea (COLEBROOK, J.M. & G.A. ROBINSON, 1965); and the analysis and interpretation of long-term change in the planktonic ecosystem (COLEBROOK, J.M, & G.A, ROBINSON 1964). These analyses of interannual variations were to become Michael's most important work. At a time (1970s) when it was fashionable to attribute planktonic changes to pollution, he identified climate as the predominant factor. Fortunately the issue of climate change was to come more and more to the fore so that in the late 1980s when the survey was threatened with closure, Michael's efforts brought sustained pressure to bear from the international scientific community and contributed directly to the survival and subsequent success of the Survey. Though determined in support of his Survey, Michael would have been too shy and private an individual to make these claims on his own behalf; but in September 2011, when 180 scientists from 21 countries came to Plymouth to celebrate 80 years of CPR operation, he would have reflected with quiet satisfaction that by then, the Recorder had been towed for a total of almost 6 million nautical miles, the CPR Team had analysed 245,000 samples from its regular monitoring routes and a new Global Alliance of CPR Surveys (GACS) had just been formed. It is appropriate too that the first award of this Volume in 2012 is to two (past and present) members of the SAHFOS Team.

MICHAEL COLEBROOK

References: COLEBROOK, J.M. (1960). *Continuous plankton records: methods of analysis, 1950–59*. Bull. Mar. Ecol., 5, 51–64. COLEBROOK, J.M. (1964). *A principal components analysis of the geographical distribution of zooplankton*. Bull. Mar. Ecol., 6, 78–100. COLEBROOK, J.M, & G.A, ROBINSON (1964). *Continuous Plankton records: annual variations of abundance of plankton, 1948–1960*. Bull. Mar. Ecol., 6, 52–59. COLEBROOK, J.M. & G.A. ROBINSON (1965). *Continuous plankton records: seasonal cycles of phytoplankton and copepods in the north-eastern Atlantic and the North Sea*. Bull. Mar. Ecol., 6, 123–139.

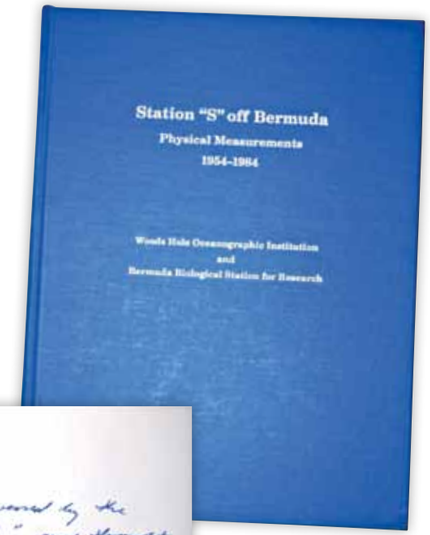


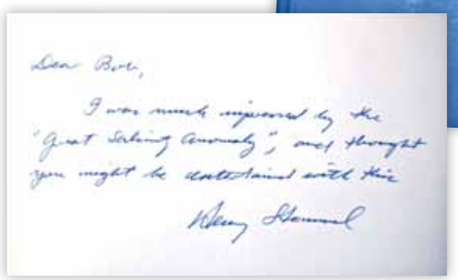
5 Award for Numerical Climate Studies

While this volume may appear at first sight to be the least prepossessing of the set, it is in fact one of the treasures of the Inspiration Awards scheme, presented to me for this purpose by Peter Rhines of the University of Washington and containing the imprint of three major figures of our science, L.F. Richardson, Henry Stommel and Peter Rhines himself. Lewis Fry Richardson (1881–1953) was an English mathematician, physicist, meteorologist, psychologist and pacifist whose interest in meteorology led him to propose a scheme for weather forecasting by solution of differential equations which he published in 1922 as *«Weather Prediction by Numerical Process»*. This became in Peter's words *«the spark for all numerical climate studies»*. The Award volume is an unbound copy of this book, together with a range of manuscript notes on a range of topics, that he presented to Henry Stommel with the simple inscription *«Henry Stommel, complements of L.F.R.»* in 1948. Thirty years later, Hank passed-on the volume to Peter with the words, *«L.F. gave me this unbound copy of his book. Attached are some experimental notes in his own hand. I think you may like to have them for sentiment's sake, Henry, April 1978»*. And Peter Rhines' ownership signature completes the set.

6 Award for Physical Oceanography

This simple volume on the origins and data set at *«Station "S" off Bermuda»* by Henry Stommel has already been described in the introduction to these notes, as has its inspirational impact on myself. The story of the Great Salinity Anomaly that Henry refers to was one that I published with others in 1988 telling the tale of a huge freshwater pulse that passed out of the Subarctic Seas through Denmark Strait in the late 1960s to circle the Northern Gyre over a 14-year period before returning to the northern Nordic Seas once again around 1982. It was a special event for all sorts of reasons: its spreading gave a first direct estimate of the mean circulation-speed of the Atlantic subpolar gyre (~3 cm s -1) and helped us to test and improve a range of ocean-circulation and hydrobiological models; the export of this 2000 km^3 of extra fresh water from the Greenland-Iceland Seas to the North Atlantic carried the potential for significant effects on global climate via its control of the changing effectiveness of deep water formation; and it *«generated more variability in fisheries during the last quarter of a century than any other hydrographic event in recent years»* (Jakobsson, 1992; 15 major stocks were affected). However, I like to think that Henry's kind note reflected none of these things. In those days, when one long hydrographic time-series after another was being shut down across the North Atlantic, the tracing of even such a large and (one might think) unmissable feature as the GSA through the gappy and fragmentary historical hydrographic record was the hard part. So I like to think that the data series that Henry helped build at *«Station "S" off Bermuda»* was sent to reflect this. Inspirational or not, it is not an especially gripping read. So although Stommel's writings in manuscript are very hard to find – he burnt a lot of his papers and others are sequestered in the libraries of Woods Hole and MIT – I have tucked whatever m/s pages we have inside the cover for added interest; no doubt these can be supplemented with time as other papers come to light.





