Arctic Climate Change, Economy and Society

Final Report Summary - ACCESS (Arctic Climate Change, Economy and Society)

Executive Summary:
The impacts of climate change in the Arctic are accelerating. This is the result of feedbacks and other processes commonly referred to as “Polar” or “Arctic” amplification. The Arctic has warmed twice as fast as the global average. Climate change is expected to transform the Arctic Ocean from an ocean with a year-round covering of sea-ice to an ocean that is free of ice in summer and a covering of thin ice in winter. Such drastic change will likely have sizeable impacts on climate, marine ecosystems, economic activities, governance and the lives of indigenous peoples and other inhabitants in the Arctic. The Arctic Ocean is an integral part of the Earth climate system. It contains substantial resources and provides important services for the global economy far beyond the region.

Within the joint call “the Ocean of Tomorrow” of the 7th framework program, the European Union project ACCESS (Arctic Climate Change Economy and Society, 2011-2015), has evaluated climatic impacts in the Arctic on marine transportation (including tourism), seafood production (fisheries & aquaculture) and the offshore extraction of hydrocarbons up to 2040 with particular attention to environmental sensitivities.
and sustainability. ACCESS has also focused on Arctic governance issues, including the framework UNCLOS (United Convention for the Law of the Sea) and strategic policy options. Regarding marine shipping, ACCESS findings indicate that the potential trade benefit through the reduction in distance for reaching final destinations is large and would result in significant cost saving. However an increase in shipping will depend mainly on the ice conditions in the Arctic, as well as icebreaker assistance and infrastructure along the Northern Sea Route (NSR). Thus in practice the potential volumes of traffic are unlikely to be reached even in the medium term. In the long term, if largely ice-free as predicted and with the required infrastructure, the NSR could carry significant traffic and new Polar Routes might be envisioned.

Concerning the effects of climate change on Arctic sea food production, ACCESS results indicate that we should expect some change in plankton biomasses and distribution but these changes do not seem very dramatic although large uncertainties surround them. Climate change is likely to have a larger impact on fisheries through its impacts on global markets. Other elements likely to impact Arctic seafood production include natural variability in ecosystem dynamics, policy and conflicts of interest, behavior of coastal communities and development of other sectors of activity in the Arctic.

ACCESS projected some effects of increased offshore production of hydrocarbons in the European Arctic but concluded that neither European Arctic offshore natural gas, nor European Arctic offshore oil, are a game changer for Europe. While production in the European Arctic might in the long term alleviate some effects of severe supply disruptions as well as energy security worries in Europe, Asia is likely to attract most of the production we might witness in Greenland, the Norwegian Barents Sea or even the Russian Arctic.

ACCESS delivered three management tools aimed to ease integrated approaches to management: a Marine Spatial Planning tool (MSP) covering the whole Arctic, a framework for integrated Ecosystem Based Management (EBM) and a set of indicators of sustainable development. These tools were designed to offer a non-political, pan-national data integration system for the purposes of planning proposed activities or responding to unforeseen events. This allows the development of informed planning strategies and provides a comprehensive framework within which scenarios of governance can be analyzed and tested. In this context, ad hoc regional or bilateral agreements may offer a more efficient path to timely solutions than legislatively cumbersome treaties.

Four ACCESS Policy Briefs were released concerning air pollution by ship emissions in the Arctic, oil spill risks and contingency in sea ice covered ocean, Arctic seafood production in the context of global economy and food supply and the implementation of the Polar Code recently released by the International Maritime Organization (IMO).

Three ACCESS scenarios were built around oil spill under sea ice, Arctic seafood production and the Polar Code implementation with a vision for the next 30 years. During the four years of the project, ACCESS delivered 11 newsletters highlighting ACCESS various activities publically accessible. The ACCESS consortium submitted 137 deliverables to the European Commission in four years and more than half of them during the last year of the ACCESS project.

Project Context and Objectives:

The context
During the 20th century, human activities have expanded into a globalized society, enhancing the material standard of living for most people on Earth. These activities have resulted in global environmental changes like climate change and massive biodiversity loss that could probably reach planetary thresholds and tipping points. Hence, while these developments have led to amazing improvements in human well being...
tipping points. Hence, while these developments have led to amazing improvements in human well-being in the past, they now challenge the future of the human population on Earth. 

Already today, due to the increase of the greenhouse gasses (GHG) concentration in the atmosphere and the amplification of global warming in the Arctic, the impacts of climate change in the region are apparent, e.g. in sea-ice reduction (mass and volume, concentration and thickness), in changes in weather patterns and cyclones or in the melting of glaciers and thawing permafrost. It is therefore not surprising that models clearly predict that Arctic sea ice will disappear in summer in a near future, yielding new opportunities and risks for human activities in the Arctic. These changes are particularly significant for the native peoples, regions neighboring the Arctic and global citizens. Indigenous peoples in the Arctic have a long history of dealing with harsh environmental conditions and change. Traditional knowledge with a profound connection with Nature have fostered adaptation strategies. Today, however, the rapid pace of climate change, its impacts and the potential for significant shifts in the economic and cultural landscape raise concerns about adaptive capacity and how to ensure sustainability in the fragile Arctic. The perceptions of indigenous peoples provide a valuable human perspective essential to comprehend the implications of the evolving environmental conditions in the Arctic.

The Arctic is engaged in a deep climatic evolution. This evolution is quite predictable at long time scale (multi-decadal time scale), but it is the decadal intermediate time scale that is the most difficult and uncertain to predict. This is because the natural variability of the system is large and dominant at this decadal time scale and the system response is highly non-linear due to positive and negative feedbacks between sea-ice, the ocean and the atmosphere. This climatic evolution is going to have strong impacts on both marine & terrestrial ecosystems and human activities in the Arctic. This in turn, has large socio-economic implications and consequences for Europe.

The Arctic sea ice variability has drastically evolved during the past 30 years and in particular since early 2000s when almost half of the sea-ice extent melted away in summer of 2007 and 2012 (from 8 million km2 to less than 4 million km2) and mean sea ice thickness was reduced by half (from a mean thickness of more than 3m thick down to less than 2m). Taken together this corresponds to a 75% decrease in sea-ice volume (or mass) and a quasi-disappearance of the old Arctic sea-ice (the multi-year ice) as stated both by observations and models. The reduction of Arctic sea-ice is mainly due to milder winters generating less sea-ice during the freezing season. Models predict a decrease in sea ice concentration and volume but the range of variability between and within models is large. Hence despite a general long-term negative trend of Arctic sea ice cover, estimations of future development in economic activities in the Arctic that are strongly depending on sea ice conditions, must account for uncertain sea ice projections.

The European Union ACCESS project, in response to the joint call “The Ocean of Tomorrow” of the EU 7th framework program, evaluated climatic impacts in the Arctic on marine transportation (including tourism), fisheries, marine mammals and the extraction of hydrocarbons for the next 30 years with particular attention to sensitivity and sustainability of the Arctic fragile environment. In the context of ACCESS, meso-economic issues were extended to the macro-economic scale in order to highlight trans-sectorial implications and provide an integrated assessment of the socio economic impact of climate change for the Arctic region. Given the geostrategic implications of Arctic States, an important aspect of ACCESS concerned Arctic governance issues, including the UNCLOS framework (United Nations Convention for the Law of the Sea). ACCESS dedicated a lot of attention for integrating Arctic climate changes, socio-economic impacts and Arctic governance issues.

The 4-year ACCESS project convened around 75 scientists from 27 partner institutions from 10 European countries (including Russia) for the period March 2011-February 2015. The scientific part of the project was organized around five main work packages devoted to: climate change (WP1), marine transportation
was organized around five main work packages devoted to climate change (WP1), marine transportation (WP2), fisheries (WP3), resource extraction (WP4) and governance and synthesis (WP5). ACCESS scientists background covered a wide range of disciplines ranging from social sciences, law, economics, social anthropology, to systems ecology, marine biology and climatology.

The objectives
Climate scenario and current climate models are unable to reproduce substantial changes observed recently in the Arctic. With this in mind the objectives of ACCESS for quantifying climate change impacts on key economic sectors in the Arctic were threefold:
1. to improve our understanding and the predictive capacity of how Arctic climate and Arctic marine ecosystems respond to a combination of natural and anthropogenic factors.
2. to improve our understanding of how rapid environmental changes might affect human activity in the Arctic and impact on sectors and regions.
3. to evaluate which risks to humans and the environment at large will result from expected economic changes and which measures could be developed to address these risks.

The first objectives of ACCESS was to monitor the current status and changes of the Arctic sea-ice to provide a baseline against which to compare projected future changes within the next 30 years and to maintain critical measurements that are needed to confirm and determine trends in the ocean, ice and atmosphere changes (WP1).
Within WP2 ACCESS was considering all the necessary preparatory work involved for shipping marine activities including a growing interest by the tourism industry in Arctic waters. That meant taking into account all the climate, weather, sea-ice variables impacting on these activities in order to optimize the kind of necessary scientific, technical and operational information needed for such activities.
Within WP3 ACCESS was carefully looking at the sensitivity of marine ecosystems exposed to climate changes involving essential climate variables and was proceeding to an in depth analysis of socio-economic aspects related to fisheries industry in the context of climate changes in the Arctic.
The melting of sea-ice is increasing the accessibility of offshore oil and gas deposits. The main goal of WP4 was to assess the opportunities and multiple risks related to oil and gas extraction in the Arctic Ocean, to highlight potential environmental pressures, to provide pathways for technological, legal and institutional solutions and to analyze the socio-economic impacts of resource extraction activity on European, world markets and societies.
The wide range of legislative instruments, agreements, conventions at national and international level provide a complex and sometimes conflicting system of regulation requiring special integrated overview. WP5 was uniquely positioned to provide this reflection process, to identify lacunae in the system and to offer strategic policy options for the medium and long-term future in the context of climate change.
Recognizing the particular vulnerability of the Arctic region and its crucial importance to the world climate system, ACCESS contributed formulating and implementing EU actions and policies that impact on the Arctic with respect for its uniqueness, the sensitivities of ecosystems and their biodiversity as well as needs and rights of Arctic residents, including indigenous peoples. In addition the interaction of ACCESS with the stakeholders/end-users communities, was a major undertaking.
A project like ACCESS has multiple aims. An essential one was to monitor and analyze the change in the Arctic Ocean and to continue key observations and analysis that have already begun in previous EU projects like DAMOCLES (Developing Arctic Modeling and Observing Capabilities for Long-term Environmental Studies, FP6, 2005-2010) and Arctic Tipping point (ATP, FP7). A major goal was to
Environmental Studies, FP6, 2005-2010) and Arctic Tipping point (ATP, FP7). A major goal was to provide accurate estimates of current status and changes and provide predictions and uncertainties for future development up to 2040. The ACCESS project also aimed to improve the knowledge-base associated with Arctic infrastructure and assess forecasting capabilities. Hence the ACCESS project was related to developments in sea-ice, atmosphere and ocean conditions, as well as current situation and future needs regarding forecasting and monitoring capacity of the Arctic.

