European
MARINE BOARD
Advancing Seas & Oceans Science

4TH EUROPEAN MARINE BOARD FORUM

# ARCTIC 2050
# Towards ecosystem-based management in a changing Arctic Ocean

12 March 2014, Brussels, Belgium



## PROCEEDINGS

*“At present we are unprepared for the environmental and societal implications of increased human access to the Arctic that will come with the receding ice… We have not fully anticipated the consequences of an increase in activities like hydrocarbon exploration, mineral extraction, bioprospecting and pelagic and demersal fisheries.”*

Peter Haugan, European Marine Board Vice-Chair



www.marineboard.eu

# European Marine Board profile

*European Marine Board provides a pan-European platform for its member organizations to develop common priorities, to advance marine research and to bridge the gap between science and policy, in order to meet future marine science challenges and opportunities.*

The European Marine Board (established in 1995) facilitates enhanced cooperation between European organizations involved in marine science (research institutes, research funding bodies and nationally-based consortia of third-level institutes) towards development of a common vision on the research priorities and strategies for marine science in Europe. In 2014, the European Marine Board represents 36 member organizations from 19 countries.

The European Marine Board provides the essential components for transferring knowledge from the scientific community to decision makers, promoting Europe's leadership in marine research and technology. Adopting a strategic role, the European Marine Board provides a unique forum within which marine research policy advice to national agencies and to the European institutions is developed, with the objective of promoting the establishment of the European marine Research Area.

The European Marine Board operates in association with the European Science Foundation (www.esf.org).

**www.marineboard.eu**

# KEY MESSAGES FROM THE 4TH EUROPEAN MARINE BOARD FORUM



On 12 March 2014, representatives of 64 organizations gathered at the 4th European Marine Board Forum in Brussels to discuss how to best manage the consequences of a changing Arctic Ocean. The European Marine Board convened this flagship event in collaboration with the European Polar Board, working in association with the European Science Foundation, in the knowledge that industry and science must work together to achieve sustainable management of resources such as fishing and oil and gas exploration while at the same time, protecting and conserving the Arctic environment. The 4th European Marine Board Forum, recognized as an official ICARP III event (Third International Conference on Arctic Research Planning), promoted the need for an ecosystem-based management approach in the Arctic Ocean, in order to adapt to and manage rapid environmental change and commercial exploitation.

Dramatic changes, largely attributed to anthropogenic activity, have taken place in the Arctic in recent decades. These changes include melting of glaciers and sea ice, altered oceanic current patterns, movement and accumulation of contaminants and range shifts in many species. As a result of these changes the Arctic region is being transformed, with wide-ranging impacts and opportunities including the potential for ice-free shipping routes in the future, increased activity in oil and gas exploration, changes to Arctic fisheries and biodiversity, and impacts on residents' livelihoods.

Moderated by David Shukman, BBC Science Editor, forum sessions included sessions on 'Living with a Changing Arctic Ocean', 'Arctic Ocean Observation' and 'Utilizing and Managing Arctic Ocean Resources'. Forum participants stressed the need for industry and science to work together, with the main priorities requiring collaboration identified as concerted data collection and analysis, which would contribute to sustainable management of the Arctic Ocean by providing data for mitigating the impacts and addressing the opportunities posed by current environmental changes in the region.

Five key messages emerged as a result of the presentations and discussions that took place over the course of the 4th European Marine Board Forum.

## Key Messages from the 4th European Marine Board Forum

- A strategic plan for data collection in the Arctic Ocean is urgently needed, along with new observation technologies .
- Developing a marine spatial plan for the Arctic is necessary for managing marine and maritime activities, e.g. shipping and resource extraction, as well as protecting biodiversity hotspots.
- More effective use must be made of local and traditional knowledge by engaging Indigenous communities in citizen science for data collection and ecological management.
- Arctic Ocean research investment requires multidisciplinary and cross-sector partnerships for securing long-term strategic funding.
- With the Arctic being perceived as a new market by the shipping industry, associated activities like maritime trade, tourism and transport are likely to emerge faster than the necessary infrastructures for safe, secure and reliable shipping in the Arctic Ocean. Therefore, it is critical to anticipate infrastructure changes in the Arctic rather than respond to them.







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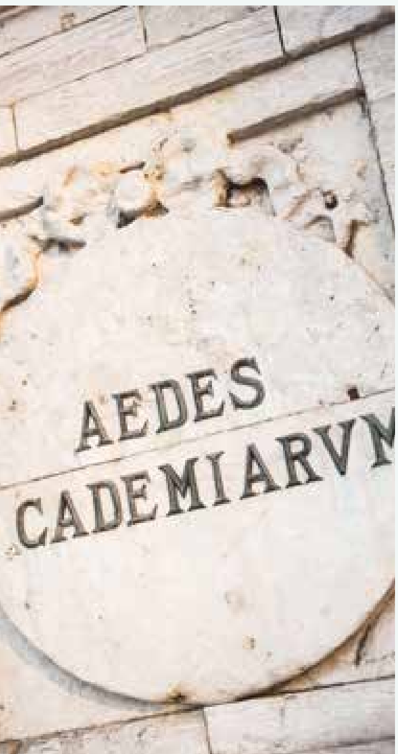
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# EUROPEAN MARINE BOARD FORUM SERIES



**The European Marine Board Forum** brings together European marine research stakeholders, representatives of the marine science community, funding agencies and national and European science institutions, to advance research and to promote marine science in Europe and globally. In line with this objective, the European Marine Board Forum provides a platform for European Marine Board members, partner organizations, individual scientists and European and national policymakers to interact on a particular topic or theme of strategic importance for European marine science. For each selected topic or theme, the European Marine Board Forum aims to:

- Provide a focal meeting point for discussion among individual scientists, policymakers and other relevant stakeholders;
- Facilitate the exchange of information and ideas and agree a common position;
- Enhance collaboration and reduce fragmentation and/or duplication in the European research effort.

The main messages, discussions and decisions from European Marine Board fora are recorded and published as proceedings. Presentations and outputs of the three European Marine Board fora are available on the European Marine Board website: **www.marineboard.eu/fora**

The **1st Forum in 2008** ***(Marine Data Challenges: from Observation to Information)*** brought together representatives of some of the key European marine observation and data centres, researchers, national and European policymakers and data end-users from the maritime and offshore industries. The Forum's discussions contributed to the development of the European Marine Observation and Data Network (EMODnet) initiative launched by the European Commission. Furthermore, the Forum led to a joint Marine Board – EuroGOOS publication on EMODnet.

The **2nd Forum in 2010** ***(Towards a European Network of Marine Observatories for Monitoring and Research)*** emphasized the need for long-term time series data, which can best be provided by a coherent European network of marine observatories to support monitoring and research. These form a crucial component of the ocean observing system and the original end-to-end EMODnet.

The **3rd Forum in 2012** ***(New Technologies for a Blue Future)*** highlighted innovation hotspots for the European marine sector, showcasing emerging technologies for driving growth, novel applications for human wellbeing and tools for next generation marine knowledge.

Dramatic changes, largely attributed to anthropogenic activity, have taken place in the Arctic in recent decades. These changes include melting of glaciers and sea ice, altered oceanic current patterns, movement and accumulation of contaminants and range shifts in many species. As a result of these changes the Arctic region is being transformed, with wide-ranging impacts and opportunities including the potential for ice-free shipping routes in the future, increased activity in oil and gas exploration, changes to Arctic fisheries and biodiversity, and impacts on residents' livelihoods. The **4th Forum** ***(Arctic 2050: Towards ecosystem-based management in a changing Arctic Ocean)***, held on 12 March 2014, Brussels, brought together experts from academia, industry and policy from 64 organizations to discuss how to best manage the consequences of a changing Arctic Ocean.

The 4th Forum highlighted the need for industry and science to work together, with the main priorities requiring collaboration identified as concerted data collection and analysis, which would contribute to sustainable management of the Arctic Ocean by providing data for mitigating the impacts and addressing the opportunities posed by current environmental changes in the region.

