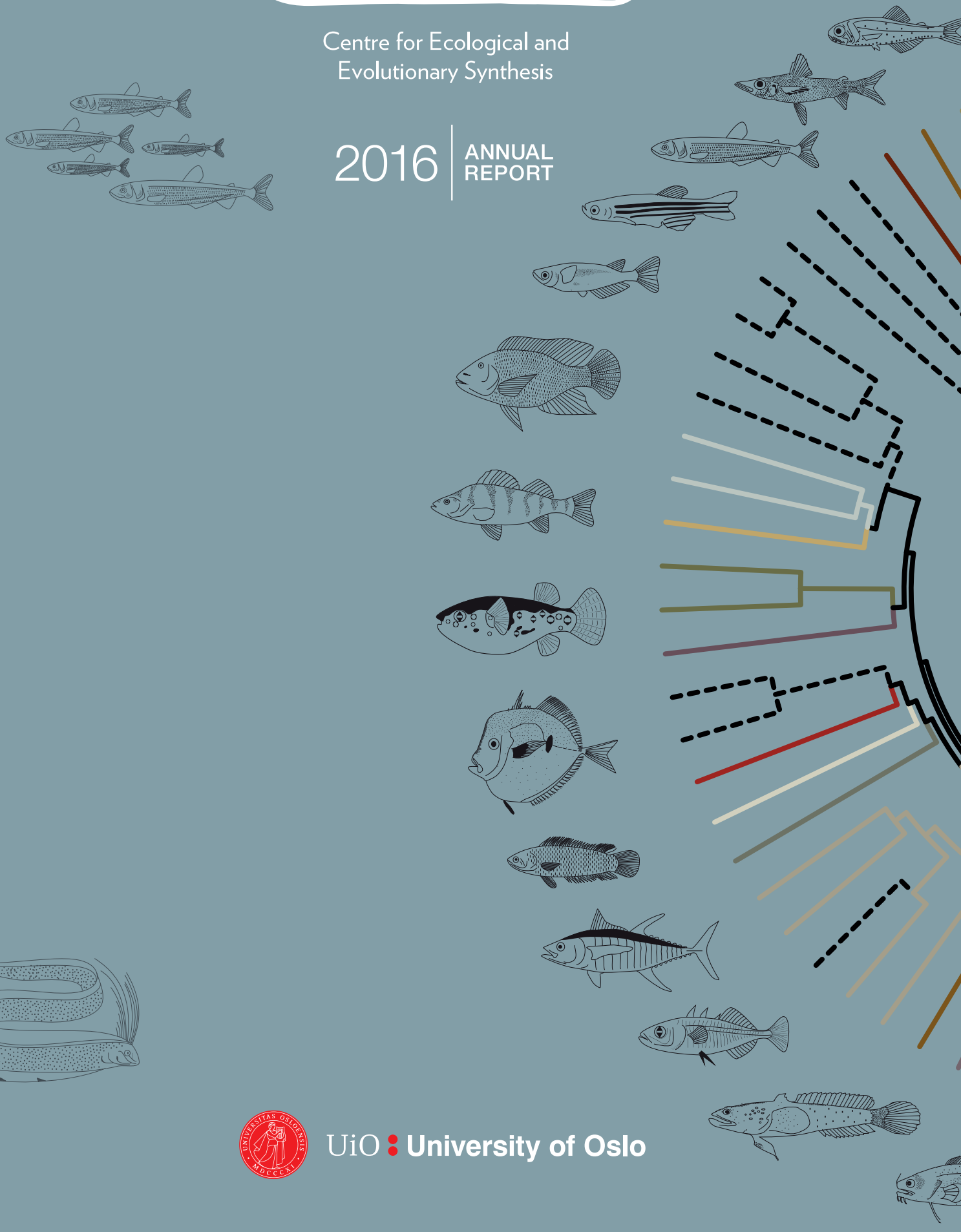
CEES

Centre for Ecological and Evolutionary Synthesis

2016 | ANNUAL REPORT



UiO : University of Oslo

The Centre for Ecological and Evolutionary Synthesis (CEES) combines a broad spectrum of disciplines (such as population biology, statistical and mathematical modelling, and genomics) to foster the concept of ecology as a driving force of evolution via selective processes, with a corresponding influence of evolutionary changes on ecology.

Cover photo: Teleost illustrations by Geir Holm. See the scientific highlight Speciation rate in teleost fishes is influenced by their immune system *on pages* 20–23.

Editor-in-chief: Tore Wallem. Copyediting: Sari C. Cunningham.
Contributions when not credited: The CEES administration.

CEES IN BRIEF

In 2016, CEES consisted of 189 members (including Core staff, postdocs and researchers, PhDs, research assistants, technical and administrative staff, and Master's students). In addition, 24 guests stayed for more than one month, and 29 guests for less than one month. The members represented 25 nationalities and the guests 22 nationalities (a total of 34 unique nationalities). The centre has a core group of 16 employees (not counting the Chair and Deputy Chair); two are employed by the Department of Mathematics and one by the Institute of Marine Research. CEES is chaired by Professor Nils Chr. Stenseth.

CEES supervised 44 Master's and 35 PhD students in 2016, and CEES permanent scientific staff was also involved in the teaching of 11 PhD/Master's courses and 13 Bachelor's courses. 8 new PhD students were employed, and 3 PhD students and 17 Master's students completed their degrees. The CEES Student Conference was held at Holmen Fjordhotell with 139 delegates.

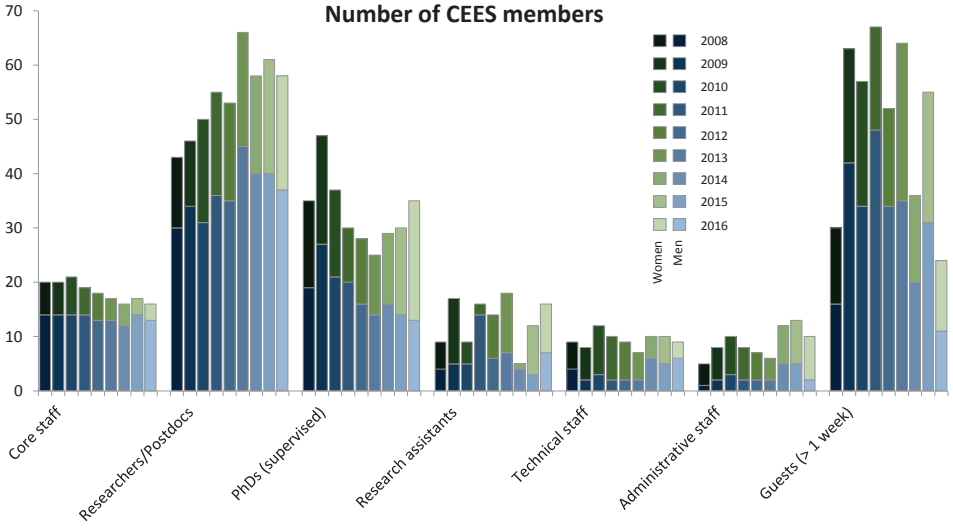
Approximately 88 MNOK of the total budget of 170 MNOK came from the 53 externally funded research projects conducted by CEES in 2016. Most of these were funded through the Research Council of Norway. CEES is also involved in various EU-funded projects. 18 new projects were started.

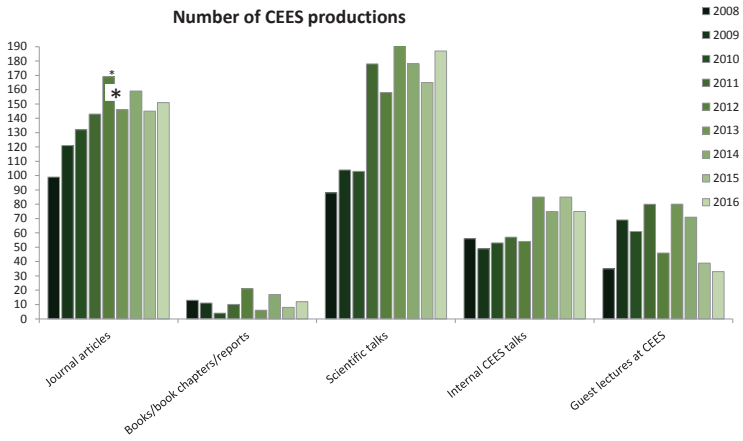
CEES members published 151 articles in peer-reviewed journals and 12 books/book chapters/reports in 2016. The majority of these results lie within the core scope of CEES. 187 talks at conferences were conducted. The centre hosted 31 guest speakers, primarily from abroad.

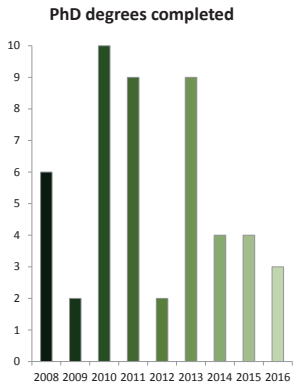
The work of CEES is structured into *Colloquia* and *Themes*, the former being focussed projects each lasting for three years and the latter consisting of ongoing, long-term work that is accommodated within the centre. The *Themes* are *Theme 1*: The role of population structuring in adaptive evolution. *Theme 2*: The potential for adaptation. *Theme 3*: The evolution of reproductive isolation. The topics of the *Colloquia* are as follows: *Colloquium 1*: Selection and evolvability: Concepts, measurements and statistics. *Colloquium 2*: Bridging the gap between genomics and evolutionary biology. *Colloquium 3*: The ecology and evolution of infectious diseases with an environmental reservoir. *Colloquium 4*: Integration of ecology and evolution: A synthesis.

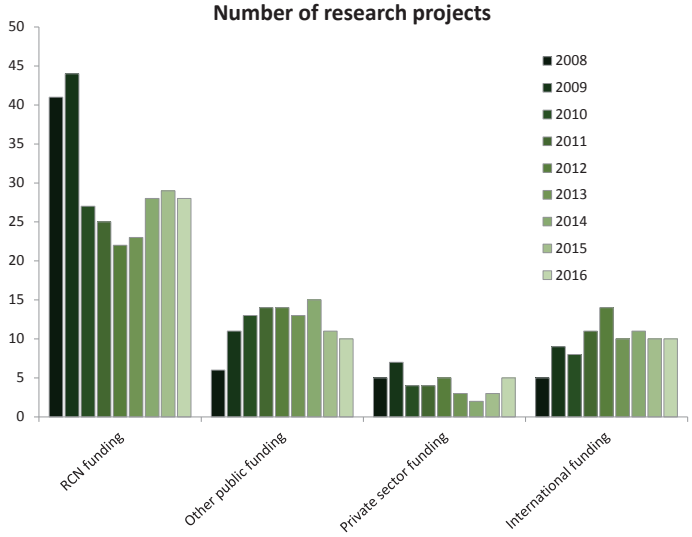
Aurora Borealis over the Kvaløya mountains west of Tromsø © Julia M. I. Barth.

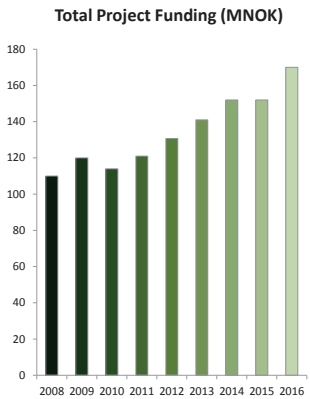
CEES IN BRIEF CONT.











*A change in the national routines for registering publications (inclusion of online first) skews the numbers in favour of 2012.

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1 THE CHAIR'S COMMENTS

Chair Nils Chr. Stenseth. © Eva C. Simensen.

Beyond 2017 – optimism for the future of CEES

Given the level of productivity and success that we have achieved over the years, as documented in this and previous reports, it is difficult to come to terms with the fact that our Centre of Excellence (CoE) is nearing its planned conclusion in the autumn of 2017. It is obvious that we ought to capitalise on our success and continue as a research and training centre, as pointed out by both the Board and the Scientific Advisory Board (SAB) (see pages 11–14). Indeed, in 2003, when the Centre of Excellence programme was first established by the Research Council of Norway (RCN) and the Norwegian Government, the aim was to create centres that had clear visions beyond the CoE-funding period. Our aim is to continue as a centre, maintaining the excellent infrastructure and management that we have in place (an administrative staff that serves our scientists – both students and faculty), and benefitting from the CEES trademark which is recognised both nationally and internationally. I am convinced that both the department as well as the entire university will benefit from our continued existence.

A department can obviously not "absorb" the entire CEES. We hope that a few positions within the focal areas of CEES will be advertised in the very near future. However, we are already happy to announce that one of our young researchers, **Sanne Boessenkool**, was offered and accepted a permanent position at the department. This will be of great importance for the scientific activity in the ancient DNA lab, to say the least. We are furthermore happy that major parties in the Norwegian Parliament (the Conservative Party and the Labour Party) have both included in their respective party programmes a mechanism for continuing some of the more successful CoEs – a category we hope CEES will be included in. It remains to be seen though whether these political declarations materialise in financial allocations. I personally remain optimistic.

We are always working towards cooperating with the best international partners. I would in particular like to mention our cooperation – announced on Darwin Day, 12 February 2016 – with the newly established Milner Centre for Evolution based at the University of Bath. The Milner Centre for Evolution was made possible by a generous donation from Bath alumnus, Dr. Jonathan Milner. Its focus is on studying some of the fundamental evolutionary questions which still persist in biology, and using this insight to find new technological and clinical research applications. By joining forces, we aim to promote international excellence in collaborative research which will lead to important breakthroughs, in particular in applied healthcare.

New projects secured in 2016

In 2016, we secured several new prestigious projects, covering a broad range of research interests. What follows is a taste of the exciting research to come:

REPEAT (Evolutionary and functional importance of simple repeats in the genome)
This project will test the hypothesis that hypervariable coding/regulatory repeats promote the ability of a species or population to adapt to a changing environment.

Research will be carried out using Atlantic cod and *Arabidopsis* as model systems. Other organisms will be looked at as well, as representatives of the various branches in the tree of life. A key aspect of the project is that it is cross-disciplinary in nature, using genomics, bioinformatics, statistics, and experimental approaches. **Kjetill S. Jakobsen** is the project leader for REPEAT, which is funded by the RCN through the FRIPRO Toppforsk programme for selected frontier research projects.

Abiota, Biota, Constraints in Macroevolutionary Processes
The aim of this project is to bridge the gap between macroevolution and microevolution. In the process, it might challenge the viewpoint that the generation and maintenance of new morphologies over large timescales arise from the culmination of many smaller changes on shorter generational timescales. In order to accomplish this, the project will study bryozoans, at both the macro- and microevolutionary levels, in both living and fossil species. This project is led by **Lee Hsiang Liow**, and is funded by a European Research Council (ERC) Consolidator Grant.

MOLBAR (The molecular basis of postzygotic hybridization barriers in plants)
This project will study the postzygotic reproductive barriers that arise when two plant species cross to form hybrid offspring. In particular, embryo and endosperm development in seeds resulting from these crosses will be investigated and related to genomic imprinting and underlying gene networks. The project aims to determine whether reproductive barriers are the same 1) in different plant genera, 2) between species pairs which have been separated over long evolutionary time and species pairs that have originated recently, and 3) between species pairs having the same number of chromosomes and species pairs with unequal number of chromosomes. To do so, wild populations of *Arabidopsis* and *Draba* will be used. **Anne K. Brysting** is the project leader for MOLBAR, which is funded by the RCN through the FRIMEDBIO programme.

Catching the Past
The aim of this project is to uncover long-term anthropogenic impacts on harvested fish populations, and to see if evolutionary changes are driven by the impacts on the ecology of these populations. Specifically, it will investigate whether the intensive historical exploitation of Atlantic cod has resulted in demographic and selective impacts on the species. To do so, state-of-the-art genomic tools will be used to analyse ancient DNA from Atlantic cod bones uncovered at archaeological sites in the North Atlantic – bones which are up to 9 000 years old. This project will be led by **Bastiaan Star**, and is funded by the RCN through the FRIMEDBIO programme for Young Research Talents.

NEOPOLL (Effects of Neonicotinoids and Temperature on Crops Pollination)
This project will investigate how pesticide application leads to exposure and accumulation in important pollinators, and how this might affect the ecosystem service they provide. The effect of Current Use Pesticides (CUPs) on wild species, such as bumblebees, will be looked at. In particular, the widely used pesticide thiamethoxam, a neonicotinoid, will be studied to determine its effects on behaviour and population (colony) development of the buff-tailed bumblebee, *Bombus terrestris*. **Anders Nielsen** is the project leader for NEOPOLL, which is funded by the RCN through the MILJØFORSK programme.

MICRO-MACRO EVOLUTION (Drivers of evolutionary change: understanding stasis and non-stasis through integration of micro- and macroevolution)
The project will investigate whether – and how – macroevolution can be fully understood as a result of microevolutionary processes. The aim will be to bring ecology and evolution closer together by advancing and integrating two different mathematical modelling frameworks: 1) population/species-based evolutionary modelling, and 2) community-based evolutionary modelling. Focus will be placed on two key aspects: stasis (and non-stasis) in macroevolution, and the relationship between evolution-

1 THE CHAIR'S COMMENTS

ary change and biotic and abiotic drivers of evolution. I am the project leader, and funding comes from the RCN through the FRIMEDBIO programme.

Current scientific research – patience and persistence

I am pleased to see that the scientific community of CEES continues to produce high impact research in top-tier journals. Some of the exciting research that we published in 2016 is highlighted in our section on scientific activity (starting on page 15). In addition, it is worth noting the progress being made within our colloquia.

Two colloquia are currently running – *Colloquium 3* (Ecology and evolution of infectious diseases) and *Colloquium 4* (Integration of ecology and evolution). Within the umbrella of *Colloquium 3* we are actively carrying out field-, lab and theoretical work.

We continue our work on plague, anthrax and Lyme disease, within the framework of *Colloquium 3*. A proposal for a new CoE on infectious vector-borne diseases with an environmental reservoir, headed by **Atle Mysterud**, was submitted to the last CoE-call. The proposal made it all the way to the second stage of consideration by the RCN. Although it was ultimately not funded, I am happy to observe that Atle Mysterud did a fantastic job in organising and promoting it. As such he is better prepared for the next call, four years from now. Patience and persistence often pay off; it's good to remember that CEES did not receive funding the first time we submitted our CoE proposal – but we did receive funding the second time around.

Our collaboration with our Chinese counterparts on plague research continues, involving experimental work both in the field and the laboratory, in order to understand both the evolution of virulence and the possible evolutionary effects of climate change.

Our name includes the word "synthesis", and the synthesis of ecology and evolution is the main focus of *Colloquium 4*. We are progressing with this nicely. The work being done on bryozoans is already yielding interesting results, published in *Proc. R. Soc. B.* (Liow *et al.* 2016). I look forward to following further research developments in this field.

In addition, our work on the Red Queen co-evolutionary theory is connected to our work on synthesis. The overall question addressed is under what circumstances evolution will continue, or cease, under constant abiotic conditions. Closely linked to this topic is the phenomenon of stasis, which **Kjetill L. Voje** has published on (2016 *Evolution*). We continue to make strides in our research on the Red Queen theory, together with Professor Jan Nordbotten from the University of Bergen – a mathematician working on differential equations with evolution of the structure of the system (i.e., coupling ecology and evolution). This research has sparked several developments, including collaborative work with Eörs Szathmary from Eötvös Loránd University in Budapest, and Simon Levin from Princeton University. I'm particularly pleased to see that our work on multispecies communities in *PNAS* (Nordbotten & Stenseth 2016) has been favourably discussed by Eörs Szathmáry and colleagues in *Grand Views of Evolution* (de Vladar *et al.* 2016).

To underscore our progress on the topic of synthesis, we are currently working on a book on the subject of how to bring together ecological and evolutionary thinking. In this book we will report on the work that we have done within CEES towards bridging ecology and evolution, as well as have external colleagues contribute individual chapters. When finished, this book will definitely constitute an important part of our legacy. We are also working on a major review paper with both internal and external contributors on the relative importance of abiotic and biotic drivers of evolution.

Success in both quantity and quality

Having assessed the progress that CEES has made during 2016, I am pleased to see that we have maintained a high level of activity within the Department of Biosciences. We continue to excel with regards to our scientific out-

put, with publication in such journals as *PNAS*, *Nature Communications*, and *Nature Genetics*. In addition, we contribute sizably towards the non-technical communication of both evolutionary biology and science in general. During 2016, we published 152 peer-reviewed articles in established journals, and kept up our strong public presence both online and through the media. Additionally, we secured a sizable amount of external funding, totalling 170 MNOK (divided over 53 projects).

Our community continues to evolve. In 2016, we had 189 members – 16 core members (not counting the Chair), 58 postdocs/researchers, 35 PhD students, 16 Research Assistants, 44 Master's students, and nine technicians. A total of ten people, some of them on a part-time basis, have contributed to the administration of CEES. Our family is diverse (when including our guests, we had 35 nationalities represented in 2016), young and dynamic (the median age of our members, not including the Master's students, was 37). We are proud of the young researchers that we have educated – in 2016, 17 Master's students and three PhD students graduated from CEES.

Congratulations to our award recipients. Several of our members achieved prominent awards and memberships in 2016, and I would like to take this opportunity to highlight a few of the more recent ones. **Lee Hsiang Liow**, together with her UC Berkeley collaborator, Seth Finnegan, was awarded the Peder Sather Grant for the proposal "Dissecting the timing, ecological signature, and environmental context of the largest biodiversification in Earth history". **Franziska Franeck**, a PhD student at CEES, received a National Geographic Young Explorers Grant to carry out fieldwork on changes in biodiversity in Early to Middle Ordovician sedimentary successions on Svalbard. **Leonie Färber**, a PhD student connected to our MARmaED project, was awarded an Early Career Scientist Award for Best Poster from the International Council for the Exploration of the Sea (ICES), presented at the Annual Science Conference in Riga, Latvia.

In addition, two awards from 2015 were regrettably, and unintentionally, omitted from the previous report: **Nanna W. Steen** received the Frode Olsgards Memorial Prize, honouring her years-long work within health, safety and the environment (HSE). The award ceremony took place on 13 March 2015. Also, **Jo Skeie Hermansen** received the King's Gold Medal for his doctoral dissertation on speciation by hybridisation in *Passer* sparrows. The award ceremony took place on 2 September 2015. ***Congratulations to all of you!***

Giving credit where credit is due

Thanks. I would like to thank **Sissel Jentoft** for her excellent work as Deputy Chair, helping me make CEES an exciting hub for the merger of ecology, classical evolutionary biology, and genomics. **Anne K. Brysting** receives thanks for being a valuable link to the department management. **Anders Nielsen** and colleagues did an excellent job organising the 3rd Conference of the Norwegian Ecological Society (NØF) at UiO. Special thanks go to the many organisers of the Late Lunch Talks, various journal clubs, and all sports and social activities. I'd like to thank all members of CEES: the scientific staff for doing great science, and the administrative and technical staff for making it possible to do so.

As I have said in previous years: Excellence starts with people – without talented people grant money is of little use. At CEES, we have both talented people and excellent funding sources. To all members of CEES – your contributions make our centre such a stimulating place to work at, both intellectually and socially.

Thanks!

2 MANAGEMENT AND ADMINISTRATION

CEES is established as a Centre of Excellence (CoE) by the Research Council of Norway (RCN). It is hosted by the Department of Biosciences (IBV) under the Faculty of Mathematics and Natural Sciences at the University of Oslo (UiO). The research at IBV is divided into five sections, of which CEES is the largest. RCN and UiO are the main financial contributors and constitute the final reporting entities that define the guidelines under which the centre operates.

Administrative structure

The centre is run on a daily basis by the Chair, the Deputy Chair and the CEES administrative team. The Chair and Deputy Chair communicate on a daily basis regarding scientific progress within the centre. Management and strategic issues are dealt with at weekly meetings. In order to facilitate the running of CEES, and to provide a good cooperative relationship with its host, IBV, weekly meetings are conducted where the Head of Department, the Head of Administration at the Department, representatives from the economy section and HSE, and a representative from the CEES administrative team are all present. The CEES administrative team is responsible for the daily running of the centre. This includes managing the budget and accounting, coordinating funding proposals and reporting (RCN, EU and other), employment, and ensuring that guest researchers are well received and enjoy their stay. It also includes implementing arrangements like weekly seminars, conferences, workshops and public lectures, maintenance of the website, and contact with the media. The administrative team also organises and takes minutes at all Core, Board, and SAB meetings. Most of the general correspondence with the university, the department, RCN, and the media goes through the CEES administration. In addition, the CEES Lab Board is responsible for the running of the laboratories, and arranges a mandatory introductory course for new users.

Chair	Nils Chr. Stenseth, Professor
Deputy Chair	Sissel Jentoft, Researcher and Project Coordinator
Administrative team	Gry Gundersen, Senior Adviser Kari B. Rygg, Senior Adviser Delphine C. Nicolas, Adviser (until August 2016) Tore Wallem, Adviser Ane Mari Bjørnæs, Higher Executive Officer Jenny Hewitt Tokstad, Higher Executive Officer
Lab Board	Anne K. Brysting, Professor, Leader of the Lab Board Kjetill S. Jakobsen, Professor Cecilie Mathiesen, Head Engineer Nanna W. Steen, Head Engineer Ave Tooming-Klunderud, Senior Engineer
Administrative Leader of Fieldwork Resources	Atle Mysterud, Professor

The Board and the Scientific Advisory Board

The CEES Board is an administrative body that meets approximately twice a year to focus on strategic and control functions as well as approving budgets, accounts and annual reports.

The Board in 2016	Home institution
Chair	
Knut Liestøl	Head of the Department for Informatics, University of Oslo, Norway
Members	
Rolf A. Ims	Department of Arctic and Marine Biology, University of Tromsø, Norway
Finn-Eirik Johansen	Chair of the Department of Biosciences, University of Oslo, Norway
Hanne C. Winther-Larsen	School of Pharmacy, and Centre for Integrative Microbial Evolution (CIME), University of Oslo, Norway
Bernt Øksendal	Centre of Mathematics for Applications, Department of Mathematics, University of Oslo, Norway

Comments by the Board Chair: Knut Liestøl

The CEES Board met twice in 2016, on 17 March and on 20 October. The agendas included discussions of budgets; reports on economy, applications and funding; and strategic issues, with emphasis on the continuation of core CEES activities past 2017.

The centre's economy is well-managed, and the budget indicates a satisfactory economy and a high activity level in the remaining year. Nevertheless, continued work on securing new funding is vital to keep up the high activity level past 2017. Thus, the board is pleased by the continued focus on applications. In 2016, a total of about 45 applications were sent to the EU/European Research Council (ERC), the Research Council of Norway (RCN), and other funding agencies.

An impressive list of foreign guests visited and worked at the centre. Additionally, events like the Darwin Day and Kristine Bonnevie Lectures were well organised and very well attended. In general, CEES' high activity level was maintained in 2016 through seminars, workshops, conferences and other scientific meetings.

The Scientific Advisory Board (SAB) states in its 2016 report that "exciting research is being done at CEES, and that the Centre has been an outstanding success in all key metrics". Moreover, the SAB notes that the "development of a cohesive, supportive and well-resourced research environment has clearly attracted a wealth of talent and led to a melting-pot of imaginative ideas and research questions". Given these statements, the pressing strategic issue is to ensure the continuation of core CEES activities past 2017.

While today's research funding system includes several options for project funding, obtaining resources for the continuation and management of "a melting-pot of imaginative ideas and research questions" is unfortunately much more challenging. Accordingly, the board fully supports efforts aimed at generally creating new opportunities for the long-term funding of extraordinarily successful research milieus, and specific actions to ensure the further development of the already outstanding achievements in the CEES environment.

The board wants to thank all members of the CEES scientific staff and management team for their dedicated work, and congratulate them with another very successful year.

Knut Liestøl

2 MANAGEMENT AND ADMINISTRATION

The CEES Scientific Advisory Board (SAB) has been appointed by the CEES Board. The SAB holds an annual meeting, and provides invaluable feedback on the research carried out at CEES. In 2016, the SAB meeting was held at the University of Oslo 5–6 September.