FINANCES

Finances

NORDFORSK-APPROVED BUDGET 2011—2015

EXPENSES	EXPENSE DESCRIPTION	2011	2012	2013	2014	2015	SECTION TOTAL
1. Fellowships for visiting professors		**118,450**	**122,004**	**125,664**	**106,923**	**110,131**	**583,171**
	Johan Hjort Chair	25 750	26,523	27,318	28,138	28,982	
	PINRO Scientist	20 600	21,218	21,855			
	Centre Advisory Panel	72 100	74,263	76,491	78,786	81,149	
2. Fellowships for post docs		**709,687**	**1,408,941**	**1,482,350**	**1,544,409**	**804,575**	**5,949,962**
	PD1 – Copenhagen	307,713	646,196	678,505	712,430	374,026	
	PD2 – Oslo	401,974	762,745	803,845	831,979	430,549	
3. Fellowships for PhD students		**2,980,761**	**4,319,154**	**5,886,987**	**2,878,949**	**1,474,249**	**17,540,100**
	PhD A1 – Stockholm		298,708	651,727	678,883	339,441	
	PhD A3 – Åbo		274,030	564,503	581,438	299,440	
	PhD B1 – Bergen		354,846	685,382	709,370	367,099	
	PhD B2 – Copenhagen	673,527	653,365	681,262			
	PhD B5 – Reykjavik	441,254	472,141	505,191			
	PhD C1 – Torshavn		428,531	882,775	909,258	468,268	
	PhD C3 – Nuuk	673,527	653,365	681,262			
	PhD D1 – Oslo	685,693	662,205	697,264			
	PhD D2 – Helsinki	506,760	521,963	537,622			
4. Research training		**69,100**	**90,481**	**93,346**	**73,786**	**76,149**	**402,862**
	Special courses		21,218	21,855			
	Misc. materials costs	69,100	69,263	71,491	73,786	76,149	
5. Workshops and conferences		**113,300**	**116,699**	**120,200**	**123,806**	**127,520**	**601,525**
	Annual meetings / workshops	113,300	116,699	120,200	123,806	127,520	
6. Travel and accommodation		**211,150**	**565,460**	**797,472**	**452,229**	**190,121**	**2,216,432**
	PhD travel costs		347,975	573,463	221,500		
	Postdoc travel costs	168,920	173,988	179,207	184,583	190,121	
	Climate Scientist travel	42,230	43,497	44,802	46,146		
7. Equipment		**0**	**0**	**0**	**0**	**0**	**0**
8. Administration		**0**	**0**	**0**	**0**	**0**	**0**
9. Salaries incl. max 20% overhead		**513,140**	**685,753**	**706,326**	**727,516**	**572,540**	**3,205,275**
	SMHI Scientist	152,640	314,438	323,872	333,588	166,794	
	Administrative manager (50%)	360,500	371,315	382,454	393,928	405,746	
Period Total		**4,715,588**	**7,308,492**	**9,212,345**	**5,907,618**	**3,355,285**	
TOTAL							**30,499,328**

PROJECT 1 — OSLO

EXPENSES IN NOK		2012	2013	PERIOD TOTAL	NOTES
Salary incl. social costs (incl. max 20 % overhead)					
	Project 1: Salary (Oslo)	NOK 669,137	NOK 631,779	NOK 1,300,916	First year is calculated with 12 months pay, 2nd year with 11 months
	Project 1: Overhead (20%)	NOK 133,827	NOK 126,356	NOK 260,183	
				NOK 1,561,099	
Mobility costs (incl. max 10 % administration)					
	Project 1: Secondment (6 months @ 26000/mo)	NOK 78,000	NOK 78,000	NOK 156,000	RCN standard stipend for living abroad (defined as Oslo, since the Postdoc will spend less time here)
	Project 1: Annual NorMER Conferences / Workshops / Events	NOK 35,000	NOK 38,000	NOK 73,000	includes flight and hotel costs.
	Project 1: Other conferences + travel costs	NOK 30,000	NOK 40,000	NOK 70,000	includes secondment flight costs and attendance at 3 international conferences
	Project 1: Mobility for NorMER Collaborations	NOK 50,000	NOK 50,000	NOK 100,000	For travel for collaborating with NorMER Postdocs and PhDs
				NOK 399,000	
Administration (max 10 % of mobility costs)					
		NOK 19,300	NOK 20,600		
				NOK 39,900	
TOTAL				**NOK 1,999,999**	

PROJECT 2 — ICELAND

EXPENSES IN NOK		2012	2013	PERIOD TOTAL	NOTES
Salary incl. social costs (incl. max 20 % overhead)					
	Project 2: Salary (Reykjavik)	NOK 438,100	NOK 455,624	NOK 893,724	
	Project 2: Overhead (20%)	NOK 87,620	NOK 91,125	NOK 178,745	
				NOK 1,072,469	
Mobility costs (incl. max 10 % administration)					
	Project 2: Secondment (12 months @ 26000/mo)	NOK 234,000	NOK 78,000	NOK 312,000	RCN standard stipend for living abroad
	Project 2: Annual NorMER Conferences/Workshops/Events	NOK 35,000	NOK 38,000	NOK 73,000	Includes flight and hotel costs.
	Project 2: Other conferences + travel costs	NOK 30,000	NOK 40,000	NOK 70,000	Includes secondment flight costs and attendance at 3 international conferences
	Project 2: Mobility for NorMER Collaborations	NOK 50,000	NOK 50,000	NOK 100,000	For travel for collaborating with NorMER Postdocs and PhDs
	Project 2: NorMER Adaptation Workshop costs		NOK 315,000	NOK 315,000	Workshop led by this Postdoc. Includes travel and lodging costs for NorMER students and staff for workshop attendance.
				NOK 870,000	
Administration (max 10 % of mobility costs)					
		NOK 34,900	NOK 20,600		
				NOK 55,500	
TOTAL				**NOK 1,997,969**	