All documents and materials from the Forum are available online at:
**http://www.marineboard.eu/4thforum**

# 4TH EUROPEAN MARINE BOARD FORUM

## Programme



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| Moderator | David Shukman, BBC Science Editor, UK |
| **08.20** | **Registration & welcome coffee** |
| **09.00** | **Opening statements** |
| | **Peter Haugan,** Vice-Chair, European Marine Board |
| | **Harald Loeng,** Chair, European Polar Board |
| | **Naja Mikkelson,** Geological Survey of Denmark and Greenland / Third International Conference on Arctic Research Planning (ICARP III) |
| **09.20** | **David Shukman,** Moderator's introduction |

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| **Session 1. Living with a Changing Arctic Ocean** | | |
| 09.30-09.55 | ***Ice2Sea: Glacier melting and Sea level rise from the European Perspective*** | **David Vaughan,** British Antarctic Survey (BAS) |
| 09.55-10.20 | ***Records of past and present contamination in the Arctic*** | **Carlo Barbante,** Institute for the Dynamics of Environmental Processes, Italian National Research Council (CNR) |
| 10.20-10.45 | ***Footprints of climate change in Arctic marine ecosystems*** | **Paul Wassmann,** University of Tromsø |
| 10.45-11.00 | ***Discussion*** | |
| **11.00-11.30 Networking & coffee** | | |
| **Session 2. Arctic Ocean Observation – the key to sustainable management** | | |
| 11.30-11.50 | ***Tracking Arctic sea ice loss*** | **Stein Sandven,** European Space Agency (ESA) – Climate Change Initiative on Sea Ice |
| 11.50-12.10 | ***Arctic biodiversity assessment: from plan to action during times of rapid environmental change*** | **Kári Fannar Lárusson,** Arctic Council, Conservation of Arctic Flora and Fauna (CAFF) |
| 12.10-12.30 | ***Arctic Seafloor Observatories*** | **Antje Boetius**, Alfred Wegener Institute for Marine and Polar Research (AWI) |
| 12.30-12.45 | ***Discussion*** | |
| **12.45-13.45 Lunch** | | |
| **Session 3. Utilizing and managing Arctic Ocean resources** | | |
| 13.45-14.10 | ***Arctic fisheries – present shifts and future perspectives*** | **Paul Connolly,** President, International Council for the Exploration of the Sea (ICES) |
| 14.10-14.35 | ***The Industry perspective of Arctic Oil and Gas Exploration*** | **Robert Blaauw,** Shell Den Haag and International Association of Oil and Gas Producers (OGP) |
| 14.35-15.00 | ***Arctic Shipping*** | **Paul Berkman,** University of California |
| **14.35-15.00 Networking & Coffee** | | |
| 15.00-16.15 | ***Panel Discussion:***<br>***Can industry and science work together to achieve sustainable management of the Arctic Ocean?***<br>***David Vaughan,*** British Antarctic Survey (BAS)<br>***Robert Blaauw***, Shell Den Haag and International Association of Oil and Gas Producers (OGP)<br>***Paul Berkman***, University of California, Santa Barbara<br>***Kurt Vandenberghe***, European Commission DG Research and Innovation<br>***Karin Lochte***, Alfred Wegener Institute for Marine and Polar Research (AWI)<br>***Martha McConnell***, International Union for Conservation of Nature (IUCN)<br>***Peter Pissierssens***, Intergovernmental Oceanographic Commission of UNESCO, Project Office for International Oceanographic Data and Information Exchange (IODE) | |

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|---|---|
| **16.15-16.30** | **Final Statements and Closing Remarks** |
| **16.30** | **End of Forum** |

# 4TH EUROPEAN MARINE BOARD FORUM

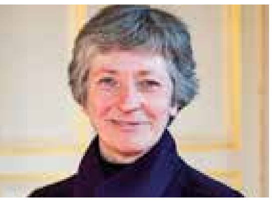
## Opening Statements



*The challenges presented by a changing Arctic region and future directions for research and industry were the subject of the opening addresses of the 4th EMB Forum which were given by* ***Peter Haugan (European Marine Board vice-Chair, University of Bergen, Norway), Harald Loeng (European Polar Board Chair, Institute of Marine Research, Norway) and Naja Mikkelson (ICARP III, Geological Survey of Denmark and Greenland).***

**Peter Haugan** opened the Forum by welcoming all participants and speakers. He commended the European Marine Board and its strong secretariat for organizing the event together with the European Polar Board and used it to illustrate the European Marine Board's fruitful association with the European Science Foundation. Peter Haugan emphasized the opportunity for increased marine research in the Arctic region as a result of receding ice, stating that, *"The Arctic is becoming more marine offering new opportunities for marine scientists to investigate this ever changing system."*

**Harald Loeng** stayed with the theme of opportunity and challenge afforded by a changing Arctic with his statement, *"The rapid changes observed in the Arctic are a clear indication of future impact to environment and industry that pose both challenges and opportunities."* He pointed to Horizon 2020 as a suitable mechanism with which to address Arctic issues and highlighted the importance of trans-Atlantic cooperation to ensure that world-class research can be carried out in the Arctic region.



**Naja Mikkelson** spoke about the importance of prioritising research in the Arctic and how the forum's findings will be brought forward through ICARP III which *"aims to show future directions of Arctic research in a global context."*

# Moderator's Introduction



**David Shukman, BBC Science Editor**, introduced himself as moderator and stated what a pleasure it was to be at the Arctic Forum among people so interested in Arctic issues. He recounted his personal impressions of change in the Arctic based on three trips that he made with the BBC. On these trips he saw evidence of human pollution, contemplated the increase in access to the Arctic region and the nature of global warming, and witnessed a society divided on the benefits of increased opportunities for development in the Arctic region.

On his first trip to Greenland, while observing a glacier from a helicopter, David was surprised to see that the surface of the ice sheet was dark in colour due to trapped soot. This was as a result of human pollution. A few years later, David was on a Canadian research ice breaker travelling through the Northwest Passage. He recounted that for 400 years the Royal Navy tried to find a way through and it was the Norwegians who were the first to sail the Northwest Passage. Although the European Space Agency noted that there was not much ice that year, they encountered much ice on the trip, which led David to reflect on the complicated nature of global warming. He noted that it does not take the form of an instant change, but is a steady change.

On his third trip, David went to the north coast of Alaska where there is potential for expansion of the oil industry. Speaking to the people there, he found that society was divided on whether expansion due to the oil industry was a good or a bad idea. With potential positive and negative impacts, such as an increase in jobs and interruptions to the migration of bowhead whales in the region, David posed the question of how society should decide whether to exploit resources, safeguard them or how we find a way of doing both.

*"There is evidence of steady change in the Arctic and no question the trends are there. We now need to look at what the science is telling us, what resources are likely to be exploited and how we handle these for a sustainable future."*

David Shukman, BBC Science Editor

# SESSION 1

## Living with a Changing Arctic Ocean



*Chair: David Shukman (BBC Science Editor)*

## Ice2Sea: Glacier melting and Sea level rise from the European perspective

**David Vaughan (British Antarctic Survey, UK)** presented Ice2Sea, an EU funded project which focused on the future contribution of glaciers to sea level rise.

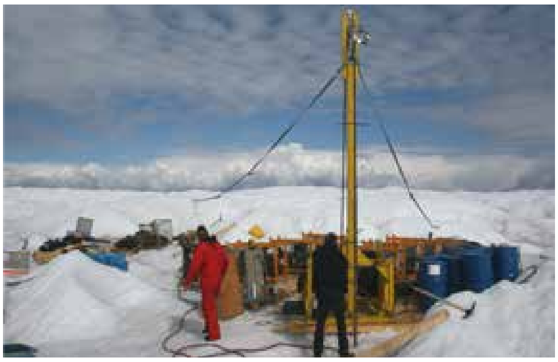
As the basis for the Ice2Sea project, David explained that sea level rise is the result of multiple contributors including ice melting; changes in salinity and the thermal structure of the oceans; on a regional basis, vertical land movements and changes in ocean dynamics; terrestrial storage of water in reservoirs and groundwater; inland seas losing water and; reservoirs being generated that contain water from the oceans. Each of these contributors need to be understood in their entirety if we are going to be able to project sea level rise effectively.