The Scientific Advisory Board	Specialisation and home institution
Chair	
Rita R. Colwell	Microbiologist, University of Maryland, USA
Members	
Tim Coulson	Population Biologist, Imperial College, London, UK
Edward J. Feil	Microbiologist, University of Bath, UK
Olivier Gimenez	Biostatistician, Center for Functional and Evolutionary Ecology (CEFE), France
Barbara Mable	Evolutionary Biologist, University of Glasgow, UK
Anne Magurran	Behavioural Ecologist, University of St. Andrews, UK
Gordon H. Orians (Corresponding member)	Evolutionary Biologist, University of Washington, Seattle, USA

Comments by the Scientific Advisory Board Chair: Rita R. Colwell

The Scientific Advisory Board (SAB) of the Centre for Ecological and Evolutionary Synthesis (CEES), a national Centre of Excellence (CoE), met on 5–6 September, 2016, at the University of Oslo. The SAB is, as ever, very grateful to Nils Chr. Stenseth and his administrative team for organising a highly productive and informative meeting. A full schedule of talks arranged for the SAB included a summary of key CEES findings from the previous twelve months, details of grants for research and networks awarded and pending, and a broad range of research summaries. It is clear from this meeting, as well as those of previous years, that exciting research is being done at CEES, and that the centre has been an outstanding success in relation to all key metrics. It was particularly impressive to see a marked increase in the number of publications in the very best journals (*Nature*, *PNAS*, *Science*), as well as continued success in securing significant external funding.

The development of a cohesive, supportive and well-resourced research environment has clearly attracted a wealth of talent and led to a melting pot of imaginative ideas and research questions. Given that only one year remains of core CoE-funding, CEES is now faced with two major challenges. The first of these is essentially logistical, and relates to the administrative structure of CEES and its relationship with the rest of the department (and faculty) going forward, once the core CoE funding ends in September, 2017.

Maintaining its administrative structure

It is the SAB's view that one of the reasons for the success of CEES is that it has had a dedicated administrative team that provides direct and specialised support connected to: grant writing and submission, post-grant administration, and maintenance of a cohesive community of researchers (including a large number of short- and long-term visitors) at all levels through social activities and workshops, in addition to finance and human resources.

The spirit of collaboration and the interdisciplinary nature of research at CEES both drive the unique and vibrant discovery environment that has been nurtured so productively over the last few years. The SAB believes it is important to protect the infrastructure (the excellent administrative team, the sequencing facilities, and the DNA laboratory) that facilitated this environment. The SAB had useful discussions with the Dean of the Faculty of Mathematics and Natural Sciences and the Head of the Department of Biosciences on the full cognisance of the inevitable conflict in priorities that arises in such circumstances. It is quite clear to the SAB that the success of CEES has been wholly reliant on a robust and efficient administrative structure and that, ultimately, the continued success of CEES will benefit the department, faculty, University of Oslo, and even Norwegian science in general. The CEES "brand" can be exploited to continue to attract research funding and the best international talent. This can only occur if the dedicated team of support staff is allowed to continue its administrative tasks as an integral part of CEES, rather than having those tasks fall on the academics. It is the experience of the SAB internationally that when administration is centralised, the heavier burden falls on the academics, reducing time and energy for research, with an inevitable fall in overall productivity.

Blazing a trail towards a new synthesis

The second challenge is more conceptual, and almost certainly even more difficult. This relates to how CEES will build on its brand in order to blaze a trail towards a new synthesis, so that the essence of CEES will continue – not just as a great place to do science, but as an outstanding *way* to do science.

The excellent review of ongoing activities in a series of "speed talks" provided by staff scientists on their scientific research gave a broad picture of the research that is underway. The SAB was particularly impressed with the quality of work on ancient DNA recovery and analysis, notably the findings from analysis of ancient fish bones (as one example), providing insight into the Viking age origin of the Norwegian cod fishery. This capacity in genomics, as well as the tools of this new and burgeoning field, built by CEES, must be preserved. These constitute a very rich resource for the University of Oslo and should not be lost. The research conducted by CEES scientists provides useful information towards sustainable management in today's changing world. Examples of such explored areas include the palaeogenomics of domestic animals, and the relationship between climate change (environmental changes) and harvested ecosystems.

The SAB is impressed with the large number of high quality, high impact manuscripts being published. Clearly the CEES team manifests a strong initiative and drive to excellence in its prolific publication. There is a risk, however, of too many directions of research being followed, and the SAB therefore recommends that CEES maintains focus on its unique, scientific strengths. Nevertheless, it should be emphasised that the CEES scientists are asking the right questions, questions that are large in scope, and seeking answers to these questions with new, powerful analytic tools.

The core of CEES is based on the challenge of successfully integrating ecology and evolution, thereby uncovering relationships that would not have been discovered if the focus had been on these two disciplines separately. The work on emerging diseases represents a good example of this synthesis, but it is important to highlight how a focus on the intersection between ecology and evolution leads to new general principles for other areas as well (sparrows, cod, ancient DNA). The SAB strongly believes that CEES is uniquely positioned to elucidate the many

ways in which evolutionary change is rooted in evolutionary principles, and, as a result, to influence many other fields of science.

Success breeds success – tools for further dissemination

The SAB addressed the need for an exit strategy beyond 2017. CEES clearly has become internationally recognised as a scientific unit, and visibly so. Using genomics as a tool and working closely with classical biologists is a commendable and successful strategy. However, the SAB strongly recommends a greater communication of the findings of CEES scientists. Their findings should be communicated beyond the scientific community, expanding the audience to the public in general. The SAB recommends that a major symposium be held annually or biannually in Oslo to highlight the knowledge gained on diseases with an environmental origin, and on the integration of ecology, evolution, and genomics. This would be a valuable contribution to global science, and would offer a mechanism for the dissemination of work done at CEES. A suitable name for such a symposium could be "The Oslo Symposium on Ecology, Evolution, and Genomics". This would become a lasting trademark for the University of Oslo.

In addition, a scientific equivalent of the Dahlem workshop could possibly achieve global dialogue and produce useful documents that are focussed on the synthesis of ecology and evolution. The title of such a workshop could be "The CEES Workshop on Integration of Ecology and Evolution". A Dahlem-type workshop was indeed recently organised by CEES, and a publication from that endeavour is currently under preparation (tentative title: "Biotic drivers of macroevolution"). Perhaps infectious diseases would be a logical theme for the next workshop.

The immediate task for CEES is to work on outward facing and branding, in order to protect and expand its success. The tools of today's communication – an up-to-date blog, tweeting new papers as published, listing collaborators on its website, etc. – are important to communicate the success of CEES in today's world.

Time should be dedicated to define how to continue this extraordinary enterprise, during the closing year of core CoE funding to CEES. The challenge is to define a core set of characteristics that comprise the essence of CEES, and to ensure that they continue. Much has been gained and much has been learned. It takes a firebrand to start such an initiative, as Nils Chr. Stenseth has done. Now the University of Oslo has the opportunity to build on this successful initiative.

What the future holds

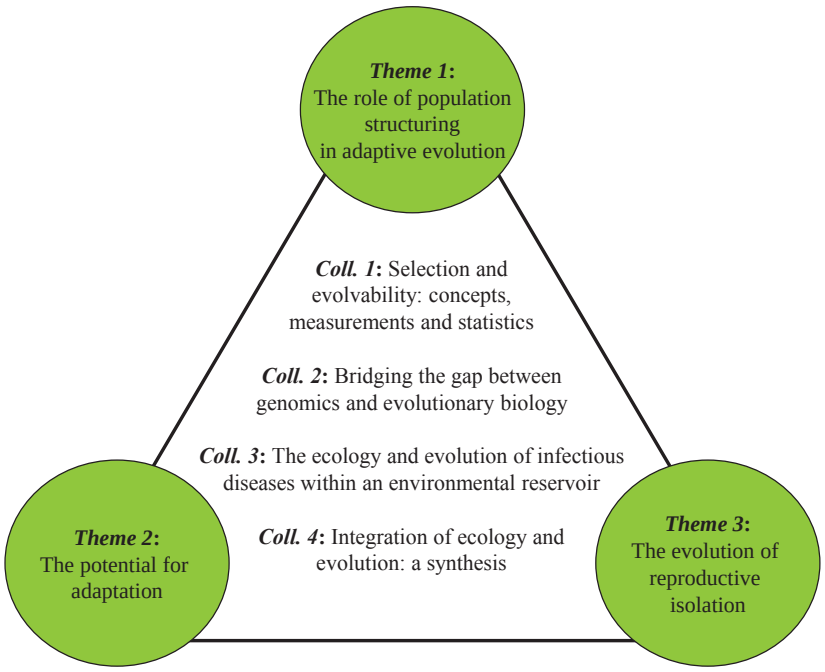
Clearly, we should take a lesson from Charles Darwin; he was just as concerned with ecology as with evolution. His writings provide an intellectual basis that argues for the continuation of CEES, to ensure its funding beyond the inaugural ten-year timeframe in order to provide impetus and a spirit of discovery.

In summary, the SAB strongly believes that the University of Oslo should embrace CEES as an outstanding success and seek further development of what has already been achieved. The publication rate is high and the young staff scientists are increasingly publishing their results in top journals. An infrastructure has been created and it should not be lost. The University of Oslo stands to gain immeasurably in retaining the success of CEES in recruiting outstanding faculty, and has an opportunity to capitalise on the teaching and research, incorporating it into its life science initiative.

Written by Rita R. Colwell, SAB chair, and SAB members: Tim Coulson, Edward Feil, Anne Magurran, Gordon Orians, and Barbara Mable.

3 SCIENTIFIC ACTIVITY

"Bridging the gaps" has become a trademark of CEES – fitting very well with our overall aim of bringing ecological and evolutionary thinking closer together. CEES has been successful in getting classically trained, organismic-oriented scientists (focussing on both ecological and evolutionary processes) to work together with genomics-oriented scientists. That in itself is an achievement we are very proud of, and we consider it a major accomplishment. To a large extent it has been made possible by the work within *Colloquium 2* ("Bridging the gap between genomics and evolutionary biology") and the subsequent work building upon that colloquium. Our work on the ecology and evolution of cod populations and on the hybrid speciation in sparrows – both part of *Colloquium 2* – are prime examples of the integration of ecological and evolutionary thinking. Another such example is the work that we are conducting on plague. This is part of *Colloquium 3* ("The ecology and evolution of infectious diseases within an environmental reservoir"). Much exciting synthesis work is currently taking place in that colloquium. Our ancient DNA laboratory certainly facilitates this work. *Colloquium 4* ("Integration of ecology and evolution") is the final colloquium of CEES, within which the synthesis work is to be concluded. Within this colloquium we are bringing together paleobiological work, experimental microbial work, and theoretical work. The synthesis work within this colloquium has received additional external funding, greatly facilitating it. Few if any other research groups cover such a broad range of competence in the quest to understand how evolutionary and ecological processes are mutually interwoven and lead to macroevolutionary dynamics.



The research at CEES is organised around three intertwined Themes and four multidisciplinary Colloquia. Each colloquium has a limited number of years for the main activity, and together they span the 10-year CoE period.

Scientific highlights 2007–2016

At CEES, scientists operate at the cutting edge of research, as indicated by our track record of publications in top peer-reviewed journals. Our scientific highlights span the years from 2007 to 2016, and cover all research fields that we are actively engaged in. We mention just a few of these highlights below.

Our sequencing of the cod genome, published in *Nature* (Star *et al.* 2011), revealed that the Atlantic cod has lost genes essential for the functioning of the major histocompatibility complex (MHC) class II pathway (one of the pathways involved in combatting infections). The loss of MHC II occurred around 100 million years ago in the branch leading to codfishes, and the alterations in immune genes have influenced the speciation rate in this important group of vertebrates, as shown in *Nature Genetics* (Malmstrøm *et al.* 2016).

Our marine research also includes the study of potentially significant economic effects resulting from fishing pressure, published in *PNAS* (Eikeset *et al.* 2013, 2016). Overfishing can lead to evolutionary changes in fish populations, and both evolutionary and ecological factors interact to influence the growth and size of fish.

Publications in *Molecular Ecology* (Hermansen *et al.* 2011, Elgvin *et al.* 2011) have provided insight into speciation by identifying an example of hybrid speciation: the ubiquitous house sparrow has interbred with the Spanish sparrow, forming a third distinct species, the Italian sparrow.

Our empirical and theoretical work explores the evolution, persistence, and distribution of disease pathogens in the wild. We have concentrated on the rapid emergence of Lyme disease in Europe, as published in *Nature Communications* (Mysterud *et al.* 2016), and on outbreaks of plague – caused by the bacterium *Yersinia pestis*. In particular, work in *PNAS* by Schmid *et al.* (2015) has shown a strong association between climate-driven outbreaks of *Y. pestis* in Asian rodents and waves of plague in Europe.

Research in *Proc. R. Soc. B.* (Voje *et al.* 2015), and *Evolution* (Voje 2016) further demonstrates how we link ecological and evolutionary thinking. Voje (2016) tackled a long-standing question; whether established species remain more or less unaltered during their existence. By investigating 450 fossil time series, he showed that lineages showing stasis often undergo sizable amounts of evolution. However, this evolution does not accumulate to produce large net evolutionary changes over time. On a related note, research published in *PNAS* (Nordbotten & Stenseth 2016) shows that both Red-Queen type evolution and evolutionary stasis can occur within a multispecies community, under different ecological conditions.

New scientific highlights in 2016

The role of ecology and evolution

One of the core activities of CEES is to understand the dynamics between ecological and evolutionary processes for different biological systems. In a study recently published by *PNAS* (Eikeset *et al.* 2016), we showed how evolutionary and ecological factors interact to influence the growth and size of fish, using cod (*Gadus morhua*) as our model organism. Overfishing can lead to evolutionary changes in fish populations – since fishers usually harvest larger fish, fish populations adapt to the pressure of heavy fishing by evolving to mature earlier and at smaller sizes. Through a growing body of research, scientists are sorting out to what extent observed changes in fish populations are caused by non-reversible genetic changes (evolution), and to what extent the changes are influenced by the environment rather than genetics (phenotypic changes). In our new study, we addressed this question by exploring the relative impact of two factors: 1) density dependence, i.e., when the cod population shrinks through fishing, more food is available and fish mature earlier, and 2) life-history evolution, i.e., an evolutionary change towards earlier maturation induced by the selective harvesting of larger fish.

The study focusses on northeast Arctic cod, currently the world's largest cod stock. We studied how the historic fishing pressure from 1932–2005 affected the fish stock at the population level, by building an individual-based model. This model could reproduce 74 years of historical data on age and length of maturation for this particular cod stock (figure 1). We used this model to show that ecological and evolutionary dynamics do not work in isolation, but rather as part of a complex system. Specifically, we found that a combination of these two processes was likely responsible for the observed

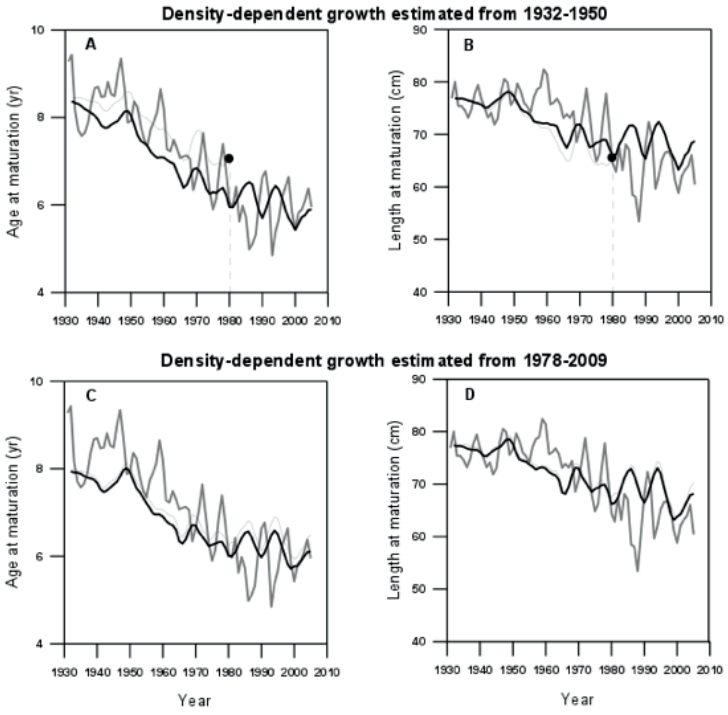


Figure 1: Comparison of model predictions and observations for age and length at maturation in NEA cod for (A and B) the historical growth model and (C and D) the contemporary growth model. Observations are shown with grey lines; eco-evolutionary model predictions, with thick black lines; and nonevolutionary model predictions, with thin black lines. The shown models possess the highest likelihoods among all 16 model variants and associated CV combinations. In A and B, the nonevolving population goes extinct at the point indicated by the filled circles and dashed lines. Model predictions are the mean ages and lengths at maturation among individuals in the population, averaged over 30 independent model runs (Eikeset et al. 2016).

changes in cod age and size at maturation. Our carefully calibrated quantitative model also revealed that the cod population could have collapsed around 1980 had it not undergone some life-history evolution, making it more resilient to the high fishing pressures it experienced after World War II.

Understanding the interplay and relative contribution from the combination of these two processes is not only interesting from a scientific perspective, but also vital for fisheries management. This is because this complex dynamic is responsible for the observed changes in exploited populations worldwide. Our study underscores both the economic and environmental ramifications: economically speaking, smaller fish lead to a smaller catch for fishers; and environmentally speaking it is unclear what the broader impact of these changes will be. It is thus vital for fisheries management to adopt an integrated approach, as a comprehensive understanding of both evolutionary and ecological processes will allow fisheries to be understood and managed in a sustainable way.

A related study in *Ecological Applications* (Dunlop *et al.* 2015) explored the impact of evolution on population growth rate, stock collapse and recovery potential, using a more theoretical model. The findings of that study were further highlighted by Nusslé *et al.* (2016 *Trends in Ecology & Evolution*); in particular, that 1) evolution has the strongest effect on population growth when the harvest rate is high, and 2) evolution affects how the population growth rate changes over time. Growth rate, *r*, initially decreases as the largest individuals are removed via harvest, but later recovers when density is sufficiently reduced to trigger overcompensation, i.e., density-dependent growth (figure 2, left side). Evolution first slows down the initial reduction and accelerates the subsequent recovery. During a fishing moratorium, the transient dynamic is reversed; growth rate, *r*, first increases as the moratorium protects the larger fish, but later decreases as fish density increases and the population approaches carrying capacity (figure 2, right side).

Our *PNAS* paper (Eikeset *et al.* 2016) received a lot of attention, and generated further discussion in *PNAS* (Eikeset *et al.* 2017). In our follow-up paper, we re-emphasised that it is essential to carefully integrate models and empirical data (figure 3). In addition, we underscored that our research question is framed within the context of understanding the dynamics *between* ecology and evolution, not whether changes in the fish stock dynamics are due to ecology *or* evolution. Our results emphasise that it is important to understand these dynamics and how they interact, in order to prevent fisheries collapse. This is because these processes are truly intertwined, and the underlying ecological and evolutionary mechanisms continuously change over time. For example, as density dependence grows through food availability, competition, density, etc., so too does the selective pressure through harvesting. Hence, the drivers for these ecological and evolutionary processes are not stable, and we therefore have to understand when one may matter more than the other. Our study steps up to that challenge.

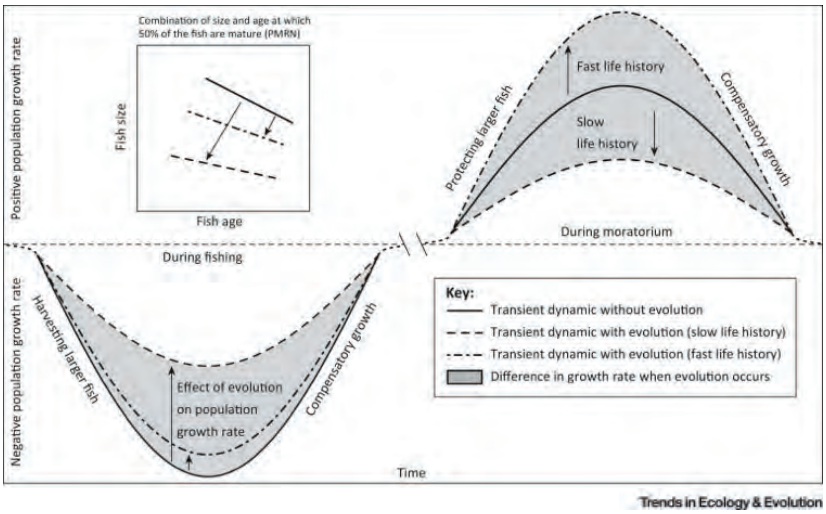


Figure 2: Transient Dynamic of Population Growth Rate (r) through Time. The unbroken line in the left side of the graph describes the transient dynamic of population growth rate (r) during intense fishing (i.e., harvest rate greater than 40%), with a negative and decreasing growth rate when the largest fish are harvested, followed by an increasing (but still negative) growth rate due to compensatory growth linked to density-dependent factors. The population growth rate eventually stabilizes when the population reaches carrying capacity. The unbroken line in the right side of the figure represents the reverse transient dynamic that occurs during a fishing moratorium with the same phenomenon reversed. The broken lines represent the trajectories of species with fast (broken-dot) versus slow (broken) life history speeds after evolution of the probabilistic maturation reaction norm (PMRN), which is represented in the box in the upper left part of the graph. The PMRN represents the combination of fish size and age at which 50% of individuals are mature (represented by the unbroken bar), that is, at a given age, larger fish are more likely to be mature than smaller ones. PMRN evolution is expected to trigger maturation at smaller sizes and younger ages (Nusslé et al. 2016).

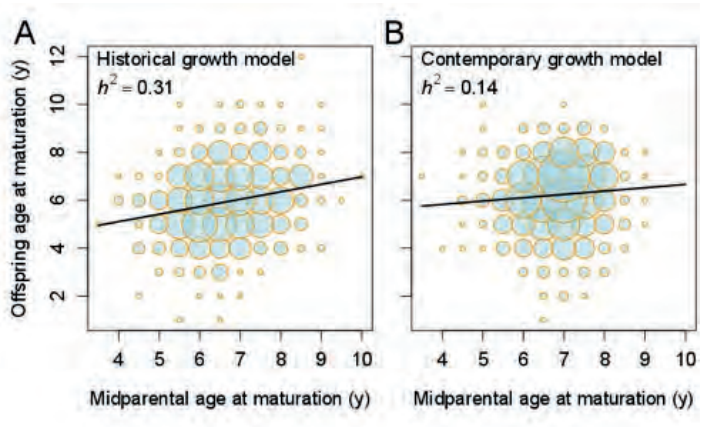


Figure 3: Heritabilities of age at maturation in our model for (A) the historical growth model and (B) the contemporary growth model. Emergent heritabilities (h2) are estimated for the two growth models by regressing the age at maturation of offspring individuals on the mean age at maturation of their parents. The median of five replicate model runs is shown for each model, with circle sizes being proportional to counts of values for 1995–2005. The lines indicate the resultant linear parent–offspring regressions, with their slopes equalling h2 (Eikeset et al. 2017).

Summarised by Anne Maria Eikeset.

Further reading:

Dunlop, E. S., **Eikeset, A. M.**, **Stenseth, N. C.** (2015) From genes to populations: how fisheries-induced evolution alters stock productivity. *Ecological Applications*, 25 (7), 1860–1868.

Eikeset, A. M., Dunlop, E. S., Heino, M., Storvik, G., **Stenseth, N. C.**, Dieckmann, U. (2016) Roles of density-dependent growth and life history evolution in accounting for fisheries-induced trait changes. *Proceedings of the National Academy of Sciences of the United States of America*, 113 (52), 15030–15035.

Eikeset, A. M., Dunlop, E. S., Heino, M., Storvik, G., **Stenseth, N. C.**, Dieckmann, U. (2017) Reply to Enberg and Jørgensen: ecology and evolution both matter for explaining stock dynamics. *Proceedings of the National Academy of Sciences of the United States of America*, doi: 10.1073/pnas.1703865114.

Nusslé, S., Hendry, A. P., Carlson, S. M. (2016) When should harvest evolution matter to population dynamics? *Trends in Ecology & Evolution*, 31 (7), 500–502.

Anne Maria Eikeset

Rate of evolution is consistent across modes in the fossil record

When studied on short timescales, evolution seems easy. Most artificial selection experiments are able to create large phenotypic changes, and natural populations commonly change due to natural selection. Observations of evolution on generational timescales (microevolution), therefore, indicate a gradual process, one where populations have the ability to respond to natural selection. Studies of macroevolution, however, often tell a different story. Palaeontological data suggest species exist more or less unaltered during their existence. Why do we see so little evolution over million-year timescales when evolution appears to happen all the time over shorter timescales?

The contrast between levels of evolution observed over long and short timescales is often referred to as the paradox of stasis. Resolving this paradox would help us understand how observations on microevolutionary timescales may explain macroevolution, or if there are processes governing long-term morphological evolution that cannot be understood by understanding microevolution alone.

A potential solution to the stasis-paradox lies in how we interpret the fossil record. A lineage shows stasis when its species show no net evolution over time. However, the morphology of a species is rarely constant and usually displays fluctuations, which over time do not accumulate to produce net evolutionary change. The magnitude of the stationary fluctuations in the morphology of a species during stasis has commonly been assumed to be very small, representing neglectable amounts of evolution. Indeed, a fundamental assumption underlying the paradox of stasis is that stasis represents minimal evolution. However, to what extent fluctuations during stasis in fact represent minimal evolution has yet to be formally tested.

In a study published in *Evolution* (Voje 2016), I analysed 450 time series in order to investigate the amount of evolutionary change in fossil lineages over time. I first categorised the time series into different evolutionary modes by testing which model of evolution best described each time series (models representing stasis, directional trend, etc.). I then tested whether traits that fit different modes travelled different distances in morphospace. For example, if we add together all the evolu-

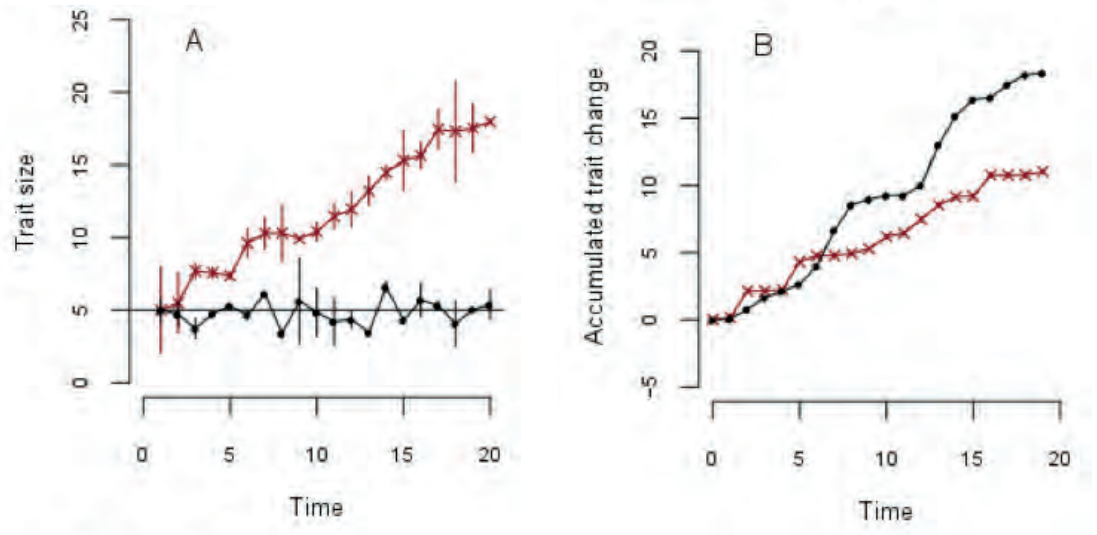


Figure 1: Measures of net evolution and distance travelled in morphospace. Panel A shows two traits fitting the modes directional change (red, crosses) and stasis (black, filled circles). The stasis trait fluctuates around a fixed mean (horizontal line), showing minimal net evolution compared to the trait moving directionally in morphospace. Panel B shows the accumulated distance travelled in morphospace for the two traits in panel A. The accumulated distance travelled in morphospace shows how much the trait changes over time, irrespective of the direction of the change (i.e., whether the trait gets larger or smaller) (Voje 2016).

tionary changes when a trait fluctuates during stasis, is that amount of evolution comparable to the amount of evolutionary change happening in a trait that shows a directional trend over time (figure 1)?

The results of the analyses of the 450 morphological time series show that the nonaccumulating morphological fluctuations during stasis travel similar distances in morphospace, compared to lineages showing directional change. Hence, lineages showing stasis commonly undergo considerable amounts of evolution, but this evolution does not accumulate to produce large net evolutionary changes over time. This represents a rereading of the fossil record, one which suggests that rates of evolutionary change across modes in the fossil record may be more homogenous than previously assumed and advocated.

The conclusion of the paper contradicts the dominating view of evolution based on the fossil record – that established species remain more or less unaltered during their existence. The study was selected as a Research Highlight in *Nature*.