While direct impacts of climate change are likely to be substantial in the Arctic, they will differ somehow between economic activities, some important issues span several sectors of activities and therefore needed to be treated separately within the ACCESS project. ACCESS aimed to identify such cross-sectoral elements and selected four particular topics dealing with Arctic infrastructure, local and indigenous peoples, marine protected areas and pollution in the Arctic. Short-lived climate forcers (SLCFs) such as black carbon, represent an important threat for Arctic indigenous Peoples health. ACCESS provides an overview of each of the regulatory systems, legislation and agreements governing the relevant activities in the Arctic. This component of the ACCESS project critically assessed the strengths and weaknesses of the governance system, its response to the stresses on the system caused by the natural and human impacts of climate change and its relevance to sustainable development of the region. A relevant response to change at the scale of the whole Arctic system requires integrated management capacity. An important goal of ACCESS was to improve this capacity by providing appropriate management tools to cope with this change. ACCESS has built a pan-Arctic marine spatial planning tool, provided a framework for the implementation of integrated ecosystem based management and developed a set of Arctic indicators for governance and sustainable development.

Project Results:
The Arctic has experienced substantial changes in recent years. These changes are most likely caused by a combination of natural variability of the high latitude climate system, anthropogenic induced changes in the Earth radiation balance and subsequently in atmospheric and oceanic heat transports and feedbacks of the air-sea-ice-ocean coupled system resulting in a thinning and more vulnerable Arctic sea-ice cover. To allow for a better understanding and a better prediction, ACCESS worked both on models improvements and intense observations. In ACCESS we monitored the current status and the changes of the Arctic sea-ice in connection with the Arctic Ocean below and the Atmosphere above. This does provide a baseline against which to compare projected future changes and to maintain the critical measurements that are needed to confirm and determine the trends in the Arctic Ocean, Sea-ice and the Atmosphere. Projections and estimates of uncertainties for future developments on time scales of up to 30 years were provided by dedicated simulations driven by IPCC models. This allowed deriving projections in the range of possible sea-ice conditions in regions of likely enhanced future use. Furthermore improvements of weather forecasting in this area were investigated. For long time, an Arctic shortcut that would allow increasing the efficiency of trade between Asia and the West has been discussed and the shrinking sea-ice cover has enhanced those ideas. ACCESS has taken into account all the climate, weather, sea-ice variables impacting on these activities in order to identify and possibly close gaps in the scientific, technical and operational domains related to such activities. In addition ACCESS also investigated the potential impacts these shipping activities would have on the sensitive marine environment including air pollution and long range transports of pollutants by the atmospheric circulation, soot and black carbon deposition on sea-ice, oil spill and noise pollution. Similarly increasing activities with economic benefits and with associated risks were investigated in the field of oil and gas extraction.

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Just as important as the scientific advances in the different fields, which were and are published in respective journals, were insights into the social and legal frameworks around shipping, seafood production and hydrocarbon development in the Arctic. These included the development of legal and institutional solutions to new challenges and legal conflicts, as well as assessing the impact on sustainable development (e.g. a 3D concept involving environmental protection, social equity and cohesion and economic prosperity). An all-encompassing highlight ACCESS was the development of an indicator set to measure the impact of climate changes in economic activity constrained by sustainable development in the Arctic Ocean.

The opening of the Arctic Ocean to increasing human activities has already begun. Vessel traffic is predicted to increase. Arctic tourism is likely to greatly increase. Offshore hydrocarbon activities currently occur at only a limited number of locations in the Arctic but future development is likely inevitable despite recent operational setbacks and economic competition from shale gas and other non-conventional sources. There are currently no commercial fisheries in the Pacific sector north of the Arctic Circle and fisheries in the High Arctic on the Russian, US and Canadian shelves are limited to small-scale subsistence fisheries, mostly for anadromous species. However large scale commercial fisheries already exist in the more southerly Arctic waters of the Bering Sea, Barents Sea, Baffin Bay and the East coast of Greenland. Various predictions on the future impacts of climate change on commercial fish stocks in the Arctic are emerging. It seems very likely that aquaculture will be affected both positively and negatively by warmer water and more extreme weather. All these developments have social, cultural, economic and geopolitical implications.

Coupled with unprecedented changes to the environment which forms the basis for traditional livelihoods and cultures, Arctic coastal communities are faced with rapid population growth, technological changes, economic transformations, social and health challenges and locally as well as globally political and institutional changes. National and regional agencies are the primary means of addressing these issues. However across the circumpolar Arctic there are huge disparities between the size and distribution of populations, the economies, cultures and institutional frameworks of the five coastal States. ACCESS put substantial focus on climate change and the impacts of climate change on important economic activities in the Arctic such as marine transportation and tourism, seafood production including fisheries and aquaculture, resource extraction including minerals, oil & gas and impacts on air and water pollution of rapidly increasing human activities in the Arctic in the context of climate change. An essential objective and goal of ACCESS was to monitor and to analyze the change in the Arctic Ocean and to provide accurate predictions and uncertainty estimates of future developments up to 2040. The project also aimed at improving observation infrastructure of the Arctic system and to assess modeling and forecasting capabilities.

The Arctic environment from a climate and weather perspective.

The natural variability of the Arctic Climate system depends largely on its atmospheric, sea-ice and ocean components and multiple interactions between these elements impacted by solar radiation. Recently Arctic sea-ice attracted a lot of attention due to the drastic change of the parameters characterizing sea-ice thickness, concentration, extent and age. The Arctic atmosphere has evolved drastically too but this evolution is more difficult to analyze due to a serious lack of data and information regarding the atmospheric boundary layer (the lowest part of the atmosphere) and the inversion layer above sea-ice. The Arctic Ocean is also characterized by some typical variability but it is the most stable elements among the three.
The major elements regarding the Arctic Ocean stratification and circulation and water mass distribution and evolution influencing sea-ice concern
1. the freshwater cycle including the run-off from Siberian and Canadian rivers at surface,
2. the advection of warm and salty waters North Atlantic waters through Fram Strait and the Barents Sea at intermediate depth,
3. the advection of low salinity but high temperature North Pacific waters through Bering Strait at shallow depth,
4. the heat storage due to solar radiation in the ocean surface layer.

One of the main characteristics of the Arctic Ocean compared with other Oceans, is the low level of turbulence at all depths. This is enabling the double diffusive convection in the main thermocline in particular. With less sea-ice, these characteristics will change because the Arctic Ocean will become more and more exposed to wind stress and vertical heat exchange like the other Oceans.

The atmospheric variability in the Arctic is mostly characterized by the so-called Arctic Oscillation (AO). The Arctic oscillation index is the first EOF (Empirical Orthogonal Function) of the atmospheric pressure field at a Pan-Arctic scale. A high AO index corresponds to a low atmospheric pressure pattern enhancing cyclonic circulation and high temperatures all over the Arctic Ocean. In contrast a low AO index corresponds to high atmospheric pressure pattern and low temperatures all over the Arctic Ocean. Today a new aspect of the Arctic atmospheric variability is related to a weakening of the polar vortex inducing more heat and water vapor exchange between low and high latitudes. This is generating atmospheric blocking situation over the North Pacific and North Atlantic Oceans and cold air outbreaks over the North American and North Eurasian continent strongly impacting weather systems at mid latitudes in the Northern hemisphere. The main remaining question concerns the large sea-ice retreat observed recently in the Arctic Ocean: Is it a cause or a consequence of the northern polar vortex weakening?

The Arctic sea-ice has drastically melted during the past 30 years and in particular since the early 2000s when half of the sea-ice extent melted away in summer 2007 (as observed during the International Polar Year (IPY) and the EU DAMOCLES project) and 2012 (as observed during the EU ACCESS project). Combined with a reduction of half of the sea-ice thickness, this corresponds to a reduction of 75% of the Arctic sea-ice mass (or volume) and a quasi-disappearance of the old Arctic sea ice (the multiyear ice) as stated both by observations and models. The drastic reduction in Arctic sea-ice mass (or volume) is largely due to milder winters producing less thick ice during the freezing season as illustrated by the decrease in number of freezing degrees days (ACCESS newsletter N°6, December 2013) observed during recent years. Another important aspect regarding sea-ice concerns the early break-up and late freeze-up observed from satellites measuring sea-ice extent and concentration with passive and active microwave sensors. This is a factor of great importance for marine shipping in the Arctic but also for marine mammals including polar bears (not part of the ACCCESS objectives) very dependent on sea ice conditions during the different seasons for feeding and reproduction (ACCESS newsletter N°3, June 2012).

Observational sea ice related work focused on the transpolar drift and the Fram Strait. These two features of sea ice dynamics are most important for the Arctic overall sea ice mass balance. The observational program thus provided not only important input for documenting and understanding physics of the sea ice system but also essential input for assessing and improving the numerical tools within ACCESS and elsewhere. An array of instruments, including sea ice mass balance buoys (IMB) and investigations of the melt pond energy budget were employed to complement the mass balance estimates from the thermodynamic side (melting and freezing). Field campaigns in the 2012 summer season gathered a
thermodynamic side (melting and freezing). Field campaigns in the 2012 summer season gathered a complete set of measurements of the energy balance of thin first-year sea-ice in the high Arctic. Shipping and offshore operations are most affected by the frequency, height and other properties of sea-ice pressure ridges. Information on these issues was obtained from submarine and ULS and AUV instruments in parts of the Arctic and given to the appropriate work packages concerned with shipping (WP2) and resource extraction (WP4). Ice thickness information from various remote sensing observations was inter-compared. The changed composition of ice between North Greenland and the North Pole with ridged first-year ice replacing older multi-year ice between 2004 and 2007, was confirmed. The results also showed that the central Beaufort Sea was by 2007 almost entirely an area of first-year ice, whereas multi-year ice dominated in 1976. The all-pervasive replacement of multi-year ice by first-year ice implies a lower mean ice thickness, fewer deep ridges, a lower degree of underside roughness from a drag point of view so that the ice can move faster under wind action as observed during the IPY Tara transpolar drift (EOS Vol 89 No.3 15 January 2008).

