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The Kongsfjorden System

– a flagship programme for Ny-Ålesund

A concluding document from Workshop 28-31 March, 2008

Editors:
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Svalbard Science Forum

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Summary

A Svalbard Science Forum workshop about research on the Kongsfjorden System was held in Ny-Ålesund on 28-31 March, 2008. The aim was to discuss focal areas for future research and to initiate the **Kongsfjorden System Integrated Research Flagship**.

Current work and future plans of the individual research groups in Ny-Ålesund related to the Kongsfjorden System were presented. This built the base for identifying knowledge gaps and the following **future research priorities** were identified: There is a great need to combine the atmospheric measurements of long-range pollutants with measurements of the contaminant levels in the biota, to study the feedback mechanisms from the biosphere to the atmosphere and to investigate the interactive effects of rising temperatures and enhanced UV-radiation. Furthermore, knowledge is scarce about the changes in the pelagic fish community of Kongsfjorden, a monitoring programme for phytoplankton is needed and data on organic carbon mineralization is lacking. Also, the knowledge about water exchange processes in the fjord and small scale turbulences should be improved. Finally, it was suggested to use clams as environmental indicators. Two **major infrastructure innovations** were suggested; a cabled oceanographic monitoring platform that will allow real-time data retrieval and an integrated comprehensive monitoring station on one of the central islands in inner Kongsfjorden to monitor and study the processes on the atmosphere/ocean surface interface. It was also emphasised that a **database for long-term data** series from the Kongsfjorden System needs to be established and made available for the research community, as well as the **metadata bases** already established have to be coordinated and further developed.

Several initiatives were proposed that will contribute to an integrated approach to better understand the seasonal and annual dynamics of the Kongsfjorden ecosystem in the light of pollutant effects and climate change: The monitoring programme of atmospheric pollution at the Zeppelin Station will be further developed and linked to the marine research activities in order to identify the major drivers influencing the atmosphere/ocean surface interface. This will be supplemented by a marine monitoring platform that will allow real time monitoring of oceanographic and biological parameters in the fjord. The effects of discharges of terrigenous organic carbon and terrestrial particles from permafrost soils on the physiology of benthic organisms will be investigated. It is suggested that Kongsfjorden should be established as a main reference system for studies on the transport patterns of anthropogenic and natural contaminants throughout the marine food web and the consequences for the biota communities. Also, the variability of abiotic conditions and the effects on the biota will be addressed. The alteration of algal spring bloom needs to be studied in the light of observed changing oceanographic parameters and the possible consequences for the higher trophic levels. Furthermore, clams will be used as indicators for changes in climate and environmental parameters due to their behavioural modulations as response to environmental parameters. A special emphasis will be to advance the understanding of overwintering strategies of key components of the Kongsfjorden ecosystem. Also, climate data on longer time-scales than the instrumental records are needed to assess the significance of the current warming in the context of the Holocene and to produce more reliable predictions for the future Arctic climate.

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1. Main features of the Kongsfjorden System Integrated Research Flagship

1.1 Kongsfjorden System Integrated Research

- ***Kongsfjorden System is an established reference site for Arctic marine studies with great potential for international, multidisciplinary collaboration due to the presence of the international research platform in Ny-Ålesund.***
- ***Kongsfjorden represents a natural laboratory in the Arctic and is an established reference site in close proximity to Kings Bay Marine Laboratory.***
- ***Kongsfjorden functions as a climate indicator on a local scale because it is directly influenced by climate related changes on Spitsbergen Shelf and Fram Strait.***
- ***Kongsfjorden and the adjacent Zeppelin Station for Atmospheric Monitoring and Research represent the most important environmental monitoring locations in the Arctic.***
- ***Ny-Ålesund is an ideal site for studies of environmental contaminants due to the established research infrastructure with the Zeppelin Station for Atmospheric Monitoring and Research.***

1.2 Flagship innovations

- ***Kongsfjorden contains several moored installations for monitoring physical and biological parameters. A new cabled installation to Kings Bay Marine Laboratory would allow for real-time data retrieval from an oceanographic monitoring platform.***
- ***The ongoing long-term atmospheric monitoring programmes in Ny-Ålesund should be linked to the comprehensive hydrological, oceanographic and marine biological research programmes performed in the Kongsfjorden ecosystems. For this purpose, an integrated comprehensive monitoring station needs to be established on the central islands within Kongsfjorden.***