People at NorMER

NORMER CORE STAFF

NAME	INSTITUTE	ROLE	POSITION	COUNTRY
Gry Gundersen	CEES, University of Oslo	Oslo Node	NorMER Administrator	Norway
Kjetill S. Jakobsen	CEES, University of Oslo	Oslo Node	Professor	Norway
Nils Chr. Stenseth	CEES, University of Oslo	NorMER Chair, Oslo Node Leader	Professor, Chair of CEES	Norway
Anne-Maria Eikeset	CEES, University of Oslo	Oslo Node	Researcher	Norway
Dag Hjermann	CEES, University of Oslo	Oslo Node	Researcher	Norway
Geir Ottersen	CEES, University of Oslo	Oslo Node	Researcher	Norway
Joël Durant	CEES, University of Oslo	Oslo Node	Researcher	Norway
Leif Chr. Stige	CEES, University of Oslo	Oslo Node	Researcher	Norway
Jason D. Whittington	CEES, University of Oslo	Oslo Node	Scientific Coordinator	Norway
Carl Folke	Stockholm Resilience Centre	NorMER Co-Chair, WWStockholm Node Leader	Professor, Head of Stockholm Resilience Centre	Sweden
Christoph Humbold	Stockholm Resilience Centre	Stockholm Node	Reseacher	Sweden
Magnus Nyström	Stockholm Resilience Centre	Stockholm Node	Reseacher	Sweden
Örjan Bodin	Stockholm Resilience Centre	Stockholm Node	Reseacher	Sweden
Thorsten Blenckner	Stockholm Resilience Centre	Stockholm Node	Reseacher	Sweden
Johanna Mattila	Åbo Akademy University	Åland Node	Marine Station Head	Finland
Marie Nordström	Åbo Akademy University	Åland Node	Postdoc	Finland
Erik Bonsdorff	Åbo Akademy University	Åland Node Leader	Professor	Finland
Katri Aarnio	Åbo Akademy University	Åland Node	Researcher	Finland
Christoffer Boström	Åbo Akademy University	Åland Node	Senior Researcher	Finland
Philippe Cury	CRH Sete, Universite Montpellier	CAP Chair	Director of CRH	France
Kjell Arne Brekke	Department of Economics, University of Oslo	Oslo Node	Professor	Norway
Geir Storvik	Department of Mathematics, University of Oslo	Oslo Node	Professor	Norway
Simon Levin	Dept. of Ecology and Evolutionary Biology, Princeton Univ., USA	CAP Member	Professor	USA
Petur Steingrund	Faroe Marine Research Institute	Faroe Node	Researcher	Faroe
Helle Siegstad	Greenland Institute of Natural Resources	Nuuk Node Leader	Department Head	Greenland
Øystein Lie	MareLife	CAP Member	Marelife President	Norway
James Hurrell	National Center for Atmospheric Research	CAP Member	Director of NCAR	USA
Dan Holland	Northwest Fisheries Science Center, NOAA	Postdoc Mobility Programme Collaborators	Researcher	USA
Markus Meier	Swedish Meteorological and Hydrological Institute	SMHI Node Leader	Division Head	Sweden
Helen Andersson	Swedish Meteorological and Hydrological Institute	SMHI Node	Researcher	Sweden
Kari Eilola	Swedish Meteorological and Hydrological Institute	SMHI Node	Senior Researcher	Sweden
Robinson Hordoir	Swedish Meteorological and Hydrological Institute	SMHI Node	Senior Researcher	Sweden
Ulrike Löptien	Swedish Meteorological and Hydrological Institute	SMHI Node	Senior Researcher	Sweden
Thomas Kiørboe	Technical University of Denmark	Copenhagen Node Leader	Head of DTU Aqua	Denmark
Henrik Madsen	Technical University of Denmark	Copenhagen Node	Head of DTU Informatics	Denmark
Andy Visser	Technical University of Denmark	Copenhagen Node	Professor	Denmark
Brian MacKenzie	Technical University of Denmark	Copenhagen Node	Professor	Denmark
Einar Eg Nielsen	Technical University of Denmark	Copenhagen Node	Professor	Denmark
Ken H. Andersen	Technical University of Denmark	Copenhagen Node	Professor	Denmark
Kai Wieland	Technical University of Denmark	Copenhagen Node	Senior Researcher	Denmark
Keith Brander	Technical University of Denmark	Copenhagen Node	Senior Researcher	Denmark
Sigrun Jonasdottir	Technical University of Denmark	Copenhagen Node	Senior Researcher	Denmark
Uffe Thygesen	Technical University of Denmark	Copenhagen Node	Senior Researcher	Denmark
Daniel Pauly	UBC Fisheries Centre	UBC Collaborators	Professor	Canada
Rashid Sumaila	UBC Fisheries Centre	UBC Collaborators	Professor	Canada
William Cheung	UBC Fisheries Centre	UBC Collaborators	Professor	Canada
Guðrún Marteinsdóttir	Univeristy of Iceland, MARICE	Reykjavik Node Leader	Head of MARICE	Iceland
Tara Marshall	University of Aberdeen	CAP Member	Professor	Scotland

NORMER CORE STAFF CONT.