While the launch of the Cryosat-2 satellite by the European Space Agency in principle offers an opportunity for systematic and synoptic mapping of ice thickness over the whole Arctic by radar altimeter, the conversion of the signal received by the satellite into ice thickness is not trivial. It is hampered by difficulties of identifying the actual interface between ice and snow necessary to calculate a correct freeboard (the height of the sea-ice sticking out of the water) and hence a correct thickness. ACCESS examined and evaluated the data from Cryosat-2 comparing them with other estimates that use more direct observations but on a rather local scale. It showed that the interpretation of ice thickness data based on Cryosat-2 measurements still differs substantially from other, more direct methods of thickness estimates. As a consequence of these investigations, it seems unlikely that satellite derived ice thickness information with an appropriate accuracy for climate science or applied questions like ice forecasts for navigation, will be obtained soon. More research is needed in this field.

The passive microwave sea-ice concentration produced at the Ocean and Sea-Ice satellite application facility high latitude processing center (OSISAF) is considered one of the best coarse resolution sea-ice concentration products for the climate modeling community. OSISAF still overestimated sea-ice extent during the winter months and underestimated sea-ice extent during the summer months. A revised version of the OSI SAF products where the whole satellite record from 1978 to present was treated consistently, is under development and will be public in 2015. This will be a better product for long-term predictions but users will have to consider the seasonal limitations in particular in summer.

Indeed the poor fit between the predictions of global climatic models and actual observations of sea-ice retreat is often attributed to poor model representation of complex summer melt processes. To address this issue ACCESS performed field experiments of decaying sea-ice during an 8 days long summer drift cruise. The data set obtained represents the first complete summer season record of coincident albedo and snow thickness evolution in the central Arctic Basin. The change in albedo and thus the amount of solar radiation (shortwave) absorbed by snow and ice could explain the majority of ice melt observed. Thus the ice in the central Arctic basin is quite sensitive to the length of the melt season especially an earlier melt onset when incident levels of sunlight are high.

Climate modeling studies with a global Earth system model in ACCESS assessed the modeling capabilities of the strong downward trend in sea-ice which many climate models were and are still not able to reproduce. The studies indicated that one source of uncertainty is the difficulty to model snow on sea ice and that climate is sensitive to this aspect. Furthermore, fully coupled climate model experiments extending from the 20th century into prediction of future development from CMIP5 program of the IPCC were sub-sampled to pick out those models which show best results for the past 30 years in comparison to...
were sub-sampled to pick out those models which show best results for the past 30 years in comparison to sea-ice extent observed from satellites. Only these models were used to provide possible sea-ice conditions (extent and thickness) in key areas of the Arctic to the ACCESS work packages dealing with future shipping (WP2) and resource extraction (WP4). This included estimating number of days with maneuverable conditions in the North East passage in future climate. It turned out that despite a general tendency towards less sea-ice cover in summer, we will still have to deal with a large inter-annual variability superposed on the downward trend for the next three decades. As a consequence, the decline of summer sea-ice will most likely not be continuous and years with less ice might be followed by those with more ice. In addition even largely ice free summer months might still show blockage of shipping routes by sea-ice in straits and narrows. For the affected economic sectors, this means they would have to deal with a range of possible sea-ice situations rather than a clear-cut prediction for a certain sea-ice distribution.

Model studies to quantify impacts on climate and air pollution levels from local Arctic emission sources both for the current and future were performed in synergy and addition to chemistry oriented climate work in WP2 and WP4 which was focusing on smaller scales using aircraft campaign data measuring pollutants. Modeling studies also quantified the change in radiative forcing from greenhouse gases by moving ship traffic to higher latitudes. Different future emission scenarios in the simulations show increases in concentrations of pollutants both globally and in the Arctic. This does not appear to have a big effect globally. The situation would be different locally. In the season with potential transit traffic increasing throughout the Arctic for 2030, ACCESS projected increased concentrations of all pollutants in large parts of the Arctic.

A key component in reducing risks in future activities in the Arctic is the quality of weather forecasts. Main challenges for a better weather forecasting, in particular taking into account requirements of a future observing network, were identified along with scenarios to improve the situation. A key element will be efforts to enhance the extraction of information from polar orbiting satellites along with an increase of direct atmospheric observations in the interior Arctic. This could include surface buoys drifting and increased density or at least frequency of existing radiosondes releases to be used by the weather forecasts. Our capabilities for seasonal forecasting of sea ice conditions were also studied. For an ocean sea ice modeling system to provide a seasonal forecast, applying satellite based sea ice information is crucial input both for parameter estimation and to define the initial state as a starting point for the simulation. A method for doing this successfully was pointed out by ACCESS.

Previous warm periods in the Arctic like the early twentieth century warming of the 1930s to 1940s can provide essential clues for the understanding of the recent warming and the natural variability in this region. ACCESS partners were active in making available data from past Russian literature for this purpose which was interpreted in conjunction with more recent ocean and ice observations.

As a consequence of the Arctic climate system’s rapid transition in the recent years and prospects of its further change and the associated sea-ice extent and mass reduction, human activities such as resources extraction and shipping, are expanding. For these activities, it is essential to anticipate anomalous ice conditions and in particular sea-ice hazards associated with seasonal cycle and short term variations in ice cover. In this context, high quality predictions of the ice conditions are of paramount importance and interest. Such predictions are typically performed by numerical models of the sea-ice ocean system in combination with appropriate observations. However it is not trivial to identify which kind of observations are optimal for a specific purpose in terms of logistical and financial limitations taking into account the physics of the climate system itself. So to design an observational network in the best possible way, existing knowledge of the physics and information based on observations should be combined with the
Existing knowledge of the physics and information based on observations should be combined with the potential of numerical modeling. In ACCESS such a modeling system was developed to assist the design of an Arctic Observing System. The Arctic Observational Network Design (AOND) can evaluate candidate observational networks in terms of their constraint on target quantities of interest such as predicted sea-ice area or volume for a given region. The system was adapted to specific requirements for shipping and resource extraction and used during ACCESS to evaluate potential observational networks.

**Marine transportation in the Arctic**

Changing ice and weather conditions are expected to substantially impact the conditions for Arctic transportation and tourism in the Arctic. ACCESS focused on the socio-economic impacts of climate change on Arctic transportation and tourism and addressed the infrastructure needs. The effect of Climate change on Arctic shipping was analyzed by ACCESS partners who compiled historical data and forecast for upcoming decades of air temperatures and ice cover changes in the Arctic. Future options for shipping along the Northern sea route and also at higher latitudes in the Arctic were analyzed. Changes of air temperature and ice extent were characterized by 60, 40 and 20 years fluctuations and overlapped recently by the warming trend.

Rules, regulations and guidelines for marine Arctic transport were reviewed and assessed considering the relatively fast changing ice conditions and taking into account future growth of shipping activities in the Arctic. Convincing arguments were defined for filling significant gaps within the infrastructure in the Arctic regions such as telecommunication, salvage and rescue, sea depth control in the entire Arctic in order to avoid ship groundings. Shipping efficiency can be improved significantly by better ice forecasts and making use of a better design of the future Arctic observing system for safer shipping.

Pollution in the Arctic Ocean from increased shipping was investigated based on a successful aircraft campaign North West of Norway. Ship emissions were measured right behind the ship from an airplane. Presently the total CO2 emissions from Arctic shipping is relatively small. Model experiments revealed that most of the black carbon pollution in the Arctic is carried out from the outside, however locally a black carbon pollution can be expected from increased ship traffic if using current fuel and technology. LNG technology will be a preferable and less polluting fuel for future Arctic shipping.

ACCESS dedicated substantial effort for studying and analyzing the intensified usage of the Northern Sea Route NSR for transit navigation during recent years and confirmed the profitability of the regular cargo transportation from Europe to East Asia and back. Decreasing sea-ice conditions in summer along the NSR, increase of the cargo transportation, application of flexible rate policy, easier administration bureaucracy, contributed to the intensification of transit shipping in this part of the Arctic. Increasing of cargo transport along the NSR (or other higher latitude routes), require maintaining existing icebreakers, building new ones and improving the infrastructure in this area. ACCESS performed travel time and fuel consumption calculations for different ice scenarios based on ice data for the period 2000-2007 contrasting with light sea-ice conditions as a showcase (deliverables D2.16). Generally, the potential trade effect through the reduction in distance, which would result in significant additional shipping, is large. The shorter sea routes would be expected to increase trade volumes and therefore shipping significantly. However an increase in shipping to an extent that would be a significant fraction of the world traffic, would depend on possibilities to extend the shipping into winter, which due to persistent ice cover in the Arctic, would require icebreaker assistance and ad hoc infrastructure along the NSR. Thus in practice, the potential volumes are unlikely to be reached even in the medium term. In the long term, if largely ice free and with the required infrastructure, the route could carry a significant amount of traffic.

The following actions were identified necessary for a sustainable development of Arctic shipping:
The following actions were identified necessary for a sustainable development of Arctic shipping:

1. Improvement of safety, telecommunication, ports and coastal infrastructures
2. Environmental protection regarding oil spill, air and noise pollution from ships
3. Economic considerations regarding value, volume and fees for shipping.

Marine infrastructure is significantly lacking in most of the Arctic. Except for the Northern Norwegian coast, Northwest Russia and the Icelandic coast, extensive areas of the remaining regions of the maritime Arctic have insufficient or non-existent infrastructure to support safe marine operations. Marine infrastructure (ports, navigation charts, places of refuges and port calls, aids to navigation, search and rescue facilities, telecommunications, radars and lighthouses, emergency response, ship routing, ice navigator training, ice and weather forecasts and more) is critical and instrumental for providing a baseline level of Arctic marine environmental protection and marine safety. Reducing the infrastructure deficit is an urgent task for the Arctic states and the global maritime industry. New public-private partnerships could be explored as noted by the Arctic Council’s Arctic Marine and Aviation Transportation Infrastructure Initiative.

ACCESS identified eight strategic challenges that focus on addressing the large infrastructure gap in the maritime Arctic:

1. Lack of navigation charts and hydrography,
2. Climate change impacts in the Arctic coastal zone,
3. Lack of an integrated Arctic Observing System,
4. Training of Polar Operators and Ice Navigators,
5. Development of an Arctic Marine Traffic awareness system,
6. Implementation of the Arctic Search and Rescue and oil pollution agreements,
7. Evaluation of risk with minimal marine infrastructure,
8. Arctic marine infrastructure investments.

We could add an overarching challenge for implementing the recently released IMO Polar Code that will become mandatory by 2017. The eight challenges listed above are part of this overarching challenge for developing safe marine transportation activities in the Arctic in coming years and decades. While filling many gaps in shipping legislation in the polar environment, the new Polar Code does not cover all important marine safety and environmental protection issues. Thus some issues remain to be addressed. There is little if any discussion within the new Polar Code of the impacts of climate change on marine transportation across the Arctic Ocean. There is currently no Arctic-specific ballast water convention; however a global ocean ballast convention is near ratification. None of the conventions address damage to the High Seas beyond national jurisdiction.