1.3 Kongsfjorden as a Flagship Site for international research

Kongsfjorden as reference site

Kongsfjorden is an established reference site for Arctic marine studies, and in many regards it functions as a natural laboratory in the Arctic. The EU's 5th Framework Concerted Action BIOMARE (2000-2002) generated the idea of European Marine Biodiversity Sites (EMBS): a selection of localities where marine biodiversity research will be focused in the coming years. Both Kongsfjorden and Hornsund have been declared European Flagship Sites of Biodiversity, which will be of importance for long-term research and monitoring of biodiversity in these waters (http://www.iopan.gda.pl/projects/biodaff/).

Ny-Ålesund as international research platform

Ny-Ålesund (78° 55' N, 11° 56' E), a settlement situated on the shore of Kongsfjorden, has developed into an international research platform, with stations from 11 nations (China, France, Germany, India, Italy, Japan, Korea, Norway, Russia, Sweden, UK) and many visiting international researchers. The Norwegian Government has designated Ny-Ålesund as the centre for environmental research in Svalbard, and Ny-Ålesund has already become a leading international environmental research and monitoring station in the Arctic. It is a focus point for both Arctic fjord studies and atmospheric research. The Kings Bay Marine Laboratory, which opened in 2005, provides an excellent facility for experimental work in the Arctic. Its location on the shore of Kongsfjorden makes it possible to easily conduct combined field and laboratory studies.

Long-term data series

Scientific data have been sampled in Kongsfjorden since 1905. There is a significant amount of observations available from the Kongsfjorden area, including historical and recent databases on: oceanography of Svalbard waters (1905-), meteorology (1911-), contaminants (1988 -), tide gauge measurements (1974-), hard-bottom benthos (1980-), seabirds (1988-), CTD -measurements (1993-), zooplankton (1995-), stable isotopes and lipids (1996-), ice concentration, snow and ice thickness (2003-, occasionally 1997-) and radionuclides as tracers of C-flux and mixing processes (1996-). Several underwater observation platforms are installed in Kongsfjorden, including multi-instrumental biological-physical moorings since 2002, which makes it possible to record continuously throughout the year. Continuously logged or periodically recorded data provide the monitoring backbone for environmental studies in the Kongsfjorden System. The monitoring stations for CTD and zooplankton in Kongsfjorden (NPI/IOPAS) are currently being linked to the Hausgarten (AWI) station network in Fram Strait, and will become a *Svalbard marine long term ecosystem monitoring system* (KongHau project). Kongsfjorden was protected against trawling in 2007, which was an important step toward securing moored instruments in the fjord.

Study site for effects of climate change

The Kongsfjorden–Krossfjorden fjord system is particularly suitable for studies of effects of climate change on ecosystems because it lays adjacent to both Arctic and Atlantic water masses. Kongsfjorden is an open fjord, without sill, and therefore largely influenced by the processes on the adjacent shelf. The fjord is influenced by Transformed Atlantic Water (TAW) from the West-Spitsbergen Current and freshwater from glacial run-off at the inner bay. Southerly winds will produce down-welling at the coast and have a blocking effect on exchange processes between shelf and fjord, while northerly winds will move the TAW water below the upper water layer towards the coast. For instance, TAW was observed in Kongsfjorden in July and September in the six years 1999-2005, but not in April and June 2002. A geostrophic control mechanism in the mouth area of broad fjords governs the exchange between the fjords and adjacent coastal water. It is expected that such a control mechanism appears in the outer part of Kongsfjorden.

The combined influence of Atlantic water masses and glacial run-off results in strong temperature and salinity gradients in the fjord. The fjord ranges from Atlantic-Boreal (outer) to Arctic (inner), and this is reflected in the communities of flora and fauna. The fjord contains a mixture of Atlantic and Arctic components, and in warm years the boreal fauna becomes relatively more abundant due to advection.

The Kongsfjorden–Krossfjorden system can be used as an indicator for the larger climate driven processes in Fram Strait. Because Kongsfjorden receives variable Arctic/Atlantic climatic signals between years with measurable effects on the physical and biological systems, it functions as a climate indicator on a local scale. Changes in benthic and pelagic primary production and in the zooplankton and fish composition will result in altered energy transfer within the pelagic food web with potential consequences for growth and survival of seabirds and marine mammals. Temperature changes will also affect the physiology and adaptations of marine organisms, which will influence their growth or production.

