Arctic Days

International workshop on Arctic marine ecosystems

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Plouzané, IUEM

Proceedings

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Plenary sessions

Chairman: ***Joëlle Richard, Nathalie Morata and Fanny Narcy***

The two first mornings were dedicated to plenary presentations from invited speakers from France, Norway, Poland, Germany, UK, Spain, USA and Canada.

The 13 scientific plenary talks included 2 distinct parts. The first part aimed to give a broad background on the state-of-art of the field of expertise of the invited speaker. This part was specifically designed to be accessible to the master students, who attended in the framework of their mandatory courses. The second part aimed to present recent results for the more senior scientists.

These plenary talks covered a broad spectrum of disciplines including: physical oceanography (F. Cottier, UK), glaciology (M. Griselin, France), physical-biological coupling (V. Le Fouest, France), remote sensing and primary production (M. Babin, Canada), sea-ice algae (M. Gosselin, Canada), microbial food webs (D. Vaque, Spain), ocean acidification (H-O. Pörtner, Germany), krill (J-Y. Toullec, France), ice fauna (J. Berge, Norway), bivalves as proxies (M. Carroll, Norway), sea ice proxies (G. Massé, Canada), benthos communities (Maria Włodarska-Kowalczuk, Poland), ecosystem functioning (J. Grebmeier, USA).

The presentations comprised all areas of the Arctic: Chukchi and Bering Seas, Canadian archipelago, Barents Sea, Fram Strait, Svalbard, White Sea…

In addition to these scientific plenary presentations, the French local and national contexts related to the importance of Arctic studies were highlighted in two presentations by the INSU-CNRS scientific delegate for polar affairs (D.D. Rousseau) and by the director of the IUEM (Y.-M. Paulet).

Arctic oceanography: a view from the coast

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The arctic is a tremendously dynamic and variable place in terms of its oceanography. There exist huge contrasts in water temperature and salinity, heat fluxes, ice cover and seasonality. Yet it is so easy to assume it is just a slowly evolving, quiescent, sub-zero ocean. In this talk we will examine some of the key characteristics and research topics within different regions of the arctic ocean by taking a journey from the glacier front, through the coastal waters and into the deep arctic basin. In particular we will consider the role of fresh water, sea ice formation and warm inflowing waters in shaping the oceanographic conditions in the arctic.

Contribution of Arctic glaciers to fresh water discharge in the ocean: Observation of the Austre Lovén glacier, Svalbard, 79°N

Griselin Madeleine[1*], Marlin Christelle[2], Bernard Eric[1], Tolle Florian[1], Saintenoy Albane[2], Quenet Mélanie[2], Delangle Emerick[2], Friedt Jean-michel[3]

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[3]Franche-Comté Electronique Mécanique Thermique et Optique - Sciences et Technologies (FEMTO-ST), CNRS : UMR6174, Université de Franche-Comté, Ecole Nationale Supérieure de Mécanique et de Microtechniques (ENSMM), Université de Technologie de Belfort-Montbeliard, Besançon
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In polar regions, glacier basins contribute to the flux of fresh water by melting of snow and ice through a very complex hydrological equation.

Since 2006, we intensively surveyed a small glacier basin of Spitsbergen and its reaction to the present and recent (50 years) climate fluctuations.

An important number of loggers has been set on the basin (10 km2) in order to quantify the different terms of the hydrologic equation of the Austre Lovénbreen basin.

Combining data from 20 air temperature loggers and 12 automatic stations, we obtain potential melting provided by snow and ice.

Potential melting is therefore compared to real melting observed through the mass-balances. Five consecutive hydrological years are examined to compare five mass-balances with the meteorological data. These five years belong to a hot decade which affects Svalbard glaciers. The observation of the glacier shows the crucial impact of liquid precipitations on the glaciers in every season. The result is complex: an average warm and dry summer will have few incidence on the glacier balance, while a warm and very dry winter could be seen as catastrophic at sea level but will contribute to important snow accumulations on the glaciers over the 0°C isotherm. 2011 has a huge negative mass balance equivalent to the total 2007-2010 value. 2011 is characterised by a very thin snow coverage in winter, an early disappearance of the snow cover on the glacier, and very high air temperatures at the end of summer, with huge liquid precipitation all the way to the top of the basin.

The important retreat of the glacier since the PAG implies a decrease of the glacier/basin ratio. Less ice is exposed to air and fresh water reaching the sea should decrease too. But the opposite happened melting water volume increased by 50% since the 60s.

Modelling of the physical-biological coupling in the Arctic: an emphasis on the land-ocean connection

Le Fouest Vincent[1]

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The Arctic Ocean undergoes profound changes of its physical and biotic environments due to climate change. Their impact on present and future levels of primary production depends on the nutrient supply into the photic zone that mediates the plankton ecosystem structure and functioning. At the panarctic scale, the importance of horizontal river supply of nutrients relative to oceanic processes is poorly constrained. Our first objective was then to estimate the riverine nutrients inputs from 9 large Arctic rivers from an extensive historical dataset (1954-2012) and assess their contribution to the AO biogeochemistry. Using data collected during the Malina project (2008-2012) in the Beaufort Sea, one-dimensional and tridimensional physical-biological modelling approaches were also set up. Model runs were analyzed to assess i) the removal by marine bacteria of terrigenous organic carbon and ii) the contribution of photo-chemical processes involved in the degradation of dissolved organic matter to primary production.

Light, carbon fluxes & ecosystems in a changing Arctic Ocean

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The ongoing spectacular changes in the Arctic are expected to profoundly modify marine ecosystems and biogeochemical cycles. The decrease in summer ice cover that exposes sea surface to more solar radiation and physical forcings, the thawing of permafrost and increased river runoff, both of which lead to an increase in the export to the ocean of organic carbon previously sequestered in the Tundra, and an increase in ultraviolet radiation will all affect the structure and functioning of microbial communities and, ultimately, of the entire trophic network. Ocean color remote sensing has recently proven to be a powerful tool for monitoring Arctic marine ecosystems and improving our understanding of their current mutation. Its full exploitation, however, is currently impeded by major limitations. The peculiar optical properties of Arctic waters, prevailing low sun elevations at high latitudes, omnipresence of sea ice and clouds, vertical distribution of phytoplankton biomass and specific adaptation of phytoplankton to extreme growth conditions limit the extent and quality of ocean color data and their derived products such as primary production. New observing platforms equipped with various optical sensors will certainly complement surface remote sensing data. Their use in the Arctic ocean, however, requires that new deployment approaches be developed to cope with the presence of sea ice. In this presentation, I will describe the state- of-the-art in marine optics and ocean color remote sensing for the Arctic Ocean, as well as the challenges faced by optical oceanographers to optimize observing technologies for addressing key scientific questions in the Arctic. I will also present the most recent progress made in our understanding of Arctic marine ecosystems and their response to climate change.

Importance of sea ice algae in the Arctic marine ecosystem

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Sea ice plays a significant role in the biology and ecology of polar marine systems as it supports a productive community of unicellular algae as well as a diversity of heterotrophs ranging from bacteria to metazoans. Ice algae have been estimated to contribute 10 to 60% of annual primary production in the Arctic. However, their ecological role as an early, high-energy food source in the Arctic ice-associated ecosystem may far outweigh their relative contribution to total production. Recent expeditions in the Canadian High Arctic gave us the opportunity to investigate ice algal communities during the fall to early summer transition. In fall, algae from the water column are incorporated into the newly formed sea ice. During the dark winter period, algal cells that remain in the sea ice appear to retain their vegetative form. In spring, they become highly concentrated in the bottommost centimetres of first-year sea ice, where light transmitted through the snow-ice cover and nutrients supplied from the underlying surface water regulate their production. During the spring melt season, bottom ice diatoms are released into the water column, flagellated cells develops in the surface melt ponds and phytoplankton blooms under the ice. The presentation will discuss these recent discoveries on the dynamics of ice-associated primary producers in the coastal Arctic Ocean.