Arctic fisheries and Aquaculture

The main objective regarding fisheries and aquaculture activities within the ACCESS project, was to estimate and quantify how climate change impacts Arctic seafood production and also the livelihood of communities and economic actors depending on these industries. Fisheries and aquaculture are some of the most important industries in the Arctic constituting together relatively large shares of GDP in some countries (Greenland 15%, Iceland 10%).

Research predictions building on the SINMOD model and the IPCC A1B scenario of possible future climate development, show that primary (phytoplankton) and secondary production (zooplankton) can be expected to decrease on an overall basis in the Arctic waters for the next 40-100 years. A spatially distributed model of the Barents Sea cod fishery was developed to complement the SINMOD model and employed to study the potential changes in the fishery industry under climate change for the next 30 years. According to joint outputs of the SINMOD model and the cod model, primary and secondary production in
According to joint outputs of the SINMOD model and the cod model, primary and secondary production in the Barents Sea area contribute in increasing the environmental carrying capacity for cod by about 10% at the end of the 30 year period. Fleet diversity, management and markets are all factors that seem to have a greater impact than climate change effects alone on the cod fisheries during the next 30 years.

ACCESS experts have scrutinized the Arctic aquaculture industry today and pointed out some possible future trajectories for this industry, influenced by expected climate changes. Today aquaculture in the Arctic is dominantly northern Norwegian salmonids farming even though we find limited volumes from Swedish and Finnish fresh water farming as well as marine fish farming in Russia, Canada and Iceland. Arctic aquaculture constitute about 2% of global farming, while in terms of European production (Norway excluded) it is considerably more than 50% of the volume. In a warmer future where the sea temperature increase, aquaculture will expand northwards, particularly North of Norway and towards Kola where reduced ice will open new areas for farming. With global warming, these waters becoming more productive, will improve fish growth. Other indirect impacts of climate change have more uncertain influence on the economic conditions of Arctic aquaculture production. The distribution of pathogens and diseases might change due to warmer temperature and/or invasive species. Storm frequencies will not have major impacts as current regulations impose that farms must be built to resist storm conditions.

Increased freshwater run-off is also unlikely to be of major importance since fish populations are adapting well with changing salinity and fresh water has a documented positive effect on the lice problem in current aquaculture.

The foreseeable climate change effects in the Arctic, seems to have positive aspects for fishing and aquaculture since warmer waters will increase productivity. Warmer waters can imply changes in fish stock distribution and that salmon aquaculture will move further North and East. Other effects are more uncertain, e.g. increased extreme weather, fresh water run-off, ocean acidification, invasive species and fish diseases among others. For aquaculture, most of these effects could be mitigated at relatively low cost with disease being the notable exception. Changes in disease prevalence and distribution of pathogens can have major negative impacts on aquaculture production. For fisheries, the impacts are not so easily assessed. Carbon footprint from fish production is relatively modest compared with production of other biological protein sources and an increasing world population will contribute to upheld and increased demand for Arctic fish.

Where climate change can impose great challenges to the management of marine living resources, economic, demographic and urbanization trends can put additional stress on the communities and inhabitants of these scarcely populated areas of the world. Analysis of the societal impact identified gaps in legal foundation of the sustainability concept in fisheries and its interpretation in national discourses. What is a sustainable quota and how to reach a multilateral agreement over shared fish stocks? This might be reflected in the case of Atlantic mackerel where Coastal States set their quotas unilaterally, despite the obvious need for a multilaterally regulated fishery. Moreover, a survey among Arctic fishers demonstrates that they do not anticipate any drastic impact on fisheries from climate change in the near future. Economic experiments indicate however, that uncertainties regarding natural fluctuations in the resource base and market conditions might substantially impact fishers’ behavior and consequently future management options.

Marine mammals are also present in the Arctic, in various degrees for different stocks and in different areas. Stock monitoring and assessments are difficult and often expensive. Traditional hunters (i.e. local and indigenous people) can greatly help for providing unique data to assess the conservation status (sustainable conditions) of the region. ACCESS WP3 produced a set of environmental, economic and social indicators for a sustainable development in the Arctic fisheries sector. The sustainability framework
Social indicators for a sustainable development in the Arctic fisheries sector. The sustainability framework has become a powerful concept in shaping national and international objectives. Nevertheless the concept may face considerable challenges when applied for example to marine seafood production. There are still several uncertainties over its underlying meaning as well as effectiveness in addressing emerging social and environmental problems. The analysis identified different understandings of sustainability concept in national discourses. While EU and Norway emphasize sustainable resource use, underpinned by the precautionary principle (a total allowable catch TAC), Russia and Iceland tend to refer to “rational resource use” in securing the sustainable utilization of the fish stock.

A recurring theme in discussions among experts and politicians in relation to fisheries regulation is the movement of fish stocks into new waters, due to ongoing environmental changes and potentially evolving ecosystems because of:

1. possible disruption of existing management regimes,
2. increased likelihood of establishing new commercial fisheries in some areas that may be considered as currently underdeveloped from a fisheries perspective,
3. expansion of invasive species (e.g. king crab, snow crab in Arctic waters).

Our analysis showed that one of the objectives in the governance system and international regulatory frameworks in relation to fisheries is a “regulatory effectiveness”. Fishery management must be structured in a way that is able to function effectively even with uncertainty and to create incentives encouraging conservation and a long-term management and sustainability of this renewable resource.

The substantial uncertainty surrounding the effect of climate change on seafood production and the complex interactions influencing outcomes in Arctic fisheries, make it difficult to predict whether Arctic fisheries will be able to take an increasing share of world seafood production or not. However unlike many other places in the world, Arctic fisheries are relatively well managed today. This gives some hope that if climate change impact turns out to have a positive impact on biomass production, the industry may be able to profit from that without undermining the sustainability of that production, provided the market structure does not change too much.

Arctic resource extraction

Arctic sea ice loss offers easier marine access to the Arctic Ocean in summer, which will likely lead to an increase in human marine-related activities such as fishing, shipping, tourism, oil & gas and mineral exploration. Of all these commercial activities, the most divisive is likely to be the exploitation of non-renewable resources that are held within the Arctic region, i.e. hydrocarbons. In fact the Arctic Ocean holds some of the world’s largest remaining oil & gas reserves. Estimates by the United States Geological Survey (USGS) have suggested that the Arctic holds 30% of the world’s undiscovered gas and 13% of the world’s undiscovered oil. These are very large numbers.

The extraction of hydrocarbons under the sea floor is not an easy business, especially so in the Arctic. The remoteness, lack of infrastructure and extreme conditions of the Arctic, are main challenges for oil & gas extraction. Other issues include an effective oil spill response/monitoring, search and rescue, as well as a large number of health and safety concerns. Even with these challenges, a recent study by Lloyds suggested that over the next decade the Arctic is likely to attract substantial investment, potentially reaching $100 billion. However the overriding pressure behind the extractions oil hydrocarbons may not be climate change, but the price of the commodity itself. At the end of the day, economics and policy will drive the development of the Arctic hydrocarbon industry.

During the ACCESS years, hydrocarbon development in the Arctic has gone through many ups and downs. These include...
Mothballing/delay of the Shtokman field. This field is one of the world’s largest natural gas fields and is located in the North-Western part of the Southern Barents Sea (Russia).

Dry wells drilled off the coast of West Greenland

Serious issues with a 2012 drilling campaign in the Chukchi Sea region (USA)

Significant drop in the value of oil and gas products since the start of ACCESS

The changing nature of collaborations between some major oil companies with respect to the exploitation of Arctic oil & gas.

Given the complexity, it goes without saying that hydrocarbons exploitation in the Arctic involves many sectors. To reflect this diversity ACCESS WP4 covered a broad range of disciplines and brought together a wide range of expertise related to the extraction of hydrocarbons in the marine environment. This included an analysis of the socio-economic impacts of hydrocarbon extraction in the Arctic region, the technologies that are needed to safely extract these resources, as well assessing the risks of resource exploration and the rescue crafts that are needed should an accident occur. Another important part of ACCESS WP4 involved assessing the potential environmental pressures that hydrocarbon exploitation brings along with an understanding of the legal and institutional challenges and possible legal conflicts that may arise.

One of the novel approaches within ACCESS WP4 was the multi-sector way various tasks were tackled. A good example of this was the analysis of the socio-economic impacts of Arctic resource extraction activity on European and Global markets and the impact of Arctic resource extraction on European policy objectives. This task involved leading economists, physical and social scientists and engineers. As a general conclusion, the production of natural gas in the European Arctic, while having some modest regional effects, is certainly not a game changer for Europe. The effects on import diversification are minuscule as economic possibilities on competing markets, especially Asia, are more tempting for natural gas producers. Also the impulses for economic development remain small and confined to the producing countries or selected energy intensive sectors.

Another area of excellence within ACCESS WP4 was the consolidation and assessment reports of our knowledge in other key areas. These included

(1) Infrastructure:
   a. Assessment of existing technologies, including fixed and floating structures as well as subsea-systems for a safe extraction of energy resources under Arctic conditions.
   b. Assessment of the suitability of existing rescue and evacuation crafts or vessels. Identification requirements for adjustments to account for the special challenges needed for them to be fit for the Arctic environment.
   c. Identification of technological gaps that provide minimal impact on the Arctic environment and provide sustainable development opportunities for the Arctic region

(2) Environment concerns
   a. Assessment of the risks of resource exploration, extraction and transportation in Arctic waters. This was achieved through in depth assessment of oil spill response capabilities and technologies in ice-covered waters including contingency planning. The assessment concluded that whilst much work has been performed knowledge gaps still exist in a number of key areas including modeling, detection and the recovery of oil spills in ice-covered waters.
   b. Providing recommendations for the design of an environmental observing system that is tailored to improving our monitoring of the Arctic marine environment.
   c. Identification of ecologically vulnerable areas and existing conservation plans for the rarest species in...
c. Identification of ecologically vulnerable areas and existing conservation plans for the rarest species in the areas of possible oil & gas development, including questions of sound pollution and the endangerment of marine mammals.
d. Assessment of the accuracy of iceberg remote detection and forecast methods. Especially for areas with high sea ice concentrations. This was achieved through observations, remote sensing and modeling. Recommendations for improving the detection and tracking of icebergs within the ice covered seas of the Arctic were also performed.
e. All available data on the emissions of different atmospheric compounds by existing oil & gas extraction facilities was collated in one data set.