Environmental monitoring and research

The Ny-Ålesund area is an ideal site for studies of environmental contaminants due to the established research infrastructure and the Zeppelin Station for Atmospheric Monitoring and Research. Contaminants found in Arctic sediments and biota originates from two types of sources, remote and local. Most of the contaminants found in the high Arctic come from the denser populated and industrialised areas of the world at lower latitudes. The contaminants are distributed globally and are transported to the Arctic by air, water and sea ice. Therefore, the investigation of exchange processes between environmental compartments (atmosphere/sea, soil/atmosphere) is essential to understand adverse effects of pollutants in the Arctic environment. Persistent Organic Pollutants (POPs) in particular have low water solubility but high vapour pressure, which makes them suitable for adsorbing onto particles and aerosols, as well as for direct atmospheric transport. Atmospheric mercury transported to the Arctic, which is almost entirely highly volatile inorganic gaseous Hg^0, is considered as the main source for the increasing concentrations observed in the Arctic. Cold condensation and fallout from cold Arctic air masses are thought to be the most important deposition pathways for these compounds to Arctic environments, and the Arctic has become a global sink for contaminants. Anthropogenic contaminants, both of local and distant origins, may accumulate in body tissues of organisms, particularly lipids, and become biomagnified in the marine food web. High levels of POPs will have effects on animals on the top of the food chain and combined with adverse effects from climate change this may affect individuals as well as whole populations.

The inorganic carbon content of the ocean is increasing due to partial equilibration with rising atmospheric carbon levels from anthropogenic perturbations of the natural global carbon cycle. This increase in oceanic CO_2 uptake results in a reduction in seawater pH (termed ocean acidification) and a change to the speciation of the inorganic carbon system. The high latitudes, and especially the Arctic, are anticipated to undergo the greatest changes with respect to ocean acidification. Experimental evidence suggests that there will be significant ecosystem (and organism) responses to ocean acidification. Processes affected include a reduction in planktonic calcification, such as aragonite shells of the pteropod *Limacina helicina*, and a large increase is expected in the carbon and nutrient assimilation of major plankton types, leading to carbon over-consumption, with a rapid increase in primary production along with changes in food quality.

Because of its detrimental effect on many biological processes, the increase of UV-B radiation (UVBR) on the earth's surface due to stratospheric ozone depletion represents a major threat to life. Numerous biological processes are impaired during exposure to UVBR, especially photosynthesis, as has been shown for Kongsfjorden macroalgae. Despite the damaging effects of UVR, the photosynthetic abilities of macro-algal species from the upper and mid-sublittoral zones appear to be able to acclimate to it. One physiological basis of acclimation may be the accumulation of UV-absorbing mycosporine-like amino acids (MAAs), which are thought to function as natural UV sunscreens. Both UV and Photosynthetic Active Radiation (PAR) influence phytoplankton production, and thus the energy base of the marine food web in Kongsfjorden.

1.4 Kongsfjorden System Workshop

In order to discuss focal areas for future Kongsfjorden System research, Svalbard Science Forum invited leading researchers to a workshop in Ny-Ålesund, 28-31 March, 2008. Four focal areas were identified:

1. Ecological processes in Kongsfjorden
2. Kongsfjorden in a changing environment
3. Anthropogenic input to the Kongsfjorden System and effects on marine biota
4. Long-term monitoring of the Kongsfjorden System: Marine environment and atmosphere.

2. Knowledge gaps and future research priorities

During the workshop, gaps in knowledge and accordingly, future research priorities were identified.

Database for long-term data series

To allow predictions for the future development of the ecosystem under different global change scenarios, the past history of the ecosystem must be described using long-term monitoring. There are many long-term monitoring series for the Kongsfjorden System available. These data series need to be organized and made available for the research community. There was a broad agreement that a database for oceanographic data is needed. It is evident that several projects now collect their own physical data for background interpretation of biological variation. Most of the ship-based oceanographic data are collected by NPI, IOPAS, UoB and UNIS, whereas SAMS obtains continuous recordings from the fjord moorings in a collaborative project with NPI. The value of the data will increase with an open and available database, and mechanisms have to be established to ensure that such data can be shared between all projects conducted in Ny-Ålesund. Data can be protected by a data protocol that regulates e.g. co-authorship and ownership of data.