In the past century there has been a strong increase in the rate of sea level rise, with most recent satellite data showing a rise of about 3 mm per year for the past 2 decades, although not occurring equally across the globe. This poses a threat to vulnerable environments on the European coastline, such as the machair habitats on the west coasts of Ireland and Scotland, as well as to the substantial capital investments on our coastlines, such as Sizewell B nuclear power station on the Suffolk coast of the UK, that need to be protected from flooding.

*"In addition to thermal expansion of the oceans, ice melt in the Arctic will become an increasingly dominant factor in sea level rise into the future… our projections need to be accurate as they will be applicable over a long time."*
David Vaughan, British Antarctic Survey, UK

The Ice2Sea project was developed in response to the vacuum of information highlighted in the IPCC's fourth assessment report in 2007 regarding current contributions of ice sheets to sea level rise. As a result, there were many different projections of the rates of sea level rise expected by 2100, with some projections based on physical data and extrapolations based on past temperature and sea levels.

Ice sheets are one of the contributors to sea level rise.
*Credit: Hans Oerter*



Fieldwork at Russell Glacier, Greenland

*Credit: Paul Smeets, University of Utrecht*

The objective of the Ice2Sea project was to build a physical basis and computer simulations to allow projection of ice sheet change. This required field work and process studies to increase the knowledge on which the models would be based. For example, sensors were placed at the bottom of Greenland's Russell Glacier to assess the rate at which surface melting affects the total speed of the ice flow, which is one of the mechanisms that's expected to increase outflow from ice sheets in the future. As a result of this fieldwork, the project produced a very clear set of parameterisations that show how, with increasing surface run-off, the flow speed of the glacier accelerates. Physically-based projections of ice loss from Greenland, Antarctica and the global population of glaciers were produced over the course of the project.

Ice2Sea also investigated the factors driving ice sheet change. It is expected that for all of Antarctica and at least 50% of Greenland, changes in the ocean, including both warming of water masses and changes in direction of flow that allows warmer water to be brought towards the ice and to increase the rate at which ice is melting, will have the strongest impact on ice sheet loss. Consequently, the projections for the future are that there will be big changes to the rate at which heat is delivered to ice.

The Ice2Sea project built a new generation of ice sheet models and for the first time we are beginning to understand the ice fracturing processes that lead to iceberg formation and how they might be responsive to atmospheric climate change in the future. The main number produced as a result of projections was that the global contribution of continental ice to sea level rise for a mid range climate change scenario would be in the range of 3.5-36 cm by 2100.

Moving from a global to a regional level, Ice2Sea also investigated a set of ports around Europe to see how the one in 50 year storm surge will increase in the future, estimated using contributions from changes in the storm surge climate, ice melt, thermal expansion and the associated ocean dynamics, and vertical land movement at each site. There is an identified need for future IPCC reports to attain a higher level of specificity about regional sea level rise. We need good projections of storm heights and statistics for sea defence planners around our coasts.

Overall, the results of the Ice2Sea project have contributed to a big step forward in our current and future understanding of sea level rise and although uncertainties remain, they have been significantly reduced.

## Records of past and present contamination in the Arctic

**Carlo Barbante (Italian National Research Council, Italy)** spoke about pollutants present in the Arctic region that are largely emitted at lower latitudes and then transported to northern regions.

Carlo explained how global warming affects the presence and concentration of pollutants in the Arctic. For example, methane is one of the most powerful greenhouse gases, high quantities of which are stored in Arctic soils and in marine sediments. As temperature increases, methane is released via a positive feedback mechanism whereby an increase in temperature leads to an increase in the release of methane which in turn contributes to a further increase in temperature. For other pollutants, there are several pathways by which they are transported in the environment and reach the Arctic. Most pollutants are emitted in lower latitudes and are transported to the Arctic region through the Pacific and Atlantic oceans, through river inflow and through the air. In the case of persistant organic pollutants (POPs), their relatively high concentration in the Arctic is explained by an efficient low to high latitude transport effect known as the grasshopper effect, whereby light volatile compounds are transported through the air in the gaseous phase and are released through condensation in the cooler temperatures of northern regions.

*"Most of the pollutants produced in lower latitudes are transported through the Pacific and Atlantic and accumulate in the Arctic region... Ice melt will result in a blast from the past with the release of high concentrations of chemicals from previous decades of human impact"*
Carlo Barbante, Italian National Research Council, Italy

Contaminants emitted in lower latitudes accumulate at higher latitudes in the biosphere and enter the food chain. Contaminants such as POPs, metals and mercury undergo biomagnification through the food chain, exceeding background concentrations obtained through diet in Arctic fauna. This results in high concentrations of metals and organic pollutants in tissues of whales, seals and polar bears. As a food source for indigenous people, Arctic communities are exposed and particularly vulnerable to these pollutants.

Arctic fauna such as the walrus can accumulate contaminants in their tissues due to biomagnification through the food chain.
*Credit: Jens Kube*

Ice acts as a reservoir for contaminants and can be analysed to reconstruct the pollution record.

*Credit: Jens Kube*

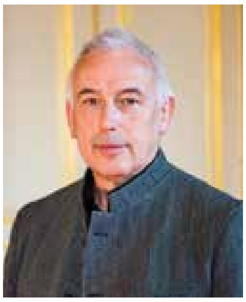
There has been much recent effort to collect data on contaminants in the Arctic. However, considerable gaps remain in relation to time-series data. In the past we did not realize we were emitting such substances and until recently, analytical methods did not exist for many of these contaminants.

However, analysis of ice cores allows us to reconstruct the pollution record as ice records the atmosphere of the past and acts as a reservoir for contaminants. Through examining ice in Greenland dating back 200 years, large amounts of black carbon are observed which is representative of coal. There is an increase in this black carbon over the beginning of the last century. Different patterns are also apparent in the ice. For example, there is an increase in sulphur dating from the 1950s and 1960s due to oil combustion. This pattern decreases and increases, corresponding with gasoline use.

Looking to the future and the consequences of global warming for pollutants in the Arctic region, increased melting events will result in the release of legacy contaminants that are currently stored in ice sheets. This will lead to higher concentrations of contaminants such as copper and polychlorinated biphenyls (PCBs) in the Arctic. Although our use of some legacy pollutants has decreased in recent years, they are being replaced with emerging contaminants, which refers to new chemicals being emitted into the environment and for which data on their toxicity and environmental effects is still lacking.

To conclude, Carlo reiterated that climate change is influencing the occurrence, transport and pathway of contaminants into the Arctic, representing one of the hidden effects of climate change. He called for an improvement in our observations and our capacity to observe the system via data collection, climate modeling and environmental modeling.

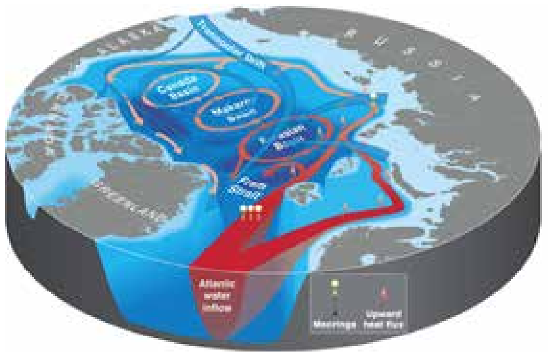
# Footprints of Climate change in Arctic Marine Ecosystems



**Paul Wassmann (University of Tromsø, Norway)** talked about ecosystem-based management for the Arctic Ocean. He stated that at the moment we are unable to afford such management because we do not know enough about the Arctic, but if Europe prepares for it now, we can achieve this goal in the European Arctic Corridor by 2050.

As background, Paul explained that the European Arctic corridor controls much of the Arctic marine climate. In fact, 90% of water exchange to the Arctic takes place in the European side; 60% of the primary production in the Arctic takes place in the European side and; it probably has the best managed fish stocks. It is important to note that Atlantic water inflow dominates much of the Arctic climate.

Previous work that Paul has been involved in determined 51 examples of 'marine Arctic footprints of climate change'. Paul pointed to the difficulties of identifying evidence of climate change in understudied parts of the Arctic due to a lack of investigation prior to the rapid changes taking place which makes it difficult to determine if changes are due to climate change or variability. Consequently, *"the Arctic Ocean with the world's greatest climate change is also the least investigated ocean."*




The Atlantic Ocean has a large influence on the Arctic Ocean via the European Arctic corridor.