Summarised by Kjetil Lysne Voje.

Further reading:

Voje, K. L. (2016) Tempo does not correlate with mode in the fossil record. *Evolution*, 70 (12), 2678–2689.

Kjetil Lysne Voje

Speciation rate in teleost fishes is influenced by their immune system

In 2011, the Atlantic cod genome was published in *Nature* (Star *et al.* 2011). A major finding based on the complete catalogue of its genes was that cod had lost an important part of its adaptive immune system (MHC II), while another part was highly expanded (MHC I). As a continuation of this discovery, Martin Malmstrøm, Michael Matschiner, and a team of colleagues from both CEES and other international institutions investigated a large number of additional fish species and found that cod is not unique in this instance. It became clear that the loss of the MHC class II pathway, normally responsible for protection against bacterial infections, occurred already very early on in the evolution of cod-like fishes. Therefore, all living members of this order (Gadiformes) lack components of the adaptive immune system (CD 4, Invariant chain, and MHC II). However, the expanded repertoire of MHC class I – the defence mechanism against viral pathogens – showed a more complex phylogenetic pattern by displaying expansions both in Gadiformes and another species-rich group, Percomorphaceae. Our analyses suggest that copy number expansions of MHC I have played a central role in the evolutionary success of at least these two large clades within teleosts. Our findings, published in *Nature Genetics* (Malmstrøm *et al.* 2016), have not only changed the traditional view of a static and highly conserved immune system in all vertebrates. They have additionally illuminated that MHC genes have a pleiotropic role by influencing speciation rates in many different species.

Teleost fishes comprise close to 33 000 species, and thus constitute more than half of all living vertebrates. Despite this, little is known about how this group became so numerous, and which evolutionary changes enabled their success. These issues have been the focus of many research projects, but only in recent years has it become feasible to elucidate this conundrum through whole-genome sequencing. While Atlantic cod was the first fish species (and the second among all vertebrates) to be sequenced with new high throughput sequencing technology, dramatic improvements in the technology have since resulted in many new genome assemblies, as well as a substantial improvement of the cod genome (publically available from 2016; Tørresen *et al.* 2017). The availability of these genomic resources has changed the field of cod research fundamentally. It has led to a shift away from a purely ecological, fishery and economic focus and towards becoming a model system for genomic and immunological research. In the process, we uncovered an important piece in the puzzle for our understanding of teleost speciation.

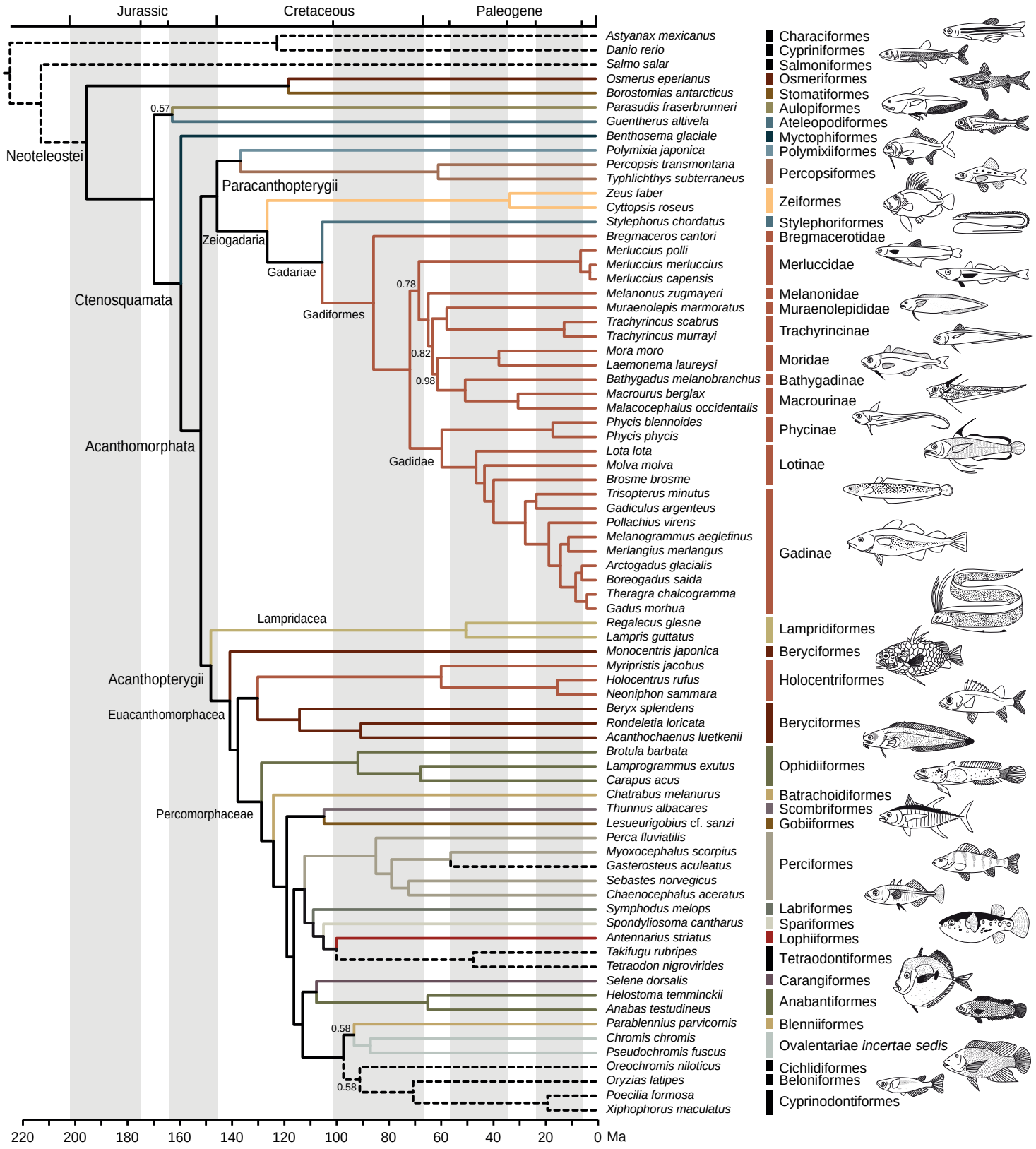


Figure 1: Teleost phylogeny based on 76 fish genomes. Divergence times were estimated using 17 fossil constraints. Except where noted, all nodes were supported with maximum support. Higher-level clades are indicated to the left of the respective node, and drawings illustrate examples of the diverse fishes used for genome sequencing (Malmstrøm et al. 2016).

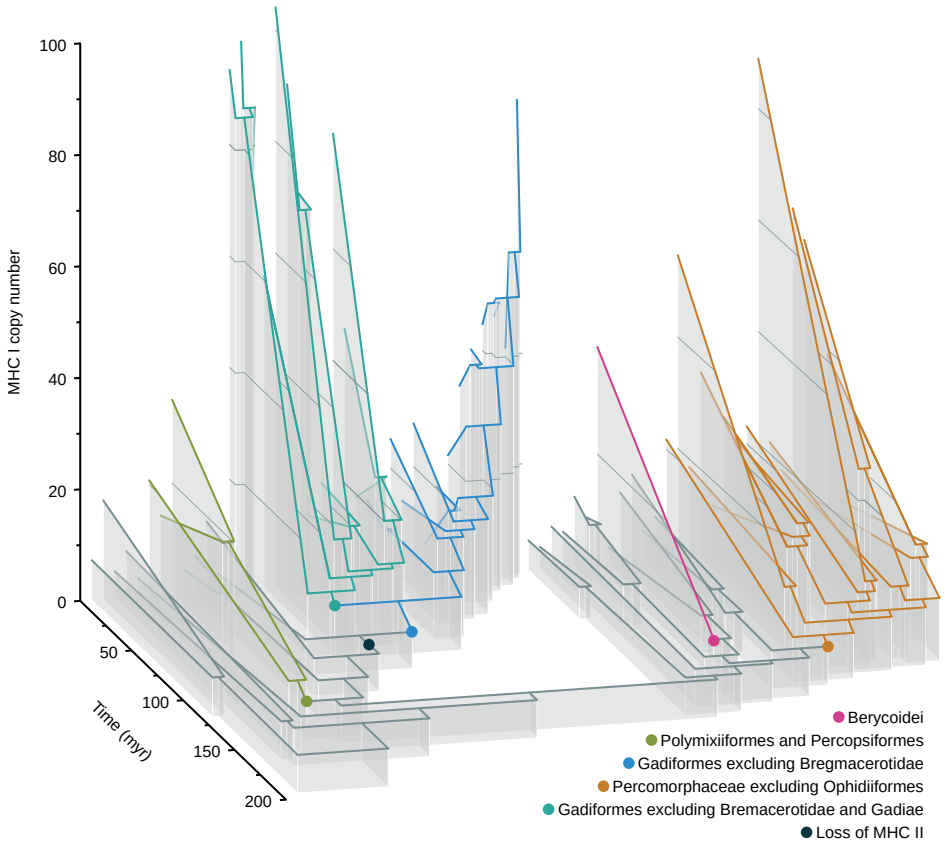


Figure 2: 3D representation of the new teleost phylogeny illustrating the evolutionary history of the MHC class I copy-number expansion based on ancestral-state reconstruction with the best-fitting Ornstein-Uhlenbeck model. This model supports five shifts towards elevated copy-numbers of MHC I, marked with coloured circles. The loss of MHC II in the common ancestor of Gadiformes is indicated with a black circle (modified from Malmstrøm et al. 2016).

To investigate variation in the immune systems of codfishes, Malmstrøm and colleagues sequenced the genomes of 65 additional fish species. Twenty-six of these species were close relatives of the Atlantic cod, representing all major families of Gadiformes (figure 1). Altogether, this sequencing effort more than doubled the number of available fish genomes, and has already formed the basis of several other research projects. This vast new dataset allowed the CEES team to construct a new dated phylogeny of the bony fishes, enabling the interpretation of the genomic data in a truly evolutionary framework. The dataset itself has attracted considerable attention, and has also been described by the CEES team in a separate article in *Scientific Data* (Malmstrøm *et al.* 2017) in order to facilitate the reuse of available genomic resources.

Our main goal was initially to identify when in the Atlantic cod's ancestry these massive changes to the immune system had occurred, and whether the loss of one immune pathway could be connected to the extreme expansion of another. However, an even more interesting pattern emerged from the analysis of the genomic data when the phylogenetic relationships were taken into account. This pattern, revealed with software (SLOUCH) developed by CEES core member Thomas Hansen, showed that expansions of other immune genes in codfishes were mirrored in other species-rich fish lineages (figure 2). This finding was in line with previous research that suggested a link between immune gene variation and the potential for lineages to speciate. To test this hypothesis more explicitly, we incorporated data on phylogeny, species diversity, and immune gene expansions into a joint statistical analysis. The results were unambiguous – the hypothesis that immune gene expansions influence speciation received strong statistical support. Thus, despite the loss of some important immune genes in codfishes, their unique immune systems do not appear to have limited their evolution, and instead may even have been the key to their extraordinary diversity. Within less than 100 million years, codfishes diversified into over 600 species, which is comparable to other rapidly diversifying groups such as wrasses (belonging to the Percomorphaceae).

Michael Matschiner and Martin Malmstrøm on fieldwork at Sørøya (Finnmark) – far away from labs and computers. © Paul R. Berg.

Our findings in *Nature Genetics* (Malmstrøm *et al.* 2016) were further highlighted in a "News and Views" article in the same journal by Prof. Peter Parham, a highly renowned immunologist at Stanford University (Parham 2016). In this article, Parham pointed out that these immunological changes may have allowed these species to avoid retroviral attacks – viruses that circumvent the immune system by duping the MHC II defence system – thus allowing these species to spread to, and inhabit, a greater variety of marine habitats.

Notably, the important biological results of this research were the result of a multidisciplinary approach – a core concept of CEES – and a focal point of the activities of *Colloquium 2*: "Bridging the gap between genomics and evolutionary biology". This research is thus exemplary for how the combination of different branches of biological science – cutting-edge genome sequencing technology, statistical approaches, and macroevolutionary analyses – can have synergetic effects on the scientific process.

Summarised by Martin Malmstrøm, Michael Matschiner and Kjetill S. Jakobsen.

Further reading:

Malmstrøm, M., **Matschiner, M.**, **Tørresen, O. K.**, **Jakobsen, K. S.**, **Jentoft, S.** (2017) Whole genome sequencing data and de novo draft assemblies for 66 teleost species. *Scientific Data*, 4, doi: 10.1038/sdata.2016.132.

Malmstrøm, M., **Matschiner, M.**, **Tørresen, O. K.**, **Star, B.**, Snipen, L.-G., **Hansen, T. F.**, **Baalsrud, H. T.**, **Nederbragt, A. J.**, Hanel, R., **Salzburger, W.**, **Stenseth, N. C.**, **Jakobsen, K. S.**, **Jentoft, S.** (2016) Evolution of the immune system influences speciation rates in teleost fishes. *Nature Genetics*, 48 (10), 1204–1210.

Parham, P. (2016) How the codfish changed its immune system. *Nature Genetics*, 48 (10), 1103–1104.

Star, B., **Nederbragt, A. J.**, **Jentoft, S.**, **Grimholt, U.**, **Malmstrom, M.**, Gregers, T. F., **Rounge, T. B.**, **Paulsen, J.**, **Solbakken, M. H.**, Sharma, A., Wetten, O. F., Lanzen, A., Winer, R., Knight, J., Vogel, J.-H., Aken, B., Andersen, O., **Lagesen, K.**, **Tooming-Klunderud, A.**, Edvardsen, R. B., **Tina, K. G.**, **Espelund, M.**, Nepal, C., Previti, C., Karlsen, B. O., Moum, T., **Skage, M.**, **Berg, P. R.**, Gjoen, T., Kuhl, H., Thorsen, J., Malde, K., Reinhardt, R., Du, L., Johansen, S. D., Searle, S., Lien, S., Nilsen, F., Jonassen, I., **Omholt, S. W.**, **Stenseth, N. C.**, **Jakobsen, K. S.** (2011) The genome sequence of Atlantic cod reveals a unique immune system. *Nature*, 477 (7363), 207–210.

Tørresen, O. K., **Star, B.**, **Jentoft, S.**, **Reinar, W. B.**, Grove, H., Miller, J. R., Walenz, B. P., Knight, J., Ekholm, J. M., Peluso, P., Edvardsen, R. B., **Tooming-Klunderud, A.**, **Skage, M.**, Lien, S., **Jakobsen, K. S.**, **Nederbragt, A. J.** (2017) An improved genome assembly uncovers prolific tandem repeats in Atlantic cod. *BMC Genomics*, 18 (1), 95.

Martin Malmstrøm

Michael Matschiner

Kjetill S. Jakobsen

The role deer populations play in Lyme disease emergence in humans

The re-emergence and spread of Lyme disease throughout Europe has been caused by global environmental changes. There are now some 85 000 cases of Lyme disease reported annually in Europe, with 7 000 of these cases occurring in Norway alone. Lyme disease is usually not lethal in humans, but in severe cases may cause a considerable decrease in quality of life for many years. Lyme disease is caused by bacteria (spirochetes) from the *Borrelia burgdorferi* sensu lato complex, with reservoirs in small vertebrates. The vector of the pathogen is the tick *Ixodes ricinus*. It may take 3–6 years for the life cycle of the tick to be completed, involving three life stages (larva, nymph, and adult). Each life stage requires a blood meal in order to moult into the next stage or to reproduce. The life cycle of *I. ricinus* involves a niche shift as it develops from the larval and nymphal stages through to the adult stage, since the various stages use different sized hosts. The larval and nymphal stages use a wide range of hosts, and pick up the pathogen causing Lyme disease from small vertebrates, whereas the adult stage depends on larger (non-transmission) hosts, typically deer (figure 1). Because of this complexity, the role played by different host species in the emergence of Lyme disease remains controversial. Deer specifically may amplify tick numbers, due to their role as reproduction hosts for adult female ticks (a mechanism increasing disease hazard). However, deer can also lower the prevalence of the pathogen in ticks (dilution), as they are not competent hosts of the pathogen (a mechanism decreasing disease hazard).

A team of researchers from CEES has documented in *Nature Communications* (Mysterud *et al.* 2016) the mechanisms of how deer populations affect disease hazard, and how variations in both spatial and temporal deer population density affect the incidence of Lyme disease. As a basis, we used a combination of techniques to look

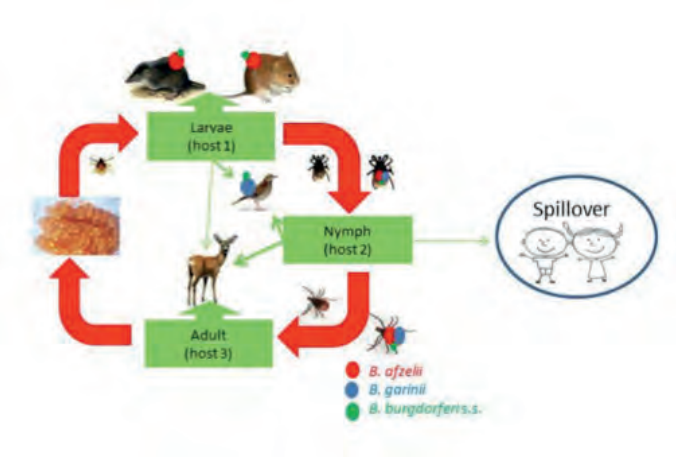


Figure 1: The life cycle of the tick Ixodes ricinus *which acts as a vector for the pathogen causing Lyme disease in humans.*

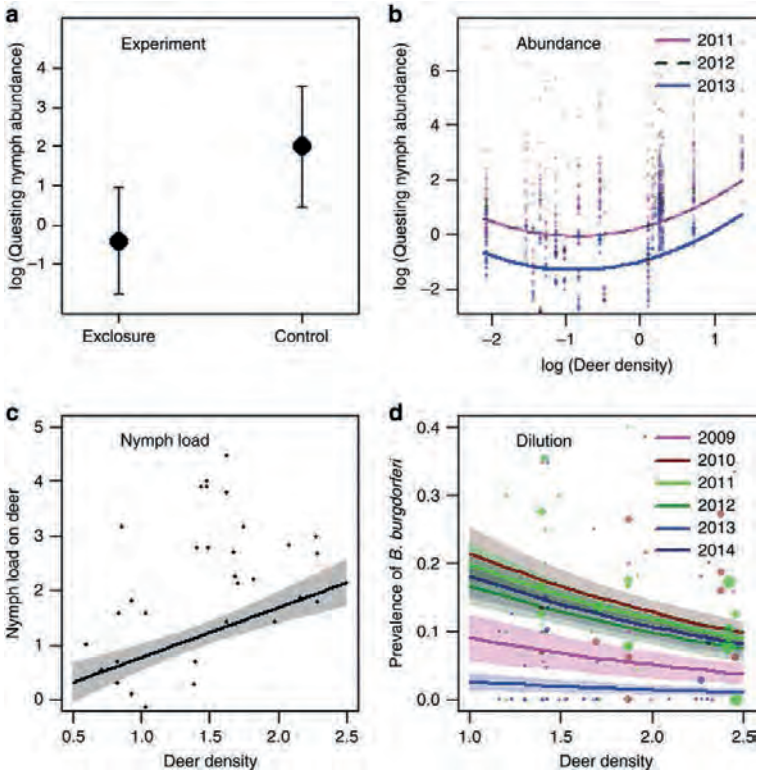


Figure 2: Relationship between a) the abundance of questing tick nymphs inside and outside of deer exclosures, b) the abundance of questing tick nymphs and deer population density index, c) the nymphal tick load on red deer ears and deer population density index, and d) the prevalence of Borrelia burgdorferi *sensu lato in ticks and deer population density index along the west coast of Norway (Mysterud et al. 2016).*

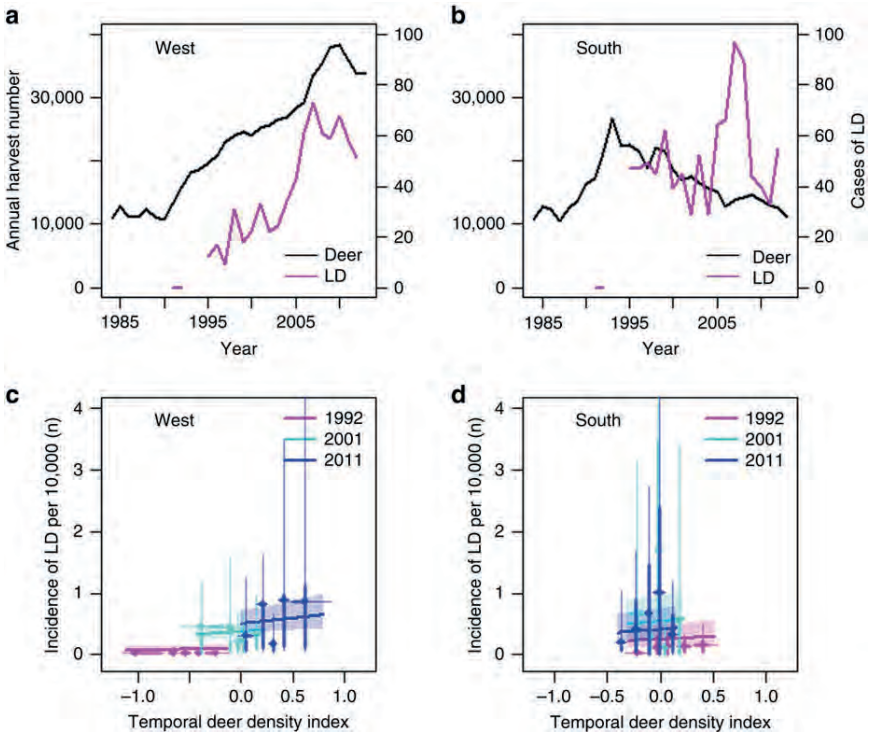


Figure 3: The annual number of harvested deer and Lyme disease cases in humans in region a) West and b) South and the relationship between LD incidence (per 10 000) and the temporal variation in deer density index in the c) West and d) South regions of Norway for years 1991, 2001 and 2011 (Mysterud et al. 2016).

at the mechanisms determining disease hazard (number of infected tick nymphs). These techniques included field sampling of host-seeking (questing) ticks, experimental manipulation of deer density through fencing, and real-time PCR techniques to detect the pathogen in ticks. We also performed statistical analysis of the incidence of Lyme disease over the whole of Norway for the years 1991–2012. These statistics were derived from the Norwegian Institute for Public Health, and included only the more severe cases of (systemic) Lyme disease. High deer density led to a somewhat higher number of questing ticks and tick load on deer (i.e., tick amplification), but the prevalence of pathogen in the ticks was reduced at high deer density (i.e., pathogen dilution) (figure 2). Nevertheless, the net sum of these opposing mechanisms was a clear measurable increase in the incidence of Lyme disease in humans as a result of both high temporal and spatial deer population density. However, the trajectories of deer population sizes played an overall limited role for the recent emergence of Lyme disease in Norway (figure 3).

Our article resolves a pointed topic that has been at the centre of a controversial debate within Lyme disease and other vector-borne disease research over the past several decades. The study suggests that managing deer populations will have some effect on Lyme disease incidence, but that Lyme disease nevertheless may increase as multiple drivers are involved. The paper has received media attention from many countries across Europe, due to the important implications for human health. This work provides one good example of the One Health concept, in which the health of the environment and animals are linked to the health of humans.

Summarised by Atle Mysterud and Hildegunn Viljugrein.

Further reading:

Mysterud, A., Easterday, W. R., Stigum, V. M., Aas, A. B., Meisingset, E. L., **Viljugrein, H.** (2016) Contrasting emergence of Lyme disease across ecosystems. *Nature Communications*, doi: 10.1038/ncomms11882.

Atle Mysterud

Hildegunn Viljugrein

Disentangling the mechanisms behind climate effects on a key zooplankton species

Zooplankton play a key role in marine ecosystems, channelling energy from primary producers (phytoplankton) to higher trophic levels. Throughout the North Atlantic, the copepod *Calanus finmarchicus* (figure 1) is a dominant zooplankton species and an important prey item for a range of organisms. In the Norwegian Sea and southwestern Barents Sea, *C. finmarchicus* serves as a food source for commercially valuable fish stocks such as capelin, herring and larval cod.

Temperatures in the upper oceans are increasing, with the strongest warming occurring at high latitudes. Rising temperatures are linked to increased thermal stratification (shallower mixing layer), and both of these factors potentially influence zooplankton biomass. However, investigating climate effects on zooplankton is challenging due to the influence of advection, in other words, the movement of organisms with water currents. Observation data typically give a snapshot of the plankton community in a specific location and moment, but do not reveal the observed individuals' past drift trajectories or the environment experienced *en route* prior to sampling.

In a study published in *PNAS* (Kvile *et al.* 2016), we explored potential climate effects on *C. finmarchicus* in the northeastern Norwegian Sea and southwestern Barents Sea. We combined long-term spatiotemporal observation data from Russian surveys conducted between 1959 and 1993 with state-of-the-art statistical methods and oceanographic particle tracking. Our goal was to quantify the importance of both 1) drift from spring to summer and 2) environmental variation likely experienced in spring on the spatial variation in *C. finmarchicus* biomass in summer. We also explored how environmental variation influences 3) year-to-year variation in *C. finmarchicus* biomass and 4) spatially resolved chlorophyll biomass in spring, a proxy for phytoplankton biomass and thus for food availability for *C. finmarchicus*.

A key result from the study was that the combination of shallow mixing-layer-depth (MLD) and high wind speed apparently increases chlorophyll biomass in spring, and in turn *C. finmarchicus* biomass in summer (figure 2). Chlorophyll biomass was positively linked to ambient wind speed when MLD was shallow. Wind-induced mixing might increase phytoplankton biomass after the spring bloom initiation, possibly due to nutrient renewal

Figure 1: Calanus finmarchicus *dominates mesozooplankton biomass in the Norwegian Sea and southwestern Barents Sea. This water sample from the Barents Sea contained a large number of* C. finmarchicus, *together with one specimen of the larger sibling-species* C. hyperboreus *(middle) and one predator copepod of the genus* Paraeuchaeta *(left). © Kristina Øie Kvile.*

from deeper waters. *C. finmarchicus* biomass in summer was similarly positively related to the combination of increased wind and shallow MLD at back-calculated positions in spring.

These results indicate that bottom-up effects of food availability in spring influence *C. finmarchicus* biomass in the Norwegian Sea–Barents Sea area in summer, highlighting the need to consider climate effects "beyond temperature" when projecting zooplankton dynamics under climate change. Phytoplankton production is predicted to decrease globally due to increased stratification resulting from ocean warming. At higher latitudes, however, increased stratification might strengthen the coupling between phytoplankton production and zooplankton ingestion, increasing zooplankton biomass in late winter/early spring (Stock *et al.* 2014). Our study additionally suggests that the interaction between MLD and wind can impact the phytoplankton biomass available to high-latitude zooplankton in spring, and thereby influence the zooplankton biomass in the following summer.

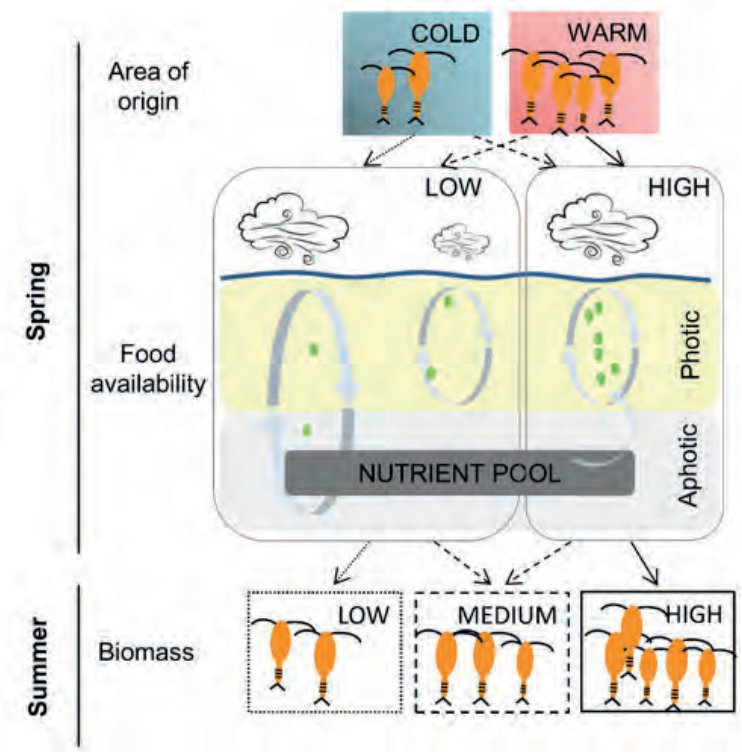


Figure 2: Schematic presentation of key results: More C. finmarchicus *originate from warm than cold areas. The combination of shallow mixing-layer-depth (MLD) and strong winds favours phytoplankton production, which in turn positively influences* C. finmarchicus *growth and/or egg production. As a result, the combination of high temperature, shallow MLD and increased wind in spring leads to high summer biomass on a local scale (solid arrow), while alternative combinations of lower temperature, increased MLD and wind, or reduced MLD and wind, result in medium or low summer biomass (dashed or dotted arrows).*

Accounting for drift, we furthermore found that spatially resolved biomass in summer related positively to temperature at back-calculated positions in spring. This most likely occurs because more biomass originates from warmer, southwestern areas closer to core distribution areas of *C. finmarchicus* in the Norwegian Sea. On the other hand, while annual mean *C. finmarchicus* biomass in spring was positively related to temperature in spring, the mean change in biomass from spring to summer was in general lower after a warm spring than a cold spring. This might be due to an earlier zooplankton biomass peak occurring with higher temperatures, earlier descent to overwintering, or increased competition or predation pressure after a warm spring. Increased temperatures, as predicted in future climate scenarios, might thus increase the *C. finmarchicus* biomass available for predators in spring, but not necessarily in summer.