Consequences of the Global Warming on microbial food webs in the Arctic Ocean

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Warming is particularly intense in the Arctic, where temperatures increase at rates of 0.4 ºC per decade. The consequences of these increasing temperatures are already visible, thus, losses of ice cover are now affecting the habitat of large mammals, birds and humans and extensive sea ice melting has led to large changes in the biogeochemistry of the Ocean, as well as in the functioning of the microbial food web. The outcome of this warming was analyzed taking into account, the impact of the melted ice and the effect of temperature on the components of the microbial food web.

In summer 2007 a historical minimum of Arctic ice coverage was observed, and significantly more carbon was channeled to protists in ice melted affected waters, than in unaffected waters. In the other way around virus transformed higher bacterial biomass to dissolved organic matter in no affected than in affected waters. These results indicated that sea ice melting could modify the carbon flow through the microbial food web. This process would be particularly important in case of massive sea ice melting due to climate change. Also, in summer 2009 Arctic microbial communities submitted to increasing temperatures, showed a temperature threshold, where the phototrophic microorganisms shifted from big diatoms and dinoflagellates to pico-nanoplankton as *Micromonas sp*. and *Pheocystis sp*., respectively, and at the same time the heterotrophic microbial community took over. This suggest that warming would trigger shifts favoring heterotrophic communities, which could have a large impact on carbon and nutrient cycling and carbon storage in the Arctic Ocean.

Although, all these studies point out that warming will be responsible of crucial changes in the biogeochemistry of the Arctic Ocean, we need to do more research in cold seasons and in different areas of the Arctic of the ones studied until now.

Oceans in a high CO_2 world: Integrating climate-related stressor effects on marine organisms

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Climate change effects on marine ecosystems involve various drivers, predominantly temperature, hypoxia and CO_2, and possibly further anthropogenic stressors such as pollutants. All life forms respond to these drivers, following potentially common principles, which are, however, insufficiently understood. The specific understanding may be most advanced in animals where the concept of oxygen and capacity dependent thermal tolerance (OCLTT) appears as a suitable integrator of such effects, linking molecular to ecosystem levels of biological organisation. Recent studies confirm OCLTT involvement in the field, causing changes in species abundance, biogeographical ranges, phenology and species predominance. At whole animal level, performance capacity set by aerobic scope and energy budget, building on baseline energy turnover, link fitness (within thermal window) and functioning at ecosystem level. In the variable intertidal, animals also exploit their capacity for passive tolerance. While presently the temperature signal appears predominant in the field, effects may well begin to include other stressors, acting synergistically by modifying (narrowing) the aerobic OCLTT window. Recent findings support the OCLTT concept as a common physiological basis linking apparently disjunct effects of ocean warming, acidification and hypoxia. In brief, warming induced CO_2 accumulation in body fluids links to the effects of ocean acidification mediated by the weak acid distribution of CO_2. Temperature induced hypoxemia links to the hypoxia sensitvity of thermal tolerance. Future research needs to develop proxies for these effects and to also identify the principles operative in organisms other than animals and their underlying mechanisms. Mechanism-based modelling efforts are then needed to develop reliable, organism to ecosystem projections of future change.

Krill and its response to temperature changes

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Today, most of the scientists agree on the future of the global warming. The Polar Regions are first to be concerned. Average Arctic air surface temperatures are increasing at approximately twice the global average (IPCC 2007). Regional climate change along the Antarctic Peninsula has been rapid with air temperature rises of up to 3 °C and elevation in the surface layers of the Bellingshausen Sea of 1 °C in 50 years (Meredith and King, 2005). The impacts of these modifications, are difficult to measure because our weak knowledge on endemic organisms.

The krill constitutes the base of the food web of the Antarctic Ocean and is suffering simultaneously intensive fishing and modification of its biotope. The consequences are numerous and affect all the levels of the polar biodiversity. A best knowledge of its physiology is now a priority in the frame of global warming. This will enable to predict consequences on animals, which are stenotherm since million years and so on the whole regional food web.

The main objective of this project is to study the capacities and the molecular pathways involved in euphausiids from Antarctic (*Euphausia superba* and *crystallorophias*) versus Arctic (*Thysanoessa inermisandraschii*) regions when they are under thermal shock. This study will mix in vivo and molecular physiology to estimate euphausiid thermal tolerances but also to characterize molecules implied in the response. In parallel to the heat shock protein (HSP especially 70) study, a global approach on characterization and follow-up of new molecular markers, in relation with high temperature conditions, will be realized via transcriptome analyses. Beyond the immediate study of consequences and responses of euphausiids to temperature increase of the medium, this project, via its comparative approach, take a large interest in cold adaptation processes and in prevention of any temperature variations.

The arctic part of the project, which is just beginning and focus on *Thysanoessa inermisandraschii*, is made in collaboration with Pr Buchholz (AWI). The major objectives are to identify the metabolic adaptability to high temperature (10°C) and to understand the metabolic pathways involved in adaptation. The project will form a link between physiology and transcriptomics for a better understanding of the physiological reaction in connection with the species molecular life strategy.

Retention of ice-associated amphipods: possible consequences for an ice-free Arctic Ocean

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Recent studies predict that the Arctic Ocean will have ice-free summers within the next 30 years. This poses a significant challenge for the marine organisms associated with the Arctic sea ice, such as marine mammals and, not least, the ice associated crustaceans generally considered to spend their entire life on the underside of the Arctic sea ice. Based upon unique samples collected within the Arctic Ocean during the polar night, we provide a new conceptual understanding of an intimate connection between these under-ice crustaceans and the deep Arctic Ocean currents. We suggest that downwards vertical migrations, followed by polewards transport in deep ocean currents, are an adaptive trait of ice fauna that both increases survival during ice-free periods of the year and enables re-colonization of sea ice when they ascend within the Arctic Ocean. From an evolutionary perspective, this may have been an adaptation allowing success in a seasonally ice-covered Arctic. Our findings may ultimately change the perception of ice fauna as a biota imminently threatened by the predicted disappearance of perennial sea ice.

Use of bivalves proxies to monitor environmental variability in Arctic marine ecosystems

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Bivalves can be very long-lived and they also incorporate in their shells a history of environmental conditions at the time of shell synthesis. The presence of periodic banding, or growth lines, in shells makes it possible to assess precise ages of individual organisms and furthers allows development of chronologies of environmental conditions over the life of the individual. Analysis of bivalve shell increments (sclerochronology) thus provides a means to reconstruct long-term patterns in growth histories and assess factors that regulate marine ecosystems on local scales. Further, comparing bivalve chronologies across climatic gradients provides understanding of how climate and local environmental conditions interact and are linked to biological systems. Finally, combining analysis of long-term growth patterns with other bioproxies such as shell mineralogy and stable isotopic compositions of shells and tissues can provided added information on mechanisms of climatic regulation on trophic dynamics. Chronologies of bivalve growth have proven useful in linking ecological processes via growth rates to climatic variability around Svalbard and the Barents Sea. I will present case studies of sclerochronological and geochemical analyses of two bivalve species, *Serripes groenlandicus* and *Clinocardium ciliatum* demonstrating the utility of these bioproxies in reconstructing climatic conditions and ecosystem dynamics in a changing Arctic.

Benthos in Svalbard - how do glacial inflows shape benthic communities in Arctic fjords?