*Credit: Paul Wassmann*

An important consideration is to determine how much of a temperature rise is needed before the Arctic ecosystem experiences: a tipping point, where the future state of the system is qualitatively altered or; the point of no return, at which time an irreversible regime shift takes place. Good time series data are needed to both determine and anticipate tipping points. An analysis of data for sea ice cover identifies a clear tipping point in 1996. Previous to this, an approach towards this tipping point could be seen in 1990 when the interannual variability of the sea ice doubled. There may also have been a tipping point in 2007. Experimental approaches can also be used to determine tipping points, for example by analyzing chlorophyll concentration in relation to temperature rise, the response of bacterial production to increasing temperature, and net community production and community respiration in response to rising sea temperatures in the Arctic, giving a tipping point of between a rise of 5 - 6°C in surface water.

Anticipating changes to primary productivity with a decrease in ice based on modeling and current knowledge, it is predicted that there will be decreases in primary productivity in the Norwegian, Svalbard and east Greenlandic seas by 2100 and an increase of 55% in the Russian zone due to an increase in warming of the surface layer.

Arctic landscape
*Credit: Anne Hormes*

> *"Climatic changes are accompanied by new infrastructure, new industries, new pollution sources: cumulative effects are notoriously difficult to predict…You cannot manage an ecosystem that you do not measure and understand."*
> Paul Wassmann, University of Tromsø, Norway

Regarding the challenges in predicting future scenarios and the reliability of ecosystem models, Paul emphasized that ecosystem models have predictive power when a system is close to equilibrium but lose their predictive power when a system is out of equilibrium. Therefore, science is not able to predict future states of extremely changing ecosystems. The extent of change is outside our 'empirical window' because we do not have historical analogies for what is currently taking place. Therefore, we are not making predictions as such, but projections of what we think we know today into the future.

In order to increase our predictive capacity, research of Arctic ecosystems needs to change its *modus operandi* to include more extensive real-time observations than theoretical model projections including time series data for all major ecosystems of the Arctic Ocean; more long-term and continuous than short-term campaigns and programmes and; more holistic and ecosystem-based than fragmented and indicator based programmes.

The gold standard for managing rapidly changing ecosystems involves determining an appropriate model and hypothesis on which predictions are based, designing observation and management and collecting, analyzing and interpreting data. This process leads to updated knowledge which is used to improve the model and hypothesis. Management is informed of what measures they should take according to what has been predicted. Feedback is sought from management on design and management of observations. This is an iterative process to improve the management and the model. At every round publication and outreach is required to illustrate what has been found and what has been changing.

Based on the approach above, ecosystem-based management in the future requires competence, multidisciplinarity and partnerships.

# Session 1 - Q&A



**Paul Tréguer** (Ifremer, France) asked Paul to explain the predicted increases in primary production considering that the Arctic Ocean is a nutrient limited system. **Paul Wassmann** answered that primary production is governed by light and nutrients. Therefore, the retreat of ice leads to more light and nutrient production, leading to an increase in primary production. In addition, shelf breaks induce upwelling of nutrients to the surface. Paul explained that primary production will not increase vastly in Arctic, but in some places it will clearly increase. He continued to explain that due to thermal stratification, in the central Arctic, there is no major increase in primary production. Regarding Atlantic waters which are currently highly productive, thermal stratification will increase and decrease today's high primary production.

**Gilles Lericolais** (Ifremer, France) commented on the lack of understanding regarding how the paleoclimate enhances our understanding of climate change factors in relation to sea level rise and that we need to assess Arctic change in the context of long-term geological cycles such as the Milankovitch cycle. Gilles also mentioned that it is important that we consider and discuss how ice melting in the Arctic will effect changes to features such as the jet stream. **Carlo Barbante** agreed that understanding the past is the key to the future and that we need to better understand how climates reacted in the past to changes in CO2, methane and temperature for example, to understand what will happen in the future. **David Vaughan** also agreed that the past paleo data informs what we will see in the future. Past data shows that Earth is a sensitive system that responds to changes.

**Denis Hamro-Drotz** (Alleco, Finland) asked **Carlo Barbante** how local communities could be integrated into data collection. Carlo Barbante noted that at present indigenous people are not being involved in data collection at research centres in the Arctic but that their expertise is needed. They could be involved in measurements of sea ice extension for example and their historical data would be very valuable. As they are living in the Arctic they observe more than researchers who can only go to the Arctic occasionally.

**Torgeir Edvardsen** (OECD, France) asked Paul Wassmann to substantiate his omission of economists with regard to contributing to ecosystem-based management in the Arctic. **Paul Wassmann** replied that economists are not needed for management of an ecosystem. However, economists need the management to be in place. Economists need sustainability and management reports before action.

**Jon Fuglestad** (Arctic Monitoring and Assessment Programme, Norway) asked for Carlo Barbante's thoughts on the use of environmental specimen banks to monitor emerging contaminants. **Carlo Barbante** replied that he is very much in favour of an ice core bank for future studies, noting that there are aspects we do not measure today because we don't have the analytical methods. For example, ice and snow store a lot of viruses and bacteria that we are not analysing at present. Specimen banks are a very useful way to store such samples for the future. He also noted that more coordination of existing specimen banks is necessary.

# SESSION 2

## Arctic Ocean Observation-the key to sustainable management



*Chair: David Shukman (BBC Science Editor)*

## Tracking Arctic sea ice loss

**Stein Sandven (European Space Agency, Norway)** spoke about a series of sea ice parameters used to estimate the extent of sea ice and predict when we can expect a nearly ice-free Arctic.

To understand sea ice processes, data from a range of sources is required including satellite observations and various climatic parameters such as ocean and atmospheric temperatures. Sea ice processes are sensitive, reflecting a balance between freezing and melting due to atmospheric processes such as radiation from the sun providing heat and surface properties such as albedo. For example, the presence of soot on ice is a critical parameter because as soot increases, albedo is reduced. In short, to understand the freezing and melting of ice we need to understand heat exchange with the ocean and atmosphere.

Regarding the observations that we do have of the Arctic region, the longest climate records come from air temperature measurements, recorded for over 100 years in some places. With this data it's possible to generate century-long time series of air temperature around the Arctic. The data demonstrates warming in the 1920s and '30s, followed by cooling in the 50's, 60's, 70's, and warming in the last decades.

Climate models are an important tool to learn about the climate system but their quality must always be questioned. An example is the Bergen climate model, a Norwegian earth system model developed in the last 10 years to simulate global climate. It is one of the IPCC models used for climate assessment, the results of which are compared to other models to make projections. By comparing climate models, the IPCC evaluates how robust the climate predictions are. In terms of projecting temperature change in the Arctic, there are many uncertainties and it is difficult to judge which models are best. However, a number of papers have assessed climate predictions for the Arctic with the result that there are certain conclusions that are robust and others that are not so certain.

*"By 2050 most models show that ice in the Arctic will be less than a million km$^2$ but many other models show later ice free conditions… The questions to be asked of climate models are always, how good and how realistic are the models."*
Stein Sandven, European Space Agency, Norway

Measurement of sea ice extent in the Arctic from 30 years of satellite data shows a characteristic seasonal cycle with stronger reduction of sea ice in the summer. The data also demonstrates large variability in minimum ice cover. It is this seasonal cycle which gives rise to the discussion of when sea ice will disappear in the summer. In 2007 the lowest ever area of ice was recorded and a similarly low measurement was made in 2012. Spatial and temporal trends in sea ice reduction can be calculated when we have time series data. Looking at 30 years of data, it can be seen that there has been a stronger decline in sea ice extent in the last 2 decades than previously.

A particular feature of Arctic sea ice is the transition from predominantly older ice cover to younger ice, in particular 1st year ice. By analyzing satellite data on age categories of ice from the early 80's, a reduction in 5 year old ice can be seen as well as a reduction in 4, 3 and 2 year old ice. On the other hand 1 year old ice is not changing largely. Antarctica is also dominated by 1st year ice.