Summarised by Kristina Øie Kvile and Leif Christian Stige.

Further reading:

Kvile, K. Ø., **Langangen, Ø.**, Prokopchuk, I., **Stenseth, N. C.**, & **Stige, L. C.** (2016) Disentangling the mechanisms behind climate effects on zooplankton. *Proceedings of the National Academy of Sciences of the United States of America*, 113 (7), 1841–1846.

Stock C. A., Dunne J. P., John J. G. (2014) Drivers of trophic amplification of ocean productivity trends in a changing climate. *Biogeosciences*, 11, 7125–7135.

Kristina Øie Kvile

Leif Christian Stige

The potential of prokaryotes in carbon capture and storage

Anthropogenic CO_2 emissions pose a global threat, contributing to global warming and ocean acidification. In 2016, atmospheric carbon dioxide levels passed the symbolic 400 ppm mark. To mitigate further escalations in warming and acidification, CO_2 gas can be captured from large-source emitters, such as the cement industry, and stored in geological formations – a process known as carbon capture and storage (CCS). As a potential solution to rising CO_2 levels, CCS has enormous promise. However, this promise comes with risks. Some of the biggest concerns with CCS are the risk of leakages and the environmental impact if a leakage occurs. Leakages can be abrupt or gradual, and small gradual leakages from subsurface reservoirs are especially difficult to detect with the available geological and seismic tools utilised today.

Advances in high throughput sequencing techniques during the last decade have revolutionised the field of microbial ecology. Prokaryotes have been detected in virtually all niches on Earth, from deep subsurface environments to far up in the atmosphere. They encompass a huge variety of metabolic pathways, enabling them to thrive in all environments. Six different metabolic pathways for CO_2 assimilation have so far been identified in Archaea and Bacteria, including the Calvin-cycle also found in plants and other photosynthetic eukaryotes (figure 1). Contrary to this metabolic cycle, several of the CO_2 assimilation pathways found in prokaryotes can occur in darkness (using other energy sources than light).

In our paper in *Trends in Biotechnology* (Hicks *et al.* 2016), we bridge the knowledge between microbial ecologists, geneticists, geologists, biogeophysicists and bioinformaticians. Within this multidisciplinary framework, we suggest the utilisation of prokaryotes for monitoring leakages from CCS, for enhanced CO_2 sequestration, and for carbon capture utilisation (CCU).

Under a CCS leakage scenario, gas will migrate through the overburden and into the overlaying surface sediments. In our paper, we argue that prokaryotic communities in surface sediments can be used to detect even small gradual leakages, leakages that are difficult to detect with the tools available today. Advancements in high throughput sequencing techniques have the potential to reveal even small changes in the metagenome of prokaryotic communities caused by environmental alterations, such as a leakage event. We claim that a streamlined automated system for detection of leakages based on amplicon and/or metagenome analyses of surface sediment prokaryotic communities is feasible. Furthermore, this method would provide a cost- and time-efficient way of monitoring CCS.

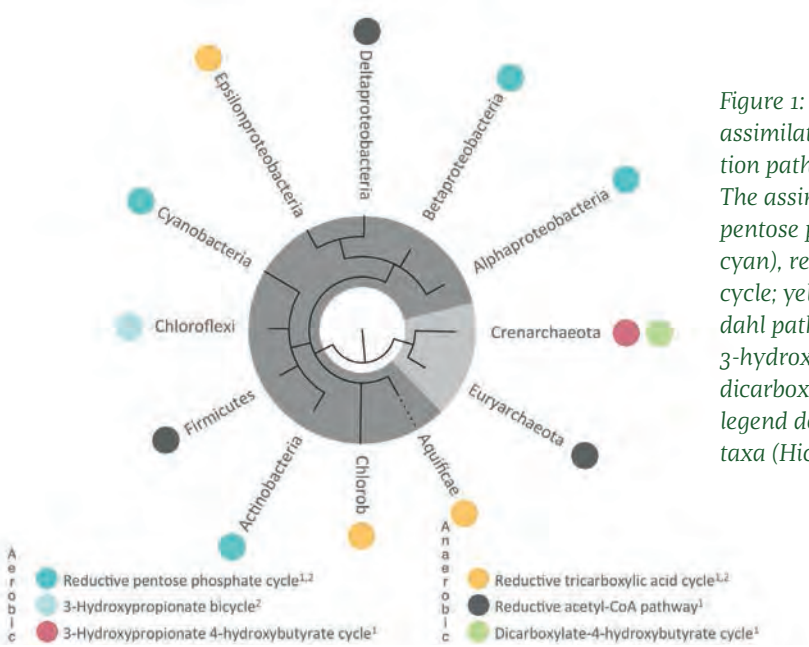


Figure 1: Phylogenetic representation of the diversity of CO2-assimilating prokaryotes using any of the six CO2 assimilation pathways. Bacteria: darker grey, Archaea: lighter grey. The assimilation pathways depicted here are the reductive pentose phosphate cycle (Calvin–Benson–Bassham cycle; cyan), reductive tricarboxylic acid cycle (Arnon–Buchanan cycle; yellow), reductive acetyl-CoA pathway (Wood–Ljungdahl pathway; grey), 3-hydroxypropionate bicycle (light blue), 3-hydroxypropionate-4-hydroxybutyrate cycle (pink), and the dicarboxylate-4-hydroxybutyrate cycle (green). The figure legend denotes [1]chemolithotrophic taxa and [2]photosynthetic taxa (Hicks et al. 2016).

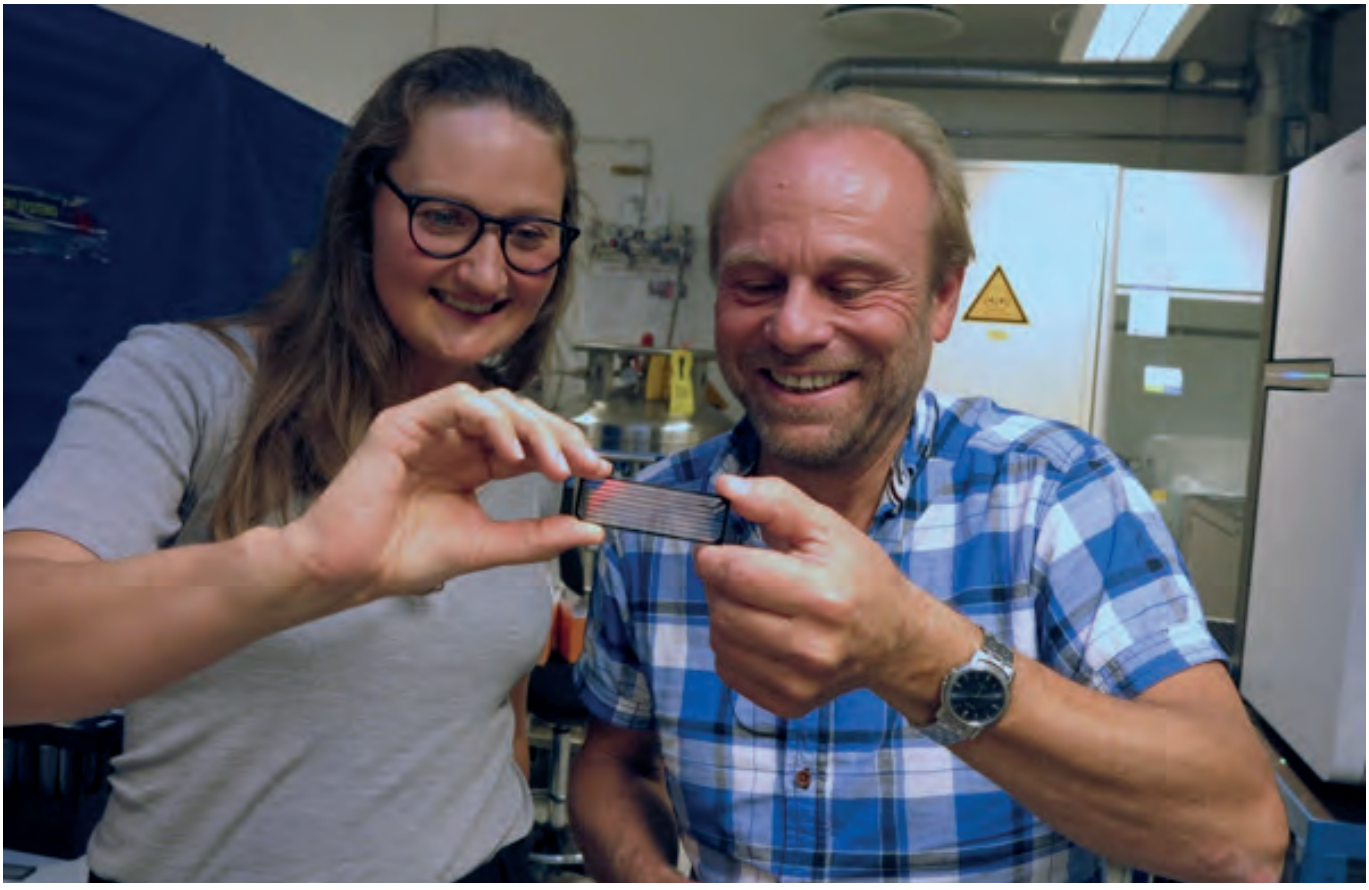
Leakages from CCS reservoirs can be avoided by trapping the gas into a solid state, such as calcium carbonite. Over a long timescale (tens of thousands of years), the injected and stored CO_2 may naturally precipitate onto sediment grains within the reservoirs as carbonate, and hence be sequestered in a stabile phase. Several prokaryotic groups are reportedly involved in biomineralisation, converting CO_2 into calcium carbonite, and can potentially speed up mineralisation rates. We suggest that such groups may be inoculated into CCS reservoirs to enhance the mineralisation process in a minimum amount of time, and thereby prevent leakages from these reservoirs.

Today, CCS is far from being economically profitable. Capturing and storing the gas is an energy-demanding and costly process. A range of anaerobic prokaryotes are able to convert CO_2 into a variety of different chemicals, including fuels and other products for industrial use, such as ethanol, acetate (acetic acid), butanol, methane, formate (formic acid). We argue that CCS reservoirs can be turned into CCU, where the reservoirs are used as bioreactors for value-added chemicals. To successfully utilise CCS reservoirs as bioreactors, the reservoirs may be inoculated with prokaryotic taxa and/or communities that are not only able to withstand high concentrations of CO_2 but can also convert the compounds into value-added chemicals. Such inoculum may comprise of natural, engineered, or even synthetic prokaryotes. It is necessary to identify highly CO_2-tolerant prokaryotes in order to reveal the genes encoding for enzymes and metabolic pathways that promote the ability to withstand elevated levels of CO_2. Enzymes and metabolic pathways with desired traits (e.g., utilising CO_2 with maximum efficiency) can then be identified. Using these genes in synthetic and engineered biology could provide a novel method of engineering prokaryotes to alter existing carbon assimilation, fixation, or conversion pathways, thereby maximising the efficiency of CO_2 utilisation.

Summarised by Unni Vik and Kjetill S. Jakobsen.

Further reading:

Hicks, N., **Vik, U.**, Taylor, P., Ladoukakis, E., Park, J., Kolisis, F., **Jakobsen, K. S.** (2016) Using prokaryotes for carbon capture storage. *Trends in Biotechnology*, 35 (1), 22–32.



Unni Vik and Kjetill S. Jakobsen. Source: https://titan.uio.no/node/1924. License: CC BY 4.0. © Bjarne Røsjø.

GreenMAR

Green Growth Based on Marine Resources: Ecological and Socio-Economic Constraints

GreenMAR is a project funded by Nordforsk that studies the complexities of marine systems in the Nordic regions, and how these systems adapt to increasing stress factors. Marine ecosystems provide unique opportunities to meet a growing global demand for healthy and nutritious food, if harvested more efficiently and sustainably. Yet, overexploitation, climate change and other anthropogenic stressors challenge such a development. The fundamental challenge of green growth is to use our renewable natural resources more efficiently, while ensuring that ecosystems retain their functionality. By investigating how the ecological and social components of complex marine systems can adapt to growing stress factors, we can provide management recommendations for improved harvesting strategies.

The GreenMAR panel at the Arctic Circle meeting in Reykjavík, Iceland. From left to right: Nils Chr. Stenseth (CEES), Jostein Sundet (Nordforsk), Matilda Valman (Stockholm Resilience Center – SRC), Susa Niiranen (SRC), Bryhildur Davidsdottir, (University of Iceland), Anne Maria Eikeset (CEES), and Thorsten Blenckner (SRC). © Anna V. B. Mazzarella.

GreenMAR consists of an interdisciplinary Nordic research team, linked to researchers in the USA, Russia, and the Netherlands. We bring together some of the best scientists in the fields of climatology, ecology, sociology, and economy. All of our partners have considerable experience within the broad theme of sustainability, but typically focus on different sub-topics or have different and complementary approaches. Their disciplines need to be integrated to produce the knowledge necessary to achieve green growth. To achieve such integration, GreenMAR brings together research groups which in the past have only collaborated loosely or not at all.

Our climatologists and oceanographers provide state-of-the-art model results on how climate affects sea surface temperature, ocean circulation, and freshwater run-off. Modelled and observed environmental data are combined with biological time-series to unravel effects on fish populations, with particular focus on possible critical thresholds in the effects of climate and fishing. Our sociologists perform in-depth studies on how fishermen adapt to changes in their environment. These insights are now being integrated in social-ecological models to quantify how systemic properties, such as resilience, sustainability, and viability, will be affected by climate change. In parallel, bio-economic models are being developed to predict the economic effects of climate change and to investigate how industry and regulation can adapt in a cost effective way. Together, such a multidisciplinary approach provides knowledge to ensure the sustainable management of our oceans, as a necessity and a catalyst for green growth. In ad-

dition, by including a leading Nordic fishing company (Havfisk ASA), the relevance and utility of the research is enhanced. Moreover, through a strong focus on training and communication, we aim to contribute to the formation of a new generation of multi-disciplinarily skilled scientists, administrators and industrialists. Our training and communication initiatives include: 1) organising a special issue in *Marine Policy*, 2) having Special Sessions at international scientific meetings such as Arctic Circle, Arctic Frontiers, and the American Association for the Advancement of Science (AAAS), and 3) other outreach events, workshops and courses. Our consortium is contributing profoundly to the competitiveness of the Nordic region, both scientifically and in the sustainable management of common resources.

The dedication of the partner institutions to this collaboration is signified by their high own contributions (>50% of total budget), including funding dedicated to developing new collaborative projects using GreenMAR as a stepping-stone. A significant side benefit is the establishment of interactions between members of three Norwegian Centres of Excellence (NorMER, Nord-Star, and SVALI), centres which otherwise would not have a reason to collaborate. GreenMAR further strengthens the links between academia, industry and other stakeholders within the topic of green growth, through the involvement of Havfisk ASA and the environmental NGO, WWF Norway. Finally, GreenMAR is strongly devoted to hands-on training of young researchers: they receive a wide range of workshops and courses in education, innovation and communication, with emphasis on outreach. All seminars are open for other scientists to attend/apply, and are also open to the public where feasible. GreenMAR is thus contributing to educate, facilitate and encourage a new generation of scientists in an era with demand for green growth.

Summarised by Anna V. B. Mazzarella.

GreenMAR is administered by CEES.

Website: greenmar.uio.no

The GreenMAR panel at the AAAS meeting in Boston, USA. From left to right: Jane Lubchenco (Oregon State University), Scott Barrett (Columbia University), and Oran Young (University of California, Santa Barbara). © Anna V. B. Mazzarella.

MARmaED

MARine MAnagement and Ecosystem Dynamics under climate change

MARmaED is a Marie Skłodowska-Curie Innovative Training Network funded by the European Commission. It is an international and interdisciplinary network that unifies specific and complementary competences in marine sciences from Norway (University of Oslo – CEES, University of Bergen), Finland (University of Helsinki, Åbo Akademi University), Denmark (Technical University of Denmark), the Netherlands (Wageningen University), Germany (University of Hamburg) and France (Météo France). This collaboration allows us to investigate how the cumulative stress from biodiversity loss, climate change and harvesting will affect Europe's complex marine systems, and the consequences this will have for optimal resource management. Our network integrates European education and research in essential disciplines, specifically genetics, ecophysiology, ecology, climatology, physical oceanography, statistics and economics, to achieve new knowledge and improved management of the marine systems in question. Through targeted secondments in the non-academic sector, MARmaED

Similar to its older siblings (NorMER and GreenMAR), MARmaED puts its Early Stage Researchers at the forefront. Photo taken at the 2nd Annual Meeting and course, Kristineberg Research Station, Sweden, 7 April, 2017. © Joël Durant.

also constitutes an intersectorial project, providing the network's students with broad training and strong favourable employment opportunities within industry and other non-academic sectors.

The second year of MARmaED is well in progress, and our 15 Early Stage Researchers (ESRs) are now fully into their respective PhD studies with their first papers published, submitted or ready to be submitted (see table 1). The visibility of MARmaED at international conferences is significant. For example, five ESRs have presented papers and posters at the ICES Annual Science Conference (ASC) in Riga, Latvia alone (where the ESR from CEES, Leonie Färber, was awarded Best Poster). By the end of 2016, MARmaED researchers had already attended 19 conferences, presenting a total of 14 talks and ten posters.

All the secondments at partner nodes have started, and some have already been successfully completed. Through this process the ESRs are exposed to different scientific cultures, which will lead to a paper per secondment per ESR; some of them are already in the writing process. Even more excitingly, the secondments at the non-academic partner nodes have also taken place. We are very satisfied with the success of these secondments; the scientific pursuit complemented the non-academic one so well, and achieved such strong collaboration, that we were asked to prolong the experience with a new period for some of the ESRs.

There is thus no doubt that the MARmaED ESRs are currently acquiring extremely valuable experience – experience which is both scientific, through the cross-disciplinary approach, and trans-sectorial in nature. MARmaED is fully fulfilling its role by providing the ESRs with broad training and increased employment opportunities within industry and other non-academic sectors. The new generation of researchers emerging from MARmaED will, I am sure, continue the legacy of NorMER and become a trademark of the marine research coming out of CEES for the international scientific community, as these researchers move through their respective careers.

Summarised by Joël Durant.

MARmaED is administered by CEES.

Website: marmaed.eu

Table 1: Tracking each Early Stage Researcher (ESR): the number of conferences attended, and papers published and in progress.

ESR	Institution	Conference	Papers	
		#	Published	In progress
Romain Frelat	University of Hamburg	4	--	2
Camilla Sguotti	University of Hamburg	2	--	1
Sezgin Tunca	University of Helsinki	2	2	2
Tin-Yu Lai	University of Helsinki	1	--	1
Esther Beukhof	Technical University of Denmark	1	--	2
Rob van Gemert	Technical University of Denmark	1	--	1
Sanmitra Gokhale	Wageningen University	1	--	1
Esther Schuch	Wageningen University	1	--	1
Leonie Färber	University of Oslo	1	--	3
Cecilia Helmerson	University of Oslo	--	--	1
Pierre Olivier	Åbo Akademi University	--	1	1
Christina Henseler	Åbo Akademi University	--	1	1
Gabriella Ljungström	University of Bergen	1	--	1
Tom Langbehn	University of Bergen	3	--	2
Sofia Darmaraki	Météo-France	1	1	1

SUSTAIN

SUSTAIN

SUSTAIN is a project funded by the Norwegian Research Council that studies the combined impacts of environmental change and harvesting across natural ecosystems. Terrestrial, freshwater, and marine ecosystems are currently all affected by major anthropogenic stressors, like climate change and harvesting. Yet, the interactive effects of these stressors remain poorly understood, and they are generally studied separately within each system. Such interactions may alter ecosystem functions and processes in previously unexpected ways, impacting the ability to provide ecosystem services. SUSTAIN addresses the general question of how expected climatic changes affect the way species can be harvested in an ecosystem perspective, and how management strategies can be improved to ensure sustainable exploitation and resilience in those ecosystems.

SUSTAIN brings together three of the strongest scientific groups within ecology and evolution in Norway: CEES at the University of Oslo, the Centre for Biodiversity Dynamics (CBD) at the Norwegian University of Science and Technology (NTNU), and the Dept. of Arctic and Marine Biology at the University of Tromsø. This effort counteracts the profound fragmentation within Norwegian environmental science and establishes collaboration networks for a new generation of scientists and managers. The SUSTAIN network also consists of other research institutions/organisations from Norway, with expertise ranging from statistics and ecology to meteorology and marine science. These partners include the Norwegian Institute for Nature Research (NINA), Norwegian Institute for Water Research (NIVA), Norwegian Polar Institute, Norwegian Computing Center, Institute of Marine Research, Norwegian Meteorological Institute, and the Norwegian Ornithological Society. In addition, SUSTAIN collaborates closely with a panel of end-users. These are representatives from NGOs, stakeholders, monitoring programmes and management bodies for the ecosystems and renewable resources concerned. Examples of our end-users include the Governor of Svalbard, the Norwegian Environmental Agency, Finnmark Estate Agency, and the County Governor of Hedmark.

The work in SUSTAIN is organised around a "strategic foresight protocol" (see figure 1), a framework that provides a structured process whereby rigorous science scopes the options for an uncertain future. In collaboration with the panel of end-users, SUSTAIN uses both theoretical development and empirical analyses of high-quality data to develop an ensemble of ecological models and explore impacts of climate change and management interventions across environments, spatiotemporal

The Gudbrandsdalslågen river site is one of the SUSTAIN study areas. © Chloé Rebecca Nater.

scales, and from single populations to entire food webs. The project deals with terrestrial, marine and freshwater ecosystems and has seven case studies focussing on species that are harvested in these ecosystems: 1) semi-domesticated reindeer in boreal–Arctic ecosystems, 2) Arctic fox, reindeer and ptarmigan on Svalbard, 3) willow and rock ptarmigan in mountain and tundra systems, 4) increasing red fox populations in northern areas, 5) moose and small game in boreal forest, 6) fish stocks and brown trout in lake Mjøsa, and 7) fish stocks in the Barents Sea.

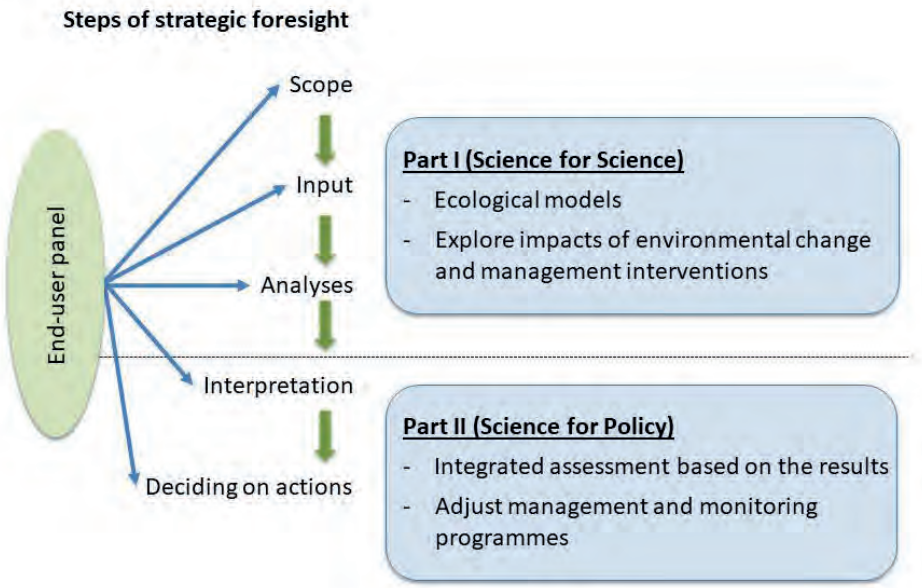


Figure 1: The strategic foresight protocol forms the backbone of SUSTAIN.

Some of the scientific results achieved so far provide insight into: relationships between different species in marine food webs and both climate and fishing, spatial variation and synchrony in life history traits in moose and reindeer, and changes in the seasonal dynamics of plankton in lake Mjøsa. These results, and others, are already published in scientific journals, and have been presented in conferences (see www.sustain.uio.no). The results of these scientific analyses are intended to provide an integrated assessment of the studied ecosystems and evaluate their management strategies. This information can then be used to adjust management interventions as well as monitoring programmes, facilitated in part by continuous interaction with our panel of end-users. This interaction began at SUSTAIN's 1st annual meeting, in January 2016, where researchers, postdocs, PhD students and end-users came together, and has continued through more smaller-scale, targeted meetings.

In addition to these meetings, SUSTAIN has organised workshops with such topics as how to approach contact with end-users, and what specific tools can be used for statistical modelling. These workshops are important, because a focal point of SUSTAIN is the training of young researchers. New PhD students and postdoc researchers make up the workforce of the project, and a number of them are financed directly by the three main partner institutions. As part of the training provided by SUSTAIN, younger, more junior scientists are mentored by the more senior members of the team, in particular the PI and co-PIs, so as to help them become project and science leaders. This will help the junior scientists to develop their careers, so that they can be more competitive with regards to European funding. The mentoring is organised across nodes, so that each one of the three co-PIs mentors researchers from the other two nodes, both in person and via Skype meetings.

Mobility is another key aspect of training within SUSTAIN. The PhD students appointed to the project are required to spend at least four months at another national node, as well as at a collaborating institution outside the country, and the postdocs are encouraged to do the same. So far, PhDs have already moved across the three main nodes, and taken courses on Svalbard or done fieldwork in Finnmark, and some postdocs and researchers have also moved across nodes.

SUSTAIN is currently moving forward six PhD projects and more than ten investigations at the postdoc/researcher level, mentored by the three co-PIs. This reflects the formation of a new generation of skilled scientists in the field of sustainability. Throughout the project, and towards its end, SUSTAIN will provide sound scientific knowledge to assist decision makers in improving both the management and the monitoring of important harvested ecosystems. In this way, SUSTAIN will contribute greatly towards ecosystem sustainability.

Summarised by Luis Cadahia.

SUSTAIN is administered by CEES.

Website: sustain.uio.no

PlagPART

An international research and training network on the study of plague

PlagPART is a Norwegian-Russian-Chinese research and training network on the study of plague, funded by the Research Council of Norway. In the current geopolitical, demographic and economical situation, developing ties between European, Russian and Chinese institutions is of great importance for meeting security challenges on several levels. On a scientific level, rapid population growth both globally and in Asia, climate change, and economic instability, all mean that it is of paramount importance to understand zoonotic diseases (which make up the great bulk of emerging and re-emerging infectious diseases).

Against this backdrop, PlagPART is developing a highly visible international consortium (figure 1). This consortium will play a central role in the training of disease researchers on all levels in the study of the ecology and evolution of infectious diseases with an environmental reservoir, using plague as the focal model and study system. Through student and researcher mobility and workshops, PlagPART will organise joint courses and develop a common platform for research and training. The main aim of PlagPART is to extend the collaboration among disease researchers and scholars, mutually connected by their research on plague, training a new generation of interdisciplinary students within an international setting.