Whilst the above reports delivered a state-of-art knowledge, ACCESS WP4 also extended our knowledge in a number of key areas. Examples included:

(1) Laboratory Experiments
a. Controlled oil spill experiments under sea ice. These experiments were performed in large cold-facilities and provided new information on the behavior of oil in ice covered waters

(2) Modeling
a. Economic modeling: A model-based analysis on economic-wide implications of offshore oil & gas extraction in the European Arctic. This was performed using the DART and COLUMBUS models.
b. Oil spill modeling: To better understand the impact of present and future Arctic oil spill events, we updated the OSCAR model to run both present and future oil spill scenarios.
c. Air pollution modeling: We used regional and global models to quantify the impact of the oil & gas Arctic extraction sites on the pollution and climate at Northern latitudes.
d. Noise pollution: New modeling of sound propagation and its impact on marine mammals, was performed.

(3) Observations:
a. Ocean: Before oil & gas can be extracted at any given site, a baseline understanding of the ocean environment needs to be established. The ability to autonomously monitor the health of the Ocean environment was realized through the successful trials of a European designed sea glider in the central Barents Sea in the vicinity of the Shtokman gas field.
b. Atmospheric pollutants: Key flights were performed over active drilling sites to measure trace gases and aerosols concentrations in emission plumes downwind of active drilling sites.
c. Observational network design: within ACCESS an observational network design system was developed. This model optimizes the design of a future Arctic observing system. By doing so, we will be able to optimally monitor the marine environment in targeted regions of the Arctic, in particular those regions subjected to active resources extraction and exploitation.

Just as important as the scientific advances were insights into the social and legal frameworks around hydrocarbon development in the Arctic. These included the development of legal and institutional solutions to new challenges and legal conflicts, as well as assessing the impact on sustainable development taking into account of future uncertainties. An all-encompassing highlight of ACCESS WP4 was the development of an indicator set to measure the impact of changes in economic activity on sustainable development in the Arctic Ocean, especially with respect to energy production.

Arctic governance
To assess the impact of the effects of long-term climate change upon the existing regulatory regimes, ACCESS simulated two major marine events in the Arctic Ocean, one a major oil extraction platform failure similar to the Deep Water Horizon oil spill in the Gulf of Mexico in April 2010, the other a shipping accident similar to the MV Costa Concordia disaster in January 2012 off the coast of Italy. The simulations
accident similar to the MV Costa Concordia disaster in January 2012 off the coast of Italy. The simulations highlighted critical areas in need of observance, review, revision and implementation. The existence of regulations and guidelines is not enough to ensure safety for the environment and the people who live and work in it. The harsh conditions and changing environment mean that the coordinated and effective maintenance and application of any regulatory systems, is of paramount importance. In the Arctic environment a continual process of forward projection and continual revision and update of existing regulations, guidelines, agreements, legislation, treaties and controls has to be an essential part of any legislative system. Further gaps in the existing regulatory regime are two-fold, one is lacunae in the law and the other is ineffective implementation of existing regulations. Many of the international agreements relevant to the marine Arctic are framework instruments rather than regulatory conventions and, as such, lack critical details on implementation. It is the implementation by individual States that gives weight to these agreements. However their effectiveness can be undermined by poor implementation. This challenge to effective governance is compounded by lack of harmonization of regulations between Arctic Ocean States.

An ACCESS report reviewed five potential ways forward for future Arctic Ocean governance. These comprised of

1. the establishment of a single over-arching instrument, an Arctic Treaty, similar to the Antarctic Treaty,
2. the strengthening of the powers of the Arctic Council to encourage this regional body to establish binding legislation over the Arctic Ocean,
3. the modification, enhancement and amendment of existing regulations and instruments to create a range of standardized regulations,
4. the specific targeting of areas with existing regulations where chronic failure is predicted due to the effects of climate change,
5. retain the status quo and maintain without revision the existing complex and diverse panoply of regulatory systems.

Following the report’s review of current thinking and commentary, the ACCESS experts concluded that a most pragmatic and actionable scenario would be the pursuit of a middle ground of prescription and guidance to expand and strengthen existing instruments and agreements avoiding the need to develop new arrangements involving lengthy negotiations. In effect this is what is occurring almost by default. Such a hybrid system would be positioned somewhere in the middle of an integration-fragmentation spectrum of governance options.

Given the high levels of uncertainty related to upcoming Arctic change, governance mechanisms must be adaptive. Any new instruments must be thoroughly thought through and at the same time put in place quickly to accommodate the rapid changes. While existing governance instruments are scattered and sometimes inefficient, a pan-Arctic Treaty is not likely to be politically feasible. Meanwhile recent governance developments (e.g. the Polar Code) show that substantial improvement can emerge also in the current decentralized system.

To facilitate the increasing pressure on governance and management faced with rapid change, ACCESS has developed three management tools aimed to improve integrated approaches to management:

1. A Marine Spatial Planning tool covering the whole Arctic. It provides an innovative, interactive and practical method to visualize in space and time critical factors relevant to sustainable development in the Arctic, in order to assess the impacts of climate change in a qualitative way and provide key inputs to scenario planning and cross-sectoral analysis.
2. A framework for integrated ecosystem based management is a more analysis-oriented tool that helps assess, model and quantify interactions between geophysical, ecological and socio-economic elements of...
assess, model and quantify interactions between geophysical, ecological and socio-economic elements of the Arctic system and their links to the rest of the world, providing essential information for scenario analysis, in particular related to where surprising or abrupt changes might occur. It is also useful to develop and test effectiveness of potential policy instruments.

3. A set of indicators of sustainable development that could be used for monitoring future developments in the Arctic. Each sector of activity of ACCESS is covered by a sub-set of indicators that can be used as a stand-alone product if the user has a specific sector focus as well as in combination with the other indicator sets for a more comprehensive picture.

These tools were designed to offer a non-political, pan-national data integration system for the purposes of planning proposed activities or unforeseen events. This capability is of specific interest to stakeholders and user groups including in particular indigenous and local people of the Arctic. This allows the development of informed planning strategies and provides a comprehensive framework within which scenarios of governance and regional management can be analyzed and tested. The tools could be used individually but the most of their potential can be released if they are used and further developed in an interactive way.

The ACCESS main achievements

ACCESS explored the actual climate variability of the Arctic Ocean subjected to profound and significant changes occurring at the planetary scale. Following the previous DAMOCLES tradition, that implied deep insights of the interactions between the Arctic Ocean, the Arctic Atmosphere and the Arctic Sea-Ice. These investigations were based both on new and traditional observations and on models in order to establish some reliable predictions for the next 30 years. 22 deliverables were submitted to the EU Commission ranging from in situ and space observations to numerical models climate projection into the next 30 years and weather forecasts improvements; from quantitative network design to quality control, calibration/validation and accuracy of space observations; from in situ sea-ice thickness observations from AUV and submarines, to melt onset, break-up and freeze-up of sea ice; from reanalysis of historical data, to data assimilation in numerical models and short range weather forecasting.

ACCESS explored three major domains of human activities in the Arctic impacted by climate change.

1. Marine transportation across the Arctic Ocean including transportation of goods from East to West and West to East, exportation of Arctic mineral resources (oil & gas) and living resources (seafood) and Arctic tourism transporting passengers. 25 deliverables were submitted to the EU Commission ranging from navigation along the Northern Sea Route impacted by climate change, to current and future monitoring and forecasting for navigation at high latitudes; from rules and regulations for Arctic shipping, to infrastructure needs for polar navigation in ice infested waters; from identification of governance related issues on Arctic shipping and tourism, to indicators for a sustainable development of marine transport and tourism in the Arctic; from threat by icebergs and ice massifs to Arctic shipping, to design and fabrication of lateral stress sensor measuring lateral stresses in Arctic ice.

2. Arctic seafood production involving fisheries and aquaculture in a local, regional and global context impacted by global changes. 12 deliverables were submitted to the EU Commission ranging from economic settings, societal and cultural priorities in the fishery and aquaculture sectors, to international and national fishery from climate change and aquaculture, to market responses to climate change; from climate change impacts and human responses affecting traditional whaling, to indicators for sustainable development in the Arctic fisheries sector.

3. Offshore extraction of oil & gas, pollution and protection of the marine environment. 21 deliverables were submitted to the EU Commission ranging from oil spill response capabilities and technologies in ice...
Submitted to the EU Commission ranging from oil spill response capabilities and technologies in ice-covered waters, to emission of a large set of atmospheric compounds in gas/oil extraction facilities; from implications of Arctic energy supply for European policies, to management and adaptation practices and strategies versus climate-related issues; from identification of ecologically vulnerable areas, to safety zones and noise exposure criteria for marine mammals exposed to anthropogenic noise; from recommendations on future Arctic observing systems for safe resource extraction to indicators for sustainable development of the offshore oil & gas extraction; from iceberg remote sensing detection, trajectory forecasting and tracking, to report on rescue and evacuation systems; ACCESS dedicated a lot of attention to management and governance related to economical, geopolitical and cultural relevant issues in each of these specific domains of human activities and proposed new tools for dealing with each of them. 11 deliverables were submitted to the EU Commission ranging from scientific and ethical evaluation of the impact of indigenous seal hunting, to operational conditions of an effective participation of Arctic indigenous peoples in the future Arctic governance; from conditions for an integrated ecosystem based management in the Arctic, to the development of marine spatial planning concept and principal framework; from assessment regarding climate change effects and impacts on regulatory systems, to a cross-sectoral synthesis of economic, policy and governance options for sustainable development. New tools were produced in this context (Marine Spatial Planning MSP, Ecosystems Based Management EBM and Indicators) to help not only for the synthesis and integration of ACCESS results but also for future applications dealing with Arctic issues similar to those explored during the ACCESS project. This is a remarkable ACCESS legacy.

ACCESS communications, dissemination and outreach activities were exemplified by 27 deliverables of WP6 (the most prolific ACCESS work package) related to the ACCESS newsletters (11), the ACCESS Policy Briefs (4), the ACCESS summer schools (2) as already reported but also by the active participation of ACCESS partners to many conferences (including press conferences during the four annual ACCESS General Assemblies) and international meetings of importance such as the Arctic Science Summit Week (ASSW), the Arctic Frontiers, the Arctic Circle conference, the Arctic Observing Summit (AOS), the Sustainable Arctic Observing Network SAON and other Arctic Council working groups and task forces (AMAP/ACAA) to name a few.