NAME	INSTITUTE	ROLE	POSITION	COUNTRY
Dag L Aksnes	University of Bergen	Bergen Node	Professor	Norway
Jarl Giske	University of Bergen	Bergen Node	Professor	Norway
Øyvind Fiksen	University of Bergen	Bergen Node Leader	Professor	Norway
Christian Jorgensen	University of Bergen	Bergen Node	Researcher	Norway
Alan Hastings	University of California Davis	Postdoc Mobility Programme Collaborators	Professor	USA
Louis Botsford	University of California Davis	Postdoc Mobility Programme Collaborators	Professor	USA
Lynne Shannon	University of Cape Town	CAP Member	Professor	South Africa
Kathleen Segerson	University of Connecticut	CAP Member	Professor	USA
Soile Kulmala	University of Helsinki	Helsinki Node	Postdoc	Finland
Markku Ollikainen	University of Helsinki	Helsinki Node	Professor	Finland
Marko Lindroos	University of Helsinki	Helsinki Node Leader	Professor	Finland
Olli Tahvonen	University of Helsinki	Helsinki Node	Professor	Finland
Bruce McAdam	University of Iceland, MARICE	Reykjavik Node	Researcher	Iceland
Heidi Pardoe	University of Iceland, MARICE	Reykjavik Node	Researcher	Iceland
Kai Logemann	University of Iceland, MARICE	Reykjavik Node	Researcher	Iceland
Tim Grabowski	University of Iceland, MARICE	Reykjavik Node	Researcher	Iceland
Eyðfinn Magnussen	University of the Faroe Islands	Faroe Node	Professor	Faroe
Andre Punt	University of Washington	Postdoc Mobility Programme Collaborators	Professor	USA

NORMER CAPS

NAME	INSTITUTE	ROLE	POSITION	COUNTRY
Philippe Cury	CRH Sete, Universite Montpellier	CAP Member, Chair	NorMER	France
James Hurrell	National Center for Atmospheric Research	CAP Member	NorMER	USA
Kathleen Segerson	University of Connecticut	CAP Member	NorMER	USA
Lynne Shannon	University of Cape Town	CAP Member	NorMER	South Africa
Øystein Lie	MareLife	CAP Member	NorMER	Norway
Simon Levin	Dept. of Ecology and Evolutionary Biology, Princeton Univ., USA	CAP Member	NorMER	USA
Tara Marshall	University of Aberdeen	CAP Member	NorMER	Scotland

NORMER PHDS AND POSTDOCS

NAME	INSTITUTE	ROLE	POSITION	COUNTRY
Andries Richter	CEES, University of Oslo	NorMER Postdoc	Postdoc	Norway
Florian K. Diekert	CEES, University of Oslo	NorMER Postdoc	Postdoc	Norway
Lauren Rogers	CEES, University of Oslo	NorMER Postdoc	Postdoc	Norway
Wijnand Boonstra	Stockholm Resilience Centre	NorMER Postdoc	Postdoc	Sweden
Martin Snickars	Åbo Akademi University	NorMER Postdoc	Postdoc	Finland / Åland
Martin Wæver Pedersen	DTU Aqua	NorMER Postdoc	Postdoc	Denmark
Pamela Woods	University of Iceland, MARICE	NorMER Postdoc	Postdoc	Iceland
Giovanni Romagnoni	CEES, University of Oslo	NorMER Student	PhD Student	Norway
Kristina Kvile	CEES, University of Oslo	NorMER Student	PhD Student	Norway
Johanna Yletyinen	Stockholm Resilience Centre	NorMER Student	PhD Student	Sweden
Alexandros Kokkalis	DTU Aqua	NorMER Student	PhD Student	Denmark
Ana Sofia Ferreira	DTU Aqua	NorMER Student	PhD Student	Denmark
Benjamin Weigel	Åbo Akademi University	NorMER Student	PhD Student	Finland / Åland
Emmi Nieminen	University of Helsinki	NorMER Student	PhD Student	Finland
Maija Holma	University of Helsinki	NorMER Student	PhD Student	Finland
Hlynur Bárðarson	University of Iceland, MARICE	NorMER Student	PhD Student	Iceland
William Butler	University of Iceland, MARICE	NorMER Student	PhD Student	Iceland
Nadia Fouzai	University of Bergen	NorMER Student	PhD Student	Norway
Rebecca Holt	University of Bergen	NorMER Student	PhD Student	Norway
Katharina Maj Ottosen	University of the Faroe Islands	NorMER Student	PhD Student	Faroe Islands
Sara Bonanomi	Greenland Institute of Natural Resources	NorMER Student	PhD Student	Denmark

NORMER GUESTS

NAME	INSTITUTE	ROLE	COUNTRY
Bob Dickson	Cefas	2011 Johan Hjort Chair	USA
Gregory Beaugrand	Universite de Lille	Invited Speaker	France
Harry Zilliacus	Nordforsk Senior Adviser	NCoE Programme Secretary	Norway
Jukka Kola	Vice Rector of the University of Helsinki	Invited Speaker	Finland
Rashid Sumaila	UBC Fisheries Centre	2012 Johan Hjort Chair	Canada
Tora Aasland	Former Minister of Higher Education and Research in Norway	Invited Speaker	Norway
Ville Niinistö	Finnish Minister of the Environment	Invited Speaker	Finland

NORMER SECOND ANNUAL MEETING

NorMER Second Annual Meeting

4–5 October 2012, Helsinki, Finland

THURSDAY, 4 OCTOBER 2012

➠ **Morning Programme** *(0930–1210).* Venue: *Pieni Juhlasali, Small Hall, Fabianinkatu 33 (University of Helsinki Main Building).*

0930–0940: Prof. Marko Lindroos (NorMER Partner). *Welcome. Importance of NorMER.*

0940–0950: Prof. Nils Chr. Stenseth (Chair of NorMER). *NorMER – status and further development.*

0950–1000: Jukka Kola (Vice Rector of the Univ. of Helsinki). *«The Role of the University of Helsinki».*

1000–1010: Ville Niinistö (Finnish Minister of Environment). *Topic to be determined.*

1010–1020: Dr. Robert Dickson (Centre for Environment, Fisheries and Aquaculture Science, UK). *University of Oslo Inspiration Awards.*

1020–1030: Tora Aasland (Former Minister of Research and Higher Education, Norway (18.10.07–23.03.12)). *«The importance of political leadership in scientific programmes».*

— 10 min break

1040–1110: Prof. Gregory Beaugrand (Centre National de la Recherche Scientifique, Laboratoire d'Océanologie et de Géosciences, Wimereux France). *«The effects of climate change on biological and ecological systems».*

1110–1140: Prof. Kathleen Segerson (Department of Economics, University of Connecticut, USA). *«Voluntary Approaches to Marine Conservation: An Economic Perspective».*

1140–1210: Johan Hjort Chair – Prof. Rashid Sumaila (University of British Columbia, Fisheries Centre, Canada). *«Climate change effects on the economics and management of world fisheries».*

1220: Bus to Rantapuisto Hotel.