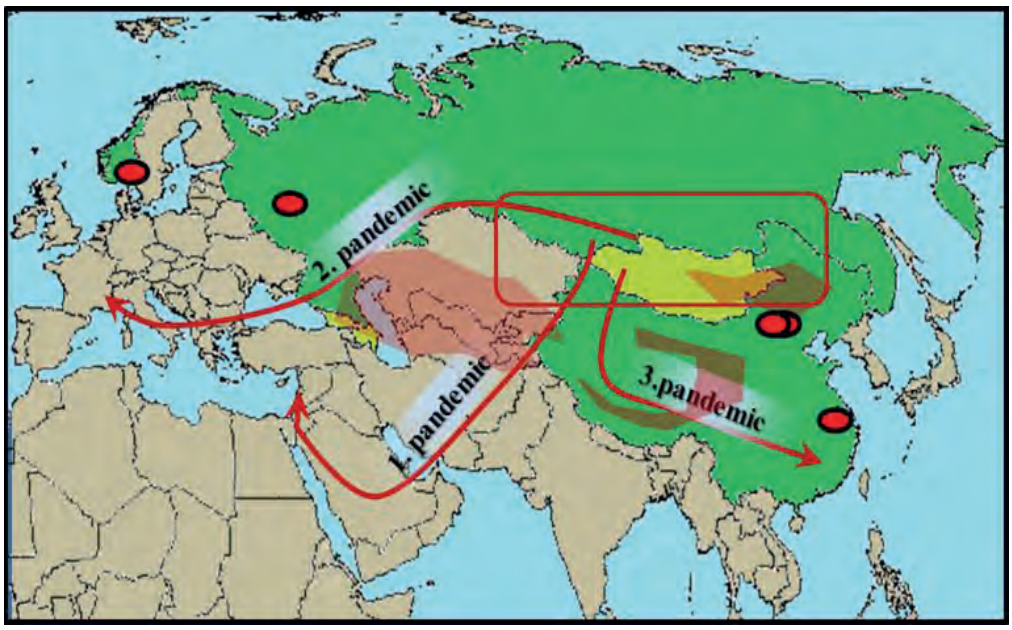
The PlagPART consortium consists of CEES (Principal Collaborating Institution) and leading research and education institutions in China and Russia. The main Chinese partners are Beijing Normal University, Tsinghua University and Zhejiang University, and the main Russian partner is Lomonosov Moscow State University. In addition, Chinese associated institutions include the Chinese Academy of Sciences, the Beijing Institute of Microbiology and Epidemiology, the Academy of Military Medical Science, and the Chinese Center for Disease Control and Prevention. Russian associated institutions include the Russian Academy of Sciences and the State Research Center for Applied Microbiology and Biotechnology. Third party institutions linked to the consortium include the National Center for Disease Control and Public Health of Georgia, the National University of Mongolia, and the Republican Anti-Plague Station of Azerbaijan.

The main outcomes of PlagPART will be 1) students trained in an interdisciplinary, international, world-leading environment and 2) the informal development of networks and skills through lectures, courses and supervision, by researchers at all involved institutions. Another key outcome will be the formalisation and expansion of course and curriculum development, to target and improve the subjects that benefit most from joint training. In addition, PlagPART will facilitate the continuation of research and education collaboration into the future, with the development of agreements on various joint activities regarding teaching, the training of research students, and research collaboration. Added value will result from new knowledge emerging from the comparative work within the PlagPART network, as well as from training candidates for employment at research institutions and in the public sector (such as public health institutions within the countries involved).

In addition to current research, both China and Russia draw on centuries of data from plague research and surveillance – data largely unparallelled by any other ecological system. Collaborating with these institutions places CEES and the University of Oslo at the centre of zoonotic disease research, and in the global forefront of plague research.

CEES
Centre for Ecological and Evolutionary Synthesis

UiO : University of Oslo



Summarised by Jo Skeie Hermansen.

PlagPART is administered by CEES.

Website: mn.uio.no/cees/english/research/projects/plagpart

Figure 1: The Norwegian-Russian-Chinese Plag-PART consortium, in relation to the spread of plague during the three great pandemics. The red dots on the map shows the location of the main partners.

4 EDUCATION AND RESEARCH TRAINING

CEES aspires to provide excellent education and training facilities for our students, to supply outstanding candidates for future positions. Our host department, as well as other units of the university, delivers the basic education to our Bachelor's and Master's/PhD programmes. In 2016, CEES permanent scientific staff contributed to the teaching of 13 Bachelor's courses and 11 Master's/PhD courses. Forty-four Master's students were supervised by CEES members, and 17 completed their degrees in 2016. We provide a stimulating research environment for our students by organising workshops, regular seminars and journal clubs, and by frequently inviting prominent scientists as speakers.

The Annual Student Conference

The CEES Annual Student Conference is a compulsory event that provides a good forum for students to hone their communication and presentation skills in a professional setting. This year the conference was held 22–23 November at Holmen Fjordhotell with 139 delegates. A total of 61 talks were given, including 27 by Master's students (or Master's students who had just completed their degree) and 28 by PhD students.

Journal clubs and discussion groups

CEES arranges several different journal clubs, e.g. the Colloquium Four Reading Group (27 sessions in 2016), the Speciation Journal Club (16 sessions), the Structured Population Modelling Journal Club (13 sessions), the Plague Journal Club (six sessions) and the Microbiome Group (six sessions).

Participating students select relevant papers that focus on scientific challenges within the field of ecology and evolution. The journal clubs encourage critical reading of scientific papers and provide an opportunity for students to keep updated in their field of study, as well as in related scientific fields, thereby also promoting synthesis within the centre.

Late Lunch Talks (LLT)

The Late Lunch Talk seminar series is a forum where employees, visiting scientists, and students at CEES present and discuss their work and ideas. The format is informal, with the objective being the facilitation of stimulating, topical discussions. A total of 14 sessions were held in 2016.

Delegates at the CEES Annual Student Conference, Holmen Fjordhotell. © CEES.

5 GENDER EQUALISING STRATEGY

Gender balance in high-ranking academic positions is a priority for both the Research Council of Norway (RCN) and the University of Oslo. CEES has implemented several guidelines to counter the attrition of women at all levels, from Master's students to tenured scientific staff, and all stages in between. Our strategy to attract and keep women scientists is based on optimising the conditions for our women students, and emphasising women role models. We acknowledge that in order to develop good scientific leaders for the future, one must give the young talented women (and men) an opportunity to develop, and receive the necessary training under the right conditions.

During the ten years that CEES has been running, we have had 153 researchers/postdocs as members of the centre, and 41% of these have been women. Of 86 PhD positions, 51% have been held by women. In addition, the Scientific Advisory Board is chaired by a woman, the Deputy Chair is a woman, and two of the three *Themes* are co-chaired by women scientists.

In collaboration with CEES, the Department of Biosciences submitted a proposal to the UiO gender balance funds ("UiO sentrale likestillingsmidler") in 2014. The proposal was granted close to half a million NOK, and was matched by the same amount from IBV, to perform several measures that were initiated in 2015. All women at the Department of Biosciences holding a PhD degree, but without a permanent position (this constitutes approximately 40 persons), were offered two hours of career prospects guidance with a hired professional consultant from Yellow Research, in collaboration with different resource persons from the department. Each woman had her CV reviewed, and each received specific guidance and a tailored plan of action as to how to improve her competitiveness and chances of pursuing a further career within academia.

Eight women (including Sanne Boessenkool, Anne Maria Eikeset, Barbara Bramanti and Melissah Rowe from CEES) with exceptionally good prospects were then prioritised for further measures. Some were granted a research stay abroad, others received some months of research assistance (e.g., for lab work and fieldwork), and one received funding to arrange a workshop to improve her international scientific network. All of them were offered help and funding in order to establish a mentoring agreement, and received funds for travel and accommodation in order to interact with their mentors. All women were offered guidance via a research leader course, and also offered skilled help to build their own professional personal webpages. There were also several smaller facilitations, for instance helping them to increase their teaching and supervising experience. Several expensive publications were also funded. As mentioned above, each woman received a tailored plan of action, well suited to her specific needs. We believe that this is the reason for the success that we have so far observed from this project. It is worth mentioning that in 2016 Sanne Boessenkool was offered a permanent position as a faculty member at IBV, and Barbara Bramanti started in a permanent position in Italy. The project is still ongoing.

6 SCIENTIFIC OUTREACH

An important goal of CEES is to communicate our research and findings, as well as to increase the appreciation and understanding of science. Our aim is to reach both Norwegian and international audiences.

Public events

A central part of our scientific outreach is the open seminars featuring high-profile researchers and communicators of science, held both on the university's campus and at public venues such as Oslo's House of Literature (Litteraturhuset). For the eleventh year in a row, the annual events of Darwin Day and the Kristine Bonnevie Lectures on Evolutionary Biology were held, the latter constituting a regular part of the university's annual anniversary day.

In 2016, the topic for **Darwin Day** (12 February) was: *Still evolving – Evolution today and in the recent past*. The event featured lectures by Richard Lenski (Michigan State University, USA), Ludovic Orlando (Centre for GeoGenetics, Natural History Museum of Denmark, University of Copenhagen, Denmark), Peter Zimmerman (Case Western Reserve University, Cleveland, Ohio, USA) and Marlene Zuk (University of Minnesota, USA). Marlene Zuk also gave a lecture the following day at the House of Literature on: *Paleofantasy – What evolution tells us about the way we eat and live*.

Marlene Zuk and Richard Lenski, two of the Darwin Day lecturers, holding the University of Oslo Science Library's 1st edition copy of Darwin's On the Origin of Species. © CEES.

The Kristine Bonnevie Lectures on Evolutionary Biology (2 September) consisted of talks by Corina E. Tarnita (Princeton University, USA) on: *The geometry of ecosystems in a changing world*, and Jan M. Nordbotten (University of Bergen, Norway) on: *The unknown unknowns: Communicating scientific uncertainty*.

The Fridtjof Nansen Lectures on Ocean Life was held for the first time on 20 June. The event was co-organised with the Nordic Centre of Excellence NorMER, in support of international research on the sustainable use of marine systems. The main lecture was held by marine biologist, explorer, and author Sylvia A. Earle on: *Exploring the deep frontier*.

CEES' plague research group represented the Department of Biosciences with an information stand and hands-on activities at the **Oslo Science Expo** (Forskningstorget in Oslo – part of National Science Week), 23–24 September. This was a great opportunity to connect with people of all ages.

Open scientific events

Our Friday seminars and Extra seminars are also open to the public, although they are more technical and aimed at researchers and students. In 2016, 19 such seminars were held.

Media

The members of CEES are accessible to the media, and are encouraged to contribute their comments on issues of public concern when their expertise is applicable. The press coverage of research conducted at CEES is conveyed through a broad array of both national and international media, including newspapers, magazines, radio, television, and web-based information channels. Several CEES members, though not mentioned here by name, contributed extensively towards communicating their research in 2016.

Social media

Scientists, academic organisations and research groups use social media to broadcast their work, and CEES is no exception. CEES has several active bloggers (www.mn.uio.no/cees/english/outreach), and is active on Facebook (www.facebook.com/CEESUiO) and Twitter (@CEESUiO).

7 EXPERIMENTAL FACILITIES

CEES manages labs dedicated to DNA/RNA isolation, separate PCR facilities, post-PCR, sequencing services, and ancient DNA.

The CEES DNA lab is a molecular research core facility and is fully equipped for DNA and RNA extraction from various types of bacteria, protists, algae, fungi, and animal and plant tissues (including blood, faeces, and ancient DNA). It contains all the basic instrumentation of a modern molecular biology laboratory, including equipment for gene cloning, genomic libraries, real-time PCR, DNA/RNA quantification, and chip-based analysis of DNA, RNA, and protein. The CEES DNA lab is open to users from the Department of Biosciences, and is at present actively used by CEES and the Microbial Evolution Research Group (MERG).

The revenue from the CEES DNA lab comes mainly from the bench fee, which in 2016 amounted to 26 400 NOK. In addition, CEES allocates an amount of 50 000 NOK annually to this lab. The CEES lab has seen stable activity throughout the year, with between 26 and 28 users per quarter. In the course of 2016, there were 58 paying users of the lab, performing a total of 53 months' work.

The ancient DNA (aDNA) laboratory

Ongoing methodological advancements have revolutionised our ability to obtain ancient DNA. These approaches are increasingly used in a variety of research fields, such as evolutionary biology, biomedicine, forensic sciences, archaeology and physical anthropology. Ancient DNA is typically degraded post mortem, resulting in limited amounts of DNA that consist of short fragments with specific biochemical modifications. The degraded nature and minute quantities of aDNA require that experiments are carried out in a dedicated and specially designed laboratory.

An ancient DNA laboratory was recently opened at IBV (May 2015), and established on the initiative of CEES. A driving force behind the lab's creation was the ERC-funded project on medieval *Yersinia pestis* outbreaks (the MedPlag project chaired by Barbara Bramanti). The laboratory was established through a tight and successful collaboration with IBV, the Museum of Cultural History (KHM), and the Natural History Museum (NHM), and has had strong support from the Faculty of Mathematics and Natural Sciences, the Medical Faculty, and the Estate Department. The competence and services of the Norwegian Sequencing Centre (NSC) at CEES provide an

Research Assistant Oliver Kersten in the milling room (used to mill bones) in the aDNA lab. © Agata Teresa Gondek.

ideal backdrop for the aDNA lab activities, adding international competitiveness to this interdisciplinary core facility. The laboratory is spacious, well-equipped, and capable of handling both human and non-human aDNA.

The laboratory board is headed by Sanne Boessenkool, and includes representatives from all partner institutes. In 2016, 11 scientists from UiO worked in the laboratory (postdocs, PhD students and laboratory technicians), financed by various projects, and there were two overseas visitors from Sweden and Italy who used the facility. On average, 1–2 people worked inside the laboratory every day. Projects using the laboratory were financed from a number of different sources, including the RCN, Horizon2020, the Nansen Foundation and the Icelandic Research Fund. The annual turnover of the aDNA lab was approximately 150 000 NOK in 2016. The daily management of the laboratory is delegated to CEES. To date, CEES has accomplished this management by partially funding a temporarily employed technician (10%) who works in the lab, together with help from Nanna Winger Steen, manager of the CEES labs.

Overall, the ancient DNA laboratory has provided UiO with infrastructure supporting aDNA research at the international forefront of science.

Summarised by Bastiaan Star and Sanne Boessenkool.

7 EXPERIMENTAL FACILITIES

NORWEGIAN SEQUENCING CENTRE

The Norwegian Sequencing Centre (NSC) has two nodes hosted by the Centre for Ecological and Evolutionary Synthesis (CEES) at the Department of Biosciences at the University of Oslo, and the Department of Medical Genetics (DMG) at Oslo University Hospital and the University of Oslo. NSC has been on the National Roadmap for research infrastructures and large national projects since 2014, and thus is a nationally prioritised infrastructure in Norway.

Offered sequencing applications: NSC offers the Norwegian research community access to a broad range of high-throughput sequencing technologies (HTS) and applications. We possess state-of-the-art facilities and provide services covering most applications within the deep sequencing field, e.g., de novo genome sequencing, exome sequencing, sequencing of ancient DNA and other degraded DNA samples, as well as transcriptome-, miRNA-, amplicon-, bisulphite- and chromatin immunoprecipitation (ChIP)-sequencing, and base modification detection for smaller genomes.

Platform updates: In 2015, a large increase in national sequencing capacity was made possible by funding from the Research Council of Norway's National Financing Initiative for Research Infrastructure (INFRASTRUKTUR) as NSC entered into partnership with HTS facilities at Radium Hospitalet (Oslo), Haukeland Universitetssjukehus (Bergen), and the Norwegian University of Science and Technology (Trondheim). In 2016, the University of Tromsø also joined. This network of collaboration is known as the Norwegian Consortium for Sequencing and Personalized Medicine (NorSeq), and NSC is the major partner (hub). As part of this agreement, several additional sequencing instruments have been installed at the CEES node in 2016. Taking these into account, NSC now has the following instruments available: 4 x HiSeq X, 2 x HiSeq 3000/4000, 2 x Illumina HiSeq 2500, 2 x Illumina NextSeq500, 3 x Illumina MiSeq, and 1 x Pacific Biosciences RSII. Finally, we have purchased a PacBio Sequel instrument (in production from 2017). According to the specifications, the PacBio Sequel offers seven times the output per run, relative to the RSII for the same types of reads. However, the Sequel does not yet deliver such amounts, and there have been some initial challenges with this new technology. Altogether, NSC has by far the largest instrument park for HTS in Norway. In addition, NSC has a considerable infrastructure of supporting hardware to increase throughput and automation (Perkin Elmer Sciclone NGSx, Hamilton robot, Beckmann Biomek FX robot, two Pippin Prep instruments, Covaris DNA sonicators, etc.).

IT updates and data delivery: We have produced approximately 40 TB of data in 2016, of which nearly half are sensitive in nature. With the purchase of seven new sequencers, we expect the data production to increase drastically in 2017. To cope with this, we have purchased and installed a new primary storage solution. The current 36 TB (18 TB effective) Dell EMC X210 has been upgraded to 576 TB (322 TB effective) by the purchase of four nodes of Dell EMC X410. Thus, the movement of data within NSC will be optimised in early 2017. Integration of sequencing procedures and machines with the Genologics Clarity Laboratory Information Management System (LIMS) system is still ongoing. With the purchase of HiSeq X sequencers and SeqLab solution, the Clarity LIMS X version has been installed in parallel with our existing LIMS gold edition. All the allied instruments that are part of SeqLab have been successfully installed and connected to our NSC network and respective LIMS systems. For storage and delivery of sensitive data, NSC uses the "Tjeneste for Sensitive Data" (TSD) solution developed and offered by the University Center for Information Technology (USIT) at UiO. For non-sensitive data, we have started collaboration with ELIXIR Norway to offer users the possibility of accessing their data through the Norwegian e-Infrastructure for Life Sciences (NeLS). NeLS can be directly used for further analysis of the data, if desired.

Offered services: Services include project consultation, sample preparation, and running the sequencing reactions on the DNA sequencers, together with quality assessment of the data. For projects sequenced on Illumina instruments, mapping of the data to a reference

is performed. For bacterial PacBio projects, we continue to deliver fully assembled genomes to our users. In addition to de novo genomes, base modification analyses can be provided for bacterial and fungal genomes sequenced on Sequel or PacBio RS II. NSC may also offer advice on analysis software tools. For more advanced projects, users are referred to bioinformatics services/help desks (such as ELIXIR), or to research collaborations when appropriate. The submission of projects is handled through our website (www.sequencing.uio.no) where there is a single contact point for both nodes (CEES and DMG), to help ensure that the optimal technology is applied for each project.

Sequencing activity: In 2016, approximately 13 800 different samples in total were sequenced at NSC – a 46% increase relative to 2015. These samples represent 307 projects – mostly from Norway, but also from several other European countries. The largest fraction of the samples was run on the Illumina platform (HiSeq/MiSeq). However, the number of samples sequenced on PacBio RSII/Sequel is still steadily growing.

Large projects: To date, the largest project that NSC has been performing sequencing for is the Aqua Genome (AG) project – led by CEES. In the AG project, more than 1 000 individuals of Atlantic cod (*Gadus morhua*) have been sequenced with Illumina technology. The AG project started in 2014 and sequencing was finished in 2016. Large projects will be increasingly important for NSC in the future, and there are several such projects in the pipeline – both within biomedical and biological research.

Outreach: NSC staff, together with the Oslo node of the ELIXIR Norway Bioinformatics Platform, participated again in the yearly MSc/PhD course "High-throughput sequencing technologies and bioinformatics analysis" (INF-BIO5121/9121). NSC staff also participated in the MSc/PhD bioinformatics course "High-throughput DNA sequencing and variant calling in exome sequencing" (MBV INFx410).

Summarised by Lex Nederbragt, Ave Tooming-Klunderud and Kjetill S. Jakobsen.

Viking Age horse burials in Iceland have been sampled as part of the projects Tracking Viking-assisted dispersal of biodiversity using ancient DNA *and* The horses and sheep of the Vikings: Archaeogenomics of domesticates in the North Atlantic. *The Icelandic horse is famous for its five gaits and great variety of coat colours. © Albína Hulda Pálsdóttir.*

8 COMPUTATIONAL AND BIOINFORMATIC RESOURCES

In 2016, the bioinformatics activities at CEES encompassed a still growing field. More CEES researchers than ever are now generating large 'digital' datasets that need to be analysed using sophisticated bioinformatics tools.

Infrastructure

At CEES, we use a combination of self-owned servers, and CPU hours we have applied for on the UiO supercomputer 'Abel'. This maximises flexibility for CEES researchers in choosing the right resource for their projects. Memory-intensive applications can be run on our own servers, while CPU-intensive applications can be submitted to Abel and therefore do not take up valuable time on the servers. The servers CEES owns (see below) are attached to the Abel system. This means users can seamlessly access the same programmes and disks on the self-owned servers, as well as on Abel. For storage ('project disk space') beyond what is available on our own servers, we rent space from the University Center for Information Technology (USIT) (attached to Abel) at UiO, rather than buy and administer our own.

Hardware

Starting with the project to sequence and assemble the genome of Atlantic cod in 2009, CEES has invested in its own hardware for computation. These servers are hosted and maintained by the High Performance Computing (HPC) group of USIT. In 2015, we completely renewed the self-owned servers, using combined funds from the Norwegian Sequencing Centre and the Aqua Genome project, as well as a generous contribution from the Faculty of Mathematics and Natural Sciences. As a result of this overhaul, the following computational infrastructure is available to CEES researchers: (i) three high-memory servers with 32 CPUs and 1.5 Terabyte of RAM, and 64 TB local disk space each; (ii) a more modest server to be developed into a genome browser (see below); and (iii) 256 regular CPUs, providing us with the equivalent of 2.2 million CPU hours per year.

On the university computer cluster Abel, we have allocations on the national HPC infrastructure through Notur (notur.no), for CPU-intensive computations. We estimate that we used roughly 9.9 million CPU hours in 2016. CEES bioinformaticians use 280 TB of common, shared, disk space, with another 100 TB disk space for long-term archival of data at Norstore (norstore.no), the national Norwegian infrastructure for the archiving of digital scientific data.

Organisation

The bioinformaticians are organised through a mailing list and occasionally meet to discuss common interests or papers. Two journal clubs, the Genome Analysis Club (TGAC) and the Microbiome Group, discuss papers and programmes focussing on analytical methods for genomic data. There is a wiki containing a growing number of articles dealing with the practicalities of using the resources at CEES, tips and tricks, etc. (https://github.com/uio-cees/hpc/wiki). Although the day-to-day administration of the servers and disk space is the responsibility of USIT, there is still a considerable amount of overhead for CEES staff. Aspects of this include applying for, and reporting on the use of, CPU hours on Abel; correspondence with USIT on required software and interruptions of the servers; feedback to CEES users; administration of the user base, mailing lists, and wiki; and instructing new users.

Projects

Examples of projects requiring large computational resources and large amounts of disk space are: (i) projects to generate *de novo* genome assemblies of both small (bacterial) and large (eukaryote) genomes; (ii) resequencing projects (SNP finding and genotyping) that require many CPU hours for mapping sequencing data to a reference; (iii) metagenomics and environmental sequencing projects; (iv) transcriptome assembly: mapping transcripts to a reference genome/transcriptome, and differential expression analysis using RNA-seq data; (v) genome annotation pipelines; (vi) sequencing of mitochondrial genomes; and (vii) ecological modelling.

Genome Browser

In collaboration with the Norwegian ELIXIR environment at the Norwegian University of Life Sciences (NMBU), CEES established the Genome Browser in 2016, which can be used for genomes resulting from research performed at CEES. A genome browser is a graphical interface for viewing and accessing genomic data for a species. The first genome presented through this browser was the updated Atlantic cod (*Gadus morhua*) genome, gadMor2. A sparrow genome browser is under development.

Links to these genome browsers can be found at:

www.mn.uio.no/cees/english/genome-browser/

Outlook

In 2017, we will finalise the new wiki website and shut down the old one, and release the second (and perhaps third) genome(s) through the Genome Browser.

Summarised by Lex Nederbragt.

The old farmhouse museum in Hoyvík in the Faroe Islands is part of Faroe Islands National Heritage. For the project The horses and sheep of the Vikings: Archaeogenomics of domesticates in the North Atlantic, *Albína Hulda Pálsdóttir, PhD student at CEES, visited the Faroe Islands to collect samples of sheep bones from archaeological excavations. © Albína Hulda Pálsdóttir.*

9 FINANCES

Accounting principles

CEES funding is derived primarily from RCN sources (approximately 10 MNOK in core funding per year), supplemented by funds from UiO (2 MNOK per year plus funding for several positions), and other sources defined as own funding. Our own funding can be divided into the sub-categories: funding from RCN projects; funding from other public sector-based projects; funding from private sector-based projects; and funding from international projects. Expenditures are sub-categorised into salary expenses, indirect costs, R&D services, equipment, running costs (composed mainly of operational expenses for laboratory and fieldwork), and travel and representation. In addition to revenues and expenditures that are accounted for, we also have those that are not accounted for. These are mainly defined as the expenditures of those personnel that work within CEES, but receive their salaries from other parties. The value of these services is calculated using official UiO budgeting procedures. In this report we present the accounting figures for 2016, and the budget for 2017.

Principal Engineer Anders Herland and Master's student Christian Hügli searching for ticks on a roe deer pelt. Roe deer serve as hosts for all three life stages of ticks: larvae, nymphs and adults. © Atle Mysterud.

Revenues and expenditures 2016/Budgeted revenues and expenditures 2017

Total funding			Accounted revenues		Revenues not in account
	2016	Bud 2017	Figures 2016	Bud figures 2017	Revenues not in account 2016[1]
RCN-CoE	9 200	8 849	9 200	8 849	
UiO	39 771	13 510	7 589	13 510	32 182
RCN – CEES related projects	56 771	75 171	56 771	75 171	
Other public sector-based projects	3 155	4 451	3 155	4 451	
International funding	27 773	13 036	11 810	13 036	15 963
Private sector-based projects	225	111	225	111	
Transferred revenues	33 664	24 432	33 664	24 432	
Total funding	***170 559***	***139 560***	***122 414***	***139 560***	***48 145***

Accounted expenses 2016 (Acc 16)/Budgeted expenses 2017 (Bud 17)

	Total		RCN-CoE		UiO		RCN projects		Other public sector-based projects		International funding		Private sector-based projects	
	Acc 16	Bud 17	Acc 16	Bud 17	Acc 16	Bud 17	Acc 16	Bud 17	Acc 16	Bud 17	Acc 16	Bud 17	Acc 16	Bud 17
Salary expenses	43 471	52 869	6 697	7 421	4 231	8 672	22 730	23 432	1 697	2 370	8 114	10 974	2	
Indirect costs	13 871	17 482	938	1 066	1 260	2 534	9 328	9 900	6921	1 360	1 653	2 620		
R&D services	17 547	26 494					14 002	23 494			3 545	3000		
Equipment	7 896	3 416					7 828	3 416			68			
Running costs	14 353	25 470	696	2 489	1 977	2 061	7 594	15 089	312	774	3 665	4 830	109	227
Travel and representation[2]	843		455		388									
Total	***97 981***	***125 731***	***8 786***	***10 976***	***7 856***	***13 267***	***61 482***	***75 331***	***2 701***	***4 506***	***17 045***	***21 424***	***111***	***227***

Expenses not in account 2016 (Nacc 17)

	Nacc 16	Bud 17	Nacc 16	Bud 17	Nacc 16	Bud 17	Nacc 16	Bud 17	Nacc 16	Bud 17	Nacc 16	Bud 17	Nacc 16	Bud 17
Salary expenses	33 285				21 914						11 371			
Indirect costs	14 861				10 269						4 592			
Total[3]	***48 146***				***32 183***						***15 963***			

Balance 2016/Budgeted balance 2017

	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Revenues	136 895	115 128	9 200	8 849	39 771	13 510	56 771	75 171	3 155	4 451	27 773	13 036	225	111
Transf. revenues	33 664	24 432	1 723	2 137	1 668	1 400	8 504	3 793	106	560	21 663	16 428		114
Total expenses	146 127	125 731	8 786	10 976	40 039	13 267	61 482	75 331	2 701	4 506	33 008	21 424	111	227
Balance	***24 432***	***13 829***	***2 137***	***10***	***1400***	***1 643***	***3 793***	***3 633***	***560***	***505***	***16 428***	***8 040***	***114***	***-2***

All figures are given in 1000 NOK.
1) Not posted revenues for 2016. These are mainly defined as the efforts of those personnel that work within CEES, but receive their salaries from other parties.
2) Travel and representation is included in running costs for all funding sources except RCN-CoE and UiO.
3) Not posted expenditures for 2016.