Meta-database for Kongsfjorden

There is also a need to further develop the Kongsfjorden meta-database, operated by Svalbard Science Forum (http://ssf.npolar.no/pages/database.htm). This database should be continuously updated with information on data collected related to the marine ecosystem in Kongsfjorden. Coordination with the web page initiated by IOPAS (http://www.iopan.gda.pl/projects/biodaff/) should be achieved.

Real-time monitoring of Kongsfjorden

A physical/biological mooring cabled to the marine lab was proposed in order to improve both real-time and long term monitoring of dynamic processes in the fjord. This mooring could be placed at the bottom of the fjord outside the marine lab, with cable out along the pipeline corridor for the marine lab. This would be a high-profile infrastructure, and the data would need to be made available for all researchers in Ny-Ålesund.

Oceanographic knowledge gaps to be filled

A considerable gap in our knowledge is to quantify cause and effects of, and interaction between, each of the individual forces on the flow field. The exchange processes between the fjords and the adjacent coastal regime also need further studies. More detailed studies are needed on the exchange mechanisms to be able to distinguish the water mass exchange, which is related to wind-driven up/down welling at the coast, from that which is related to ageostrophic processes in the West Spitsbergen Current. In addition, the importance of cross-frontal exchange by canyon cascading in the large canyons that intersect the West Spitsbergen shelf has to be evaluated.

The vertical resolution in the models which has been used up to now is too coarse to allow any detailed study of these mechanisms which, together with the effect of tidal mixing, definitely need more attention in future studies in the area. Further investigations should comprise the whole water column in the gradient from the head of the fjord arms to the shelf, including the shelf slope. This procures long-time series of hydrophysical data (current and hydrography) in the gradient shelf slope – shelf – fjord combined with numerical modelling. This should include two long-term mooring platforms of the SAMS mooring type, one in Kongsfjorden and one on the shelf near the shelf break. These should also be equipped with high resolution current meter (ADV, ADCP) for measurements in the bottom layer. Data from the two moorings, combined with repeated CTD and ADCP sections between the moorings taken on cruises, will provide for an excellent base together with numerical modelling.

Effects of turbulence

The impact of circulation and water mass exchange on the biological processes in the Kongsfjorden system has received great attention in *MariClim* (RCN-project). Some less attention has been devoted to the relation between biological variations and small scale physical processes. Turbulent diffusion is often the dominant process transporting plankton vertically through the water column. Turbulence is also important for benthic mussel and clam communities. These communities filter phytoplankton from water in their local vicinity and create a "concentration boundary layer" which if not renewed by water exchange, will become low in oxygen and phytoplankton concentration. The replenishment of concentration in such boundary layers is usually attributed to turbulence. Thus, knowledge about turbulence is important as a base for interpretation of biological processes in the whole water column.

Monitoring Kongsfjorden phytoplankton

Water samples and light measurements should be obtained periodically from one location in Kongsfjorden to monitor the phytoplankton development and species composition as part of the environmental monitoring in Ny-Ålesund. Phytoplankton is a highly dynamic part of the ecosystem; hence such data will form a necessary 'background' for more irregular phytoplankton investigations in the fjord by helping to identify timing and species composition of phytoplankton blooms. IOPAS is willing to process the samples, but some of the stationary personnel (e.g. NPI) need to collect the samples. Fluorescence measurements should also be obtained with help of a fluorescence sensor on a mooring.

Organic carbon mineralization

Data on organic carbon mineralization is lacking. Such data are important for interpreting the carbon budget for Kongsfjorden, and also for climate related studies with regard to CO_2 uptake, acidification and sequestration. One new RCN-project on *Marine Ecosystem Response to Climate Change (Merclim)* may address some of these aspects through modelling and experiments in the Kings Bay Marine Laboratory. The basis for these studies is a quantification of carbon input into Kongsfjorden by phytoplankton, micro- and macrophytobenthos and its fate in the food web.

Changes in the pelagic fish community of Kongsfjorden

The pelagic fish community in Kongsfjorden represents an important prey base for seabirds and marine mammals, but its seasonal and annual variation is poorly known. Some standardized surveys with hydroacoustics (EK-60) have been performed in recent years (NPI), but there is clearly a need for standardized pelagic trawl surveys. Most likely, the composition of fish has changed from polar cod (*Boreogadus saida*) towards more capelin (*Mallotus villosus*) as well other boreal fish species, although this not well documented. Presumably as a result of this, rather dramatic dietary changes for black-legged kittiwakes (*Rissa tridactyla*) in the Kongsfjorden area in 2007 were observed, with diet of primarily capelin rather than the usual polar cod.