One of the main conclusion of the ACCESS project concerns climate change aspects of the Arctic system and the impacts climate change might have in the next 30 years on human activities such as Arctic shipping, Arctic Fisheries and Arctic mineral Resources exploitation. Among all the elements of the Arctic climate system, sea-ice is the most affected by the change and everything depending on sea-ice is directly impacted. Within the coming 30 years one can predict with a high degree of certainty that Arctic sea-ice might melt almost entirely in summer some years. But still due to the natural variability of the Arctic climate system there will be years retaining some ice in summer. The whole Arctic Ocean would become a seasonal sea-ice area similar to the Antarctic Ocean and the Arctic multi-year ice would then disappear almost entirely. This will lead to profound transformation of the Arctic marine ecosystems, water mass distribution and vertical mixing. Polar Bears (not an ACCESS topics) will be strongly affected by the new Arctic sea ice seasonal cycle. But it seems like the most disturbing effect of this Arctic climate change manifestation would concern the mid latitude weather patterns due to a weakening of the Polar vortex, an amplification of the jet stream meandering activity, an increase in atmospheric blocking and cold air outbreaks. This aspect was not investigated during ACCESS but it is already attracting a lot of interest from the international scientific community.

The impact of Arctic climate change on human activities has also a focal point regarding sea ice and the way sea ice might or might not affect the development of human marine activities in the next 30 years.
Surprisingly it does not seem like Arctic fisheries and aquaculture are deeply concerned today with climate change. The northern sea-ice retreat observed during recent years does not seem to have a deep impact on the actual fisheries and aquaculture in the Northern part of Europe. This is quite in contrast with what happened along the North East coast of the North American continent many years ago and more recently around Iceland. Regarding marine transportation along Northern Sea Route it is quite a different story. The sea-ice aspect has already and will have a deep impact on the future development of this activity but it is extremely important to note that climate change is not the only important and relevant “impact factor”. Market values, global demand for renewable resources, infrastructure and technology development, Arctic governance at local, regional and international levels are all important parts of the puzzle.

Regarding oil & gas extraction it is important to separate inland and offshore oil & gas exploitation. There is already an intense activity developing on the Yamal Peninsula as far as oil & gas are concerned. There are several ice strengthened LNG ships in construction for exporting the gas from the Yamal Peninsula to Asia and Arctic climate change has certainly influenced the decision for intensifying this LNG ship development rather than the oil & gas extraction on the Yamal Peninsula itself. At the beginning of ACCESS there was a great hope that Shtokman gas field in the central Barents Sea will open before the end of ACCESS. But due to decision by the American administration to authorize the exploitation of shale gases, Shtokman closed. The economy for exploiting the offshore gas field at Shtokman was not right any more. Not the least failed attempts by Shell to exploit offshore oil & gas in the Chukchi Sea in 2012 demonstrated the challenging aspect for exploiting offshore oil & gas in the Arctic. Some giant oil companies have decided not to risk investing in this domain at present. This may be due to conditions that are not met yet between advanced technology, environmental hazards, price markets based on global demand for energy and sources of production.

As demonstrated by the Yamal Peninsula activities, marine shipping in the Arctic will strongly depend on Arctic resources being extracted and exported rather than ships transiting between East and West or the other way around for transporting goods from Europe to Asia (or Asia to Europe). Arctic tourism is a very special activity and will certainly grow quite significantly in coming years but not necessarily because of climate change although the accessibility of polar regions will be greatly improved with sea-ice retreating further North. The new Polar Code, long time expected, is precisely made for increasing safety for navigating in Polar Waters. The difficulty is now for implementing the Polar Code that will be put into force in 2017. This is the responsibility of the International Maritime Organization in cooperation with the Arctic Council as far as the Arctic Ocean is concerned.

In Summary, we selected 9 overall challenges issued from ACCESS results

1/ Climate change. Real change is happening in the Arctic as testified by the spectacular Arctic sea-ice retreat occurring in summer 2007 and 2012. But the sea-ice volume (75%) is more affected than sea-ice extent (50%) due to sea-ice thickness reduction as well. Milder winters are the dominant factors explaining most of the Arctic sea-ice reduction in addition to longer melting season related to earlier sea-ice break-up and later freeze-up events. First-year ice is dominating the Arctic sea-ice and the multi-year ice is disappearing. Snow is an important factor but still difficult to apprehend both from models and observations and improvements should be done. There is an increasing interest in understanding linkages, between the Arctic Climate system and the mid-latitudes weather systems involving Polar vortex weakening, jet stream meandering, atmospheric blocking and cold air outbreaks. As far as the Arctic is concerned, there is a need for improving weather forecasts in this polar region exposed to a growing interest for developing human activities.
interest for developing human activities.

2/ Arctic Shipping. On the short term Arctic shipping activities along Northern Sea route is very much weather rather than climate dependent (weather in a broad sense and from a navigational point of view is also including sea-ice and icing as well as winds and fogs, waves and currents). Improving weather forecast in the Arctic is a necessity. It is clear that shipping activities for exporting Arctic resources (i.e. bulk carriers) rather than ships transiting across the Arctic, are likely the main driving force. The key issue concerns infrastructure allowing a safe and sustainable development of marine shipping in the Arctic. Infrastructure for ship navigation in the Arctic represents by far the largest investment for the future of human activities in the Arctic involving the public and private sectors as well. Climate change is rather a long-term dominant factor for marine shipping at northernmost latitudes (Polar Route). Numerous safety and pollution related issues need to be tackled, enhancing the IMO Polar Code.

3/ The Polar Code is a long expected achievement but some urgent improvements are strongly needed for a better and more efficient implementation of the Polar Code such as air pollution due to ship emission, ship noise and marine protected areas, water ballast from ship in the Arctic Ocean. ACCESS provided new results regarding air pollution and ocean noise pollution.

4/ Arctic seafood production. Aquaculture is on the rise and might benefit more from climate change than fish landings. Climate change is not a central concern for Arctic fisheries except for extreme weather events increases related to climate change and better weather forecast for safe navigation in polar waters.

5/ Oil & Gas. Hydrocarbons exploitation is on the rise in the Arctic on land (Yamal) rather than offshore. This is more a result or consequence of the global market and shale gas exploitation than due to climate change. Oil spills in sea-ice covered waters are still providing challenges that need to be addressed.

6/ Infrastructure is a key issue for all kind of human activities development in the Arctic. It requires huge investments and represents the most challenging aspect for the future development of human activities in the Arctic. ACCESS defined what is urgently needed as far as infrastructure is concerned in the Arctic such as Search and Rescue facilities, bottom charts, operational observing system, satellites communication, weather forecast and ice pilot charts to name a few.

7/ Projects like ACCESS can help identifying and reducing uncertainties in order to facilitate decision making and policy making. Being aware about existing uncertainties in all related parameters is a prerequisite for the development of optimal experimental design for observing network as demonstrated in ACCESS as well as for a realistic estimation of the quality of projections or predictions.

8/ Indigenous Peoples are legitimately expecting for better communication and a better share regarding human activities development in the Arctic. Human rights for Indigenous Peoples need protection simply because human activities in the Arctic are very influential regarding cultural and societal development. Arctic Indigenous Peoples will be strongly involved in future human activities development in the Arctic and this aspect deserves a lot of attention in future international programs dealing with Arctic research.

9/ with a growing population up to 10 billion human beings by the end of this century, Arctic resources exploitation and development of human activities in the Arctic are to be expected. This development needs to be kept under control in a sustainable way as far as possible. Marine Spatial Planning and Ecosystem Based Management are efficient tools to be promoted to aim for a more sustainable use of the Arctic Ocean resources to contribute to maintained or even improved welfare levels locally and globally if possible.

The European Union, the Arctic Council and the ACCESS project
Between 2008 and 2014, the EU Institutions have adopted a number of political, non-binding Acts, Communications, Resolutions and Conclusions addressing with varying emphasis the main priority...
Communications, Resolutions and Conclusions, addressing with varying emphasis the main priority themes of environmental protection, sustainable use of resources and international cooperation. The EU Council in its conclusions of March 2014 has instructed the Commission and the High Representative to present proposals for the further development of an integrated and coherent Arctic Policy by December 2015.

As regards governance, the EU fully acknowledges the extensive legal framework that already exists in the Arctic. To strengthen and enlarge this framework, international dialogue and cooperation is encouraged, in particular through the Arctic Council. The 2012 Communication (European Commission and the High Representative) extols the role of the EU in research and funding in the North while also acknowledging the need to recognize and cooperate with Arctic Institutions and Actors. The need to respect the concerns and enhance the well-being of local populations, particularly indigenous peoples, was also acknowledged. The Council conclusions of March 2014 recognized “the Arctic Council as the primary body for circumpolar regional cooperation” and noted the EU commitment “to work actively as an observer of the Arctic Council and contribute to its activities” agreeing that EU Observer status “would facilitate an even more effective EU contribution to Arctic cooperation” and stressing “the important role played by EU Member States in the Arctic Council as members and observers in promoting cooperation in the Arctic in accordance with their respective status”.

In the context of the EU ACCESS project, a contact was established with the Arctic Council during the Swedish Presidency. ACCESS received a positive and encouraging response for developing cooperation with the Arctic Council working groups and task forces. Since then, ACCESS developed specific cooperation in particular with the Arctic Council working group AMAP (Arctic Monitoring Assessment Project) and the task force SAON (Sustainable Arctic Observing Network). The new AACA (Actions and Adaptation to Climate Change in the Arctic) project of the Arctic Council offers new opportunities to expand further on the scientific cooperation with EU Arctic projects like ACCESS and ICE ARC.

Potential Impact:
The Arctic Ocean is a complex adaptive system in which different parts interact in an intricate and often unexpected way. Geophysical dynamics, ecosystem dynamics at sea but also on land and in the atmosphere, economic and social dynamics in and outside the Arctic are tightly interlinked in ways that are often not obvious. These interactions occur across spatial and temporal scales where global phenomena like climate change fundamentally alter living conditions for local people today and in the future. Also Arctic resources are becoming a global concern as stocks of marine seafood, oil and gas and minerals deteriorate in the rest of the world.

Under such rapid changing conditions, ponderous and protracted policy making risks to be out-of-date before it is implemented. In response to rapid climate change, new instruments or amendments to existing instruments must be relatively quick to put in place. For example, the implementation of the new Polar Code for shipping is overdue and is urgently needed. Similarly, regulation of Arctic tourist activities and associated infrastructure, requires prompt action. The Arctic Council’s working group results could benefit from a model for converting into regulations.

Meanwhile current public management and governance capacity in the Arctic is scattered across national and international authorities as well as global and local stakeholders. Historical legacy can result in particular problem being currently dealt with at an inadequate level of public management. For example, regulations relating to Arctic offshore oil and gas activities need to be strengthened and harmonized while taking into account differences in local conditions in terms of type of resource, infrastructure in place, local and indigenous communities.