Part of a walrus pelvis from the Alþingisreitur excavation in Iceland. The bone dates to between 1226 and 1500 AD, and was sampled for aDNA for the project Investigating artifacts using ancient DNA to trace historic trade and exploitation of Atlantic walrus. *© Albína Hulda Pálsdóttir.*

10 APPENDICES

CEES-members

Core scientific staff

Name	Nationality	Position	Period	Funding 2016	CEES share (%)
Brysting, Anne K.	Denmark	Professor	Oct. 2007–	UiO-IBV	75
Durant, Joël	France	Researcher	Oct. 2007–	RCN/NORDFORSK	100
Ergon, Torbjørn	Norway	Assoc. Professor	Jan. 2013–	UiO-IBV	50
Hansen, Thomas F.	Norway	Professor	Oct. 2007–	UiO-IBV	75
Hestmark, Geir	Norway	Professor	Jan. 2014–	UiO-IBV	75
Hjort, Nils L.	Norway	Professor	Oct. 2007–	UiO-Math	25
Jakobsen, Kjetill S.	Norway	Professor	Oct. 2007–	UiO-IBV	75
Lampe, Helene M.	Norway	Professor	Oct. 2007–	UiO-IBV	75
Mysterud, Atle	Norway	Professor	Oct. 2007–	UiO-IBV	75
Ottersen, Geir	Norway	Senior Scientist	Oct. 2007–	IMR/RCN-CoE	25
Slagsvold, Tore	Norway	Professor	Oct. 2007–	UiO-IBV	75
Stenseth, Nils Chr.	Norway	Professor & CEES Chair	Oct. 2007–	RCN-CoE	100
Stige, Leif Christian	Norway	Researcher	Oct. 2007–	RCN	100
Storvik, Geir	Norway	Professor	Oct. 2007–	UiO-Math	20
Sætre, Glenn-Peter	Norway	Professor	Oct. 2007–	UiO-IBV	75
Viljugrein, Hildegunn	Norway	Assoc. Professor	Oct. 2007–	RCN-CoE	20
Vøllestad, Leif Asbjørn	Norway	Professor	Oct. 2007–	UiO-IBV	75

10 APPENDICES

Postdocs and Researchers

Name	Nationality	Position	Period	Funding 2016	CEES share (%)
Atickem, Anagaw	Ethiopia	Researcher	Apr. 2013–Sep. 2017	RCN-CoE	80
Barth, Julia Maria Isis	Germany	Postdoc	Jan. 2014–Jan. 2017	UiO-IBV	100
Boessenkool, Sanne	The Netherlands	Researcher	Dec. 2012–Feb. 2018	RCN	100
Cadahia, Lorenzo Luis	Spain	Researcher	Sep. 2014–Dec. 2018	RCN	100
de Muinck, Eric	USA	Postdoc	Jun. 2014–Aug. 2017	UiO-IBV	100
Debeffe, Lucie Isabelle	France	Postdoc	Oct. 2016–Sep. 2018	UiO-IBV	25
Diaz, Pauli Beatriz	Spain	Postdoc	Nov. 2011–Oct. 2019	RCN-NMBU	17
Diekert, Florian	Germany	Postdoc	Sep. 2016–Sep. 2017 Oct. 2011–Apr. 2016	RCN/NORDFORSK	38 33
Dupont, Nicolas	France	Researcher	Sep. 2016–Aug. 2017	RCN	33
Easterday, William R.	USA	Researcher Postdoc	Jan. 2012–Dec. 2016 Jan. 2012–May 2016	RCN-CoE/RCN	58 42
Eikeset, Anne Maria	Norway	Researcher	Oct. 2007–Dec. 2017	NORDFORSK	100
Eroukhmanoff, Fabrice	France	Researcher	Jan. 2013–Dec. 2017	UiO-IBV	100
Haverkamp, Thomas H. A.	The Netherlands	Postdoc	Jun. 2012–Mar. 2016	VISTA/RCN	25
Hänsch, Stephanie	Germany	Researcher	Jun. 2013–May 2018	ERC	58
Hermansen, Jo Skeie	Norway	Researcher Postdoc	Nov. 2009–Jun. 2018	RCN/CoE, RCN	100
Hernandez-Aguilar, R. Adriana	Mexico	Researcher	Jun. 2015–May 2017	RCN-CoE	10
Holen, Øistein H.	Norway	Researcher	Oct. 2007–Oct. 2019	RCN	100
Holt, Rebecca Emma	UK	Postdoc	Oct. 2016–Oct. 2018	RCN-IMR	17
Hutchings, Jeffrey	Canada	Researcher	Sep. 2010–Sep. 2017	RCN-CoE	20
Jin, Xingkun	China	Postdoc	Jan. 2015–Mar. 2017	RCN	100
Jorde, Per Erik	Norway	Researcher	Oct. 2007–Dec. 2016	RCN-CoE/ INTERREG	100
Kausrud, Kyrre	Norway	Postdoc	Apr. 2013–May 2017	RCN	50
Kininmonth, Stuart James	Australia	Postdoc	Nov. 2016–Oct. 2019	ERC	17
Kjesbu, Olav S.	Norway	Professor	Sep. 2012–Sep. 2016	NORDFORSK	20
Knutsen, Halvor	Norway	Researcher	Oct. 2007–Jun. 2018	RCN/INTERREG	10
Krzeminska, Malgorzata	Poland	Researcher	Oct. 2016–Feb.2017	RCN	21
Kvile, Kristina Ø.	Norway	Researcher	Nov. 2015–Dec. 2016	RCN	96
Langangen, Øystein	Norway	Researcher	Sep. 2016–Aug. 2018	RCN	33

Llope, Marcos	Spain	Researcher	Jul. 2016–Nov. 2016	GreenMAR	42
Malmstrøm, Martin	Norway	Postdoc	Sep. 2014–Feb. 2017	RCN	100
Martin, Jodie	France	Senior Lecturer	Sep. 2015–Jan. 2016	CAS	4
Martinsen, Lene	Norway	Researcher	Dec. 2016–Dec. 2016	RCN-CoE	3
Matschiner, Michael	Germany	Researcher Postdoc	Sep. 2016–Mar. 2017 Sep. 2013–Sep. 2016	ERC RCN	25 75
Namouchi, Amine	Tunisia	Researcher	Oct.2016–Oct. 2017	ERC	21
Nielsen, Anders	Norway	Researcher	Oct. 2013–Mar. 2017	RCN	100
Nilsson, Anna	Sweden	Researcher	Sep. 2013–Dec. 2017	RCN	92
Nistelberger, Heidi Maria	Australia	Postdoc	Mar. 2015–Mar. 2018	RCN	83
Ohlberger, Jan P.	Germany	Researcher	Jul. 2015–Dec. 2016	RCN	15
Ottoni, Claudio	Italy	Postdoc	Aug. 2016–Apr. 2019	UiO-IBV	38
Peters, Wibke E. B.	Germany	Postdoc	Oct. 2015–Sep. 2016	CAS	75
Ravinet, Mark S. P.	UK	Researcher	Nov. 2015–Nov. 2018	UiO-IBV/RCN	100
Reitan, Trond	Norway	Researcher	Oct. 2013–Aug. 2018	RCN	40
Richter, Andries P.	Germany	Researcher Postdoc	Jun. 2016–Sep. 2017 Mar. 2010–Jun. 2016	RCN	29 9
Rivrud, Inger Maren	Norway	Postdoc	Sep. 2008–Apr. 2019	RCN, CAS	58
Rueness, Eli K.	Norway	Researcher	Oct. 2007–Sep. 2017	RCN-CoE	80
Schmid, Boris	The Netherlands	Researcher	Apr. 2012–Oct. 2016	RCN-CoE/ERC	100
Seierstad, Kristian S.	Norway	Researcher	Sep. 2015–May 2017	RCN	100
Solbakken, Monica	Norway	Researcher	Apr. 2016–Jul. 2017	RCN	71
Sperfeld, Erik	Germany	Researcher	Jun. 2016–Aug. 2019	RCN	50
Star, Bastiaan	The Netherlands	Researcher	Sep. 2008–Aug. 2017	RCN	100
Starrfelt, Jostein	Norway	Postdoc	Oct. 2014–Sep. 2017	RCN	58
Trosvik, Pål	Norway	Researcher	Apr. 2012–May 2017	RCN	100
Vik, Unni	Norway	Researcher	May 2010–Nov. 2016	RCN	18
Vindenes, Yngvild	Norway	Researcher	Apr. 2011–Dec. 2018	RCN	100
Voje, Kjetil L.	Norway	Researcher Postdoc	Aug. 2008–Jan. 2017 Aug. 2007–Jan. 2017	RCN	19 56
Whittington, Jason	USA	Researcher	Sep. 2015–Aug. 2017	NORDFORSK	100
Wortel, Meike Tessa	The Netherlands	Researcher	Aug. 2015–Feb. 2018	RCN	75
Xu, Lei	China	Researcher	Mar. 2016–May 2017	RCN-CoE	79

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PhD students

Name	Nationality	Position	Period	Funding 2016	CEES share (%)
Baalsrud, Helle T.	Norway	Research Fellow	Sep. 2012–Jul. 2017	UiO-IBV	75
Broch, Catharina	Norway	Research Fellow	Feb. 2016–Jan. 2019	RCN	92
Cloete, Claudine C.	Namibia	Research Fellow	Sep. 2013–Aug. 2016	RCN	100
Cuevas, Angelica Maria Pulido	Colombia	Research Fellow	Feb. 2015–Feb. 2019	UiO-IBV	100
Dean, Katharine Rose	USA	Research Fellow	May 2016–Apr. 2019	RCN-CoE/ERC	67
Delkaso, Dereje Tesfaye	Ethiopia	Research Fellow	Aug. 2014–Jul. 2017	Quota scheme	100
Derišˇ, Leana	Croatia	Research Fellow	Sep. 2015–Sep. 2018	UiO-IBV	100
Elgvin, Tore Oldeide	Norway	Research Fellow	Jul. 2011–Mar. 2016	RCN	25
Färber, Leonie Anette	Germany	Research Fellow	Feb. 2016–Jan. 2019	MSCA-ITN	92
Geberemedhin, Berihun	Ethiopia	Research Fellow	Jan. 2009–-Des. 2016	Quota scheme	100
Graffi, Giulia	Italy	Research Fellow	Sep. 2015–Feb. 2016	ERC	13
Guellil, Meriam	UK	Research Fellow	May 2015–Apr. 2018	ERC	100
Guldvog, Caroline Øien	Norway	Research Fellow	Aug. 2015–Aug. 2019	RCN	100
Gutema, Tariku Mekonnen	Ethiopia	Research Fellow	Jan. 2014–Dec. 2017	Quota scheme	100
Helmerson, Cecilia	Sweden	Research Fellow	Mar. 2016–Feb. 2019	MSCA-ITN	83
Isaksen, Elisabeth Thuestad	Norway	Research Fellow	May 2013–Apr. 2017	RCN	100
Kassie, Addisu Mekonnen	Ethiopia	Research Fellow	Aug. 2011–Dec. 2017	Quota scheme	100
Kibaja, Mohamed Julius	Tanzania	Research Fellow	Aug. 2014–Jul. 2017	Quota scheme	100
Krauer, Fabienne	Switzerland	Research Fellow	Sep. 2016–Aug. 2019	UiO-IBV	33
Liljegren, Mikkel	Norway	Research Fellow	Oct. 2012–Sep. 2016	UiO-IBV	75
Nater, Chloé Rebecca	Switzerland	Research Fellow	Sep. 2015–Feb. 2019	UiO-IBV	100
Ndmuligo, Sood Athumani	Tanzania	Research Fellow	Aug. 2012–Jun. 2015	Quota scheme	100
Nilsson, Pernille	Norway	Research Fellow	Aug. 2013–Jun. 2018	UiO-IBV	100
Reinar, William Brynildsen	Norway	Research Fellow	Aug. 2016–Aug. 2020	UiO-IBV	38
Riiser, Even Sannes	Norway	Research Fellow	Oct. 2014–Sep. 2017	UiO-IBV	100
Romagnoni, Giovanni	Italy	Research Fellow	Sep. 2011–Sep. 2016	NORDFORSK	54
Solbakken, Monica H.	Norway	Research Fellow	Jun. 2010–Apr. 2016	RCN-CoE	29
Stubberud, Marlene Wæge	Norway	Research Fellow	Jan. 2016–Jan. 2019	RCN	100
Sætre, Camilla Lo Cascio	Norway	Research Fellow	Aug. 2016–Aug. 2020	UiO-IBV	33
Toljagić, Olja	Serbia	Research Fellow	Sep. 2013–Aug. 2017	UiO-IBV	100
Trier, Cassandra N.	USA	Research Fellow	Sep. 2012–Jun. 2017	UiO-IBV	100
Tørresen, Ole Kristian	Norway	Research Fellow	Sep. 2011–Jul. 2016	UiO-IBV	100
Varadharajan, Srinidhi	India	Research Fellow	Sep. 2014–Sep. 2018	UiO-IBV	100
Winter, Anna-Marie	Germany	Research Fellow	Sep. 2014–Sep. 2017	NORDFORSK	100
Worku, Ejigu Alemayehu	Ethiopia	Research Fellow	Aug. 2014–Jul. 2017	Quota scheme	100

Research Assistants

Name	Nationality	Position	Period	Funding 2016	CEES share (%)
Bahlk, Sunniva Helene	Norway	Research Assistant	Feb. 2016–Jul. 2016	CEES	21
Botvar, Ole Henrik	Norway	Research Assistant	Mar. 2016–Dec. 2016	CEES/RCN-IMR	10
Byrkjeland, Ragna	Norway	Research Assistant	Jan. 2016	CEES	0.2
Enevoldsen, Emily Louise Gilbert	Norway	Research Assistant	Aug. 2016–Apr. 2017	CEES/RCN	10
Gondek, Agata Teresa	Poland	Research Assistant	Jan. 2016–Apr. 2017	CEES/Iceland Research Fund	100
Hagelin, Jon Valbjørn	Norway	Research Assistant	Apr. 2016–Sep. 2016	CEES	21
Heiberg, Hallvard	Norway	Research Assistant	Apr. 2016	CEES	2
Hoff, Siv Nam Khang	Norway	Research Assistant	Oct. 2016–Jan. 2017	CEES/RCN-CoE	21
Kersten, Oliver	Germany	Research Assistant	Jun. 2016–May 2017	CEES/ERC	58
Mjønes, Caroline Skar	Norway	Research Assistant	Jul. 2016–Oct. 2016	CEES/RCN	13
Noordzij, Hanna Theodora		Research Assistant	Jul. 2016–Oct. 2016	CEES/RCN	13
Paus-Knutsen, Julie Sørlie	Norway	Research Assistant	Sep. 2016	CEES	2
Skau, Lars Fredrik	Norway	Research Assistant	Jun. 2015–Mar. 2016	CEES/RCN-IMR	29
Stigum, Vetle Malmer	Norway	Research Assistant	May–Sep. 2015	CEES/RCN	25
Valseth, Karoline	Norway	Research Assistant	Jan. 2016–Jul. 2016	CEES/RCN-CoE	50
Walle, Eirik	Norway	Research Assistant	Nov. 2016	CEES/RCN-IMR	7

Administrative and technical support staff

Name	Nationality	Position	Period	Funding 2016	CEES share (%)
Bjørnæs, Ane Mari	Norway	Senior Executive Officer	Aug. 2015–Sep. 2017	RCN-CoE	67
Cunningham, Sari C.	USA/Belgium	Senior Adviser	Mar. 2016–Apr. 2016	RCN-CoE	5
Gundersen, Gry	Norway	Senior Adviser	Oct. 2007–	UiO-IBV	100
Henriksen, Jostein Strand	Norway	Executive Officer	Feb. 2016	RCN	3
Herland, Anders	Norway	Staff Engineer	Jan. 2008–	UiO-IBV	100
Jentoft, Sissel	Norway	Senior Adviser & Deputy Chair	Jun. 2009–Sep. 2017	RCN-CoE	100
Kollias, Spyridon	Greece	Head Engineer	Dec. 2014–Dec. 2017	RCN	83
Mazzarella, Anna V. B.	USA	Higher Executive Officer	Oct. 2014–Jun. 2018	RCN/NORDFORSK	100
Nederbragt, Alexander	The Netherlands	Senior Engineer	Oct. 2007–	UiO-IBV	80
Nerli, Emelita R.	Norway	Senior Engineer	Oct. 2007–	UiO-IBV	50
Nicolas, Delphine C.	France	Senior Executive Officer	Mar. 2014–Nov. 2017	RCN-CoE/UiO-IBV	58
Rydbeck, Kjell Erik Halfdan	Sweden	Senior Engineer	Apr. 2008–Nov. 2017	RCN	100
Rygg, Kari B.	Norway	Senior Adviser	May 2008–	UiO-IBV	100
Skage, Morten	Norway	Senior Engineer	May 2008–	UiO-IBV	100
Skau, Lars Fredrik	Norway	Executive Officer	Jan. 2016–Apr. 2016	RCN-CoE	5
Steen, Nanna W.	Norway	Staff Engineer	Oct. 2007–	UiO-IBV	100
Tokstad, Jenny H.	UK	Senior Executive Officer	Feb. 2016–Sep. 2017	RCN-CoE/MSCA-ITN	79
Tooming-Klunderud, Ave	Norway	Senior Engineer	Feb. 2011–	UiO-IBV	100
Wallem, Tore	Norway	Adviser	Dec. 2007–	RCN-CoE	100

Guests of CEES

Long-term research visits (more than one month)

Name	Nationality	Home institution	Period
Argany, Sergio Magallanes	Spain	University of Extremadura, Spain	Sep.–Oct. 2016
Bailey, Richard Ian	UK	University of Oslo, Norway	Jan.–May 2016
Bramanti, Barbara	Italy	University of Ferrara, Italy	Oct. 2015–Dec. 2016
Carneiro, Diana	Portugal	Natural History Museum, University of Oslo, Norway	Jan. 2015–Jan. 2019
Durrant, Brad	Australia		Feb.–Mar. 2016 Jul.–Aug. 2016
Fashing, Peter	USA	California State University, Fullerton, USA	Aug. 2015–Aug. 2016
Fortelius, Mikael	Finland	University of Helsinki, Finland	Jan.–Dec. 2016
Ghorbani, Atefeh	Iran	Memorial University, Canada	Aug.–Nov. 2016
Helberg, Morten	Norway	University of Oslo, Norway	Jan.–Dec. 2016
Holt, Rebecca	Norway	University of Bergen, Norway	Jun. 2016–Jul. 2017
Hunter-Thomson, Kristin Irene	USA	Rutgers University, USA	Aug.–Oct. 2016
Labra Lillo, Antonieta	Chile	Universidad de Chile, Chile	Jan. 2015–Dec. 2016
Langangen, Øystein	Norway	VISTA project	Jan. 2015–Aug. 2016
Motes-Rodrigo, Alba	Spain	University of Lindköping, Sweden	Oct.–Dec. 2016
Nguyen, Nga	USA	California State University, Fullerton, USA	Aug. 2015–Aug. 2016
Omelchenko, Dmytro	Czech Republic	Charles University, Czech Republic	Feb.–Jul. 2016
Oomen, Rebekah	Canada	Dalhousie University, Halifax, Canada, and Institute of Marine Research, Flødevigen, Norway	Feb.–Dec. 2016
Ottesen, Vibeke	Norway		Jan.–Dec. 2016
Pinsky, Malin	USA	Rutgers University, USA	Aug.–Oct. 2016
Rinaldo, Natascia	Italy	University of Ferrara, Italy	Jul.–Aug. 2016
Rowe, Melissah	Australia	Natural History Museum, University of Oslo, Norway	Jan. 2015–Dec. 2016
Runemark, Anna	Sweden	University of Lund, Sweden	Jan. 2015–Dec. 2016
Schaffer, Benjamin	USA	Princeton University, USA	Aug.–Oct. 2016
Tsuboi, Masahito	Japan	The Graduate University for Advanced Studies, Japan	Feb. 2016–Mar. 2019

Short-term guests (more than one week, less than one month)

Name	Nationality	Home institution	Period
Bardarson, Hlynur	Iceland	Marine Academic Research in Iceland, Iceland	Jun. 2016
Butler, Will	UK		Jun. 2016
Byrne, Conor	UK	University of Iceland, Iceland	Apr. 2016
Coissac, Eric Ludovic Marie	France	University Grenoble Alpes, France	Dec. 2016
Colwell, Jack	USA		Sep. 2016
Colwell, Rita	USA	University of Maryland, USA	Sep. 2016
Corina, Tarnita	USA	Princeton University, USA	Aug.–Sep. 2016
Davidsdottir, Brynhildur	Iceland	University of Iceland, Iceland	Jun. 2016
Earle, Sylvia Alice	USA		Jun. 2016
Edwige, Louise Odette Bellier	Canada	The Arctic University of Norway, Norway	Jun. 2016 Nov. 2016
Ferreira, Sofia	Portugal	Technical University of Denmark, Denmark	Jun. 2016
Hansen, Brage Bremset	Norway	Norwegian University of Science and Technology, Norway	Dec. 2016
Irvine, Robert Justin Charles	UK	James Hutton Institute, UK	Dec. 2016
Kaandrorp, Jaap	The Netherlands	University of Amsterdam, The Netherlands	Nov. 2016
Kokkalis, Alexandros	Greece	Technical University of Denmark, Denmark	Jun. 2016
Lagutov, Viktor	Russia	Central European University, Hungary	Dec. 2016
Lenski, Richard	USA	Michigan State University, USA	Feb. 2016
Lindroos, Marko	Finland	University of Helsinki, Finland	Jun. 2016
Lundström, Maria	Sweden	Lindköping University, Sweden	Jan. 2016
Macdonald, Jed	Australia	University of Iceland, Iceland	Jun. 2016
Magnussen, Eydfinn	Faroe Islands	University of the Faroe Islands, Denmark	Jun. 2016
Orlando, Ludovic Antoine	France	Natural History Museum of Denmark, Denmark	Feb. 2016
Thorbjørnsen, Susanne	Norway	University of Agder, Norway	Jun.–Jul. 2016
Thorpe, Harry A. F. W.	UK	University of Bath, UK	May–Jun. 2016
Weigel, Benjamin	Germany	Åbo Akademi University, Finland	Jan. 2016 Jun. 2016
Xingkun, Jin	China	East China Normal University, China	Nov. 2016
Yletyinen, Johanna	Finland	Stockholm Resilience Centre, Sweden	Jun. 2016
Zimmerman, Peter	USA	Case Western Reserve University, USA	Feb. 2016
Zuk, Marlene	USA	University of Minnesota, USA	Feb. 2016

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Research projects

RCN projects				
Name	**Project leader**	**Funding**	**Start**	**End**
Tracking Viking-assisted dispersal of biodiversity using ancient DNA	Boessenkool, Sanne	RCN	2014	2018
Reindeer interactions from plants and birds to humans: balancing the odds of climate change	Gusarova, Galina	RCN	2016	2020
The evolution of defence systems: theory and experiment	Holen, Øistein	RCN	2016	2019
Genetic variability in population responses of Atlantic cod to environmental change	Hutchings, Jeffrey	RCN	2014	2016
Functional and comparative immunology of a teleost's world without MHC II	Jakobsen, Kjetill S.	RCN	2013	2017
The Aqua Genome project	Jakobsen, Kjetill S.	RCN	2013	2017
Novel techniques for seabed monitoring of CO_2 leakage and monitoring campaigns based on reservoir, cap rock and overburden migration models	Jakobsen, Kjetill S.	RCN	2014	2016
The Norwegian Sequencing Centre – Phase II	Jakobsen, Kjetill S.	RCN	2014	2016
Evolutionary and functional importance of simple repeats in the genome (REPEAT)	Jakobsen, Kjetill S.	RCN	2016	2021
Long-term effects of local scale OIL pollution on fish population and COMmunities in the Lofoten-Barents Sea systems (OILCOM)	Langangen, Øystein	RCN	2016	2019
Phanerozoic diversification: linking observation and process	Liow, Lee Hsiang	RCN	2014	2018
LAND: Delimiting functional management units for partially migratory deer populations (DeerUnit)	Mysterud, Atle	RCN	2014	2017
EcoTick: Land use, climate and tick-borne diseases in dynamic multi-host ecosystems: estimated risk and experienced fear	Mysterud, Atle	RCN	2016	2019
Biogeographic and population analyses of Thermotogales bacteria from hydrocarbon-rich environments	Nesbø, Camilla	RCN	2008	2016
Pollination; an ecosystem service affected by climate change (LAND)	Nielsen, Anders	RCN	2014	2017
Evolutionary ecology and hydrology – the effects of stream flow dynamics on the white-throated dipper	Nilsson, Anna	RCN	2013	2016
On the role of hybridisation in evolution – the case of Eurasian *Passer* sparrows	Sætre, Glenn-Peter	RCN	2015	2018
Fisheries induced evolution in Atlantic cod investigated by ancient and historic samples	Stenseth, Nils Chr.	RCN	2011	2016
Bringing together evolution and ecology – Bringing together evolution and ecology through the Red Queen Perspective	Stenseth, Nils Chr.	RCN	2012	2016
Strengthening the adaptive capacity of institutions in fisheries (ADCAP)	Stenseth, Nils Chr.	RCN	2012	2016
Behavioral responses to risk and uncertainty among Norwegian fishers (FishRisk)	Stenseth, Nils Chr.	RCN	2013	2016
Climate Changes and Zoonotic Epidemiology in Wildlife Systems (ZEWS)	Stenseth, Nils Chr.	RCN	2013	2016
Red Queen coevolution in multispecies communities: long-term evolutionary consequences of biotic and abiotic interactions (ERC-Stenseth)	Stenseth, Nils Chr.	RCN	2013	2017
Sustainable management of renewable resources in a changing environment: an integrated approach across ecosystems	Stenseth, Nils Chr.	RCN	2015	2018
Modelling microbial dynamics of the human infant gut	Trosvik, Pål	RCN	2014	2017
Applying a new demographic framework to understand and project consequences of climate change in size- and age-structured populations	Vindenes, Yngvild	RCN	2013	2016
Managing ecosystems in an increasingly variable world (ECOVAR)	Vindenes, Yngvild	RCN	2015	2018
Dissecting evolutionary rates across time: Bridging micro-and macroevolution (DETERMINE)	Voje, Kjetil	RCN	2016	2019

Other public sector-based projects				
Name	**Project leader**	**Funding**	**Start**	**End**
Seasonal to decadal Changes Affecting Marine Productivity: an interdisciplinary investigation (SCAMPI)	Durant, Joël	RCN/NERSC	2015	2017
CoDINA – Cod: DIet and food web dyNAmics	Durant, Joël	RCN/IMR	2015	2019
Miljøgifter i en urban fjord – prøvetaking gråmåke	Helberg, Morten	Miljødirektoratet	2015	2017
Miljøgifter i en urban fjord 2016	Helberg, Morten	NIVA	2016	2017
Adaptation or plasticity as response to large scale translocations and harvesting over a climate gradient in the marine ecosystem?	Jentoft, Sissel	RCN/UiA	2014	2017
Spisskompetanse inom marin och akvatisk ekologi och genomforskning for uthållig förvaltning av fisk och skaldjur i Skagerrak – Kattegat – Øresund (MarGen)	Knutsen, Halvor	INTERREG/IMR	2015	2018
Sjokoladens søte lille hemmelighet	Nielsen, Anders	RCN/NTNU	2016	2017
Norwegian Marine Data Centre (NMDC)	Stenseth, Nils Chr.	RCN/IMR	2012	2022
Productivity and Resilience Enhancement of Exploited Fish stocks: an experimental approach (REEF)	Vøllestad, Leif Asbjørn	RCN/NMBU	2016	2021
Size-dependent anthropogenic perturbations – from genes to ecosystems and back	Vøllestad, Leif Asbjørn	RCN/NMBU	2016	2020

Private sector-based projects				
Name	**Project leader**	**Funding**	**Start**	**End**
Genetisk bakgrunn hos ulv *Canis lupus* i Norge og Skandinavia	Jakobsen, Kjetill S.	Skogeierforeningen Norskog	2016	2016
Climate effects on harvested large mammal populations	Mysterud, Atle	CAS/DNVA	2015	2016
Quantifying natural variability in spawning and survival of Northeast Arctic haddock (VISTA)	Ottersen, Geir	DNVA	2015	2018
Investigating artifacts using ancient DNA to trace historic trade and exploitation of Atlantic walrus	Star, Bastiaan	Nansen/UNIFOR	2016	2017
Multi-species dynamics above and beneath the sea-surface (SeaSurf)	Stenseth, Nils Chr.	SNF	2015	2018