1300–1345: Group Lunch.

➠ **Afternoon Programme** *(1400–1800).* Venue: *Rantapuisto Hotel.*

1400–1405: *Welcome.*

1405–1500: *Speed talks by continuing PhD students and postdocs (listed below).*
1500–1510: Martin Pedersen & Ana Sofia Ferreira (Copenhagen). *The «Tasty Haystack» project.*

1510–1630: Poster session *(coffee available during this session).*

Ana Sofia Ferreira (Copenhagen)
— Weak Subpolar Gyre may lead to early blooms.

Emmi Nieminen (Helsinki)
— Game theoretical analysis of multispecies fishery in the Baltic Sea.

Florian Diekert (Oslo)
— Threatening Thresholds?

Giovanni Romagnoni (Oslo)
— North Sea cod in space and time; stock-recruitment models for spatial population structure.

Hlynur Bárðarson (Reykjavik)
— Phenotypic tools to discriminate stock components.
Lauren Rogers (Oslo)
— Climate and population dynamics of Skagerrak cod: a state-space approach.

Maija Holma (Helsinki)
— Seal-fishery conflict in the Northern Baltic Sea.

Martin Wæver Pedersen (Copenhagen)
— Finding gaps in Nordic marine climate change research.

Rebecca Holt (Bergen)
— Climate responses in fish: temperature dependence of physiological performance and consequences for ecological functions.

Sara Bonanomi
(DTU Aqua Silkeborg and Greenland)
— The use of archived tags in retrospective genetic analysis of fish.

Will Butler (Reykjavik)
— Atlas of Icelandic cod spawning sites.

Wijnand Boonstra (Stockholm)
— Swedish fishing styles in the Baltic.

1630–1800: Breakout meetings and continuation of poster discussions.

1900–2100: *Dinner.*

2130–0000: *Sauna at the seashore.*

Photography: Giovanni Romagnoni

FRIDAY, 5 OCTOBER

➠ **Morning Programme** *(0900–1200).* Venue: *Rantapuisto Hotel.*

0900–1020: *Presentations by new PhD students and postdocs,* ***Part 1:***

Katharina Ottosen (Faroe Islands)
— Spatial distribution of cod on the Faroe Plateau in relation to climate and other environmental conditions.

Benjamin Weigel (Åbo)
— The role of benthic fauna in the coastal food web under environmental stress.

Anna Törnroos (Åbo)
— Species traits and benthic functioning: from toolbox to implementation.

Pamela Woods (Reykjavik)
— Bottom-up controls in fisheries management and adaptation to climate change.

Johanna Yletyinen (Stockholm)
— Using network analysis to quantify the effect of climate on spatial explicit marine food web interactions in the context of social-ecological system dynamics.

1020–1040: *Break.*

1040–1200: *Presentations by new PhD students and postdocs,* ***Part 2:***

Kristina Kvile (Oslo)
— Climatic influences on zooplankton dynamics in Lofoten and the Barents Sea.

Martin Snickars (Åbo)
— The role of habitat composition to zoobenthos.

Andries Richter (Oslo)
— Strengthening the adaptive capacity of institutions in fisheries.

1215–1300: *Group Lunch.*

➠ **Afternoon Programme** *(1330–1730).* Venue: *Rantapuisto Hotel.*

1330–1500: Session A: *Management Board Meeting.* Session B: *Slow Talk session (PhD students and postdocs).*

1500–1530: Coffee.

1530–1700: Session A: *CAP meeting.* Session B: *Slow Talk continued (PhD students and postdocs).*

1700: *Reconvene for meeting closure.*

1800: *Dinner.*

2100: *Bus from Rantapuisto Hotel for workshop attendees.*

A BRIEF REPORT FROM THE MEETING

BY FLORIAN DIEKERT, NORMER POSTDOC, UNIVERSITY OF OSLO

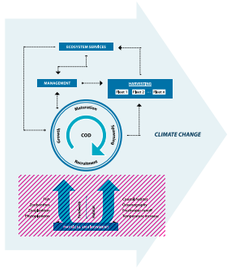
The following is a brief, and somewhat personal, account of the second annual NorMER meeting. The actual meeting was held on two days, on October 4th and 5th in Helsinki, but I think it is fair to say that the meeting was but the culmination of an inspiring week of NorMER activities: Prior to the meeting, there was a three-day course in economics, and after the meeting, there was a two-day workshop where we (the young researchers) continued to work on our collaborative project. The latter is described in more detail on page 32.

The course was taught by three renowned experts, in addition to our own Marko Lindroos. On the first day, Olli Tahvonen introduced to the core concepts of fisheries economics and dynamic optimization. On the second day, Martin Quaas highlighted market aspects and Ann-Sophie Crepin discussed threshold effects on the third day. Being an economist myself, I think that the lecturers did a truly great job of breaking the technically demanding material into digestible pieces. The course had a tremendous value in familiarizing all network members with the economic terminology, thus allowing a more effective cross-disciplinary communication.

The structure of the annual meeting was planned long before October by the NorMER postdocs. In addition to the conference-style format, we wanted to try new avenues of communicating research. To this end, we introduced 'speed talks' and 'slow talks'. 'Speed talks' were 3–5 minute presentation of a poster that the young researcher was exhibiting. After everybody had gotten a chance to advertise his/her poster, we had an extended poster session with many in-depth discussions of the individual posters. The 'slow talks' on the next day were more intimate group discussions, where 4–5 young researchers discussed each other's manuscripts. The idea was to provide a sheltered thinking room to foster inter-disciplinary discussions of ongoing work. Judged by the evaluation survey that we conducted, both innovations were a great success. A remaining challenge is how to better integrate and benefit from the presence of the senior researchers and experts. We already have a number of ideas how this could be improved, and I am very much looking forward to the next annual meeting in Reykjavik.