Ice thickness is another important parameter. Data collected in the Arctic Ocean by submarines from 1975 to 2000 shows a reduction in average ice thickness from 3.4 m in 1980 to 2.3 m in 2000. Comparison of ice thickness data obtained from submarine observations, satellite measurements and models between 1988 and 2004 shows a strong reduction in ice thickness across the Arctic region. An important consideration with satellite data is the quality of the data. Therefore, uncertainty estimations should be calculated that take account of error sources.

Satellite data is used to estimate ice thickness in the Arctic

*Credit: CNR*

*Credit: D.Ducros, CNES*

A lack of data makes it difficult to have good time series information of total ice mass in the Arctic region. However, estimations of ice thickness up to 50 cm in the Arctic have been calculated using algorithms derived from SMOS (soil moisture and ocean salinity) satellite data.

Another interesting ice parameter is sea ice drift. Sea ice moves around in response to wind and currents. A comparison of trips which tracked ice drift across the Arctic Ocean in 1894, 1938 and 2006 shows that average drift is now twice as high as it was 100 years ago, representing a significant change. The reason is that as sea ice gets thinner it moves faster, being more responsive to the winds. An increase in ice drift is reported in the last IPCC report, based on data from the Arctic buoy programme dating from the 80's and satellite data from the 90's.

Regarding when a nearly sea ice-free summer can be expected in the Arctic, most models show that the area of ice in the Artic will be less than 1 million km$^2$ by 2050. However, many other models show later ice free conditions. The latest IPCC report on sea ice change estimates a decrease of sea ice extent of -3.8% per decade and an increase in the melt season of + 5.7 days per decade.

Sea ice decrease will have many impacts, one example being the increase in Arctic shipping. For example, considering only the northern sea route (the sailing route between the Barents Sea and Bering Strait), transit traffic has increased in recent years with 71 ship sailings in 2013 which is estimated to increase to 430 by 2030.

# Arctic biodiversity assessment: from plan to action during times of rapid environmental change

**Kári Fannar Lárusson (Arctic Council, Conservation of Arctic Flora and Fauna, Iceland)** spoke about the implications of sea ice loss in relation to Arctic biodiversity and the work that CAFF is involved in.

The Conservation of Arctic Flora and Fauna (CAFF) is a working group of the Arctic Council, an intergovernmental organization comprising the 8 nations with borders in the Arctic, 6 indigenous organisations and 6 working groups. Their operational area is 32 million km$^2$, 57% of which is marine environment and the estimated population is 4.6 million. The goal of CAFF is conservation and sustainable use of Arctic environments.

We are seeing unprecedented change in the Arctic resulting in both benefits and drawbacks, change in relation to the presence of invasive species, climate change, pollution, industrial development and local disturbances.

*"Estimates of reduction in sea ice indicate that as early as 2030 we can expect to see a big reduction in the diversity of fauna that are directly dependent on sea ice, for example, algae, amphipods, ring seals and polar bears."*
Kári Fannar Lárusson, Arctic Council, Iceland

In May 2013 CAFF released the Arctic Biodiversity Assessment, the first overall assessment of Arctic biodiversity. The report comprises 4 main sections: an Arctic biodiversity trends report from 2010; a full scientific report; a synthesis report; and recommendations for policy makers. The report is informed by traditional knowledge. Although data is not available for all ecosystems in all regions, it identifies trends in Arctic biodiversity. The report provides 9 key findings and 17 policy recommendations.

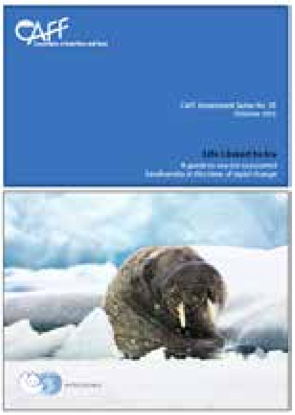
The main findings of the Arctic Biodiversity Assessment are that:

- Climate change is the most important underlying driver of overall change to biodiversity
- Management requires an ecosystem-based approach
- It is important to mainstream biodiversity by making it integral to all policy fields, for instance by ensuring biodiversity objectives are considered in development standards, plans and operations.

One of CAFF's main tasks is to follow up the Arctic Biodiversity Assessment with an implementation plan to ensure that the recommendations are implemented within Arctic governments. During the 7 year process of the Arctic Biodiversity Assessment a number of recommendations have become very prominent and CAFF have started to react to them. Recently, a report titled 'Life Linked to Ice' was released which examines the link between sea ice and biodiversity in the Arctic. Estimates of reduction in sea ice indicate that as early as 2030 we could see a relatively ice-free summer in the Arctic. The most obvious negative effects will be to species that directly depend on sea ice, for example, algae, amphipods, ring seals and polar bears. Impacts on species that depend partially on sea ice are less clear, for example polar cod and many sea birds. Impacts for humans are uncertain, but will be substantial for many indigenous communities that rely heavily on sea ice.

The Life Linked to Ice report has 4 main recommendations:

- Facilitate a move to more flexible, adaptable wildlife and habitat management and marine spatial planning approaches that respond effectively to rapid changes in Arctic biodiversity.
- Identify measures for detecting early warnings of biodiversity change and triggering conservation actions.
- Make more effective use of local and traditional knowledge in Arctic Council assessments and, more broadly, in ecological management.
- Target resource managers when communicating research, monitoring and assessment findings.




A recommendation that CAFF is working on in cooperation with WWF, UNEP and GRID-Arendal is a scoping study of ecosystem services in the Arctic which are both locally and globally important. Local ecosystem services include food and water, safe spaces to dwell and the cultural aspects of sea ice. Globally important ecosystem services include Arctic commercial fisheries and provisioning and regulating services for the global economy and climate.

CAFF is also involved in the Circumpolar Biodiversity Monitoring Programme (CBMP) in response to the Arctic Climate Impact Assessment's (2004) recommendation to expand and enhance Arctic biodiversity monitoring which was seen as lacking and uncoordinated between nations. The CBMP takes an ecosystem-based approach and aims to function as an early warning system for trends in Arctic biodiversity.

CAFF considers that Arctic biodiversity issues are global and that the sustainable future of the Arctic is based on cooperation. In this regard they have signed resolutions of cooperation with the Convention of Biological Diversity and the Ramsar Convention amongst others.

The Arctic Biodiversity Congress, organized by CAFF, takes place in Norway, December 2 - 4, 2014. It is intended to seek input into the outcomes of the Arctic Biodiversity Assessment to inform the recommendations. The event is envisioned to be a cross sectoral platform with significant involvement from the indigenous community and industry, building on the foundations of the ecosystem-based approach.

An ice free Arctic will negatively affect species that directly depend on sea ice, such as polar bears.

*Credit: Ken Collins, NOC*

## Arctic Seafloor Observatories

**Antje Boetius, (Alfred Wegener Institute, Germany)** spoke of the importance of using different methods of synchronous data collection and integration of this data to assess Arctic change.

*"The big question is are we doing the right thing to document what's happening, even if we cannot change it?... We need calibrated, standardized data and we need people on the ground to get it."*
Antje Boetius, AWI, Germany

Scientific observation and data collection assists us in understanding the world around us. The role of observatories is to repeatedly gather the same data so that we are equipped with observations over space and time that allow us to see patterns of change over long timescales. For instance, it may take 20 years of data collection before we see a pattern emerge.

Satellite observations have changed how we view the world. For example, comparing sea ice extent from satellite data between 1993 and 2012 we can see a marked decrease. However, satellites give us information at a broad scale which needs to be validated. Therefore, to assess future changes in sea ice cover people are needed to ground truth satellite data by measuring sea ice thickness which can be used to calibrate and improve future satellite data. In short, to understand ice melt we need calibrated, standardized data which requires people on the ground taking measurements.

To manage the Arctic we need to characterize the environment including existing pressures as well as estimate the costs of degradation. The determination of good environmental status is very important and setting environmental targets is outlined in existing policies, such as the Marine Strategy Framework Directive (MSFD) which also outlines how to take observations. However, this is not happening in practice due to a lack of infrastructure and a lack of people in sea and on land to record observations.