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International projects				
Name	**Project leader**	**Funding**	**Start**	**End**
The Horses and Sheep of the Vikings: Archaeogenomics of Domesticates in the North Atlantic	Boessenkool, Sanne	Agricultural University of Iceland	2016	2020
MedPlag – The medieval plagues: ecology, transmission modalities and routes of the infections	Bramanti, Barbara	ERC EU	2013	2018
678049 ERC NatCOOP – How nature affects cooperation in common pool resource systems	Diekert, Florian	EU	2016	2021
MARine Management and Ecosystem Dynamics under climate change (H2020-MSCA-ITN 675997 MARmaED)	Durant, Joël	EU	2015	2019
TerMARisk – A multidisciplinary approach to anticipate regime shifts in ecosystems	Eikseset, Anne Maria	Nordforsk	2016	2017
Climate Change Effects on Marine Ecosystems and Resources Economics – TFI NCoE Programme	Stenseth, Nils Chr.	Nordforsk	2011	2016
Green Growth based on Marine Resources: Ecological and Socio-Economic Constraints (GreenMAR)	Stenseth, Nils Chr.	Nordforsk	2014	2017
Nordic-Russian Co-operation Programme in Higher Education and Research	Stenseth, Nils Chr.	Nordforsk	2014	2017
Saving the endangered Bale monkey through protection of montane bamboo in the southern Ethiopian Highlands	Stenseth, Nils Chr.	PBNF	2016	2017
Workshops on the cumulative effects of the anthropogenic imprint of the Seas of Norden	Stenseth, Nils Chr.	Nordforsk	2016	2017

Seminars with invited speakers

Friday seminars and Extra seminars			
Name	**Home institution**	**Title**	**Date (Venue for all: Kristine Bonnevie's hus, Blindern)**
John M. Fryxell	University of Guelph, Canada	Human consumer-resource dynamics	15 January
Benjamin Weigel	Åbo Akademi University, Finland	Maintained functional diversity in benthic communities in spite of diverging functional identities	29 January
Richard Lenski	Michigan State University, USA	Dynamics of adaptation and genomic evolution in a 60,000-generation experiment	11 February
Johan Höjesjö	University of Gothenburg, Sweden	Behavioral tactics in salmonids; diurnal variation and implications of habitat complexity	18 February (co-organised with IBV)
Juan Bonachela	University of Strathclyde, Glasgow, Scotland	Eluding catastrophic shifts	26 February
Elisabeth Oberzaucher	University of Vienna, Austria	Homo Urbanus – How environments shape our behaviour	4 March
Nancy Denslow	University of Florida, Gainesville, USA	Combining Molecular Approaches with Analytical Chemistry for Evaluation of Contaminants	8 March (two part seminar co-organised with AQUA)
Peter Hodson	Queen's University, Kingston, Canada	Oil in Water: The Behaviour and Environmental Impacts of Crude Oil Released into Aqueous Environments	
Mikael Fortelius	University of Helsinki, Finland, and CEES, IBV, University of Oslo, Norway	An ecometric analysis of the fossil mammal record of the Turkana Basin	30 March
Mike Benton	University of Bristol, UK	Knowing the unknowable: form, function, and diversity through deep time	8 April
Martijn van de Pol	Netherlands Institute of Ecology (NIOO-KNAW), The Netherlands, and Australian National University, Australia	Behavioural responses to increasingly frequent extreme climatic events	15 April (two-part seminar)
Callum Lawson	Netherlands Institute of Ecology (NIOO-KNAW), The Netherlands	Population responses to environmental variation	
Fabienne Krauer	University of Bern, Switzerland	The Ebola epidemic in West Africa 2013-2015 – estimation of local transmission and quantification of population-level risk factors	27 April
David Houle	Florida State University, USA	What I learned from measuring a million fly wings	3 June
Stephanie M. Carlson	UC Berkeley, USA	Eco-evolutionary dynamics in Pacific salmon and trout	10 June
Robert M. Pringle	Princeton University, USA	The destruction and reconstruction of Africa's savanna ecosystems: large mammals as ecological linchpins	2 September

Jukka Corander	University of Helsinki, Finland and University of Oslo, Norway	100 years after William Bateson – what can we learn about epistasis by today's statistical machine learning?	9 September
Marcin Piwczyński	Nicolaus Copernicus University, Poland	Linking micro- and macroevolution: do genetic constraints predict phenotypic divergence?	23 September
Malin Pinsky	Rutgers University, USA	Global change: how odd are the oceans?	14 October
Oscar Puebla	GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany	Genomic islands in the Caribbean Sea	4 November
Jaap A. Kaandorp	University of Amsterdam, The Netherlands	Modelling and analysis of growth and form of branching scleractinian corals	25 November

Darwin Day 2016: Still evolving – Evolution today and in the recent past			
Name	**Home institution**	**Title**	**Date and venue**
Nils Chr. Stenseth	CEES, IBV, University of Oslo, Norway	Introduction	12 February 2016 Vilhelm Bjerknes hus, Aud. 5, Blindern, Oslo
Richard Lenski	Michigan State University, USA	Time travel in experimental evolution	
Ludovic Orlando	Natural History Museum of Denmark, University of Copenhagen, Denmark	Tracking recent evolution with ancient DNA	
Peter Zimmerman	Case Western Reserve University, Cleveland, Ohio, USA	Malaria: Evolving beyond the barrier of Duffy negative resistance	
Marlene Zuk	University of Minnesota, USA	Crickets, diets and songs: adaptive signal loss shows how evolution affects modern life	

Popular science lecture: Paleofantasy: What evolution tells us about the way we eat and live			
Name	**Home institution**	**Title**	**Date and venue**
Marlene Zuk	University of Minnesota, USA	Paleofantasy: What evolution tells us about the way we eat and live	13 February 2016 Litteraturhuset (The House of Literature), Oslo

The Fridtjof Nansen Lectures on Ocean Life 2016: Exploring the Deep Frontier			
Name	**Home institution**	**Title**	**Date and venue**
Nils Chr. Stenseth	CEES, IBV, University of Oslo, Norway	Introduction and presentation of the final NorMER Report	20 June 2016 Gamle Festsal, Domus Academica, Karl Johans gate 47, Oslo
Sylvia A. Earle	USA	Exploring the Deep Frontier	
HSH Prince Albert II of Monaco (Video presentation)	Monaco	International cooperation to address global marine issues	
Simon Levin (Video presentation)	Princeton University, USA, and member of the NorMER Centre Advisory Panel	Nordic marine research	
James Hurrell (Video presentation)	National Center for Atmospheric Research USA	Honoring Fridtjof Nansen	
Brynhildur Davíðsdóttir	NORDSTAR Leader/ University of Iceland, Iceland	NorMER and Beyond the added Nordic value	
Anne Maria Eikeset	CEES, IBV, University of Oslo, Norway	Marine research: A Broader Context and Life Sciences	
Jostein Sundet	NordForsk	How the Nordic Region Aims to Meet Global Challenges	
Ole Petter Ottersen, Rector	University of Oslo, Norway	Carrying the legacy of Nansen at UiO	
Siri Lill Mannes		Panel discussion chaired by Siri Lill Mannes	

The Kristine Bonnevie lectures 2016: The geometry of ecosystems in a changing world			
Name	**Home institution**	**Title**	**Date and venue**
Ragnhild Helene Hennum, Pro-Rector	University of Oslo, Norway	Introduction	2 September 2016 Helga Eng's hus, Aud. 1, Blindern, Oslo
Corina E. Tarnita	Princeton University, USA	The geometry of ecosystems in a changing world	
Jan M. Nordbotten	University of Bergen, Norway	The unknown unknowns: Communicating scientific uncertainty	

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Minisymposium: Transposons – the dark matter of genomes?			
Name	**Home institution**	**Title**	**Date and venue**
Dag Hessen	IBV, University of Oslo, Norway	Introduction to the C-value paradox	27 September 2016 Kristine Bonnevie's hus, Blindern, Oslo
Grace Wyngaard	James Madison University, USA	Programmed DNA Elimination in Copepods: A Complex Picture of Transposable Elements, Genes, and Short Simple Repeats	
Kristian Alfsnes	Norwegian Institute of Public Health, Norway	Phylogeny and genome size in arthropods	
Martin Malmstrøm	CEES, IBV, University of Oslo, Norway	The role of transposon silencing in genome miniaturization	
William Brynildsen Reinar	CEES, IBV, University of Oslo, Norway	Transposable elements in teleost fish	

PhD thesis defences

Kim Magnus Bærum. 19 February. *Climate-driven population responses of resident brown trout,* Salmo trutta*: Trends and future projections.* Supervisors: Thrond Oddvar Haugen, L. Asbjørn Vøllestad and Peter Kiffney.

Elin Sørhus. 7 March. *Crude oil and its high toxic effect on early life stages of Atlantic haddock – to the heart of the problem.* Supervisors: Sissel Jentoft, Rolf Brudvik Edvardsen, Nils Chr. Stenseth and Alexander Nederbragt.

Monica Hongrø Solbakken. 11 October. *Evolutionary and functional insight into the teleost immune system – lessons learned from Atlantic cod and other teleosts.* Supervisors: Kjetill S. Jakobsen, Sissel Jentoft, Tone F. Gregers and Oddmund Bakke.

In addition, a guest researcher at CEES defended her thesis at the Department of Psychology, Faculty of Social Sciences:

Vibeke Ottesen. 16 June. *An evolutionary psychological analysis of filicide in Norway*. Supervisors: Anne Inger Helmen Borge (main supervisor) and Tore Slagsvold.

Awards and Prizes

The following people were recognised in 2016, with awards or other distinctions.

Sanne Boessenkool was awarded the Darwin Prize for outstanding research within the field of evolutionary biology. The award was presented at the department's annual Christmas party.

R. Adriana Hernandez-Aguilar received the Beca Floquet de Neu (Snowflake Grant) from the Barcelona Zoo Foundation. The grant will fund her research project on "Assessing the spatiotemporal availability and quality of chimpanzee foods in a dry, open and seasonal habitat". She is the Principal Investigator on this project.

Melissah Rowe received a research grant of 50 000 NOK from Nansenfondene (the Nansen Foundation). In addition, she was awarded the Kristine Bonnevie travel stipend for a research stay abroad, by the Faculty of Mathematics and Natural Sciences at UiO.

Nils Chr. Stenseth was elected a member of the Russian Academy of Sciences, as a foreign associate. He is currently the only Norwegian scientist who is a member of the Russian, French and American academies of science.

Lee Hsiang Liow and her co-collaborator were awarded the Peder Sather Grant for their research proposal on "Dissecting the timing, ecological signature, and environmental context of the largest biodiversification in Earth history".

Two of our PhD students were also recognised in 2016. **Franziska Franeck** received a National Geographic Young Explorers Grant to support her fieldwork on Svalbard. In addition, **Leonie Färber** won an Early Career Scientist Award for Best Poster from the International Council for the Exploration of the Sea (ICES), during its Annual Science Conference.

Missing from the 2015 Annual Report

Three people were accidentally left out of the previous report. **Nanna W. Steen** received the Frode Olsgards Memorial Prize, for her work within health, safety and the environment (HSE). **Jo Skeie Hermansen** was awarded the King's Gold Medal for his doctoral dissertation on speciation by hybridisation in *Passer* sparrows. Last, but not least, **Nils Chr. Stenseth** was elected a member of the National Academy of Sciences (Washington, D.C., USA), as a foreign associate.

Production

Contributors affiliated with CEES in bold.

Articles in peer-reviewed journals

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Barth, J. M. I., **Star, B.**, **Matschiner, M.**, **Berg, P. R.**, **Jakobsen, K. S.**, **Jentoft, S.** Ancient genomic variation separates Atlantic cod ecotypes; implications for management. *7th World Fisheries Congress, Korea*. 23–27 May.

Blanco Gonzalez, E., **Knutsen, H.**, **Jorde, P. E.** Seascape genomics in a growing fishery: the case of a translocated cleaner fish, the corkwing wrasse (*Symphodus melops*). *7th World Fisheries Congress, Korea*. 23–27 May.

Boessenkool, S. From treasure trove to tube: aDNA research in museum collections. *UNI-MUSEER, Norway*. 8–9 March.

Boessenkool, S. Tracking the genomic composition and evolutionary heritage of the Viking's domestic animals using aDNA. *Domestic Animals in the Viking Age, Reykjavík, Iceland*. 3–6 October.

Broch, C. The ecological effects of temperature variability. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Cloete, C. C. Climate fluctuations and zoonotic diseases – the case of anthrax in Etosha National Park. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Cuevas Pulido, A. M. Genomic divergence within a hybrid species. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Dean, K. R. Human ectoparasites spread plague during the Black Death and Second Pandemic. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Delkaso, D. T. Foraging ecology *Colobus guereza gallarum* in the Ethiopian highlands and its phylogenetic relationships with the widely distributed *Colobus guereza* populations. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Deris, L. Quantifying the potential for predator-prey reversal between NSS herring (*Clupea harengus*) and NEA cod (*Gadus morhua*). *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Diaz, H., Navea, F., Troncoso-Palacios, J., Reyes, C., Lagos, J. C., **Labra, A.** Emisión de vocalizaciones en lagartos Chilenos: comparación de los llamados de *Diplolaemus sexcinctus*, *Phymaturus vociferator* y *Liolaemus nitidus*. *VII Congreso Chileno de Anfibios y Reptiles, Chile*. 28–30 November.

Diekert, F. K., Nøstbakken, L., **Richter, A. P.** Why do fishermen comply with regulations? The role of preferences. *18th Biennial Conference of the International Institute of Fisheries Economics and Trade (IIFET) Conference 2016, University of Aberdeen, United Kingdom*. 11–15 July.

Diekert, F. K., Nøstbakken, L., **Richter, A. P.**, Skjeret, F. A. Risk and risk exposure in Norwegian fisheries. *18th Biennial Conference of the International Institute of Fisheries*

Economics and Trade (IIFET) Conference 2016, University of Aberdeen, United Kingdom. 11–15 July.

Disasa, B. E. Effects of shade coffee plantation management on mammalian biodiversity in Ethiopia. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Dong, K. Bottom-up effects of phytoplankton in marine food webs. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Doroudi Moghadam, M. Estimating animal movements from light-logger data using Bayesian State-Space modeling. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Drinkwater, K. F., **Kristiansen, T.** Projection of future climate change on plankton in the Atlantic sector of the Arctic. *ESSAS Annual Science Meeting, Yokohama, Japan*. 7–9 March.

Dupont, N., Bagøien, E., Melle, W. R. Long-term trends and variability in spring development of *Calanus finmarchicus* in the southeastern Norwegian Sea during 1996–2012. *2016 Ocean Sciences Meeting, New Orleans, USA*. 21–26 February.

Dupont, N., **Stige, L. C.**, Bagøien, E., Melle, W. R. Long-term trends and seasonal patterns for *Calanus finmarchicus* and *Calanus helgolandicus* in the coastal water off southwest Norway during 1996–2012. *ICES/PICES 6th Zooplankton Production Symposium, Bergen, Norway*. 9–13 May.

Durant, J. M. MARmaED: MARine MAnagement and Ecosystem Dynamics under climate change. *German-Norwegian Dialogue on Bilateral and European Cooperation, Berlin, Germany*. 29–30 September.

Durant, J. M., **Ottersen, G.** Effect of juvenile distribution and environment on the northeast Arctic haddock. *Annual Science Conference of the International Council for the Exploration of the Sea (ICES) 2016, Riga, Latvia*. 19–23 September.

Eide, M., Puntervoll, P., Lille-Langøy, R., Goldstone, J. V., **Tørresen, O. K.**, **Nederbragt, A. J.**, Rydbeck, H., **Jakobsen, K. S.**, Stegeman, J., Goksøyr, A., Karlsen, O. A. Chemical warfare in the marine environment: genomic survey of the Atlantic cod (*Gadus morhua*) defensome reveals the absence of an important xenosensor. *30th ESCBP Congress: Unraveling Complexity: From Molecules to Ecosystems, Barcelona, Spain*. 4–7 September.

Elin, S., John, I., Furmanek, T., Scholz, N., Meier, S., **Jentoft, S.**, Edvardsen, R. Transcriptomics identifies novel adverse outcome pathways from crude oil exposure in haddock early life history stages. *SETAC 2016, Orlando, Florida, USA*. 6–10 November.

Enevoldsen, E., **Boeve, J.** A new and improved bryozoan phylogeny. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Eriksen, G., **Hernandez-Aguilar, R. A.** Foraging decisions and patch use in gelada monkeys (*Theropithecus gelada*) at Guassa, Ethiopia: testing the marginal value theorem. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Eroukhmanoff, F. Rapid evolution of character displacement in a hybrid species. *Evolution in Sweden – International Conference in Evolutionary Biology, Lund, Sweden*. 13–14 January.

Fagerli, L. A. L., Bårdsen, B.-J., **Brysting, A. K.**, **Nielsen, A.** Plant-pollinator interactions along an elevation gradient in northern Norway. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Fagerli, L.-M. Plant-pollinator interactions along an elevation gradient in northern Norway. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Fong, L., **Slagsvold, T.** Comparing the song variation of early and late arrivals of juvenile pied flycatchers (*Ficedula hypoleuca*). *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Fredriksen, S., **Eroukhmanoff, F.** The avian ejaculate-associated microbiome: inter and intraspecific variation and the potential role of geography. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Färber, L. Benefit of long distance migration. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Gessese, M. T. Conservation status, behavioral ecology and intraspecific divergence of the endangered hartebeest *Alcelaphus buselaphus* (*A. b. swaynei*, *A. b. tora* and *A. b. lelwel*) in Ethiopia. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Gokhale, S., **Richter, A. P.**, Nøstbakken, L., **Diekert, F. K.** Understanding financial risk for fishers and the role of diversification. *Annual Science Conference of the Interna-*

tional Council for the Exploration of the Sea (ICES) 2016, Riga, Latvia. 19–23 September.

Grabowski, M. W. Birth since the LCA: reconstructing the twisted evolution of human parturition. *The 85th Annual Meeting of the American Association of Physical Anthropologists, Atlanta, USA*. 13–16 April.

Guellil, M. Needle in a haystack: searching for pathogens in ancient human metagenomic datasets. *SciLifeLab Mini-Symposium: Ancient Environmental DNA, Stockholm, Sweden*. 10 March.

Guellil, M. The need for resolution: addressing the lack of multidisciplinary integration in medieval plague research. *7th International Symposium on Biomolecular Archaeology, Oxford,United Kingdom*. 14–16 September.

Guellil, M. Investigating medieval plague via ancient DNA analysis: results and challenges. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Guldvog, C. Ø. Genomic conflict resolution and genetic ancestry in a homoploid hybrid species. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Gusdal, Y., Melsom, A., Trodahl, M., Kvile, K. Ø., **Langangen, Ø.** Changes in drift pathways of fish egg along the coast of Norway. *Joint Numerical Sea Modelling Group (JONSMOD) 2016, Oslo Centre for Interdisciplinary Environmental and Social Research (CIENS), Norway*. 10–12 May.

Haugen, M. N., **Liow, L. H.** Molecular phylogeny and trait evolution of adeonid bryozoans. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Helmerson, C. J. M. T. Genomic analysis of 20th century northeast Arctic cod *Gadus morhua* (L.). *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Hermansen, J. S. A fruitful affair: speciation by hybridization in *Passer* sparrows. *Invited Lecture at the Chinese Centre for Disease Control and Prevention (China CDC), Beijing, China*. 22 July.

Hernandez-Aguilar, R. A. Chimpanzees landscape-scale changes (*Pan troglodytes schweinfurthii*): implications for long-term conservation in western Tanzania. *XXVI Congress of the International Primatological Society, Chicago, USA*. 21–27 August.

Hoff, S. N. K. Comparative genomics by targeted capture and long read sequencing reveal dynamic evolution of hemoglobin gene clusters in codfishes. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Hol, K. E., **Slagsvold, T.** On the "silver-spoon" effect: telomere length in relation to rearing conditions in blue tits. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Holen, Ø. H., Kilner, R. M. Avian brood parasitism: defend early or wait and see? *International Society for Behavioral Ecology 2016, Exeter, United Kingdom*. 28 July–3 August.

Holt, R. E. CoDINA: Cod DIet and food web dyNAmics. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Huserbråten, M. B. O. Escaping starvation in the Norwegian coastal current: key to contemporary recruitment success of northern North Sea cod? *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Høydalsvik, M. N., **Vøllestad, L. A.** Population dynamics in lobster: effects of marina protected areas. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Isaksen, E. T., Andaloussi, M. B. The environmental and distributional consequences of emission markets. *Sustainable Development Research Conference & Symposium, New York, USA*. 1–2 April.

Isaksen, E. T., Andaloussi, M. B. The environmental and distributional consequences of emission markets. *Interdisciplinary PhD Workshop on Sustainable Development, New York, USA*. 22–23 April.

Isaksen, E. T., **Richter, A. P.**, Brekke, K. A. When kindness generates unkindness. Why positive framing cannot solve the tragedy of the commons. *4th Canadian PhD and Early Career Workshop in Environmental Economics, Ottawa, Canada*. 31 May–2 June.

Isaksen, E. T., **Richter, A. P.**, Brekke, K. A. When kindness generates unkindness. Why positive framing cannot solve the tragedy of the commons. *22nd Annual Conference of the European Association of Environmental and Resource Economists (EAERE) 2016, Zürich, Switzerland*. 22–25 June.

Johannessen, I. M. The effect of gene and genome dosage on hybridization barriers in *Arabidopsis lyrata* and

Arabidospsis arenosa. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Johnsen, J. F., **Viljugrein, H.**, Bøe, K. E., Gulliksen, S. M., Beaver, A., Grøndahl, A. M., Sivertsen, T., Mejdell, C. M. Passive immunity of suckling calves and associations with colostrum management routines on organic dairy farms. *50th Congress of the International Society for Applied Ethology, Edinburgh, United Kingdom*. 12–15 July.

Karbassion, A., Haug, S., **Nielsen, A.** Pollinator activity and structure along an altitudinal gradient. *Annual Meeting of the Scandinavian Pollination Ecologists (SCAPE), Abisko, Sweden*. 13 October.

Karbassion, A., Haug, S., **Nielsen, A.** Pollinator interactions between wild raspberry and the surrounding plant community along an altitudinal gradient. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Kassie, A. M. Effects of habitat loss and fragmentation on the activity budget, ranging ecology and habitat use of Bale monkeys (*Chlorocebus djamdjamensis*) in the southern Ethiopian Highlands. *International Primatological Society XXVI Congress, Chicago, USA*. 21–27 August.

Kersten, O. *Yersinia pestis* genomes from medieval Europe and Asia during the 2nd plague pandemic. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Kininmonth, S. J. Microeconomic relationships between and among fishers and traders influence the ability to respond to socio-ecological changes in a small-scale fishery. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Kjesbu, O. S. Plenty of cod in the Barents Sea – an effect of climate or fisheries management? *North Atlantic Seafood Forum: Climate Change Session: North Atlantic Warming – Effects of Fish Stocks and their Distribution, Bergen, Norway*. 1 March.

Knudsen, J. B., Reinar, W. B., Jakobsen, K. S. Evolutionary and functional importance of simple repeats in eukaryotic genomes. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Kopperud, B. T., Hansen, T. F. Artiodactyl brain size evolution. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Krauer, F. A modelling approach to understanding the spread of plague in Europe during the second pandemic. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Kvile, K. Ø., Dalpadado, P., Fiksen, Ø., **Langangen, Ø.**, Opdal, A. F., Prokopchuk, I. P., **Stenseth, N. C., Stige, L. C.** Climate responses of *Calanus finmarchicus* in a high latitude system. *ICES/PICES 6th International Zooplankton Production Symposium, Bergen, Norway*. 9–13 May.

Kvile, K. Ø., Stige, L. C., Prokopchuk, I. P., **Langangen, Ø.** A statistical regression approach to estimate zooplankton mortality from spatiotemporal survey data. *Annual Science Conference of the International Council for the Exploration of the Sea (ICES) 2016, Riga, Latvia*. 19–23 September.

Labra, A. Estudiando las vocalizaciones de un lagarto Iguanido, *Liolaemus chiliensis*. *XIV Congreso Luso-Español de Herpetología; XVIII Congreso Español de Herpetología., Lleida, Spain*. 5–8 October.

Langangen, Ø. Multi-decadal changes in spawning ground use in northeast Arctic haddock: climate or harvest induced? *Annual Science Conference of the International Council for the Exploration of the Sea (ICES) 2016, Riga, Latvia*. 19–23 September.

Li, Y., Nøstbakken, L., **Diekert, F. K., Richter, A. P.** The impact of risk, time, and social preferences on individual investment decisions in a fishery. *18th Biennial Conference of the International Institute of Fisheries Economics and Trade (IIFET) Conference 2016, University of Aberdeen, United Kingdom*. 11–15 July.

Li, Y., Nøstbakken, L., **Diekert, F. K., Richter, A. P.** Behavioral drivers of investments in catch-share managed fisheries. *Faculty Seminar, Norwegian University of Science and Technology, Trondheim, Norway*. 8 December.

Li, Y., Nøstbakken, L., **Richter, A. P., Diekert, F. K.** Behavioral drivers of investments in catch-share managed fisheries. *Seminar Series, Bergen, Norway*. 9 December.

Lien, V. S., Ingvaldsen, R. B., **Ottersen, G.** Presentation of the projects SI_ARCTIC The Arctic Ocean Ecosystem and INTAROS. *PolarDag, Bergen, Norway*. 14 September.

Linløkken, H., Mysterud, A. Tick load and infection of tick-borne pathogens in small mammals. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Liow, L. H. Bryozoan phylogenies for understanding evolution. *International Bryozoology Association Meeting, Melbourne, Australia*. 10–15 April.

Liow, L. H. Bryozoans as a model system in macroevolution. *Conference Talk, Thurso, United Kingdom*. 18 June.

Liow, L. H., Di Martino, E., Taylor, P. D. Who's the winner? Competing for space through two million years of the New Zealand fossil record. *International Bryozoology Association Meeting, Melbourne, Australia*. 10–15 April.

Llope, M. Cod response to past and current warm phases in the Seas of Iceland, a time series analysis. *Annual Science Conference of the International Council for the Exploration of the Sea (ICES) 2016, Riga, Latvia*. 19–23 September.

MacNeish, A., **Slagsvold, T.** Variation in telomere length in blue tits in relation to age, sex, breeding success, and the telomere length of their parents. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Martinsen, V., Mulder, J., Speed, J. D. M., **Mysterud, A.**, Austrheim, G. Results of long-term grazing experiments in Norway – focus on C & N. *Project Establishment and Informational Meetings in Beijing and Hohhot, China*. 13–15 April.

Martinsen, V., Mulder, J., Speed, J. D. M., **Mysterud, A.**, Austrheim, G. Grazing & treeline advance in alpine zones: effects on ecosystem carbon stocks. *Seminar: "Soil in a Changing World", Ås, Norway*. 5 December.

Mayer, C. Resolving the relationship between evolvability and robustness using Boolean Genotype-Phenotype Maps. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Mayer, C., **Hansen, T. F.** Resolving the relationship between evolvability and robustness using Boolean Genotype-Phenotype Maps. *EED 2016, Uppsala, Sweden*. 26–29 July.

Mulder, J., Martinsen, V., Speed, J. D. M., **Mysterud, A.**, Austrheim, G. Treeline advance in alpine zones: effects on ecosystem carbon stocks. *Japan–Norway Arctic Science and Innovation Week 2016, Tokyo, Japan*. 2 June.

Mulder, J., Martinsen, V., Speed, J. D. M., **Mysterud, A.**, Austrheim, G. Grazing & treeline advance in alpine zones: effects on ecosystem carbon stocks. *Invited Lecture, Beijing, China*. 19 October.

Munkelien, F., **Mysterud, A.** The distribution of small mammals and its relationship with ticks in two coastal areas of Norway through a population cycle. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Mutch, E. Ability to adjust breeding time to earliness of spring – a comparative study of four passerine bird species. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Navea, F., **Labra, A.** ¿Es *Liolaemus lemniscatus* un lagarto fisgón de *L. chiliensis*? *X Congreso de la Asociación de Estudiantes de Biología de Chile*. 5–8 October.

Navea, F., **Labra, A.** Evaluando la habilidad de *Liolaemus lemniscatus* de fisgonear al lagarto llorón. *VII Congreso Chileno de Anfibios y Reptiles, Chile*. 28–30 November.

Ndimuligo, S. A. Vegetation structure and composition of two chimpanzee (*Pan troglodytes schweinfurthii*) savanna sites in western Tanzania. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Nederbragt, A. J. The new Atlantic cod reference genome. *ELIXIR Innovation and SME Forum: Data-Driven Innovation in the Aquaculture Industries, Norway*. 12–13 May.