Clams as environmental indicators

Growth patterns in bivalves are useful indicators of present and past climate variability, since they integrate environmental conditions over time at a particular location. Clams have been collected by divers from Kongsfjorden during the last 10-15 years, as reference proxy. One problem not yet resolved is to link growth patterns directly to physical factors. More direct relationships between seasonal growth and physical and biological factors can be established by linking clam growth to physical and biological measurements from stationary moorings. Both field recordings and laboratory experiments are needed to gain more insights into the relationship between growth patterns and environmental conditions (i.e. to calibrate the proxy).

Long-range pollutants and effects on biota

There is a great need to combine the finding from atmospheric measurements with measurements of the contaminant levels in the biota. Modelling may be a tool in order to get a better knowledge of the relationship between the atmosphere and the biota. However, it is currently not possible to model the input of long-range pollutants into the Kongsfjorden ecosystem due to lacking knowledge about deposition processes. Therefore there is a need to get more knowledge about the uptake mechanism of pollutants at lower trophic level (ice/snow/water and organism).

It is also important to acquire more knowledge about the seasonal and annual changes in contaminant level in the biota from all trophic levels in Kongsfjorden. Effect studies, which include the use of biomarkers, should be carried out on species with high contaminant levels. Other urgent topics to address are the connection between mercury and POPs as well as the combined effect of contaminants and climate change on biota.

Interactive effects of rising temperatures and enhanced UV-radiation

With respect to global change various aspects demand intense research, in particular on the interactive effects of rising temperatures and enhanced UV- radiation on organisms and communities. Global warming does not only lead to higher temperatures but also to an increased input of turbid meltwater, dissolved and particulate organic matter, into Kongsfjorden. This has certainly implications on the depth distribution and succession of benthic organisms as well as for biogeochemistry.

Feedback mechanisms from the biosphere to the atmosphere

Seaweeds produce volatile organohalogenic compounds such as bromoform, which are released in the atmosphere. The production of these compounds under changing external conditions and their fate in the atmosphere are unknown prompting for further collaborative studies between biologists and atmospheric scientists.

Project overlap and coordination

Whenever possible, projects with potential overlap should be better coordinated.
There seems to be some overlap in the phytoplankton research conducted by NCFS, KOPRI and CEES. All are sampling phytoplankton for species composition, and both KOPRI and CEES, as well as UNIS, are performing genetical surveys of the phytoplankton and microorganisms. Even if the aspects addressed are somewhat different, there should be some potential for direct collaboration.

3. Proposed projects to fill the documented knowledge gaps

In order to fill the identified knowledge gaps, new project ideas were developed during the workshop. These initiatives will contribute to an integrated approach to better understand the seasonal and annual dynamics of the Kongsfjorden ecosystem in the light of pollutant effects and climate change. The research will include atmospheric and oceanographic monitoring and molecular, cellular, organismal and community responses at all trophic levels. The described flagship programme will also complement and benefit from the Italian financed *Amundsen-Nobile Tower* for atmospheric research described in the atmosphere flagship programme for Ny-Ålesund.

The monitoring programme of atmospheric pollution from industrialised countries (aerosols, ozone, POPs, heavy metals and climate gases) at the Zeppelin Station will be further developed and linked to the marine research activities in order to identify the major drivers influencing the atmosphere – ocean surface interface (project 3.1). This will be supplemented by a marine monitoring platform with passive samplers that will allow real-time monitoring of oceanographic and biological parameters in the fjord (project 3.2). In addition, the effects of discharges of terrigenous organic carbon and terrestrial particles from permafrost soils to the Kongsfjorden on the physiology of benthic organisms, and consequently the ecosystem, will be investigated (project 3.3). The influx of terrestrial particles can result in a strong toxicological impact, i.e. nanoparticles can function as carriers of chemicals, and this effect will be amplified by increasing temperatures. Kongsfjorden should be established as a main reference system for studies on the transport patterns of contaminants from anthropogenic and natural sources throughout the entire marine food web and the consequences for the communities in all trophic levels in the fjord (project 3.4). In addition to climate change and pollution factors, marine organisms are exposed to large fluctuations in abiotic conditions. All kinds of abiotic stress and environmental pollution will impair metabolism and frequently result in perturbations of health/vitality measured by biomarkers at the cellular and molecular levels (projects 3.4 and 3.5).