Unfortunately, the common strategies that are already in place, such as a global array of temperature/salinity profiling floats are not applicable to ice-covered seas. Therefore, oceanographers have used ships to look at temperature and salinity. Autonomous observation through ice-tethered profilers (ITP) also takes place but problems experienced include drifting due to sea ice drift and currents as well as interference by polar bears. Therefore, use of autonomous buoys is not sufficient. Regarding what we can do internationally, a series of meetings organized by GOOS (Global Ocean Observing System) has recommended that biogeochemists and biologists agree on 10 essential ocean variables so that the same variables are measured. Some of the proposed biogeochemistry variables, such as oxygen and particulate matter export can be measured autonomously using buoys but others, such as suspended particulates and carbon isotopes require sampling by people. Selecting 10 essential biological ocean variables poses difficulties due to the variety of organisms and their behaviours and effects on biogeochemistry. So far two agreed variables are chlorophyll and zooplankton. Chlorophyll can potentially be autonomously collected but this is not possible for zooplankton.

Deployment of a plankton net

*Credit: Cecilie von Quillfeldt, UNIS*

There is progress, for example combining satellite and ship data to produce maps of Arctic productivity. However, satellites cannot look through ice and hence we do not know how much sea ice and sea ice algae contribute to primary productivity. We are also lacking time series data on nutrient data, in particular for nitrate in the Arctic. There is opportunistic chlorophyll data available taken by students present on ships. However, the data has been taken from many different regions and lacks repeat measurements. This hinders the analysis of trends and developing regional averages. Again, coordinated ship surveys are needed to gather more meaningful data.

The advantages of having Arctic seafloor observatories for data collection include that the seafloor is the ultimate sediment trap and it doesn't drift away, allowing for good time series observations. The Distributed Biological Observatory (DBO) initiative has produced valuable observations, for example shifts in organisms, migration, benthic biomass change indicating productivity change and a shift in the distribution of mammals and birds. The DBO has agreed on a core standardized ship-based sampling list. Another initiative is cabled ocean observatories, the first Arctic one being initiated by Canada in Cambridge Bay.

In addition, many countries use the terrestrial and sea-based observatories located in Svalbard (the Svalbard Integrated Earth Observing System) to observe change. The German seafloor observatory has been maintained since 1999 and continuous annual sampling is carried out, including core biological measurements on fish and birds and mammals. Human induced changes such as an increase in litter on sea floor related to the increase in traffic is also being observed. With warming, it has been observed that the plankton composition has shifted from mainly diatoms to coccolithophorids and other organisms. Similar shifts have been observed for zooplankton as well as a decline in megafauna and increase in meiofauna.

For the future of Arctic observation, it is important that the Arctic is connected globally and part of the Integrated Carbon Observing system. Training the next generation of Arctic observers is also important to study the small scale processes that scale up and accelerate change. Satellites cannot be used for this but with synchronous observation we can observe change.

## Session 2 - Q&A



**Martha McConnell** (IUCN, USA) asked Stein Sandven to comment on how conservative the estimates for a potential ice free summer in the Arctic provided in the AR5 report are, given the limitations that exist in measuring sea ice volume and thickness. **Stein Sandven** explained that the definition of an ice free Arctic is taken as ice cover that is less than 1 million $km^2$. At this point most of the Arctic is ice free. He stated that a large amount of uncertainty exists and that it is difficult to judge which models are the most accurate in their predictions. However, many models do predict that ice cover in the Arctic will be less than 1 million $km^2$ between 2050 and 2070. **Antje Boetius** also commented on how predictions play an important role in managing and protecting Arctic environments. For example, northern Canada and Greenland are areas where wildlife such as polar bears and sea ice algae could be protected as ice is accumulating in these areas at present.

**Josep Casanovas** (European Commission) asked Stein Sandven where he obtained the prediction that there would be approximately 480 ships transiting the Northern Sea by 2030. Stein Sandven replied that it was the Centre for High North Logistics in Norway, established by a shipping company, that has predicted these numbers taking into account many factors such as the oil price on the world market, geopolitical issues, insurance and legislation.
**Paul Berkman** (University of California, US) asked **Stein Sandven** if the same submarine data he referred to that had used sonar to estimate sea ice could be used to estimate depth across the sea floor, considering that we have only mapped the depth of approximately 8 - 11% of the seafloor. **Antje Boetius** explained that submarines have poor navigation and that the seafloor measurements contain many inaccuracies. Obtaining good seafloor maps is therefore still a big task for the Arctic region. Paul also referred to the Arctic biodiversity assessment and asked how the work compared to the work that is being done through the Convention on Biological Diversity on ecologically and biologically sensitive areas. **Kári Fannar Lárusson** replied that the Arctic biodiversity assessment complements the work of the Convention on Biological Diversity.

**Doris Abele** (AWI, Germany) asked **Antje Boetius** about how we can make the most out of the dispersed measurements we do have from the Arctic. Antje Boetius responded that there is a need for international collaboration and cooperation to standardize the parameters measured and to do more measurement so we can get better maps.

**Karin Lochte** (AWI, Germany) asked the speakers how we could cooperate better with Russian scientists who have a lot of data that could be useful for biodiversity assessments. **Kári Fannar Lárusson** said that there is much historic data available in Russia but that it has not been digitized yet and that cooperation is happening to some extent at present. **Antje Boetius** referred to the good cooperation with the Russian Academy of Sciences during the Census of Marine Life. Kari explained that the main hindrance to accessing data is a lack of resources and capacity to digitize data from across the Arctic region.

# SESSION 3

## Utilizing and managing Arctic Ocean Resources



*Chair: David Shukman (BBC Science Editor)*

## Arctic Fisheries – present shifts and future perspectives

**Paul Connolly (International Council for the Exploration of the Sea, Ireland)** addressed Arctic fisheries in terms of current resources, fish stock distribution shifts and potential new fisheries, socioeconomic considerations and the opportunity to take an ecosystem based approach to Arctic fisheries management.

Currently, 59 species of fish are being harvested by industrial fisheries in the Arctic region. The main areas of exploitation are the Bering Sea, the Barents Sea and the Norwegian Sea while other areas such as the Russian coast and central Arctic are much less exploited. Across the northern seas, the species composition that make up the main exploited stocks differ. For example, crustaceans are more prominent in Canada and Greenland than they are in the north east Atlantic and Bering sea.

Climate change affects species directly and indirectly. Factors such as temperature, current, transport, stratification and light influence phytoplankton and zooplankton which in turn affect fish species. A shift in species distribution has already been observed in the Bering sea between 1982-2006. For example species such as Greenland halibut, snow crab, Pacific halibut and walleye pollock have all shifted their distributions. There have also been distribution shifts in the North Sea for species such as cod and monkfish.

In terms of how species distributions are likely to change in the coming years, an expert group of 34 scientists met under PICES, (the North Pacific Marine Science Organization) and ICES and evaluated future distributions based on fish life history traits such as exposure, sensitivity, potential for impact and adaptive capacity. Using this framework, they found that 6 of the most common species (eg. beaked redfish, Greenland shark, Arctic skate, polar cod, Bering flounder and snow crab) have a high potential of moving into Arctic waters in the future.

*The key criteria for establishing fish stocks in the Arctic Ocean are bottom topography, climate conditions, food conditions and distance to spawning grounds…At present we have a poor knowledge of the spatial and temporal distribution of many fish species along with a lack of growth and life history traits data."*
Paul Connolly, ICES, Ireland

The main shortfalls in our knowledge of Arctic marine fish revolve around taxonomy, poor knowledge of spatial and temporal distribution and lack of quantitative data on growth and life history traits. Many fish species are caught in by-catch and little is known about their biology. Therefore, if Arctic fisheries do progress, knowledge of these by-catch species, which are an intricate part of the ecosystem, will become a fundamental question.

In terms of socioeconomic effects and the consequences in shifting fish stocks, a good example is provided by Newfoundland. Newfoundland has moved from a fisheries based economy to a service economy as a result of the collapse of cod stocks. The collapse also led to a reduction in family size and increased emigration. This situation provides a template for situations that may occur elsewhere as a result of climate change.

Industrial fisheries currently harvest 59 species of fish in the Arctic region.
*Credit: Mick Mackey*

Paul emphasized that the effects of climate change on marine fish stocks are difficult to predict with any degree of certainty, as are the socioeconomic consequences of these effects for Arctic fisheries. Management regimes with sufficient capacity in terms of robust science, regulatory frameworks that contribute to reduced fishing effort and maintenance of sustainable stock levels, and enforcement capability are more likely to respond adequately to the challenges posed by climate change than those that do not.