Nederbragt, A. J. Genomic variation detection in Atlantic cod using long reads. *SMRT Scientific Conference: Changing the World, One Molecule at a Time!, Netherlands*. 6–7 June.

Nederbragt, A. J. SMRTwishes for SMRTsoftware for SMRTreads – a user's perspective. *SMRT Informatics Developers Conference, Netherlands*. 8 June.

Nederbragt, A. J. Doing bioinformatics: a user's perspective. *Balti and Bioinformatics, University of Birmingham, United Kingdom*. 28 September.

Nederbragt, A. J., Lagesen, K. The Carpentry effort at the University of Oslo. *Miniseminar "Open Data Skills", University of Oslo, Norway*. 14 March.

Nielsen, A. Historien om blomstene og biene; er det bare griseprat? *Frokost hos Kristine, University of Oslo, Norway*. 10 February.

Nielsen, A. Verdier av økosystemtjenester. *Norsk Miljøforskning Underveis, Holmenkollen Park Hotell, Norway*. 21 April.

10 APPENDICES

Nielsen, A. Historien om blomstene og biene; Hva handler den egentlig om? *BioTorsdag, University of Oslo, Norway*. 28 April.

Nielsen, A. Historien om blomstene og biene; er det bare griseprat? *Fadderuka UiO, University of Oslo, Norway*. 17 August.

Nielsen, A. Historien om blomstene og biene. Hva handler den egentlig om? *Konferanse for "Den naturlige skolesekken", University of Oslo, Norway*. 16 September.

Nielsen, A. Tilstanden for verdens pollinatorer. Kan vi lære av andre land? *Innspillsmøte nasjonal strategi for bier og pollinering, Oslo, Norway*. 26 September.

Nielsen, A. Bienes betydning. *Sabima 20 år/Biokonferansen, Hotel Bristol Oslo, Norway*. 4 November.

Nielsen, A. Presentation of the "Dr. Nielsen I presume group". *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Nielsen, A., **Reitan, T.** The nature of unexplained variation in flower visitation data. If it wasn't complicated enough! *Seminar, Reading University, United Kingdom*. 8 April.

Nielsen, A., **Reitan, T.** Proper use of flower visitation data. *Progress in Pollination and Pollinator Research, Reading University, United Kingdom*. 9 April.

Nielsen, A., **Reitan, T.**, **Garratt, M.** The nature of unexplained variation in flower visitation data. If it wasn't complicated enough. *SUPER-B Management Committee Meeting and Conference, Cluj, Romania*. 6 September.

Nilsson, P. A reference genome of great gerbil – a highly plague-resistant rodent host. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Nærø, J. S., **Liow, L. H.** Bryozoan growth rates and life histories in the Arctic marine environment. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Oomen, R. A. Transcriptomic responses to environmental change in fishes: insights from RNA-seq. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Oomen, R. A., **Knutsen, H.**, Olsen, E. M., **Jentoft, S.**, **Stenseth, N. C.**, **Hutchings, J.** Genetic variability in population responses of Atlantic cod to temperature. *Canadian Conference for Fisheries Research, St. John's, Newfoundland, Canada*. 8 January.

Osnes, M. N. Analyses of the population dynamics of rodents in an alpine environment. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Ottersen, G. Sea fisheries and the ecosystem approach to marine management. *Lecture for Bio4150/9150, University of Oslo, Norway*. 1 April.

Ottersen, G. Marine ecosystems climate effects and management. *UiO International Summer School – a Changing Arctic, University of Oslo, Norway*. 8 July.

Palsdottir, A. H. Livestock movements in the North Atlantic. *Frændafundur 9, University of Iceland, Reykjavík, Iceland*. 26–28 August.

Palsdottir, A. H. The sheep and horses of the Vikings: archaeogenomics of domesticates in the North Atlantic. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Paus-Knudsen, J. S. Sublethal effects of imidacloprid, a neonicotinoid pesticide, on bumblebees. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Paus Knudsen, J. S., Borgå, K., **Nielsen, A.** Sublethal effects of imidacloprid, a neonicotinoid pesticide, on bumblebees. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Paz, A., **Labra, A.**, Valdecantos, S. ¿Influyen la residencia y/o el color en el éxito de una interacción agonística en machos de *Liolaemus multicolor*? *I Congreso Argentino-Paraguayo de Herpetología, XVII Congreso Argentino de Herpetología, II Congreso Paraguayo de Herpetología*. 26–30 September.

Ramsfjell, M. H., **Liow, L. H.** Is bigger better? A study of competitive abilities in bryozoa in deep time. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Ravinet, M. S. P. Interpreting the genomic landscape of speciation: finding barriers to gene flow in genome scan data. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Reyes, C., Penna, M., **Labra, A.** Variación geográfica de los llamados de angustia del lagarto llorón (*Liolaemus chiliensis*). *VII Congreso Chileno de Anfibios y Reptiles, Chile*. 28–30 November.

Richter, A. P., **Isaksen, E. T.** Tragedy, property rights, and the commons. *SURED Conference 2016, Banyuls-sur-Mer, France*. 6–9 June.

Richter, A. P., **Isaksen, E. T.** Tragedy, property rights, and the commons – disentangling the two-way causality between institutions and ecosystem collapse. *18th Biennial Conference of the International Institute of Fisheries Economics and Trade (IIFET) Conference 2016, University of Aberdeen, United Kingdom*. 11–15 July.

Richter, A. P., **Isaksen, E. T.**, Brekke, K. A. When kindness generates unkindness. Why positive framing cannot solve the tragedy of the commons – an experimental investigation. *IAREP SABE Conference 2016 – Behavioural Insights in Research and Policy Making, Wageningen, Netherlands*. 8–10 July.

Richter, A. P., Nøstbakken, L., **Diekert, F. K.** Using behavioral experiments to understand preferences with regard to risk, patience, and cooperation in Norwegian fisheries. *Annual Science Conference of the International Council for the Exploration of the Sea (ICES) 2016, Riga, Latvia*. 19–23 September.

Riiser, E. S. The intestinal microbiome of Atlantic cod: a limited number of bacterial strains prevail over an extended geographical range. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Rindal, V. L. D. A. Ecological and behavioural flexibility of vervet monkeys (*Chlorocebus pygerythrus*) living in a savanna-woodland fragment near Kigoma, Tanzania. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Rivrud, I. M. Jegernes påvirkning på hjortens høsttrekk. *Seminaret HJORTEVILT 2016, Hafjell, Norway*. 15–16 March.

Rivrud, I. M. Heritability of body size in a wild mammal: the brown bear (*Ursus arctos*). *24th International Conference on Bear Research and Management, Anchorage, Alaska, USA*. 12–16 June.

Rodrigo, A. M., **Hernandez-Aguilar, R. A.** Extraction of underground food by captive chimpanzees: techniques and laterality. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Romagnoni, G. Bioeconomic optimal management strategy for spatially structured fish populations. *Primo Congresso Nazionale Congiunto SItE-UZI-SIB, Milan, Italy*. 1 September.

Ruiz-Monachesi, M., Valdecantos, S., **Labra, A.**, Cruz, F. B. Comportamiento y morfología: casos particulares de comunicación en el género *Liolaemus*. *I Congreso Argentino-Paraguayo de Herpetología, XVII Congreso Argentino de Herpetología, II Congreso Paraguayo de Herpetología*. 26–30 September.

Speed, J. D. M., Austrheim, G., Hester, A. J., Martinsen, V., Mulder, J., **Mysterud, A.** Ecological responses to sheep grazing in Norwegian mountains: insight from long-term experimental approaches. *Grazing in a Changing Nordic Region, Reykjavík, Iceland*. 12–15 September.

Sperfeld, E. Studying nutritional ecology and the evolution of inducible defences using *Daphnia* as model organism. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Stenseth, N. C. What is the Anthropocene? (or what should it be)? *The 32nd Nordic Geological Winter Meeting, Helsinki, Finland*. 13 January.

Stenseth, N. C. Climate change and the impact on emerging infectious diseases – plague as an example. *Visting Lecture, Pune, India*. 19 January.

Stenseth, N. C. Svartedaudbakteriens populasjonsbiologi: hvordan pest-dynamikken påvirkes av klimavariasjoner. *Darwindagen i Bergen 2016, Norway*. 15 February.

Stenseth, N. C. Norge er avhengig av fremragende forskningsmiljøer: å bli og forbli et verdensledende forskningsmiljø – en forskers refleksjoner. *Arbeiderpartiets utvalg for høyere utdanning, Oslo, Norway*. 22 February.

Stenseth, N. C. Promoting research excellence – a scientist's reflections on how to widen European participation in ERC. *Lecture, Krakow, Poland*. 3 March.

Stenseth, N. C. Havbruksnæringens utvikling i Norge: fra grunnleggende vitenskap til næringssuksess. *Norges marine storbyers arrangement i Oslo, Norway*. 11 April.

Stenseth, N. C. Havbruksnæringens utvikling i Norge: "Kunnskap trumfer alt". *Norges marine storbyers arrangement i Oslo, Norway*. 11 April.

Stenseth, N. C. Challenges and opportunities for unions within a shifting global scientific landscape. *Meeting of the International Scientific Unions of ICSU, Paris, France*. 12–13 April.

Stenseth, N. C. Sustainable management of renewable resources in a changing environment: an integrated approach across ecosystems (SUSTAIN). *SUSTAIN Meeting in Tromsø, Norway*. 11 May.

Stenseth, N. C. Are Norwegian politics based on the best available knowledge? Do we need a Science Advisor in Norway? *Meeting in DNVA About Science Advice in Norway, Oslo, Norway*. 6 June.

Stenseth, N. C. Fridtjof Nansen. *The Fridtjof Nansen Lectures on Ocean Life 2016, Oslo, Norway*. 20 June.

Stenseth, N. C. A unified biology: six blind scientists and the elephant in the room, a parable for environmentally mediated diseases (with a focus on plague). *Two-Day Summer Workshop and Conference about "Making Microbes Complex: Parasites, Epidemics and the Intellectual Origins of Disease Ecology", London, United Kingdom*. 7–8 July

Stenseth, N. C. A unified biology: six blind scientists and the elephant in the room, a parable for environmentally mediated diseases (with a focus on plague). *8th International Symposium of Integrative Zoology, Xilinhaote City, China*. 25–29 July.

Stenseth, N. C. Response and adaptation of animals to the rapid global change. *8th International Symposium of Integrative Zoology, Xilinhaote City, China*. 25–29 July.

Stenseth, N. C. A unified biology: six blind scientists and the elephant in the room, a parable for environmentally mediated diseases (with a focus on plague). *Visiting Lecture, Tsinghua University, China*. 5 August.

Stenseth, N. C. A unified biology: six blind scientists and the elephant in the room, a parable for environmentally mediated diseases (with a focus on plague). *The 25th Anniversary Series at NCBC, Bangalore, India*. 24 August.

Stenseth, N. C. Coevolution in multispecies communities – the Red Queen perspective. *The NCBS Tangled Bank Student Ecology-Evolution Symposium, Bangalore, India*. 26 August.

Stenseth, N. C. A unified biology: six blind scientists and the elephant in the room, a parable for environmentally mediated diseases (with a focus on plague). *Visiting Lecture, Helsinki, Finland*. 19 September.

Stenseth, N. C. SUSTAIN: One year into the project (Sustainable management of renewable resources in a changing environment: an integrated approach across ecosystems). *SUSTAIN Meeting with the Research Council of Norway*. 29 September.

Stenseth, N. C. Blue growth in the Arctic: how to move forward? *2016 Arctic Circle Assembly, Reykjavík, Iceland*. 7–8 October.

Stenseth, N. C. The Legacy of NorMER: a Nordic Platform. *The Third Annual GreenMAR Meeting at Reykjavík, Iceland*. 7–8 October.

Stenseth, N. C. CEES: a Nordic and international platform for marine research. *BioMarine Business Convention 2016, Oslo, Norway*. 21 October.

Stenseth, N. C. A unified biology: six blind scientists and the elephant in the room, a parable for environmentally mediated diseases (with a focus on plague). *12th International Yersinia Symposium, Tbilisi, Georgia*. 25–28 October.

Stenseth, N. C. We need interdisciplinary approaches for global societal challenges. *The United Nations Climate Change Conference 2016, Marrakech, Morocco*. 12 November.

Stenseth, N. C. Ecosystem dynamics, fishery and climate change: bringing Darwinian evolution, Eltonian population dynamics and genomics together into a unified biology. *Joint Meeting of the 22nd International Congress of Zoology & the 87th Meeting of the Zoological Society of Japan about "New Waves of Zoological Science in the 21st Century", Okinawa, Japan*. 14–19 November.

Stenseth, N. C. The Norwegian system of Centre of Excellence (CoE). *Møte med AP-representanter fra Stortinget, Oslo, Norway*. 28 November.

Stenseth, N. C. The zoologist Charles Elton: lemmings & hare-lynx and the start of (empirically based) population biology. *The Björn Kurtén Club Lecture, Helsinki, Finland*. 29 November.

Stenseth, N. C. Promoting research excellence: a scientist's reflections on how to widen European participation in ERC. *National ERC Support Programmes, Ljubljana, Slovenia*. 2 December.

Stige, L. C., **Kvile, K. Ø.**, **Langangen, Ø.** Zooplankton and fish: revealing key processes in predator-prey dynamics in the Barents Sea. *Annual Science Conference of the International Council for the Exploration of the Sea (ICES) 2016, Riga, Latvia*. 19–23 September.

Stubberud, M. W. The combined impact of harvesting and climate change in structured two-sex populations. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Sundby, S., Drinkwater, K. F., **Kjesbu, O. S.** Nordatlanterens våroppblomstringssystem – der hvor klimaendringene møter vintermørket. *Torsdagsseminar ved Seksjon for oseanografi og klima, Bergen, Norway*. 30 March.

Sundby, S., **Kristiansen, T.** Fish egg – perfect sphere, perfect physical attributes. *2nd NorCoast Workshop, Geilo, Norway*. 25–27 October.

Svendsen, I. K., **Hansen, T. F.** Effects of climate change on biogeography. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Sætre, C. L. C. Rapid adaptive phenotypic change following colonization of a newly restored habitat. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Sørhus, E., Incardona, J. P., Furmanek, T., Scholz, N., Meier, S., **Jentoft, S.**, Edvardsen, R. Transcriptomics identifies novel adverse outcome pathways from crude oil exposure in haddock early life history stages. *SETAC 2016, Orlando, Florida, USA*. 6–10 November.

Sørhus, E., Incardona, J. P., Linbo, T., Sørensen, L., Nordtug, T., van der Meeren, T., Thorsen, A., **Jentoft, S.**, Edvardsen, R., Meier, S. Fleshing out crude oil cardiotoxicity adverse outcome pathways with transcriptomics in Atlantic haddock embryos. *SETAC 2016, Orlando, Florida, USA*. 6–10 November.

Toljagic, O. Diversification dynamics driven by morphological adaptations. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Tsuboi, M. Evolution of brain body allometry: insights from a comparison across six vertebrate classes. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

van der Meeren, G. I., Storeng, A. B., von Quillfeldt, C., **Ottersen, G.**, Arneberg, P. The Norwegian ecosystem-based management plan for the Barents Sea; strengths, flaws and further developments. *PAME EA Conference, Fairbanks, Alaska, USA*. 23–25 August.

van Leeuwen, C. Migration dependent fitness in a freshwater salmonid. *Advances in the Population Ecology of Stream Salmonids IV, Girona, Spain*. 25–29 May.

Varadharajan, S. Whole genome duplication in salmonids. What to do with all those extra, duplicated genes? *CEES Annual Student Conference 2016, Norway*. 22–23 November.

Vindenes, Y. Individual variation and eco-evolutionary dynamics: towards more flexible model frameworks and new applications. *OIKOS Per Brink Thematic Symposium, Turku, Finland*. 1–4 February.

Vindenes, Y., **Langangen, Ø.**, Winfield, I. J., **Vøllestad, L. A.** The relative impacts of early life conditions and maternal size effects in determining average fitness and population growth of pike. *Annual Science Conference of the International Council for the Exploration of the Sea (ICES) 2016, Riga, Latvia*. 19–23 September.

Vøllestad, L. A. Understanding contemporary evolution in grayling *Thymallus thymallus*. *Seminars on Fish in Rivers, Karlstad, Sweden*. 21 January.

Vøllestad, L. A. Økologiske konsekvenser av kultivering? *Oppstartsmøte om kultivering og innlandsfiskeforvaltning i Akershus og Oslo, Oslo, Norway*. 10 February.

Vøllestad, L. A. Is it possible to give highly effective lectures? *Spring Symposium 2016, Institute of Basic Medical Sciences, University of Oslo, Norway*. 12 May.

Vøllestad, L. A. Dødelighet i kystsonen og i havet. Hvor blir laksen av. *Forskermøte, Lysaker, Norway*. 30 August.

Vøllestad, L. A. Population differentiation and life history diversification: rapid and small scale? *Annual Science Conference of the International Council for the Exploration of the Sea (ICES) 2016, Riga, Latvia*. 19–23 September.

Worku, E. A. Behavioral ecology and conservation status of the endangered mountain nyala (*Tragelaphus buxtoni*) in Arsi and Ahmar Mountains, Ethiopia. *CEES Annual Student Conference 2016, Norway*. 22–23 November.

10 APPENDICES

Posters

(Sorted alphabetically by speakers, then by date)

Boessenkool, S., Hanghøj, K., **Nistelberger, H. M.**, Der Sarkissian, C., **Gondek, A. T.**, Orlando, L., Barrett, J. H., **Star, B.** Combining bleach and mild pre-digestion improves ancient DNA recovery from bones. *7th International Symposium on Biomolecular Archaeology (ISBA7), Oxford, United Kingdom*. 14–16 September.

Brandrud, M. K., Paun, O., Nordal, I., Lorenzo, M. T., **Brysting, A. K**. Polyploid and ecological adaptation in *Cochlearia* L. (Brassicaceae) in northern Norway. *International Conference on Polyploidy, Hybridization and Biodiversity, Rovinj, Croatia*. 11–14 May.

Enevoldsen, E., Boeve, J., Orr, R., Waeschenbach, A., **Liow, L. H.** Advancing bryozoan phylogenetics: mitochondrial and nuclear genes. *International Bryozoology Association Meeting, Melbourne, Australia*. 10–15 April.

Fagerli, L. A. L., Bårdsen, B.-J., **Brysting, A. K.**, **Nielsen, A.** Plant-pollinator interactions along an elevation gradient in northern Norway. *Annual Meeting of the Scandinavian Pollination Ecologists (SCAPE), Abisko, Sweden*. 13–16 October.

Färber, L. A., **Stige, L. C.**, **Durant, J. M.**, **Diekert, F. K.**, **Langangen, Ø.** Ticket to spawn – using economic data to shed light on biological hypothesis. *ICES Annual Science Conference, Riga, Latvia*. 19–23 September.

Gomez Munoz, M., **Namouchi, A.**, Balasingham, S., Tonjum, T. Identifiying ncRNAs expressed under genotoxic stress and dormancy in *Mycobacterium tuberculosis*. *EMBO Practical Course – Non-coding RNA in Infection, University of Würzburg, Germany*. 18–24 September.

Helmerson, C. J. M. T. Genetic structure of the Northeast Arctic cod: impact of climate change? *MARmaED Annual Meeting & T-MARmaED 1, Banyuls-sur-Mer, France*. 24 May.

Ingvild Fonn, A., Devoto, M., **Nielsen, A.** Pollination of soybean (*Glycine max*) in Argentina. *Annual Meeting of the Scandinavian Pollination Ecologists (SCAPE), Abisko, Sweden*. 13–16 October.

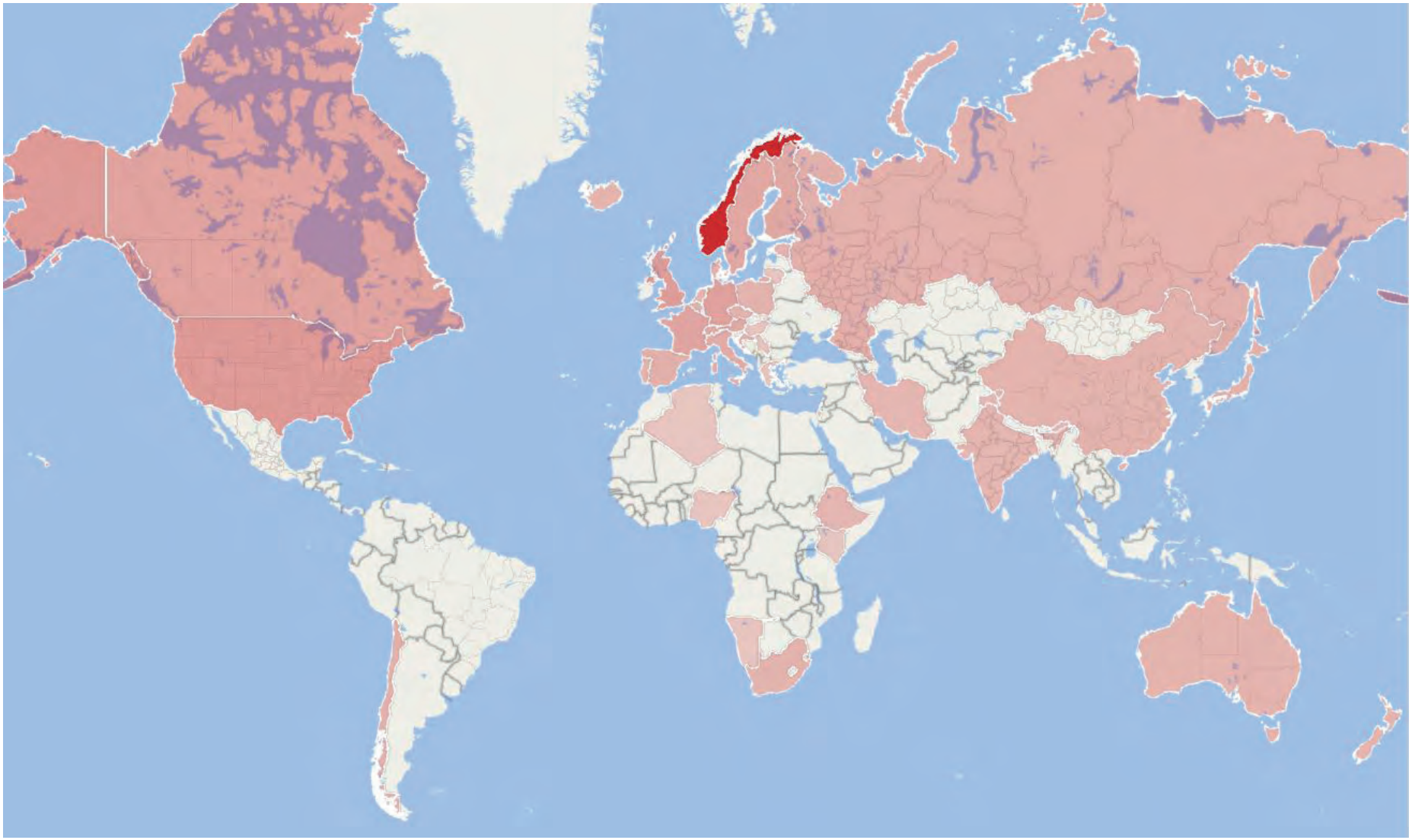
Nistelberger, H. M., Smith, O., Wales, N., **Star, B.**, **Boessenkool, S.** High throughput sequencing of charred archaeobotanicals – a cautionary tale. *7th International Symposium on Biomolecular Archaeology (ISBA7), Oxford, United Kingdom*. 14–16 September.

Star, B., **Boessenkool, S.**, **Gondek, A. T.**, Nikulina, E. A., Barrett, J. H. Viking Age trade of Atlantic cod. *7th International Symposium on Biomolecular Archaeology (ISBA7), Oxford, United Kingdom*. 14–16 September.

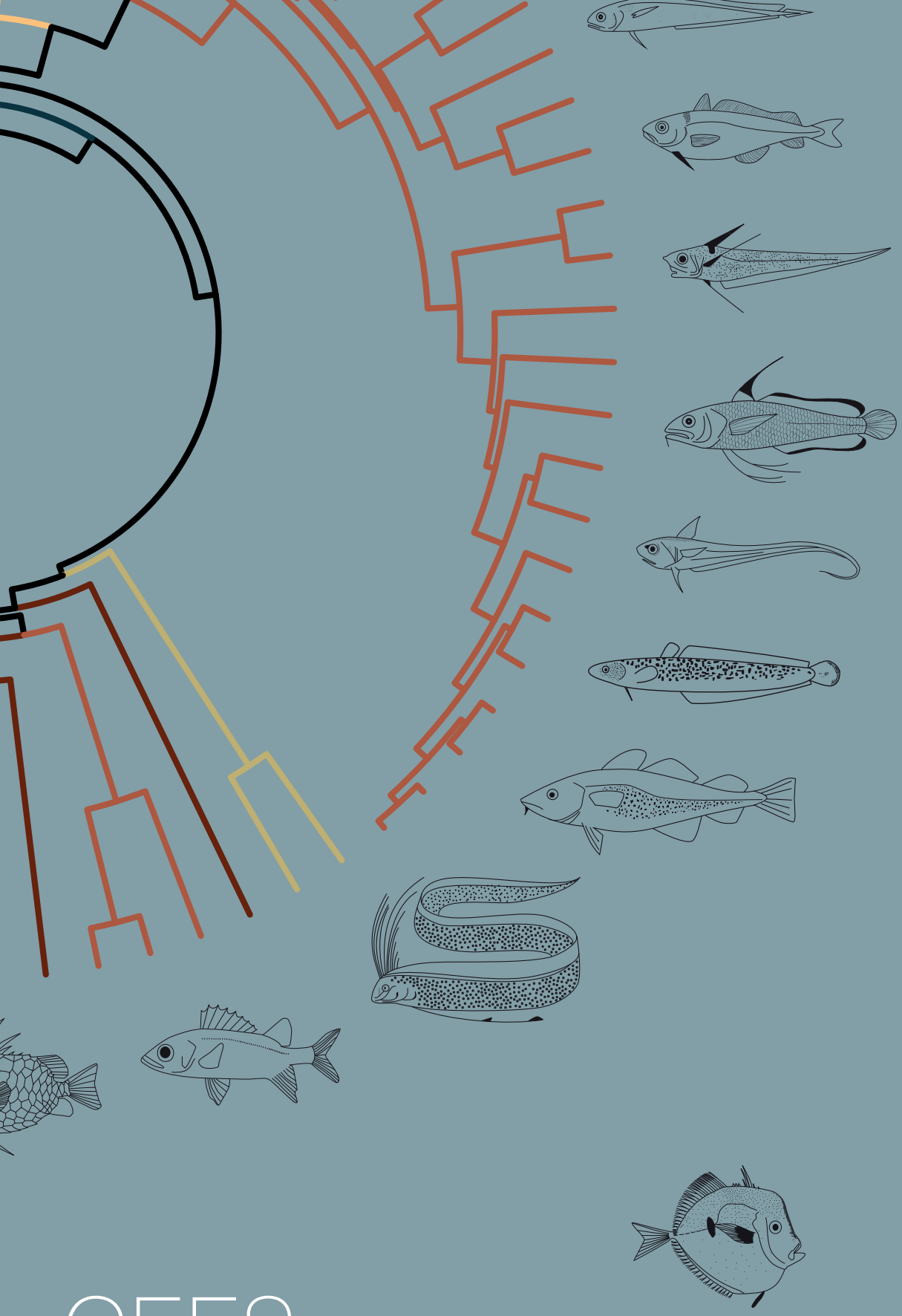
Steinbakk, G. H., Thorarinsdottir, T. L., **Reitan, T.**, Schlichting, L., Hølleland, S., Engeland, K. Propagation of rating curve uncertainty in design flood estimation. *European Geosciences Union (EGU) General Assembly 2016, Vienna, Austria*. 17–22 April.

Stige, L. C., **Kvile, K. Ø.**, **Langangen, Ø.** Zooplankton and fish: revealing key processes in predator-prey dynamics in the Barents Sea. *ICES/PICES 6th Zooplankton Production Symposium, Bergen, Norway*. 9–13 May.

Sætre, C. L. C. Range shifts and adaptation. *Workshop SIBE (Inferring Natural Selection from Genomic Data), Ferrara, Italy*. 16–18 December.



Map showing the countries of authors who CEES co-authored publications with in 2016 (according to the authors' affiliations stated in the publications). The darker the red, the more publications. The map only includes those publications regarded as scientific according to the Norwegian Scientific Index (NVI) system (141 in total).



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