Decision making should be based on best available scientific advice and use more quantified and specific
Decision making should be based on best available scientific advice and use more quantified and specific approaches to assess impacts. Such decisions should build on state-of-the-art scientific knowledge and tools like integrated ecosystem-based management, marine spatial planning, constructive and carefully chosen indicators and resilience assessment. The policy making process in the Arctic should also actively incorporate traditional knowledge. National and industry interests should not be allowed to take precedence over those of the environment or indigenous and local populations.

Adaptive capacity in policy making needs to be developed and nurtured. Ways to do so, include identifying and gathering examples of “best practice” to learn lessons from them and studying and testing more flexible instruments. In particular regulatory instruments at the pan-Arctic scale should be developed so that every new update do not necessarily require new agreement negotiations.

An active dialogue between all international governance stakeholders in the Arctic is essential for successful governance and policy. In particular the Arctic Council needs to retain dialogue also with non-Arctic States since international law requires this for High Seas fisheries and seabed areas beyond national jurisdiction, even in waters the Arctic Council considers theirs to manage (UNCLOS Art.123). Regular monitoring of the success or failure of governance arrangements is essential in development and revision of regulations and policy tools. Indicators for governance effectiveness in the Arctic need to be developed. In addition processes must be established or strengthened to ensure meaningful dialogue with stakeholders, including indigenous and local peoples, the research community and other user groups during development or revision of policy instruments. Regular assessments are necessary to gauge how changes in governance requirements may affect/are affecting Arctic users, stakeholders, regional bodies, indigenous peoples.

Trans-boundary ecosystem-based approaches to governance are essential. Standardization/harmonization of regulations would be ideal for all activities and in particular for trans-boundary resources, living and non-living. Marine Spatial Planning offers one method through which this can be approached. Aquaculture legislation, operating standards and practices, particularly on pathogen transfer, should be coordinated across borders to limit the risk of disease transfer and development. Regarding shipping gaps in the mandatory Polar Code need to be addressed such as ballast water/hull fouling, noise and air pollution (including black carbon). There is a need to develop a fund for compensation in the event of pollution from hydrocarbon activities and to develop legislation relating damage from oil pollution in the High Seas. There is a need for a mandatory regime to be developed for insurance to cover vessels operating in the Arctic Ocean. Such a regime should ensure that all ships carry adequate levels of insurance which take into account the difficult operating and recovery conditions in the Arctic. Such a regime also should ensure that ship owners are not able to evade responsibility.

Regulations of tourist activities in the Arctic and associated infrastructure, requires urgent action. The existing voluntary guidelines will need to be carefully integrated with the Polar Code and other regulatory developments to maintain a coherent regulatory framework.

Dissemination and exploitation of ACCESS results
The ACCESS website (www.access-eu.org) was the main dissemination tool collecting and posting all the information in near real time such as public ACCESS deliverables submitted to the EU Commission, ACCESS publications in peer reviewed scientific journals, international conferences with ACCESS participation, ACCESS workshops and summer schools, ACCESS General Assemblies in Paris (France), Stockholm (Sweden), Cambridge (UK) and Vilanova y la Geltru (Spain). A list of distribution for major ACCESS outcomes was established at the start of the ACCESS project. It included various interested parties such as public and private sectors, academia and a full range of stakeholders, policy and decision.
parties such as public and private sectors, academia and a full range of stakeholders, policy and decision-makers.

The ACCESS deliverables
During the four year 2011-2015 of the ACCESS project, 137 deliverables were submitted to the EU Commission, including 86 deliverables during the last (4th) year of the ACCESS project. More than half of the ACCESS deliverables went for public release.

Twenty two deliverables were produced by WP1 (climate change), twenty five by WP2 (marine transportation), twelve by WP3 (fisheries & aquaculture), twenty one by WP4 (resources extraction) and eleven by WP5 (governance and synthesis).

Twenty eight deliverables were produced by WP6 for ACCESS communication and dissemination activities, including eleven ACCESS newsletters, four Policy Briefs, two summer schools, four annual reports of ACCESS activities (one for each year of the project).

Finally eighteen deliverables were produced by the ACCESS management board and the ACCESS steering committee (ACCESS WP7 and WP8)

The ACCESS Newsletters
Eleven ACCESS newsletters were submitted between September 2011 and February 2015. The first ACCESS newsletter (September 2011) concerned the ACCESS kick-off meeting in Paris, France on March 2011 and the presentation of the main ACCESS work-packages: WP1 for Climate change, WP2 for marine transportation in the Arctic, WP3 for Arctic fisheries, WP4 for Arctic non-renewable resources extraction, WP5 for Arctic governance and synthesis and WP6 for communication, outreach and dissemination of ACCESS results. ACCESS newsletters N°2 to N°6 submitted in February 2012, June 2012, October 2012, April 2013 and December 2013 respectively, concerned work progresses by the ACCESS WP1 to WP6. It included the second ACCESS General Assembly in Stockholm, Sweden on March 2012 (issue N° 3). ACCESS newsletters N°7 to N°11 delivered on February 2014, April 2014, October 2014, November 2014 and February 2015 respectively, were dedicated to ACCESS cross-sectoral activities. Issue N°7 presented the ACCESS Marine Spatial Planning (MSP) tool as well as the first ACCESS summer school held in Bremen, Germany on September 2013. Issue N°8 was dedicated to marine transportation and various negative impacts an increasing ship traffic along the Northern Sea Route might generate (air pollution, oil spill, under water noise pollution). Issue N°9 following a special workshop organized in Villefranche sur Mer, France on June 2014, was devoted to climate change and potential impacts on all kinds of activities such as marine transportation, fisheries and oil & gas extraction in the Arctic. Issue N°10 followed a special workshop organized in Paris, France on July 2014 dedicated to Indigenous Peoples (IP) living in the Arctic. The six IP representative organizations invited by the ACCESS consortium attended this meeting. Finally issue N°11 followed the second ACCESS summer school organized in Stockholm, Sweden on September 2014. The Stockholm meeting was also a good opportunity for the ACCESS consortium to discuss about the synthesis report and the preparation of the last ACCESS General Assembly held in Vilanova y la Geltru, Spain end of February 2015. In general ACCESS newsletters extended over 20 pages or more each and in total represent more than 200 pages worth of important information that were released to the public in a timely fashion.

The ACCESS Policy Briefs
Four ACCESS Policy Briefs were produced during the ACCESS project dealing with oil spill under sea-ice (PB1), air pollution from ship emission (PB2), Arctic food production in a global economy (PB3) and the Polar Code implementation by the International Maritime Organization IMO (PB4). These Policy Briefs served as the background information for elaborating three scenarios for the next 30 years taking into account climate change in the Arctic as predicted by ACCESS experts and regarding marine
account climate change in the Arctic as predicted by ACCESS experts and regarding marine transportation along polar routes across the Arctic Ocean, Arctic sea food production in the context of future global market demand and oil spill risks and contingency in Arctic sea-ice covered waters. These scenarios will be part of a synthesis report encompassing the results of the ACCESS project.

The ACCESS Summer Schools
The first ACCESS summer school was organized in Bremen, Germany in September 23-27, 2013. Young scientists and stakeholders were brought together with ACCESS experts to bolster interdisciplinary understanding of Arctic Climate Change and developments at the Haus der Wissenschaft in Bremen, Germany. The summer school was hosted jointly by ACCESS partners from AWI and from OASYS. The main outcomes of this first ACCESS summer school were highlighted in the ACCESS newsletter N°7 in February 2014.

The second ACCESS summer school was organized in Stockholm, Sweden by the Beijer Institute and the Arctic Resilience Report team at the Royal Swedish Academy and the Stockholm Resilience Center on September 22-26, 2014 back to back with the ACCESS 2nd cross-sectoral workshop dedicated to ACCESS project’s synthesis and scenarios. The main outcomes of this second ACCESS summer school were highlighted in the last ACCESS newsletter N°11 in February 2015.

The ACCESS Workshops
All the ACCESS workpackages (WP1 to WP5) met during the yearly ACCESS General Assemblies including the kick-off meeting in Paris (France) March 2011, then in Stockholm (Sweden) March 2012, in Vilanova y la Geltru (Spain) March 2013 and February 2015 and in Cambridge (UK) March 2014. In addition ACCESS WPs met in between the ACCESS GA on twenty occasions.

WP1 met during the first year in Bremen, Germany on September 5-6, 2011 for discussing climate scenarios and climate simulations and during the last year in Villefranche sur Mer, France on June 2-3, 2014 to consolidate ACCESS results related to climate changes in the Arctic and its impacts on marine transportation, fisheries and oil & gas extraction in the Arctic.

WP2 meeting at HSVA Hamburg, Germany May 31, 2011 was followed by a second workshop at NBC in Copenhagen, Denmark on November 29, 2011. WP2 met in September 2012 in Dublin (Ireland) and in September 2013 in Hamburg (Germany) together with WP4.

WP3 met at the Beijer Institute in Stockholm, Sweden on June 8-9, 2011. This first workshop was followed by a second workshop on aquaculture organized by NOFIMA in Tromsö, Norway on December 6, 2011. WP3 met again in Stockholm Sweden on November 2013 for a workshop dedicated to indicators. WP3 met also on October 2014 in Stockholm for a workshop dedicated to the ACCESS synthesis. A smaller group from WP3 also met in Tromsö in March 2014 to discuss issues related to fisheries and aquaculture.

WP4 meeting in Hamburg, Germany May 23, 2011 was the first ACCESS workshop followed by a second WP4 workshop in Kiel, Germany on October 2011. WP4 met again in April and May 2012 in Hamburg (Germany) and then in September and October 2012 in Kiel (Germany).

WP5 met at NERC, Southampton, UK on August 10-12, 2011 jointly with the first ACCESS steering committee meeting in order to facilitate ACCESS project integration. A second ACCESS WP5 workshop was organized at the Beijer Institute in Stockholm, Sweden on January 18-19, 2012. WP5 met in Bremen Germany on September 2013 for a cross sectoral workshop. A last ACCESS WP5 workshop was organized at the University Pierre & Marie Curie, Paris, France on July 9-10, 2014 dedicated to the impacts of climate change on Indigenous Peoples in the Arctic and their participation in the future Arctic governance. The 6th IP representative organizations of the Arctic were invited and they were all
governance. The 6th IP representative organizations of the Arctic were invited and they were all represented at the meeting.

An ACCESS workshop dedicated to ACCESS field works activities was organized in Villefranche sur Mer, France on November 24-25, 2011.
ACCESS representatives met with European Officials regarding Arctic affairs (EEAS) in Brussels, Belgium on February 20, 2012.