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Fjords are semi-enclosed, geologically young marine inlets that remain under strong terrestrial influences and are considered to be strongly dependent on regional species pools of neighbouring open shelf seas. The activity of Arctic tidal glaciers, usually located in the fjords' heads results in high turbidity, high rate of inorganic particulate sedimentation and sedimentary instability in near-glacier marine basins. The chronic physical disturbance of sediments is accompanied by low input levels of organic matter. «Glacial disturbance' shapes the species composition, species diversity and functional complexity of the macrobenthic communities in Arctic glacial fjords. The patterns of diversity and community structure of macrozoobenthos documented in west Spitsbergen fjords will be presented in this context.

Ecosystem shifts in the northern Bering and Chukchi Seas

Grebmeier Jacqueline[1]

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Observations indicate that changes in the timing of sea ice formation and retreat, along with increasing seawater temperatures, are driving shifts in marine species composition that likely signal large-scale marine ecosystem reorganization. In recent years, wide variability in seasonal sea ice retreat in the northern Bering Sea has been observed, but to the north in the neighbouring Chukchi Sea ecosystem there has been consistent and large early season ice retreat and historically late sea ice formation in the fall months. The latitudinal gradient in sea ice persistence, chlorophyll concentrations, and carbon export to the sediments from the northern Bering Sea to the Chukchi Sea has a direct impact on ecosystem structure in this subarctic-arctic complex. Variations in seawater hydrography, light, primary production, pelagic-benthic coupling and benthic carbon cycling are all tied to sea ice and temperature changes. Potential biological impacts include shifts in species composition and abundance, trophic transfer efficiency, and northward range expansions. One consequence might be a transitional change from a benthic-dominated northern Bering and Chukchi shelf region to a more pelagic-dominated system, with a direct impact on higher trophic level productivity. Several programs undertaken during recent years, including the Bering Sea Research Program, Canada's Three Oceans, the Russian US Long-term Census of the Arctic Ocean, and the Western Arctic Shelf-Basin Interactions are providing insights into the key processes influencing ecosystem function and change in this region. Data sets from these programs will be discussed in the context of biological response to sea ice changes.

WG 1.1 - Master students meet Arctic scientists

Responsibles: Joëlle Richard, Nathalie Morata and Fanny Narcy
Coordinators: Coline Fardel, Alicia Floch'Lay, Florence Cornette

The objective of this working group was to enable 33 students of IUEM to meet international scientists specialists of Arctic marine sciences in an informal framework (speed-dating like session). This session was part of a larger student project. In the frame of their classes, master students (M1 - Marine biological sciences) had to do a group project in link with the scientific topics presented during the Arctic Days. A choice of subjects were presented to the students at the beginning of the university year. Eight groups of 4-5 students were then formed. The subjects, in link with the invited talks, chosen were:

- Seasonal variation of the organic matter vertical flux in the Arctic Ocean
- Primary production and sea-ice evaluation by remote sensing in the Arctic Ocean
- Ecology and life cycle of copepods of the genus *Calanus* in the Arctic
- Physiological response of the organisms facing global warming
- Global warming impact on the microbial community in the Arctic
- Structure and functioning of the benthic community in the Arctic
- Acidification impact in the Arctic Ocean
- Seasonal dynamic and primary production of sea-ice algae in the Arctic

The output of their project was a "funding application" which details the background, the objectives, the approach and methods used, logistics and an outreach project. To help them in the construction of their project, they had different things:

- Their subjects were used in the teaching unit "Expression techniques and bibliography research" during the concrete examples for the bibliographic research.
- They had a lecture of three hours before the Arctic Days divided in two parts: *i*) important steps to write a good scientific project and *ii*) an introduction on the Arctic marine ecosystem.
- They had to attend the plenary sessions during the Arctic Days.
- During the Arctic Days, a speed-dating like session was organized. Eight discussion themes were proposed to the master students (sampling/experimental strategy, logistic needs, funding sources, international collaborations, scientific careers, outreach, scientific communication and tips for a successful scientific project). International researchers have been assigned as mentor in one of these discussion themes (1-2 researchers per theme) and had therefore to interact with each of the 8 student groups. The students had prepared questions and asked the mentors for their expertise during 15 minutes time slots.

Two weeks after the Arctic Days, the students had to submit their written proposal and to present it in front of their colleagues and a jury of researchers of the European Institute of Marine Studies.

WG 1.2 - Towards a French network on Arctic marine ecosystems?

Chairman: ***Joëlle Richard, Nathalie Morata, Christine David-Beausire and Fanny Narcy***
Referent: ***Fanny Narcy***

The Arctic Days were the opportunity to identify and gather the French scientific community working on Arctic marine ecosystems. The motivations for this session came from the fact that the French community of Arctic scientists is scattered and not easily identified (from France and from abroad). In addition, a national initiative is ongoing, on a larger scale: "Chantier Arctique" (French Arctic initiative) presented during the Arctic Days by D.D. Rousseau (INSU-CNRS) and M. Babin (UMI Takuvik - CNRS). The French scientific community working on Arctic marine ecosystems would thus gain from some networking/structuring which would help this community to be united towards new Arctic projects, at the national and European level (e.g. H2020). Therefore, this working group aimed to facilitate exchanges within the French community and discuss the potential creation of a French network in Arctic marine ecology. The outcome of this discussion was briefly presented at the end of the WG 2.1 of the Arctic Days.

The objectives of this session were: **(1)** to identify the French community working on Arctic marine ecosystems, **(2)** to frame the research fields of this network, **(3)** to list the important points to be addressed within this network, and **(4)** to discuss how this network could be driven.

(1) French community working on Arctic marine ecosystems

This session gathered 28 participants coming from 16 different labs. In addition, 51 other French scientists showed their interest by either registering to the Arctic Days or sending an e-mail (see Table 1 next page).

The participants were quite diverse with respect to their involvement in the Arctic (established, new or future, exclusive or not, and bipolar research), as well as regarding their fields of research: biodiversity, ecophysiology, genetics, marine ecology (plankton and macrobenthos), primary production and remote sensing, proxy and biomarkers, benthic-pelagic coupling, sea birds, biogeochemistry, geography (glaciers), water-sediment interface, physical oceanography, modeling of sea-ice, logistics, etc…

(2) Frame of this network

Although the Arctic Days initiative started from the community working in Arctic marine ecology, it became clear during the session that this network should cover a broader field of research and encompass physical oceanography and biogeochemistry. The name of this network should thus reflect its interdisciplinarity:

→ **'Arctic marine ecosystems in a changing environment' (*in progress*)**

Labs	Nb	Names of participants
LOCEAN, Paris	5	F Vivier, E Sultan, C Rousset, M-N Houssais, D Ruiz Pino
LEMAR/IUEM, Brest	5	L Memery, N Morata, J Richard, F Narcy, L Chauvaud
IUEM, Brest	3	C David-Beausire, Y-M Paulet, P Treguer
LPO/IUEM, Brest	1	A-M Treguier
UMI Takuvik	2	M Babin, G Massé
MNHN, Paris	2	M Eleaume, F Olivier
Univ. Caen/Ifremer Brest	1	A Baltzer
Aarhus Univ. (Denmark)	1	J Fort
Univ. Franche-Comté, Besançon	1	M Griselin
CEFREM, Perpignan	1	P Kerhervé
LOV, Villefranche-sur-mer	1	V Le Fouest
Univ. Nantes	1	V Martin-Jezequel
INSU-CNRS	1	D-D Rousseau
Station Biologique de Roscoff	1	J-Y Toullec
Asso. Pôle Nord 2012	1	A Letressoler
Asso. Under the Pole	1	R Pete
Total	28	

Table summarizing the session's participants and their affiliations

(3) Important points to be addressed

a- Insertion into the "Chantier Arctique"

The French national initiative for the Arctic research "Chantier Arctique" will organize a meeting in Paris in June 2013, and will launch a webpage (early 2013). It is therefore important that our new network is visible on this webpage and that we actively prepare the meeting. This network in Arctic marine ecosystems would not overlap with the working groups planned in the frame of the "Chantier Arctique", but could rather contribute to one or several of them.

b- Goals of this network

- To structure the French community towards more national/international visibility
- To facilitate exchanges between French scientists
- To bring French expertise up to the Arctic
- To identify some key questions that the French community could address, based on the prospective reports already available in France (OA-INSU and INEE) and internationally

(4) Functioning

We will use the APECS website (Association of Polar Early Career Scientists, apecs.is) as a platform for the animation of the network, where both young scientists and seniors (as mentors) could be registered. Each participant should register online, create he's own profile and join the group "APECS France - Arctic marine ecosystems". The APECS platform enables discussions within the group, as well as the organization of webinars and virtual poster sessions. A mailing list will be used to transfer the network updates and important information to all participants, even non-registered.