Furthermore, intensive studies on lower trophic levels in combination with studies of the mechanisms of climate change and toxicity will help to predict effects on higher trophic levels. The alteration of algal spring bloom needs to be studied in the light of observed changing oceanographic parameters and the possible consequences for the higher trophic levels (project 3.6). The impact of different bloom scenarios on the benthos can be assessed by measuring the growth of filter feeding clams in the field and through lab experiments. Furthermore, clams show behavioural modulations with changing environmental parameters and can thus be used as indicators for changes in climate and environmental parameters (project 3.7).

Until now, most studies on the Kongsfjorden system have been conducted during spring and summer. Therefore, a special emphasis in the future will be to advance the understanding of overwintering strategies of key components of the Arctic ecosystem (project 3.8).

Finally, climate data on longer time-scales than the instrumental records are needed to assess the significance of the current warming in the context of the Holocene and to produce more reliable predictions for the future climate. The sediments in Kongsfjorden provide a climate archive of the Kongsfjorden system and therefore, mapping of the surface sediment distribution as well as sediment cores can be used to reconstruct the climatic and environmental changes during the last 13 000 years (project 3.9). In combination with the described monitoring of atmospheric, oceanographic, and biological patterns this will result in a solid basis for environmental models of the Kongsfjorden system.

In the future development of the flagship programme it is also expected to include studies on sea mammals and their interactions with other trophic levels in Kongsfjorden.

3.1 ATMOKONG: Atmospheric monitoring in the Kongsfjorden ecosystem

The aim of the ATMOKONG initiative is to link the on-going long-term atmospheric monitoring programmes in Ny-Ålesund with the comprehensive hydrological, oceanographic and marine biological research programmes performed in the Kongsfjorden ecosystems. For this purpose, an integrated comprehensive monitoring station will be established on the central islands within the Kongsfjorden. The station will be equipped with continuous monitoring devices for a suit of parameters equally important for the characterization of marine, oceanographic, hydrological, meteorological, chemical as well as physical processes. Thus, the variability and seasonal patterns of the major drivers influencing the atmosphere - ocean surface interface in the Kongsfjorden ecosystem can be identified, and climate change influences on aerosol and contaminant exchange processes in the atmosphere – ocean surface interface can be elucidated. The Kongsfjorden atmospheric monitoring site will be developed and coordinated with the planned marine monitoring unit.

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3.2 Towards real-time monitoring of Kongsfjorden

Kongsfjorden has been monitored with stand-alone oceanographic moorings since 2002. The most heavily instrumented mooring has been deployed by SAMS, and has typically measured temperature, salinity and velocity throughout the water column, and fluorescence and sedimentation at two depths. UNIS and the Geophysical Institute in Bergen have additionally deployed a number of physical oceanographic moorings at various times and locations since 2002.

Technological development has now made real-time data retrieval from oceanographic monitoring platforms possible, and one is suggested to be deployed in Kongsfjorden with possible connection to Kings Bay Marine Laboratory. Three levels of real-time data retrieval from in situ instrumentation can be envisioned:

Level 1: Near-bed monitoring of temperature, salinity and velocity, cabled to shore. A cabled video can be added. The technology is readily available, but the cable must be partially lifted to service instruments and therefore cannot be buried.

Level 2: A standard oceanographic mooring with underwater acoustic data telemetry. The technology is readily available, since standard mooring protocols are well tested in Kongsfjorden. No cable at risk to iceberg grounding, but also no cabled power, because the mooring location is not fixed. Some technical development is needed to bundle data from all instruments into one single acoustic modem. Benthic data retrieval is currently not possible, but stand-alone benthic observatories could be acoustically linked to shore modems.

Level 3: A cabled observatory, with a permanently protected cable and seabed node for a variety of instrumentation to be 'wet-mated' in situ using an ROV. The advantages would be unlimited data bandwidth, unlimited power available, and the cable would be protected from icebergs. However, technology is not fully developed and challenging electronic and engineering problems still need to be resolved. This solution requires significant capital and infrastructure support, and the participation of industrial or university electronic engineering R&D, but has potential as world leading science and technology.