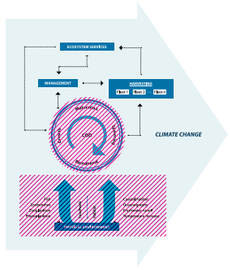
NorMER Publication List

GRAND CHALLENGE 1



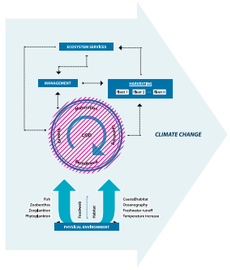
➠ Develop a comprehensive model of physical processes and their interactions with marine food webs.

GRAND CHALLENGE 2



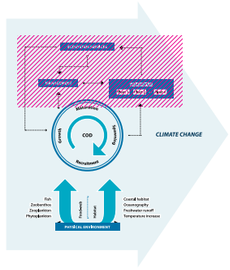
➠ Define the importance of lower trophic levels and their influence on harvested species.

GRAND CHALLENGE 3



➠ Detail the drivers, patterns, and trends of harvested populations.

GRAND CHALLENGE 4



➠ Create guidelines for optimal management of marine resources to maximize profit and yield, now and in the future.

Refer to page 23 for a bigger version of the figure

See below for a list of NorMER publications from within the last year, and their relevance to the centre. NorMER staff who are directly funded are in bold and underlined. NorMER staff receiving indirect support are in bold.

GRAND CHALLENGE 1

1. Dalpadado P, Ingvaldsen RB, **Stige LC**, Bogstad B, Knutsen T, Ottersen G, Ellertsen B. 2012. Climate effects on Barents Sea ecosystem dynamics. *ICES J. Mar. Sci.* 69: 1303–1316.
— ***Relevance:*** *Climate affects marine ecosystems through a multitude of pathways. This paper reports on how climate influences the Barents Sea ecosystem, with a focus on the lower trophic levels.*

2. Hidalgo M, Gusdal Y, Dingsør G, **Hjermann D**, **Ottersen G**, **Stige LC**, Melsom A, **Stenseth NC**. 2012. A combination of hydrodynamical and statistical modelling reveals nonstationary climate effects on fish larvae distributions. *Proc. R. Soc. Lond. B* 279: 275–283.
— ***Relevance:*** *Our new methodological approach to study climate effects on fish larvae distributions combines numerical and statistical modelling to draw robust inferences from observed distributions and will be of general interest for studies of many marine fish species.*

3. Persson J, **Stige LC**, **Stenseth NC**, Usov N, Martynova D. 2012. Scale-dependent effects of climate on two copepod species, *Calanus glacialis* and *Pseudocalanus minutus*, in an Arctic-boreal sea. *Mar. Ecol. Prog. Ser.* 468: 71–83.
— ***Relevance:*** *Climate variables can have contrasting effects on different life stages of organisms and the effects can vary seasonally. Such complex responses are ecologically important but require highly resolved data to detect.*

4. Sainmont J, **Thygesen UH**, **Visser AW**. 2012. Diel vertical migration arising in a habitat selection game. *J Theoretical Ecology.* doi:10.1007/s12080-012-0714-0.
— ***Relevance:*** *A population of identical individuals can exhibit different vertical migration behaviours even when there is no explicit density dependence. This pattern emerges through game theoretic considerations where behavioural cascades impose apparent density dependent effects.*

5. **Törnroos A**, **Bonsdorff E**. (In press). Developing the multitrait concept for functional diversity: Lessons from a system rich in functions but poor in species. *Ecological Applications.* http://dx.doi.org/10.1890/11-2042.1.
— ***Relevance:*** *Uses empirical trait-based analysis as a tool to reveal differences and similarities between assemblage structure and function. It functions as a useful tool for comparing different environments.*

6. **Visser AW**, Mariani P, Pigolotti S. 2012. Adaptive behaviour, tri-trophic foodweb stability and damping of chaos. *J Royal Soc Interface* 9(71): 1373–1380. doi:10.1098/rsif.2011.0686.
— ***Relevance:*** *The fitness seeking (adaptive) behaviour of grazers in a marine food-web can have quite a significant effect on the dynamics of the system, and promote stability in an otherwise unstable configuration.*

7. Casini M, **Blenckner T**, Mollmann C, Gardmark A, Lindegren M, Llope M, Kornilovs G, Plikshs M, **Stenseth NC**. 2012. Predator transitory spillover induces trophic cascades in ecological sinks. *Proceedings of the National Academy of Sciences of the United States of America* 109: 8185–8189.
— ***Relevance:*** *The fishing on cod affects also the food-web dynamics of other areas via spillover effects.*

8. Nyström M, Norström AV, **Blenckner T**, la Torre-Castro M, Eklöf JS, **Folke C**, Österblom H, Steneck RS, Thyresson M, Troell M. 2012. Confronting Feedbacks of Degraded Marine Ecosystems. *Ecosystems* 15: 695–710.
— ***Relevance:*** *Ecosystem that have experienced a regime shift might not respond linearily to the reduction of for example fishing instead internal feedbacks in the ecosystem needs to be broken so that the ecosystem can change into a new state.*

9. **Meier HEM**, **Andersson HC**, Arheimer B, **Blenckner T**, Chubarenko B, Donnelly C, Eilola K, Gustafsson BG, Hansson A, Havenhand J, Höglund A, Kuznetsov I, **MacKenzie BR**, Müller-Karulis B, Neumann T, Niiranen S, Piwowarczyk J, Raudsepp U, Reckermann M, Ruoho-Airola T, Savchuk OP, Schenk F, Schimanke S, Väli G, Weslawski JM, Zorita E. 2012. Comparing reconstructed past variations and future projections of the Baltic Sea ecosystem – first results from multi-model ensemble simulations. *Environmental Research Letters* 7: 034005.
— ***Relevance:*** *Ensemble modeling including climate, catchment, biogeochemical and food-web modeling have been applied to reconstruct the past changes due to eutrophication, climate and fishing and provide outlook for different management options.*