Referent scientists from different fields would be in charge of summarizing the discussions/intentions of the network in the form of a white paper (for example).

Our web page hosted on APECS website will be accessible for non-registered visitors and will summarize the important activities of the network. It is also important to communicate about this network through posters, for instance at the Arctic summit week (IASC, not. marine working group.

WG 2.1 - Arctic Challenges, geopolitics and science

Chairman: ***Denis-Didier Rousseau***
Referent: ***Christine David-Beausire***

Initial Framing

This working group aims to assess the structure of Arctic scientific research inferred from the specific geopolitical context of this region. The presentation of Laurent Mayet (from the French Ministry of Foreign and European Affairs) about the governance of the Arctic and the subsequent need for international collaborations to address the climate change challenges will serve as a base for the discussion.

Here, we will try to get an overview of the scientific leading institutions and existing networks aiming to structure the scientific communities or to bring together scientists (and sometimes scientists and managers) for trans-disciplinary approaches. Emphasis will be made on the way the marine ecosystems topic is addressed.

In the discussion, the insertion to the Sustaining Arctic Observing Networks (SAON) initiative from the Arctic Council should be mentioned and will make a link with the next working group.

Summary of the presentation by Laurent Mayet (*French Ministry of Foreign and European Affairs*)

The existence of an international diplomacy on the Arctic does not mean that effective international cooperation is already taking place. Among the “Arctic Five” (the Arctic coastal States: US, Canada, Greenland/Denmark, Norway and Russia), a posture of affirmation of the primacy of national sovereignty is adopted, despite the scale of emerging challenges that are to be faced, in the context of the newly accessible Arctic Ocean.

The Arctic Ocean has a legal regime, the United Nations Convention of the Law of the Sea (UNCLOS) upon which Arctic States have agreed, except USA. In addition, the Arctic States have undisputed sovereign control over their Exclusive Economic Zone. Several High Sea areas are “common property of all nations”, notably the central Arctic Ocean which covers 35% of the entire Arctic basin. Asserting sovereign rights is not a particularly conflicting issue in the Arctic, given the existence of a legal regime, the UNCLOS, and the willingness of Arctic Coastal States to “remain committed to this legal framework”. As stated by several geostrategic experts, the Arctic is not a potential conflict zone.

Yet, the Arctic states are still reluctant to benefit from cooperation with other nations to prepare for future development of human activities and major environmental change in the Arctic. The Arctic is however at the threshold of historically unprecedented ecological change and the perspective of an ice-free Ocean during summer allows for new development opportunities (new shipping routes, expanded oil and gas development and new commercial fishing). To ensure sustainable development for the region, these opportunities must be managed in a coordinated way by Arctic nations along with indirectly concerned nations in particular for "search and rescue" purposes.

A framework of cooperation exists: the Arctic Council, in which France as the observer status. Yet, by now, the Arctic Council is not to be used as a forum for discussing current and future challenges. The future Arctic governance will strongly depend on the willing of the Arctic Five to strengthen regional and international cooperation in the Arctic.

Summary of discussions

Institutional structure

IASC (International Arctic Science Committee), Jacqueline Grebmeier (*Univ. Maryland, USA***)**

IASC is a "non-governmental, international scientific organization, the mission of IASC is to encourage and facilitate cooperation in all aspects of Arctic research, in all countries engaged in Arctic research and in all areas of the Arctic region". IASC is an International Scientific Associate of the International Council for Science (ICSU) and observer on the Arctic Council. Its membership today includes national science organizations from 21 countries involved in Arctic research.

IASC draws on an organizational structure that provides mechanisms for initiating and implementing cutting-edge science-led international programs. Representatives of the national science organizations from all 21 IASC member countries form the IASC Council. The Secretariat is currently hosted by the Alfred Wegener Institute for Polar and Marine in Potsdam (Germany), and is responsible for the day-to-day operations of the organization.

Working Groups are IASC´s main scientific working bodies. They identify and formulate science plans, act as scientific advisory boards to the IASC Council and assist IASC in the implementation of its science mission. The six working groups are: Terrestrial, Cryosphere, Marine/Arctic Ocean Sciences Board, Atmosphere and Social & Human. Each of them has defined scientific foci.

Actions Groups are providing strategic advice to the IASC Council concerning both long-term activities and urgent needs. They are small expert groups that act within a limited timeframe of two years: Joint SCAR/IASC Bipolar Action Group on Science Development, Data Policy Group and Action Group on Geosciences. IASC has developed specific agreements with several partners, notably the World Climate Research Program (WCRP), the Scientific Committee on Antarctic Research (SCAR) or the Association of Polar Early Career Scientists (APECS).

Structuring Networks

ARCTOS (international arctic marine research network), Stig Falk-Petersen (*NPI, Norway***)**

ARCTOS is a pan-arctic network centered in Tromsø, Norway, that build bridges between senior and young scientists, national and international research, science and industry, science and culture, and add momentum to polar marine ecological research. It was initiated by scientists (bottom-up driven) in 2002.

The ARCTOS scientists conduct science over a broad range of marine ecology topics in the Barents Sea and around Svalbard, and in most of the northern waters. Several important institutions in Russia, North America and the EU are collaborating within the frame of ARCTOS, giving this research a pan-Arctic perspective. Research on the Norwegian side is financed through the Norwegian Research Council, EU-programs, own institutional funding and support from the petroleum industry (StatoilHydro, ConocoPhillips, Eni and Total). ARCTOS is organised as a research project based at the University of Tromsø.

ArcticNet: Network of Centres of Excellence of Canada, Marcel Babin *(UMI Takuvik, Canada*)

ArcticNet is one of 14 Networks of Centres of Excellence (NCE) jointly funded by the 3 Research Councils of Canada and Industry Canada. It is funded at $6.4M/y during first cycle (2004-2011) and hosted at Université Laval, Quebec City.

The general objectives of ArcticNet are: to build synergy among existing Centres of Excellence in the natural, human health and social arctic sciences, to involve Northerners, government and industry in the steering of the Network and scientific process, to increase and update the observational basis needed to address ecosystem-level questions raised by climate change and globalization in the Arctic, to provide academic researchers and their national and international collaborators with stable access to the coastal Canadian Arctic, to consolidate national and international collaborations, to contribute to the training of the next generation of experts, to help translate our growing understanding of the changing Arctic into impact assessments, national and global policies and adaptation strategies.

ArcticNet is stakeholder driven and has adopted an efficient and engaged management involving the user sector. The strength is in the network, with partners from coast to coast and beyond.

The research program is in phase III: core program of 35 projects contributing to 4 "Integrated Regional Impact Studies" (IRIS). Knowledge and technology exchanges are ensured through the Polar Data Catalogue designed for data set description, indexing, discovery, full data archiving and sharing. Major Canadian initiatives in Arctic research are Arctic Research Infrastructure Fund (ARIF), Canadian High Arctic Research Station (CHARS) and the future polar-class icebreaker Canadian Coast Guard Ship *John G. Diefenbaker*. By now, scientists have access to CCGS *Amundsen*.