The key questions related to the future management of fish stocks in terms of climate change concern how the productivity of Arctic ecosystems will change, what species are most likely to migrate and establish self-sustaining populations in the Arctic, how will successful migrations alter Arctic marine ecosystems and what research is needed to understand these ecosystem changes and the impacts of commercial fishing on them.

In turn, the future research needs for developing an ecosystem approach in the Arctic, based on Hollowed *et al*. (2013)[1] include: resolving the impacts of Atlantic inflow into the Arctic in relation to food webs and migration patterns; conducting fish/plankton surveys to determine fish responses to variability in ocean conditions; promoting novel approaches to ecosystem modeling; studying zooplankton community dynamics; studying fish community dynamics and the factors governing fish and shellfish movement and; studying benthic community dynamics.

There is a need to move away from fisheries management and to adopt a more ecosystem based approach to ocean management . In doing so, there is a need to characterise ecosystems, assess likely future impacts and to develop management plans. It is important that all stakeholders are involved in this process. In conclusion, Arctic fisheries management provides a great opportunity to develop the ecosystem approach and to move from fisheries management to ecosystem-based management.

*1: Hollowed et al. (2013) Projected impacts of climate change on marine fish and fisheries. ICES Journal of Marine Science. doi:10.1093/icesjms/fst081*

# The Industry Perspective of Arctic oil and Gas Exploration

**Robert Blaauw (Shell Den Haag and International Association of Oil and Gas Producers, Norway)** spoke about the oil and gas industry in the Arctic region in terms of why oil and gas is needed in the Arctic, current challenges for the industry, the necessity to cooperate and collaborate in the Arctic and examples of projects relevant to ecosystem-based management in the Arctic being carried out by the Arctic Committee of the International Association of Oil and Gas Producers.

Currently, energy demands are increasing due to continued growth of the economy. By 2050 there will be an estimated 9 billion people on the planet and energy demand will double compared to the year 2000. The International Energy Agency reports that in the future, 75% of our primary energy needs will come from fossil fuels and that by 2035 oil and gas imports into Europe will increase from 60 to 80%. Although renewable energy is developing, it takes time. In the meantime we must reduce our carbon emissions, be efficient with energy and move to lower carbon fuels.

In terms of the resources available in the Arctic region to meet rising energy demands, the US Geological Survey estimates that over 400 billion boe (barrel of oil equivalents) of oil and gas are yet to be found. It will take time to explore these resources and the economic development potential of those resources. Therefore, contrary to popular belief, retrieving oil and gas from the Arctic is not a quick process and there is no gold rush for oil and gas in the Arctic.

*" Industry in the Arctic isn't new – it's been there for over 500 years...Contrary to popular belief, there's no gold rush for oil in the Arctic."*

Robert Blaauw, Shell and International Association of Oil and Gas Producers, Netherlands

It is important to note that there are many different Arctic settings. For example, one can refer to the deep water Arctic, the shallow water Arctic, the open water Arctic, that which is frozen most of the time, that which is remote and that which is close to markets and infrastructure. It is also important to note that unlike the Antarctic, the Arctic is inhabited by 4 million people which make their living out of the Arctic. The oil and gas industry plays a part in supplementing their livelihoods.

The 500 year history of industry in the Arctic includes whaling, coal mining, and more recently oil and gas. There is also shipping, fishing and tourism. In 2013 and 2014 there have been oil wells drilled in those parts of the Arctic that are close to markets and infrastructure such as the southern Barents Sea, but as yet there is limited activity in the high Arctic.

The Arctic Committee is organized through the Oil and Gas Producers Association and promotes safe, responsible and sustainable oil and gas operations in the Arctic. The Committee works closely with other committees on issues such as safety, standards and environment. All the major operators in the Arctic actively participate in the Arctic Committee and cooperation exists with the Arctic Council.

A drillship in Arctic sea ice during an International Ocean Discovery Programme (IODP) Arctic coring expedition.
*Credit: M.Jakobsson, ECORD/IODP*

Work carried out as part of joint industry projects is independent, peer reviewed science that is publicly available. An example of such a project is the Arctic Oil Spill Response Technology Joint Industry Programme, the goal of which is to advance Arctic oil spill response strategies and equipment as well as to increase understanding of potential impacts of oil on the Arctic marine environment. Of the 400 offshore oil wells drilled to date there has been no incidents so far. One of the challenges being addressed as part of the project is the response to oil spills that occur under ice or on broken ice. It is timely to study this prior to the production of oil under ice which is not foreseen for the next 15 years.

There is also a Sound and Marine Life Joint Industry Programme which aims to better characterise the sounds the upstream oil and gas industry produce; to determine the potential impacts of these sounds on marine life and thereby to improve risk assessments and mitigation. Marine mammals play an important role in the ecology of the Arctic as well as to indigenous people whose cultural identity in many cases is centred around the annual whale migration and traditional hunt. With the information gained from this project, programmes can be designed to avoid harmful impacts on marine mammals.

Wherever industry goes, there is a wealth of information that is gathered to understand the environment. This information is needed to meet regulations, obtain permits and support investment decisions. Holistic understanding of the environment enables the design of operations to avoid, limit, mitigate and offset impacts. In order to achieve holistic understanding, traditional ecological knowledge is vital as well as collaboration with all stakeholders in the Arctic.

## Arctic Shipping

**Paul Berkman (University of California, USA)** spoke about shipping in the Arctic region in terms of recent observations of change as well as future shipping which will be largely driven by economics.

The Arctic Ocean has undergone an environmental state-change, shifting from a marine system dominated by multi-year sea ice throughout the year to a system that is now dominated by open water during the summer and first-year sea ice during the winter. The implications of the dominance of first-year sea ice from the Bering Strait through to the Bering Sea are significant, with thickness changing faster than lateral extent. During Winter, over 50% of the Arctic Ocean is first-year sea ice and during summer over 50% of the Arctic ocean is open water. The result is that dominance of first-year sea ice during the winter opens potential opportunities for year-round trade in and across the Arctic Ocean.

Transit shipping across the Arctic has increased from one ship in 2009 to 71 in 2013. Millions of tons of cargo are transported along the northern sea route in a manner that has not happened previously. The latest ship to travel the northern sea route was in December 2010, demonstrating that transit shipping across the Arctic is already occurring during Winter.

It is now possible to track Arctic shipping with satellite data through automatic identification systems. Using this data, reliable objective baselines can be created to track and measure how Arctic shipping is changing on an annual basis. Automatic identification systems provide real-time data on ship positions as well as associated data such as ship size, destination, cargo and origin. This type of information is critical to operational decision making.

Economics is the driving factor for year-round Arctic shipping. Destination versus transpolar trade in and across the Arctic Ocean appears to be less about environmental or ship conditions or capabilities than about the pairing of commodities sold between Europe and Asia in both directions. Currently, ships predominantly travel east to west, returning with ballast from Asia and many ships such as ice breakers are built to work in polar conditions.

The dominance of first-year sea ice in the Arctic region is making trans Arctic shipping easier.

*Credit: Ralf Prien, IOW*

*"Trans Arctic shipping has increased from 1 crossing in 2009 to 71 in 2013, transporting millions of tons of cargo along the northern sea route....Maritime trade is likely to emerge faster than the necessary infrastructures for safe, secure and reliable shipping in the Arctic.....The challenge is in balancing national interests and common interests in the Arctic."*
Paul Berkman, University of California, USA

It is anticipated that shipping through the high seas rather than in exclusive economic zones will be a threshold in the economics of Arctic maritime trade. Historically, every time a trade route has emerged in human civilization, it has fundamentally changed the balance of power among nations. Arctic shipping is currently occurring in a region where there are accepted zones of jurisdiction. Beyond the exclusive economic zone is the high seas which is explicitly beyond sovereign jurisdiction. Therefore, the challenge the Arctic Ocean represents as shipping increases is one of considering national interests and common interests.

In terms of the ability to respond to emerging interests and commercial activities in the Arctic, there are an accelerating number of policy documents being produced to deal with the Arctic and all Arctic states have developed national security policies.