10. Gustafsson B, Schenk F, **Blenckner T**, Eilola K, Meier H, Müller-Karulis B, Neumann T, Ruoho-Airola T, Savchuk O, and Zorita E. 2012. Reconstructing the Development of Baltic Sea Eutrophication 1850–2006. *AMBIO* 41: 534–548.
— ***Relevance:*** *Different models have been applied to better understand the processes of past 150 years of change in the Baltic Sea.*

11. Niiranen S, **Blenckner T**, Hjerne O, and Tomczak M. 2012. Uncertainties in a Baltic Sea Food-Web Model Reveal Challenges for Future Projections. *AMBIO* 41: 613–625.
— ***Relevance:*** *Different parameterizations of a food-web model have been tested with theories and uncertainty in data collections to illustrate the uncertainties in future food-web dynamics.*

12. **MacKenzie B**, Meier H, Lindegren M, Neuenfeldt S, Eero M, **Blenckner T**, Tomczak M, Niiranen S. 2012. Impact of Climate Change on Fish Population Dynamics in the Baltic Sea: A Dynamical Downscaling Investigation. *AMBIO* 41: 626–636.
— ***Relevance:*** *Ensemble fish modelling has been used to understand the processes affecting the fish population dynamics.*

13. Lindegren M, **Blenckner T**, **Stenseth NC**. 2012. Nutrient reduction and climate change cause a potential shift from pelagic to benthic pathways in a eutrophic marine ecosystem. *Global Change Biology* 18: 3491–3503.
— ***Relevance:*** *The paper shows that due to the reduction in nutrient load from catchments, climate and fishing a regime shift occurs changing the trophic pathways in the ecosystem.*

GRAND CHALLENGE 2

14. **Fiksen Ø**, **Jørgensen C**. 2011. Model of optimal behaviour in fish larvae predicts that food availability determines survival, but not growth. *Marine Ecology Progress Series* 432: 207–219.
— ***Relevance:*** *To understand how such spatial and temporal gradients will influence future recruitment success in cod stocks, we need quantitative models of the behavioural response of the early life stages. Here, we have developed a model that predicts larval cod survival in environmental gradients – and show that the effect of food availability will be seen in predation rates rather than in growth rates.*

15. Pécseli HL, Trulsen J, **Fiksen Ø**. 2012. Predator-prey encounter and capture rates for plankton in turbulent environments. *Progress in Oceanography* 101: 14–32.
— ***Relevance:*** *Among the physical variables that is predicted to change with climate are wind and precipitation. Both of these factors influence turbulence in the ocean. Here we have thoroughly reviewed and modelled how turbulence influence the contact rates in planktonic organisms. These models are necessary to translate from environmental change to foraging and predation in plankton models.*

16. Reglero P, Urtizberea A, Pérez A, Alemany F, *Fiksen Ø.* 2011. Cannibalism among size classes of larvae may be a substantial mortality component in tuna. *Marine Ecology-Progress Series* 433: 205–219.
— ***Relevance:*** *A zooplankton diet is shown to be frequently insufficient to sustain larval fish growth, thus piscivory in species with cannibalistic behavior, such as cod and tuna, is likely to be a major source of larval mortality.*

GRAND CHALLENGE 3

17. Dalpadado P, Ingvaldsen RB, **Stige LC**, Bogstad B, Knutsen T, **Ottersen G**, Ellertsen B. 2012. Climate effects on Barents Sea ecosystem dynamics. *ICES Journal of Marine Science* 69: 1303–1316.
— ***Relevance:*** *Change in sea temperature and water mass distribution are likely to affect the productivity and structure of high-latitude ecosystems. Here such hydrographic and ecological changes are demonstrated for the Barents Sea.*

18. Grabowski T, Thorsteinsson V, McAdam BJ, **Marteinsdóttir G**. 2011. Evidence of Segregated Spawning in a Single Marine Fish Stock: Sympatric Divergence of Ecotypes in Icelandic Cod? *PLOS One* 6(3): 1–9.
— ***Relevance:*** *This paper describes a potential mechanism for the reproductive isolation of the different cod morphs and lays a foundation for one of the NorMER student project.*

19. Jakobsdottir KB, **Pardoe H**, Magnússon Á, Björnsson H, Pampoulie C, Ruzzante DE, **Marteinsdottir G**. 2011. Historical changes in genotypic frequencies at the Pantophysin locus in Atlantic cod *(Gadus morhua)* in Icelandic waters: evidence of fisheries-induced selection? *Evolutionary Applications* 4: 562–573.
— ***Relevance:*** *This paper describes some of the life history differences between the different cod morphs and lays a foundation for one of the NorMER student project.*

20. Jonsen ID, Basson M, Bestley S, Bravington MV, Patterson TA, **Pedersen MW**, Thomson R, **Thygesen UH**, Wotherspoon SJ. 2012. State-space models for bio-loggers: A methodological road map. *Deep-Sea Res. II.* http://dx.doi.org/10.1016/j.dsr2.2012.07.008.
— ***Relevance:*** *Provides a stronger approach for extracting key information about foraging, migration, and other behaviours from animal tracking data, such as can be used to monitor cod.*

21. **Jørgensen C**, **Holt, RE**. 2012. Natural mortality: its ecology, how it shapes fish life histories, and why it may be increased by fishing. *Journal of Sea Research* 75: 8–18. doi:10.1016/j.seares.2012.04.003.
— ***Relevance:*** *The paper illustrates how a stronger focus on natural mortality may be required to better understand contemporary changes in fish life histories and behaviour and their responses to anthropogenic drivers. By focusing on classes of mechanisms underlying natural mortality, instead of particular traits, it can help broaden the perspective on how species might respond to anthropogenic and natural drivers in the seas.*