ART (Arctic in Rapid Transition), Nathalie Morata (*IUEM, France***)**

ART is a cross-cutting network integrating past, present and future to study biogeochemical cycling and ecosystem function in the Arctic Ocean. The ART initiative is an integrative, international, interdisciplinary, pan-arctic network to study the spatial and temporal changes in sea ice cover, ocean circulation and associated physical drivers over multiple timescales to better understand and forecast the impact of these changes on the ecosystems and biogeochemistry of the Arctic Ocean.

ART is an international cross-cutting network supported by the marine working group of IASC. It was conceived, developed, and remains steered by early career scientists, and will continue to support their active involvement. It has a unique focus on bridging temporal aspects (paleorecords, current observational studies, modelling efforts). And ART fosters communication and data exchange among disciplines and will improve our understanding of the Arctic marine realm as a whole.

The ART implementation plan is developed in a three-phase approach. Phase I is to develop an international multidisciplinary network of scientists sharing a common interest in improving our understanding of the biological and ecological implications of sea ice transitions in the Arctic Ocean. Phase II is devoted to the coordination of dedicated, multi-country, interdisciplinary field campaign and data collection activities that would feed into an integrated modelling effort. And phase III is the synthesis of knowledge including the conception of robust scenarios regarding the future state of Arctic marine ecosystems and their role in global processes. Mentoring and science educational programs will be integral to all three phases

CNFRA (Comité National Français des Recherches Arctiques et Antarctiques), Emmanuelle Sultan (*LOCEAN-MNHN, France*)

CNFRA is an association, member of French Committee of International Scientific Unions (COFUSI). The Academy of Science institutionally represents France at the International Council of Science (ICSU) as a "national scientific member". ICSU, which headquarter is located in Paris, is an independent non-governmental organisation. France is represented at ICSU by the COFUSI, issued from the Academy of Science.

In this frame, CNFRA objectives are: promoting French scientific researches in Polar Regions, ensuring representation of France at the Scientific Committee on Antarctic Research (SCAR), encouraging international cooperation and supporting interactions of French research with international programs, contributing to communication and information on polar and subpolar researches.

APECS (Association of Polar Early Career Scientists), Emmanuelle Sultan (*LOCEAN-MNHN, France*)

APECS is an international and interdisciplinary organization for undergraduate and graduate students, postdoctoral researchers, early faculty members, educators and others with interests in Polar Regions and the wider cryosphere. The aims are to stimulate interdisciplinary and international research collaborations, and develop effective future leaders in polar research, education and outreach.

APECS has more than 3600 in 76 countries over all continents and the Executive Committee and Council regroups 40 persons. The main costs associated with running APECS comes in supporting our International Directorate Office currently located in Tromsø, Norway. The Research Council of Norway, the University of Tromsø, and the Norwegian Polar Institute provide the majority of the finances needed to keep all our activities centrally coordinated and running efficiently. Various organizations and institutes contribute financially to the general running APECS: the Scientific Committee on Antarctic Research (SCAR), the Nordic Council of Ministers, Antarctica New Zealand, the Scott Polar Research Institute.

Providing early career professionals with the tools needed to create strong platforms upon which to base their careers takes effort from many. To help provide a plethora of opportunities for early career polar professionals, APECS has officially partnered with a number of organizations to work together to shape the future of polar research: in particular the International Arctic Science Committee (IASC), Arctic Frontiers or the Conservation of the Arctic Flora and Fauna (CAFF) program of the Arctic Council.

The International Arctic Science Committee (IASC)

Grebmeier Jacqueline[1]

[1]University of Maryland, Chesapeake Biological Laboratory, P.O. Box 38, Solomons, MD 20688

The International Arctic Science Committee (IASC) is a non-governmental, international scientific organization. The IASC mission is to encourage and facilitate cooperation in all aspects of Arctic research by many countries working across the range of scientific disciplines. IASC promotes activities undertaken by early career and established scientists working through collaborative international research efforts through activities of its working groups, networks and connections with other international organizations. This presentation will discuss the ongoing and planned activities within IASC.

WG 2.2 – Observatories and long-term monitoring in the Arctic

Chairman: ***Yves-Marie Paulet***
Referent: ***Joëlle Richard***

The issue's identification emerged from the Arctic Days 2012 workshop directly leaded to the question of how we can tackle them. The time scales and variability of the climate change impacts underlined the need for long term monitoring.

The objective of this working group was to clarify the most pertinent environmental parameters to follow, the trends to identify in order to be able to predict the impacts of global warming on Arctic marine ecosystems, together with the way these ecosystems could impact in turn other Earth system compartments. Some synergies, needs and collaborations opportunities between the French and other countries initiatives had been brought to light.

In this session, different presentation were done on some implementing or establishing observatories, long term series or observation infrastructures in Arctic marine ecosystems. This was done in the line of the precedent working group (WG 2.1) where Marcel Babin presented the "Chantier Arctique" initiated by the National Institute of the Sciences of the Universe (INSU-CNRS) in which France want to initiate a national reflection about Arctic research issues that could be addressed by the national community and inserted into international collaborative works.

Stig Falk-Petersen presented the biological and physical time series of marine ecosystem in Svalbard waters with relevance for the Svalbard Integrated Arctic Earth Observing System (SIOS) for which the definitive framing will be done in a year time. SIOS is a proposals prepared for the European Strategy Forum on Research Infrastructures (ESFRI). The working group directly relevant for the researchers from the marine community is the WG 3 "Environmental change and marine ecosystems". The goal of the SIOS proposal is to establish an Arctic Earth Observing System in and around Svalbard that integrates the studies of geophysical, chemical and biological processes from all research and monitoring platforms. This will be done through: *i*) organizing all infrastructure and all research and monitoring activities; *ii*) assessing the present infrastructure and activities to identify gaps and investing in additional infrastructures and activities; *iii*) establishing a knowledge centre for data assessment, storage and delivery, education and outreach and *iv*) coordinating the SIOS initiative with complementary ESFRI. Concerning the marine data series, the existing and proposed infrastructure for SIOS are presented in Figure 1 and are:

- Physical oceanographers from the IOPAS (Institute of Oceanology Polish Academy of Sciences) investigate the Atlantic Water pathways and transports in the north-eastern part of the Nordic Seas
- HAUSGARTEN: multidisciplinary observations and experiments
- MASOX (AOEM) and the Kongsfjord transect links the shallower regions into the Arctic node
- ARCOONE (AOEM) / DAMOCLES links the Fram Strait up to East Greenland to the Arctic node

- Hard-bottom long-term series from the University of Tromsø (Knogsfjorden, Smeerenburgfjorden, Hinlopen and Isfjorden)
- The ARCTOS Svalbard marine long-term ecosystem monitoring system (pelagic sampling and benthos on soft sediment)
- Mooring array in Fram Strait (Norsk Polar Institute, Alfred Wegener Institute)
- Ferry box (Akvaplan-Niva)
- Dynamic Arctic marine ecosystem monitoring using CTD on marine mammals
- SEAPOP (Seabird Population)

Two of this time series were presented in more details:

Finlo Cottier from the Scottish Association for Marine Science (SAMS) presented an overview of the mooring activities around Svalbard which is part of the Arctic Marine Ecosystem Observatories (ARCTOS). Two moorings are actually in place since 2002 in Kongsfjorden and Rijpfjorden with instruments measuring: phytoplankton biomass (fluorescence), vertical migration of zooplankton (ADCP), species composition of plankton (sediment traps), temperature and salinity (CTD and termistors), sedimentation rates (traps). The data are available on the SAMS website.