Sustainable Arctic shipping is inclusive of environmental protection, economic prosperity and social equity. For sustainability to emerge, the needs of the present and the needs of the future need to be considered. The International Maritime Organisation is developing the Polar Code, a mandatory international code of safety for ships operating in polar waters, which will address safety and pollution prevention. The Polar Code will effectively be built as amendments to the International Convention for the Prevention of Pollution from Ships (MARPOL) and the International Convention for the Safety of Life at Sea (SOLAS). It will also include the United Nations Convention on the Law of the Sea (UNCLOS) as well as training and certification for seafarers. The code is anticipated to be completed by the end of 2014.

There is an urgent need to strengthen all forms of infrastructure to make the Arctic safe for increased shipping. A working definition of infrastructure is: fixed, mobile and other physical assets (including observing, communications, research and information systems) as well as regulatory, policy and other governance mechanisms (including insurance). Maritime trade, tourism and other marine transport activities are likely to emerge faster than the necessary infrastructures for safe, secure and reliable shipping in the Arctic Ocean. Infrastructure is just beginning to be developed in the Arctic and the challenge is therefore to anticipate the infrastructure being built across the 21st century, rather than respond to it.

## Discussion: Can industry and science work together to achieve sustainable management of the Arctic Ocean?



Participants of the 4th European Marine Board Forum Panel Discussion (left to right): Paul Berkman, (University of California, USA), Martha McConnell (International Union for Conservation of Nature, USA), Peter Pissierssens (Intergovernmental Oceanographic Commission of UNESCO), Karin Lochte (Alfred Wegener Institute for Marine and Polar Research, Germany), Kurt Vandenberghe (DG Research and Innovation, European Commission), Robert Blauuw (Shell and International Association of Oil and Gas Producers) and David Vaughan (British Antarctic Survey, UK)

A lively panel discussion followed the speakers talks where the key messages of the forum featured prominently. With regard to **a strategic plan for data collection and observation technology in the Arctic Ocean**, all panelists agreed with Peter Pissierssen's statement that the "**Arctic region is vastly undersampled in terms of physical, chemical and biological data**" and his suggestion that this could be improved by working with industry as partners in collecting and managing data. As summed up by Paul Berkman, "**More data points equals less uncertainty**", which has knock-on effects for taking actions and making decisions. Karin Lochte pointed to the need to develop **international data collection standards and protocols** to achieve efficient data collection and highlighted the need for agreement on a **longterm strategy and funding** considering that longterm monitoring is both expensive and time consuming. Kári Fannar Lárusson of the Arctic Council seconded the call for longterm data collection and funding, stressing that this is needed for valuable data collection which can be lost when funding is reprioritized from programmes. On the issue of observation technology, David Vaughan spoke about the use of autonomous vehicles that can be used for data collection in the Arctic Ocean and stated that, "**Revolutions come at different times in different areas. We are on the verge of being able to collect enormous amounts of data.**"

The subject of **developing a marine spatial plan for the Arctic for managing resources and protecting biodiversity hotspots** came to the fore during a discussion on how well we can predict changes that will occur in the Arctic region. Karin Lochte stated that we simply do not have enough data for Marine Protected Areas, and posed the questions, "**Which areas should we protect? Do we have areas that are so biologically important that we do not exploit them?**" Robert Blauuw stressed that Marine Protected Areas can be designed to fulfil multiple functions at the same time, such as conservation and shipping, and that industry can be restricted from working in natural heritage sites for example. Martha McConnell pointed out the fact that at present, "**only 5% of the Arctic is mapped**" and that the issue of sovereignty is important to take into account when planning for Marine Protected Areas.

The use of **local and traditional knowledge in data collection and in ecological management** was discussed as an important consideration for future work. Martha McConnell pointed out that amongst the multiple uses that are made of the Arctic region, it is first of all "**a homeland to 4 million indigenous people**", as well as being a homeland to species and vast natural resources, and that we must work to **forge partnerships and relationships** among all the different stakeholders. Kári Fannar Lárusson spoke of plans for significant indigenous involvement as a result of the Arctic Biodversity Assessment. However, more work in this area is needed.

There was comprehensive discussion on the nature of **future Arctic Ocean research investment, and the need for multidisciplinarity and partnerships for multisectoral and multisource funding**. Karin Lochte and Martha McConnell started the discussion by speaking about public perception of science-industry collaborations, and existing concerns about the lack of transparency and the credibility of industry-funded research. Antje Boetius suggested that a solution to these issues would be to have a credible international foundation managing money provided by industry. The panelists agreed that future investment requires a concerted and all-inclusive approach. This was summed up by Kurt Vandenberghe when he stated "**The agenda is so huge on where the money comes from, that we have to take a multifaceted approach, including all stakeholders.**"

The term '**gold rush**' was a feature of the discussion that centred around i**ndustry interests in the Arctic, such as shipping and associated infrastructure changes**. Paul Berkman stated that, "**Economic opportunity is vast in terms of building infrastructure in the Arctic**" and that the resources needed to support the building of infrastructure is a vast industry in itself. Paul Berkman also spoke about how governments are currently staking their claims in the Arctic as a prelude to creating opportunities for industry. Robert Blauuw rejected the idea of a gold rush in terms of the oil and gas industry, explaining the lengthy process that the industry follows in terms of obtaining permits, undertaking drilling exploration and environmental impact assessments and pointing out that these processes can take up to a decade. However, Kurt Vandenberghe expressed the opinion, "**We are talking about 2 rushes, a gold rush and a data rush… Science wants to understand before acting while industry wants to act before understanding**", and that therefore, the right architecture is needed for science and industry to work together.

# ANNEXES



## Annex I: 4th European Marine Board Forum Organization

**Forum Programme Committee**
European Marine Board Executive Committee 2014:
Kostas Nittis (Chair)
Alessandro Crise (vice-Chair)
Peter Haugan (vice-Chair)
Gilles Lericolais (vice-Chair)
Ricardo Santos (vice-Chair)
Tarmo Soomere (vice-Chair)
Jacky Wood (vice-Chair)
Niall McDonough (Executive Scientific Secretary)

**Forum Organization**
*European Marine Board Secretariat:*
Niall McDonough (Executive Scientific Secretary)
Doris Abele (Visiting Scientist from Alfred Wegener Institute)
Nan-Chin Chu (Science Officer)
Veronica French (Science Officer)
Kate Larkin (Science Officer)
Noémie Wouters (Science Officer)
Dina Eparkhina (Administration & Coordination Officer)

*European Polar Board:*
Roberto Azzolini (Executive Secretary)
Barbara Weber (Administrative Coordinator)

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**Forum material and presentations**
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## Annex II: Glossary of Acronyms

| | |
|---|---|
| **AWI** | Alfred Wegener Institute |
| **BAS** | British Antarctic Survey |
| **BBC** | British Broadcasting Corporation |
| **CAFF** | Conservation of Arctic Flora and Fauna |
| **CBMP** | Circumpolar Biodiversity Monitoring Programme |
| **CNR** | Italian National Research Council |
| **DBO** | Distributed Biological Observatory |
| **EMB** | European Marine Board |
| **EMODnet** | European Marine Observation and Data Network |
| **ESA** | European Space Agency |
| **ESF** | European Science Foundation |
| **EuroGOOS** | European Global Ocean Observing System |
| **ICARP III** | Third International Conference on Arctic Research Planning |
| **ICES** | International Council for the Exploration of the Sea |
| **Ifremer** | French Research Institute for Exploitation of the Sea |
| **IODE** | International Oceanographic Data and Information Exchange |
| **IPCC** | Intergovernmental Panel on Climate Change |
| **IUCN** | International Union for Conservation of Nature |
| **MARPOL** | International Convention for the Prevention of Pollution from Ships |
| **OECD** | The Organisation for Economic Co-operation and Development |
| **OGP** | International Association of Oil and Gas Producers |
| **POPs** | Persistent Organic Pollutants |
| **SOLAS** | International Convention for the Safety of Life at Sea |
| **UNCLOS** | United Nations Convention on the Law of the Sea |
| **UNEP** | United Nations Environment Programme |
| **UNESCO** | United Nations Educational, Scientific and Cultural Organization |
| **WWF** | World Wide Fund for Nature |

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