22. McAdam BJ, **Grabowski TB**, **Marteinsdottir G**. 2012. Testing for differences in spatial distributions from individual based data. *Fisheries Research* 127–128: 148–153.
— ***Relevance:*** *A statistical method developed to analyse data used in the NorMER project.*

23. McAdam BJ, **Grabowski TB**, **Marteinsdottir G**. 2012. Identification of stock subunits using morphological markers. *J Fish Biol* 81(5): 1447–1462. http://onlinelibrary.wiley.com/doi/10.1111/j.1095-8649.2012.03384.x/abstract
— ***Relevance:*** *A method based on body morphology was developed to discriminate between the different cod morphs. This method is one of the three methods used to classify cod in one of the NorMER student projects.*

24. Opdal AF, Vikebø F, **Fiksen Ø**. 2011. Parental migration, climate and thermal exposure of larvae: spawning in southern regions gives Northeast Arctic cod a warm start. *Marine Ecology-Progress Series* 439: 255–262.
— ***Relevance:*** *The NEA cod population migrates southwards along the Norwegian coast to spawn every year. Over the last century the spawning grounds further south have been abandoned, resulting in a much lower overall temperature exposure for eggs and larvae. Here we have used general circulation models to quantify this effect, and the results show that the temperature exposure of early life stages are more sensitive to variability in spawning ground usage than to climatic variability.*

25. Pampoulie C, Danielsdottir AK, Thorsteinsson V, Hjorleifsson E, **Marteinsdottir G**, Ruzzante DE. 2012. The composition of adult overwintering and juvenile aggregations of Atlantic cod (Gadus morhua L.) around Iceland using neutral and functional markers: a statistical challenge. *Can. J. Fish. Aquat. Sci.* 69: 1–14.
— ***Relevance:*** *This paper deals with populations structure of cod and lays a foundation for one of the NorMER student project.*

26. Utne K, Huse G, **Ottersen G**, Holst J, Zabavnikov V, Jackobsen J, Oskarsson G, Nøttestad L. 2012. Horizontal distribution and overlap of planktivorous fish stocks in the Norwegian Sea during summers 1995–2006. *Marine Biology Research* 8: 420–441.
— ***Relevance:*** *Here the spatial overlap between large ecologically and commercially important pelagic fish species in the Norwegian sea is examined and reasons for temporal variability in overlap discussed. The role of processes involving competition and other inter-species interaction is of interest will beyond this one ecosystem.*

GRAND CHALLENGE 4

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27. Bjørndal T, **Lindroos M**. 2011. Cooperative and Non-Cooperative Management of the Northeast Atlantic Cod Fishery. *Journal of Bioeconomics* 14(1): 41–60.
— ***Relevance:*** *Shows the importance of achieving international cooperation in the cod fishery by using a serially correlated recruitment function.*

28. **Diekert FK**. 2012. Growth Overfishing: The Race to Fish Extends to the Dimension of Size. *Environmental and Resource Economics* 52: 549–572.
— ***Relevance:*** *The individual growth potential of commercial fish is an important margin of rent dissipation that has hitherto not been explicitly analysed from an economic, game-theoretic perspective. In this paper, it moreover shown that quotas in terms of numbers are far superior to conventional quotas in terms of biomass.*

29. **Diekert FK**. 2012. The Tragedy of the Commons from a Game-Theoretic Perspective. *Sustainability* 4: 1776–1786.
— ***Relevance:*** *Hardin's metaphor of the «tragedy of the commons» has been controversial. However it was instumental in inspiring a large literature that studies under which conditions rational actors find it in their own best interest to cooperate.*

30. Kallio-Nyberg I, Salminen M, Saloniemi I, **Lindroos M**. 2011. Effects of marine survival, precocity and other life history traits on the cost-benefit of stocking salmon in the Baltic Sea. *Fisheries Research* 110: 111–119.
— ***Relevance:*** *Cost-benefit analysis to study the salmon stockings in the Baltic Sea.*

31. Kronbak L, **Lindroos M**. 2011. On Species Preservation and Non-Cooperative Exploiters. *Strategic Behavior and the Environment* 1: 49–70.
— ***Relevance:*** *Computes critical number of fishermen (players) in the case of species interaction so that both species are sustained in the long run.*

32. Kulmala S, **Lindroos M**, Pintassilgo P. 2012. Atlantic salmon fishery in the Baltic Sea – A case of non-cooperative management. *Forthcoming in Strategic Behavior and the Environment.*
— ***Relevance:*** *A partition function game application in a four-player bioeconomic model of Baltic salmon illustrates how international cooperation may sometimes be cooperation only on paper, not shown in real fisheries policy.*

33. **Nieminen E**, **Lindroos M**, Heikinheimo O. 2012. Optimal Bioeconomic Multispecies Fisheries Management: A Baltic Sea Case Study. *Marine Resource Economics* 27(2): 115–136.
— ***Relevance:*** *Three-species (cod, herring and sprat) dynamic optimisation model with age-structured dynamics illustrates how present management could be improved by taking into account species interactions.*

34. Rahikainen M, **Lindroos M**, Kaitala V. 2012. Stability of international fisheries agreements using precautionary bioeconomic harvesting strategies. *Strategic Behavior and the Environment.*
— ***Relevance:*** *Coalition model including harvest control rules, shows the importance of including international aspect in the development of harvest control rules.*

35. **Richter AP**, van Soest DP. 2012. «Global environmental problems, voluntary action and government intervention». In: Governing Global Environmental Commons: Analytical and Political Challenges in Building Governance Mechanisms. E. Brousseau, D. T., P.-A. Jouvet, and M. Willinger (eds). *Oxford University Press, Oxford*. pp. 223–248.
— ***Relevance:*** *The global community faces several very pressing environmental challenges such as climate change, depletion of the high-sea fisheries, and unprecedented rates of biodiversity loss. This chapter provides an overview of the literature on the circumstances under which governmental policy can crowd out protective action taken by private citizens and stakeholder and how policy can be designed to preserve the intrinsic motivation to act voluntarily.*

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