Catherine Lalande from the Alfred Wegener Institute presented the HAUSGARTEN time-series (see abstract). HAUSGARTEN is the deep-sea observatory of the Alfred Wegener Institute in the eastern Fram Strait. It consists of 17 stations covering water depths between 1000 and 5500 m. Since 1999, samples were taken annually at these stations during summer. Additional deployment of moorings and free-falling systems acting as observation platforms enables seasonal measurements.

Stig Falk-Petersen really underlines the fact that SIOS is still open to new propositions and so that the French community could proposed ideas for new time-series to add in this framework.

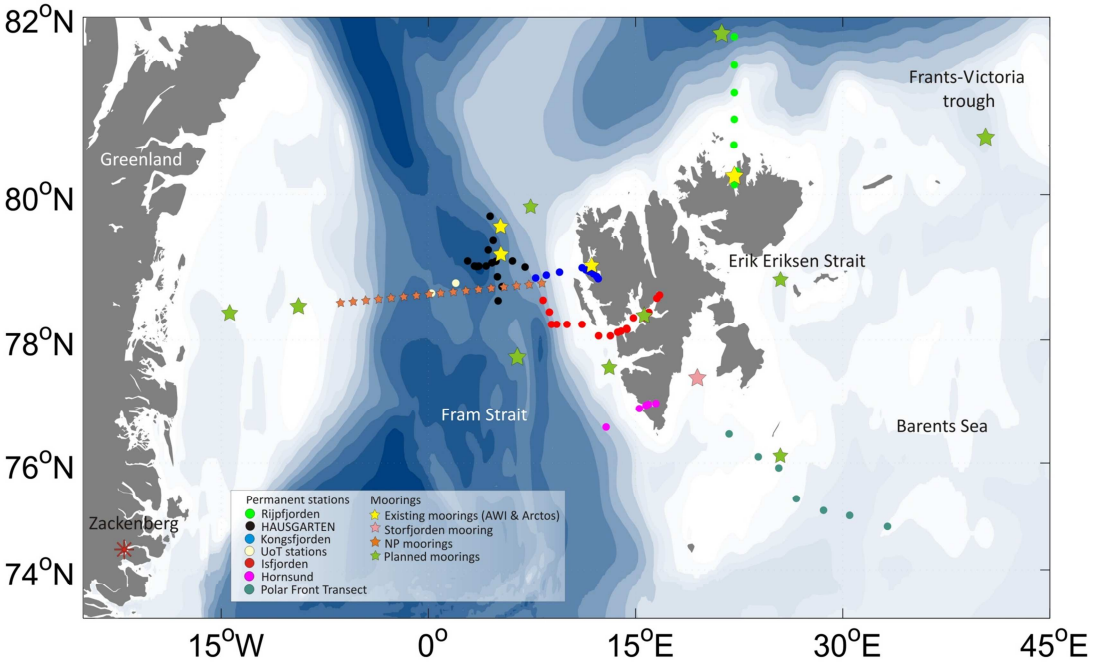

Figure 1: Existing and proposed infrastructure for SIOS concerning marine data series.

On the American side, Jacqueline Grebmeier presented the DBO (Distributed Biological Observatory) in the Pacific Arctic region (see abstract). It is being developed by an international consortium of scientists in the Pacific Arctic as a change detection array to systematically track the broad biological response to sea ice retreat and associated environmental change in the Pacific Arctic region. The DBO is tracking select biological measurements at multiple trophic levels, coincident with physical and chemical data, in a latitudinal array of transect lines and stations in the northern Bering and Chukchi seas. The DBO efforts will facilitate data collection, sharing and archiving through the US ACADIS (Advanced Cooperative Arctic Data and Information Service) data program and associated international data agreements.

HAUSGARTEN

Lalande Catherine[1]

[1]Alfred-Wegener-Institute (AWI), Am Handelshafen 12, 27570 Bremerhaven

HAUSGARTEN is the deep-sea observatory of the Alfred Wegener Institute in the eastern Fram Strait. It consists of 17 stations covering water depths between 1000 and 5500 m. Since 1999, samples were taken annually at these stations during summer. Additional deployment of moorings and free-falling systems acting as observation platforms enables seasonal measurements.

The Distributed Biological Observatory (DBO)

Grebmeier Jacqueline[1]

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The Pacific Arctic region is experiencing rapid sea ice retreat and seawater warming that can have cascading impacts on many components of the marine ecosystem. The Distributed Biological Observatory (DBO) is being developed by an international consortium of scientists in the Pacific Arctic as a change detection array to systematically track the broad biological response to sea ice retreat and associated environmental change in the Pacific Arctic region. The DBO is tracking select biological measurements at multiple trophic levels, coincident with physical and chemical data, in a latitudinal array of transect lines and stations in the northern Bering and Chukchi seas. Coordinated ship-based observations on a regular basis, together with satellite and mooring observations at the designated sites, can provide an early detection system for biological and ecosystem response to climate warming. The current 2010-2012 pilot program focuses on two areas in the Chukchi Sea where the highest number of ships from six Pacific countries agreed to participate and share data sets, both real-time and post-cruise, through the Pacific Arctic Group (PAG; http://pag.arcticportal.org/). Successful implementation of the biological change detection array as envisioned by the DBO effort will provide for a national and international network of coordinated sampling. This network will provide up-to-date information of one of the most productive regions of the Arctic. The DBO efforts will facilitate data collection, sharing and archiving through the US ACADIS (Advanced Cooperative Arctic Data and Information Service) data program and associated international data agreements. Further information on the DBO can be found at http://www.arctic.noaa.gov/dbo/.

WG 2.3 Projects and perspectives

Chairman: ***Stig Falk-Petersen and Paul Treguer***
Referent: ***Nathalie Morata***

In this last working group, the perspectives emerging from running or planned projects focusing on some process studies were presented and discussed.

The projects related to the Norwegian research network "Arctos" were presented by S. Falk-Petersen, J. Berge and J. Søreide. Most of these projects take place in the Svalbard waters. These projects cover various components of the marine ecosystems, including hydrography, water chemistry, small organisms (i.e. bacteria, microzooplankton), mesozooplankton and in particular calanus copepods, which are of particular interest for a lot of these projects, and higher trophic levels including fish and birds.

Projects from the IUEM were presented: ECOTAB and B.B. Polar. ECOTAB aims at studying the effect of climate change on the Arctic benthos in Svalbard. BB Polar aims at using bivalves as indicators of changes in environmental parameters.

National and collaborative projects presented covered a broad range of disciplines, including hydrography of the Storfjorden polynya (C. Rousset, LOCEAN), primary production and ocean acidification in the Bering/Chuckchi Seas (D. Ruiz Pino, LOCEAN), bivalve as indicator of environmental changes (F. Olivier, MNHN, France), study of higher trophic levels (birds and polar bears, J. Fort Aarhus University, Denmark and N. Longepe, CLS, France respectively).

Finally R. Troublé revealed the scientific plan of the Tara Arctic expedition, planned to happen in 2013.

Effect of climate change on the Arctic benthos (ECOTAB)

Morata Nathalie[1*], Richard Joëlle[1*], Chauvaud Laurent[1], Michaud Emma[1], Flye Sainte-Marie Jonathan[1], Jean Frédéric[1], Leynaert Aude[1], Ragueneau Olivier[1], Moriceau Brivaela[1], Amice Erwan[1], Martin Sophie[2], Heussner Serges[3], Kerhervé Philippe[3], Babin Marcel[4], Massé Guillaume[4], Bruyant Flavienne[4], Lalande Catherine[5], Pörtner Hans-Otto[5], Manno Clara[6], Søreide Janne[7], Berge Jorgen[7], Carroll Michael[8]

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It is now generally admitted that effects of climate change are enhanced in polar areas. Because of the ice-dependent character of Arctic marine ecosystems, climate-induced changes in sea-ice cover are expected to lead to shifts in primary production (decrease of ice algal production, increase in phytoplankton and microphytobenthos production) and changes in sea water chemistry (lower salinity and pH, higher temperature). Those changes will have repercussions on the entire ecosystem functioning and carbon cycling, although it is yet unclear how benthic organisms will respond to those changes in food sources and environmental conditions.