International conferences with ACCESS participation
Arctic Sciences Summit Week ASSW. International Arctic Sciences Committee IASC. Seoul, South Korea. March 28- April 1st, 2011.
Oil spill in sea-ice, past, present and future convened at the Instituto Geografico Polare “Silvio Zavatti” in the Villa Fermi in Fermo, Italy from September 20-23, 2011.
A “responding to change” workshop was convened at Queen’s University, Kingston, Canada from January 30 to February 1st, 2012 to provide a stepping stone for future discussions about transatlantic collaborations regarding climate change impacts on sustainable development in the Arctic Ocean. This workshop evaluated the alignment between data flowing from Arctic observing networks and stakeholders needs for information.
International Polar year IPY meeting in Montreal, Canada from April 22-27, 2012. This Montreal meeting was the final synthesis of the IPY (2007-2008). Several sessions were convened at this last IPY meeting by ACCESS PIs.
AMAP (AACA) meeting in Tromsø, Norway on December 10-12, 2013. Adaptation Actions for a Changing Arctic run by AMAP Arctic Council working group organized a two days meeting in Tromsø on the Barents region. The European External Affairs Services mandated ACCESS to participate to this meeting.
ISAC-ACCESS second workshop “responding to change” was co-organized in Tromsø, Norway on January 21, 2014, as a side event of the Arctic Frontiers (AF) in order to benefit from a large stakeholders community interested in Arctic issues that attended the AF 2014. The EU Arctic Information Initiative organized a stakeholder consultation in Tromsø on January 22, 2014 back to back with the ISAC-ACCESS workshop “responding to change”.
The Arctic Science Summit Week (ASSW) and the Arctic Observing Summit (AOS) in Helsinki, Finland on April 5-8, 2014. The ASSW 2014 and the AOS 2014 addressed the common concern regarding the Arctic Environment under the pressure of climate change and global economic demands for natural resources and seek strategies for advanced Arctic Observing Systems to conduct systematic, reliable and cost-effective monitoring of long-term trends and rapid changes in the Arctic.
European Geophysical Union (EGU) General Assembly in Vienne, Austria. On April 29, 2014 a special session dedicated to Polar Oceans was organized to celebrate Eberhard Farhbach who passed away a year before, on April 23, 2013.
6th International workshop on sea-ice modeling and data assimilation was co-organized by the International Ice Charting Working Group and the EU ICE ARC project in Toulouse, France on September
The second Arctic Circle Conference was organized in Reykjavik, Iceland on October 31 - November 2, 2014 overlapping all the ACCESS-related activities.

The Arctic Frontiers conference in Tromsø, Norway from January 18-23, 2015 related to Climate and Energy and the Arctic’s role in the global energy supply and security.


The ACCESS General Assemblies and Press Conferences

The ACCESS kick-off General Assembly was held in Paris, France on March 8-10, 2011. Following the ACCESS kick-off meeting in Paris, France on March 2011, the second ACCESS General Assembly was held in Stockholm, Sweden on March 2012. This was the first occasion for the ACCESS consortium to meet with the ACCESS Advisory Board. Outcomes of this first ACCESS GA were released with the ACCESS newsletter N°3 on June 2012.

The fourth ACCESS general Assembly was organized in Cambridge UK at the British Antarctic Survey on March 2014.

The third and the last ACCESS general Assembly were organized in Vilanova y la Geltru, Spain on March 2013 and February 2015 respectively.

For each ACCESS General Assemblies, a Press conference was organized and a Press release was prepared and provided to journalists attending the ACCESS GAs. Press releases were posted on the ACCESS website.

The ACCESS Advisory Board

The ACCESS Advisory Board was presented in the ACCESS newsletter N°2 in February 2012. It was composed of five experts on Arctic issues:

- Professor Oran Young is at the Bren School of Environmental Science & Management, University of California, Santa Barbara, USA. Professor Young specializes in the analysis of environmental institutions with particular reference to international regimes. He has served as Vice President of the International Arctic Science Committee (IASC), Chair of the board of Governors for the University of the Arctic and co-Chair of the Arctic Human Development report. He is the author of “Institutional dynamics: emergent patterns in international environmental governance” (2010).

- Honourable Inuuteq Holm Olsen has served as Deputy Minister for the Department of Foreign Affairs of Greenland since July 2006. He was appointed Private Secretary to the Premier from 1997 through 1999. He was posted at the Danish Foreign Ministry in Copenhagen and was at the Greenland representation in Brussels from 2000 through 2003. Minister Holm Olsen earned a BA in political sciences from the University of Alaska Fairbanks in 1994 and a MA in International Affairs from the George Washington University in 1996.

- Honourable Hannu Halinen was Ambassador for Arctic Affairs at the Ministry for Foreign Affairs of Finland. He was also a Senior Arctic Official for the Arctic Council and for the Nordic Council of Ministers as well as a member of the Committee for the Barents Euro-Arctic Council. Ambassador Halinen has provided leadership in many diplomatic arenas such as Permanent Representative of Finland to the United Nations Food and Agriculture Organization, Representative of Finland to the UN Human Rights Commission, Ambassador of Finland in Hungary and Egypt among other postings.

- Professor Hajo Eicken is at the Department of Geology & Geophysics University of Alaska Fairbanks.
Professor Hajo Eicken is at the Department of Geology & Geophysics, University of Alaska, Fairbanks, USA. His research interests include the growth, evolution and properties of sea-ice. He is particularly interested in determining how microscopic and macroscopic properties affect sea-ice processes and the climate system. Professor Eicken’s team also investigates different uses of sea-ice in Indigenous communities, the private sector and the public at large to help decision makers adapt to a changing Arctic. Professor Eicken chairs the Science Steering Committee for the study of Environmental Arctic Change (SEARCH) project.

Dr. Adele Airoldi has a master in polar studies from the Scott Polar Research Institute in Cambridge UK. She worked in the secretariat of the European Union Council of Ministers in Brussels from 1981 until 2004, mainly on environmental issues. During that period, she assisted Denmark and Greenland Foreign Affairs in preparing the 2002 Ilulissat conference. Since 2004 she is active in the field of Arctic Affairs. She is the author for the Nordic Council of Ministers of a report on the European Union and the Arctic (2008), updated in 2010 and 2014.

The ACCESS Publications
Fifteen peer-reviewed scientific ACCESS publications were submitted during the last year of the ACCESS project.
Four ACCESS papers were submitted to the European Geosciences Union journals (two in the Cryosphere and two in Ocean Sciences). Two ACCESS papers were submitted to the American Geophysical Union journals (Journal of Geophysical Research – JGR Oceans and Atmosphere). Two ACCESS papers were submitted to the American Meteorological Society (Journal of Climate). One ACCESS paper was submitted to Deep Sea Research II. One ACCESS paper was submitted to the Russian Meteorology and Hydrology journal (vol 40/issue 1, Allerton Press).
Five ACCESS papers were submitted to Environmental and Resource Economics Springer (two publications)
Marine Policy and Ecological Economics Elsevier (two publications)
Ecology and Society. The Resilience Alliance (one publication)

The ACCESS synthesis report and the ACCESS scenarios
A full synthesis ACCESS report (over 130 pages) is in preparation and will be submitted for publication in a near future. This ACCESS synthesis report is structured in 7 different chapters. Following an introduction (chapter 1), chapter 2 concerns Climate change and the Arctic Environment (20 pages) and chapter 3 concerns Marine transportation, Fisheries & Aquaculture and Resource extraction (30 pages). Chapter 4 is related to ACCESS cross-sectoral activities including Arctic Indigenous Peoples, Marine Protected Areas in the Arctic Ocean, Arctic infrastructure and Pollution (30 pages). Chapter 5 concerns Governance aspects for all activities in the context of climate change in the Arctic related to global changes (20 pages). Chapter 6 concerns ACCESS management tools including Marine Spatial Planning MSP, Ecosystems Based Management (EBM) and Indicators for sustainable development in the Arctic as a legacy of ACCESS (15 pages). Finally Chapter 7 is related to Observations on sustainable development in the Arctic (10 pages).

In addition, three scenarios were selected by the ACCESS steering committee based on the best predictions in three domains representative of the ACCESS main activities for the next 30 years. The first scenario concerned the Marine transportation along Northern sea routes based on
1. a possible sea-ice development assumed to have taken place regarding climate change and Arctic sea-ice prediction until 2040 and...
The ACCESS consortium composed of 27 partners from 10 European countries including Russia was coordinated by the University Pierre & Marie Curie, Paris, France.
- Université Pierre et Marie Curie (UPMC/LOCEAN and LATMOS), Paris, France
- OASyS Ocean Atmosphere systems GMBH, Hamburg, Germany
- Natural Environment Research Council, Southampton, UK (NOC)
- Institut fur Weltwirtschaft (IfW), Kiel, Germany
- University of Cambridge (UCAM/DAMTP), Cambridge, UK
- Alfred Wegener Institut (AWI) fur Polar und Meeresforschung, Bremerhaven, Germany
- Schwarz Joachim Company (JSC), Hamburg, Germany
- NOFIMA MARIN AS, Tromso, Norway
- Hamburgische Schiffbau Versuchsanstalt GMBH, Hamburg, Germany
- Norsk Polarinstittut (NPI) Tromso, Norway
- Meteorologisk Instituttt, (Met.no) Oslo, Norway
- FASTOPT GMBH, Hamburg, Germany
- The Scottish Association for Marine Science (SAMS), Oban, UK
- Kungliga Vetenskapsakadiem, Beijer Institute, Stockholm, Sweden
- Shirshov Institute of Oceanology of the Russian Academy of Sciences (SIO) Moscow, Russia
- IMPAC offshore Engineering GMBH, Hamburg, Germany
- Universitat Politecnica de Catalunya (UPC), Vilanova i la Geltru, Spain
- Deutsches Zentrum fuer Luft und Raumfahrt EV, (DLR, Germany
- Arctic and Antarctic Research Institute (AARI), Saint Petersburg, Russia
- Economic and Social Research Institute (ESRI), Dublin, Ireland
- Lapin Yliopisto, Rovaniemi, Finland
- SINTEF FISKERI OG HAVBRUK AS, Trondheim, Norway
- CICERO senter Klimaforsknings Stiftelse, Oslo, Norway
- Stiftelsen SINTEF, Trondheim, Norway
- Gesellschaft zur Forderung des Energiewirtschaftlichen Institut an des Universitat zu Koln GMBH, Koln, Germany
Germany
- Le Cercle Polaire Association (LCP), Paris, France
- Nordic Bulk Carriers (NBC), Copenhagen, Denmark

List of Websites:
http://www.access-eu.org/

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