Although recent Arctic ecosystem studies have focused on describing the present state of either the "pelagic" or "benthic" compartment, the link between those two compartments, the "pelagic-benthic" coupling has often been underestimated. Moreover very few studies have included experimental approach in order to predict future scenarios, while this knowledge is crucial if we are to understand possible future changes and create models.

The overarching goal of this study is to investigate how climate-induced changes in biological (food sources) and environmental conditions will impact the Arctic benthos. This project will combine existing data, new field data, and a new experimental approach which will test various scenarios of food (i.e. high food quality, low food quality) and environmental parameters (pH, salinity, temperature) therefore improving understanding of present state Arctic coastal ecosystem function, and prediction of possible feedback scenarios of the ecosystem to changes in a less ice-rich Arctic due to climate warming. The work will be separated in 4 tasks: *i*) Description in great details of the seasonal variability in pelagic-benthic coupling, combining both pelagic and benthic perspectives; *ii*) Study experimentally the impact of changes in food quality for the benthos; *iii*) Study experimentally the impact of changes in temperature, pH and salinity, on key bivalves species and *iv*) Development and calibration of models of carbon and energy fluxes in the ecosystem and in the key bivalves species.

This project will take place at the French/German research station in Ny-Ålesund, Svalbard, which will provide adequate set up and background data insuring its success.

SCLERACTIC project: the use of *Astarte spp*. bivalves as archives of climate changes' impacts on arctic benthic ecosystems

Olivier Frédéric[1, 2*], Archambault Philippe[2], Blicher Martin[3], Chauvaud Laurent[4], Gaillard Blandine[1, 2], Martel André[5], Meziane Tarik[1], Rysgaard Soren[3], Thébault Julien[4], Tremblay Réjean[2], Winkler Gesche[2]

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Among the most sensitive areas in the world to climate changes' impacts, the Arctic Ocean constitutes a model site to assess the sole effects of both SST and sea ice regression (in cover and thickness) on the ecosystem functioning, especially on the trophic web. At a global scale, the actual conceptual model predicts, when considering the relative roles of sea ice, pelagic or benthic organisms in carbon and energy fluxes, a shift from a sea ice / benthos to a phytoplankton / zooplankton system, whose consequences on the marine biodiversity are actually unknown.

Typically, due to the harsh nature of the Arctic environment and to the costs of oceanographic campaigns, observations and data collections over seasonal to decadal time scales are rare although they are essential for the understanding of the dynamics and the effects of climate changes on the benthic ecosystems. Within that context, the use of bivalve shells as archives of the environmental variability can provide a good alternative especially for large distribution long-lived sessile species.

Among the potential species, those belonging to the *Astarte borealis* complex (filter-feeder, Astartidae) could provide a very good proxy of the dynamics of primary production. Based on *Astarte moerchi* specimens of the NOW polynia, we have already shown a major shift in the food supply to the bathyal benthic compartment since the last decade (Gaillard *et al*. in prep). We hypothesize that structuring mechanisms act at a more local spatial scale in response to the dynamics of the sea ice and to match/mismatch processes between phyto- and zooplankton.

We propose thus to develop the SCELARCTIC project to use *Astarte spp*. bivalves as archives of environmental variations due to climate changing at a larger scale, within contrasting trophic and bathymetric environments of the Beaufort, Baffin and Greenland seas.

The final objective of this project, coupling schlero-chronology/geochemistry and fatty acid markers methods, is to assess the effects of climate changes in the North American Arctic on the export of primary production to the benthos.

Pan-Arctic bivalves as polar bioarchives (B.B. Polar)

Chauvaud Laurent[1*], Richard Joëlle[1*], Thébault Julien[1], Clavier Jacques[1], Jolivet Aurélie[1], David-Beausire Christine[2], Amice Erwan[1], Olivier Frédéric[3, 4], Meziane Tarik[3], Tremblay Réjean[4], Archambault Philippe[4], Winkler Gesche[4], Gaillard Blandine[3, 4], Martel André[5], Ambrose William[6], Rysgaard Soren[7], Blicher Martin[7], Carroll Michael[8], Strand Øivind[9], Strohmeier Tore[9], Gaumy Jean[10], Paumelle Sandrine[10]

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In the B.B. polar project, we propose a scientific project using marine invertebrates as biological archives of the Arctic environmental variations. Tools will be implemented to monitor environmental parameters of the Arctic ecosystem at different time scales (from the daily to the decadal scales) by using two bivalves species, *Chlamys islandica* and *Astarte spp*., and at different spatial scales (from the single fjord to a pan-arctic view). Moreover, research in ecology will serve the visual and plastic design. This project will be the occasion for scientists and artists to work together around the climate change issues, transgressing the limits of each discipline.

High resolution ice-ocean simulation of the Storfjorden polynya in Svalbard

Rousset Clément[1*], Vivier Frédéric[1], Benshila Rachid[1], Madec Gurvan[1], Cuypers Yannis[1], Bouruet-Aubertot Pascale[1], Lourenco Antonio[1], Legoff Herve[1]

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Owing to the predicted and already observed dramatic impact of climate warming in the Arctic, there is a great need for monitoring this region not only to assess the magnitude of changes but also to understand the physical processes governing heat, salt and dynamical exchanges between ocean, ice and atmosphere, with improvement of climate models predictability as a challenging perspective. OPTIMISM (*Observing dynamical and thermodynamical Processes impacting The sea-Ice Mass balance from In Situ Measurements*) is a 4-year ANR/IPEV-funded project (2009-2013) involving 5 French laboratories. A backbone aspect of this project is the development of an autonomous instrument ("Ice-T" buoy + "BEAR" meteo mast), providing a comprehensive observation of the relevant parameters driving the sea ice mass balance. Processes are investigated from observations collected at two main sites: the central Arctic, and a coastal polynya of the Svalbard archipelago. A complementary approach , yet an ongoing task, is to build up a high resolution (<2 km) ice-ocean modelisation of the Svalbard area to simulate physical processes in an Arctic coastal polynia. These spatially-limited regions have been recently known to contribute significantly to the dense water formation of the Northern Hemisphere. The simulation is based on the most recent ice and ocean models (LIM3 – NEMO3.4). It runs over a period long enough to study interannual variability but it also includes high frequency dynamics such as tides, which partly drive turbulent mixing and thus control ice melting and dense water formation. Achievements and perspectives will be presented.

SIDARUS Project (Sea Ice Downstream Services for Arctic and Antarctic Users and Stakeholders) - Example of use of satellite technologies (SAR and ARGOS) for analysis of polar animal behaviour

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The overall objective of SIDARUS is to develop and implement a set of sea ice downstream services in the area of climate research, marine safety and environmental monitoring.

The SIDARUS project funded as a Collaborative Project under the FP7 programme addresses the needs of users and stakeholders in the area of marine safety, environmental monitoring and climate research. The demand from many user groups for improved sea ice information in the Arctic and Antarctic is growing as a result of climate change and its influence on the polar environment and on socio-economic conditions for marine operations. The presently observed reduction of the Arctic sea ice extent, in particular during the summer months, and an increasing demand for natural resources are key mechanisms driving human activities and likely wildlife behaviour in these areas.

Within a consortium coordinated by Dr Stein Sandven from NANSEN SENTER (NERSC), Norway, which also includes ALFRED-WEGENER-INSTITUT (AWI) Germany, UNIVESRITAET BREMEN (UB) Germany, UNIVERSITY OF CAMBRIDGE (UCAM) United Kingdom , METEOROLOGISK INSTITUTT (met.no) Norway , Scientific foundation Nansen International Environmental and Remote Sensing Centre (NIERSC) Russian Federation, B.I. Stepanov Institute of Physics of the National Academy of Sciences of Belarus Institute of Physics NAS of Belarus;

Collecte Localisation Satellites (CLS), France is working on the development of sea ice and iceberg mapping by radar satellite (SAR) and ARGOS tracking of marine mammals combined with such sea ice maps.

After an overall description of the project, the presentation will put a focus on CLS assets in Plouzané (VIGISAT) to receive, process and combine SAR data with other sources. Examples of SIDARUS combined maps will be presented for tracking of polar bears by a Russian end user (IPEE, Institute of Ecology and Evolution, Moscow).

The use of biotelemetry to track Arctic seabirds facing the threat of a changing environment

Fort Jerôme[1]

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Seabirds are an essential component of the Arctic North Atlantic ecosystem. Indeed, due to their high abundance, they exert a strong predatory pressure on lower trophic levels and therefore play a key role in marine food-webs. Despite this ecological importance, seabirds are a highly threatened group, and their protection is a major concern. Indeed, Arctic seabirds currently have to cope with both a rapid change of their environment under the effects of climate change and to an extensive development of human offshore activities associated with enhanced pollution risks. In this context, there is an urgent need to improve our knowledge of seabird at-sea movements and distribution year-round. This will (1) allow the defining of sensitive areas where large concentrations of seabirds occur and which might require particular attention and protection, and (2) provide essential information for future predictions of the impacts of climate change, such as the identification of specific habitat requirements.

Thanks to the development of miniaturized electronic devices over the last decade, the tracking of seabirds has become a major field of research, including in the remote Arctic regions. Here, I will present some of the projects currently performed at the Department of Bioscience (Aarhus University, Denmark). These projects aim to understand the at-sea distribution of several main Arctic seabird species (e.g. little auks, kittiwakes or Brünnich's guillemots) in the context of their habitat modifications. I will also discuss implications of our results for seabird conservation.

Sea ice melting, freshening, phytoplankton and CO_2 in the Pacific Arctic

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Is Arctic phytoplankton and CO_2 sink changing as a consequence of the recent strong ice melting? To explore this question, we investigate the impact of ice melt and freshening on primary productivity and atmospheric CO_2 uptake using *in situ* observations obtained during recent summers. Three oceanographic CHINARE cruises conducted on board the Chinese Icebreaker in the Pacific Arctic within the framework of a CHINA-FRANCE cooperation provided data of phytoplankton (biomass, taxonomy and productivity) and carbonates (pCO_2, Alkalinity, TCO_2 and pH) during high ice melt periods of 2008, 2009 and 2010.

Our data suggest that increase freshening could induce more oligotrophy in the Arctic and a shift of the phytoplankton ecosystem toward smaller size species. The impoverishment of the Western Arctic could be linked to a long trend response to climate change in relation with the Arctic Oscillation. The strong ice melt and subsequent freshening resulted in an increase of available light, stratification, halocline and nutrient reservoir deepening. In contrast, over short time scales, highest biomass, primary production and abundance of large cells (diatoms and dinoflagelates) were found at higher latitude ice edge newly formed over the basin and shelf Marginal Ice Zone. Enhanced freshening would have increased atmospheric CO_2 uptake since the last 10 years. As a consequence, the Arctic is slowly becoming a source of CO_2 for the atmosphere and water acidification is increasing. pH data shows that acidification in the Arctic is higher and faster than model and theoretical predictions. Phytoplankton and CO_2 documenting in real time less icy years are on the way, together with long-term in situ monitoring should allow to evaluate further the potential changes of the Arctic ecosystem, carbon sink and acidification.

Scientific project on Tara Arctic Expéditions 2013

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Tara Arctic 2013 objective is to explore the biogeography and biodiversity of different Arctic regions and depths, mapping the distribution of organisms from viruses to bacteria and protozoans, from phytoplankton to zooplankton and fish larvae in different physical conditions. This expedition will capitalize on the Tara Oceans 2009-2012 mission as it will deploy its multidisciplinary integrated approach, tools and knowhow developed continuously over the last 3 years at sea.

Poster session

Geophysical surveys of the south coast of the Kongsfjorden to record the sedimentary actual deglaciation processes

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Our main objective was to recognize and map, in the marine domain, the evolution of different sedimentary deposits related to the Lovenbreen glacier retreat (Fig. 1), using a very high resolution (VHR) geophysical approach.

Since the sixties, a french team conducted by M. Griselin (University of Besançon), has studied the Loven Est Glacier evolution, located at 6 km east of Ny-Ålesund (Fig. 1) in front of the Kongsforden. Since 2005, this glacier is instrumented to measure the ice volume variations according to the glacial and hydrological processes (Griselinet al., 1998, 2003, 2010). The SPITSBAY program (2006-2009), conducted by J. Deloffre (University of Rouen) focused on the sedimentary fluxes supplied to the fjord by the sub-glacial channels in front of the Loven Est glacier. The Lovenbreen glacier retreat shows various speeds and supplies important sediments volume to the tidal and subtidal areas. From 2005, these glaciers have stopped and show melting processes.

Since 2009, we are studying the final part of this system : the sediment deposition in the fjord itself, in the marine domain. To study these deposits we uses geophysical surveys, both in a vertical plan (IKB- boomer Seistec seismic) and in a horizontal plan (Edgetech side scan sonar). These tools allow us to recognise and delineate sediment deposits in 3D, with a resolution lower than 50 cm. The « ground truth » will be given by different grab samples (box core, Shipeck grab, Eckman binge) to calibrate the various side scan acoustic facies.

It is of particular interest to observe and record these sedimentary deglaciation processes, with an annual step, to be able to understand them and to recognize them into Holocene sedimentary archives.

On the seasonal cycle of the Atlantic water temperature within the Arctic Basin

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Recent mooring observations in the Arctic Basin suggest the existence of a seasonality of Atlantic Water (AW) temperature. Here the DRAKKAR global ocean/sea-ice model is used to examine the seasonal cycle amplitude of AW temperature within the Arctic Ocean and to investigate the possible mechanisms governing this seasonality. The simulation as well as available mooring data reveals that the amplitude of the AW temperature seasonal cycle is significant only in the Nansen Basin along the continental slope, where AW is primarily advected.

In the model, the seasonal cycle of the AW temperature is advected from Fram Strait up to St. Anna Trough and then re-energized by the Barents Sea Branch. This suggests that the seasonal AW temperature signal survives over a finite distance (~1000 km) as it is weakened by mixing and diffusion processes. Interannual changes in the seasonal cycle amplitude can be as large as the mean seasonal cycle amplitude; thus seasonality is difficult to characterize from observations spanning only a short period.

The seasonal bias of in-situ observations taken during spring and summer does not induce a significant error when considering the interannual-to-decadal variations of AW temperature, because the seasonal cycle accounts for a small or negligible part of AW temperature variability, even near the inflow region.

The impact of river inputs on Arctic plankton: an in situ mesocosm experiment

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The impact of river inputs on processes and fluxes within the plankton community of Kongsfjorden (79N Svalbard) were studied in situ during the PREDIC project. From July, 30th to August, 20th 2012, we deployed transparent cylindrical bags of $1m^3$ (mesocosms) in the harbor of Ny-Ålesund. Melt water from the Bayelva river plume was added in a gradient to marine water from the middle of the fjord within five mesocosms. We followed the biomass stocks and production of the different components of the plankton over time, and stable isotope labelling was used to quantify and follow the fate of bacterial carbon up to the mesozooplankton. Investigating the processes linking river discharge during the arctic summer to the plankton community of Kongsfjorden should bring insights on the underlying causes of the spatial and seasonal variability of plankton data collected during the transect survey implemented by NPI.

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