The parameter suite should include as minimum: profiles of temperature, salinity, irradiance and velocity. Desirable additions are: passive hydrophones, fluorometer, turbidity recorder, sediment traps, multi-spectral optics, (e.g. seabed video), atmospheric samplers for pollutants as well as semi-permeable passive samplers for contaminants from sediments and different depth of the water column.

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3.3 The influence of terrigenous processes on the function of the Kongsfjorden system

This project will study discharge of terrigenous organic carbon and terrestrial particles to Kongsfjorden and their implications for stocks of organic carbon in the Arctic marine environment and for benthic organisms and communities. In order to estimate the effect of rising global temperatures on particle discharge and organic carbon (OC) stocks in the temperature-sensitive Arctic environment, the transfer of terrigenous particles and terrestrial organic carbon in particulate and dissolved form from permafrost soils to Kongsfjorden must be investigated. Local discharge sources, composition and pathways, detailed compositional analyses of bulk soil and sediments along a transport trajectory will be used to study alteration processes occurring in the soil and during transport. The marine settling behaviour of terrigenous particles as well as hydrodynamic processes contributing to sediment deposition and erosion will be studied as well. The impact of terrestrial particle fluxes, summer suspension load and sediment deposition (amplified due to global warming) on the physiology of benthic organisms and the related ecological consequences will be investigated.

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3.4 Impact of climate change and pollution on seabirds in Kongsfjorden

The Arctic environment and its unique wildlife are currently being threatened at several levels, including: climate change, pollution and infectious diseases. The viability of wildlife populations are regulated through individual survival and reproduction. Little is known about the combined impact of pollution and infectious organisms and on the population trends of Arctic organisms. Much of the pollution in the Kongsfjorden system is taken up and transferred through marine organisms (benthos, zooplankton and fish) to the seabirds and marine mammal communities in the fjord. The general trend is that contaminant level is declining for PCBs and DDTs, while we see an increase in the levels of new contaminants (brominated and fluorinated compounds). Pollution levels in organisms are related to their trophic position and the highest levels are found in species at highest trophic levels (glaucous gull, great skua and ivory gull). In Svalbard, effects have been documented for polar bears and glaucous gulls. New studies also indicate that eiders may be affected, with levels of pollution in the bloodstream increasing rapidly in females that starve during incubation. There is a need for more knowledge about the uptake mechanism of pollutants at physical interfaces and lower trophic levels (ice/snow/water and organisms). We also need more knowledge about the seasonal and annual changes in contaminant levels in the biota from all trophic levels in Kongsfjorden. The effect of these stressors on parameters related to individual fitness like immune function, survival and reproduction in the bird and sea mammal communities in Kongsfjorden should be assessed through individual health monitoring (biomarkers), experiments and large-scale comparisons of populations from different climatic zones with varying pollution levels. Kongsfjorden has unique possibilities of acting as a main reference system for such studies.

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3.5 Interactive effects of various abiotic factors on organisms and communities

At their natural growth site, marine organisms are exposed to large fluctuations in abiotic conditions. In particular, the species inhabiting the intertidal and upper subtidal zone are frequently exposed to high irradiances (ultraviolet and photosynthetically active radiation) as well as to changing temperature and salinity regimes. Environmental changes on a global scale as well as local anthropogenic influence may further increase abiotic stress (e.g. ozone hole, greenhouse effect, bioacidification, increase of CO_2 levels, environmental pollution). All kinds of abiotic stress will finally impair metabolism and frequently result in elevated production of reactive oxygen species (ROS). As a result, growth, reproduction and finally recruitment will be impaired. The main goal of the project is to investigate the responses on the cellular, organismal and community level to climate related environmental parameters. This will involve molecular, physiological and ecological studies.

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3.6 Changing of the spring bloom timing in Kongsfjorden?

Data from the last years have revealed that the normal timing of the spring bloom in late April is subject to changes due to changes in the Atlantic water inflow to the fjord. Compared to 2006, the spring bloom in 2007 was considerably delayed, included different dominant species and produced less biomass. In spring 2006 there was no inflow of Atlantic water and a strong convection in the period before the bloom, whereas in 2007, convection to the bottom was prevented by inflow of Atlantic water on the surface in late winter. The inoculum of the spring bloom consists of diatom resting spores which have overwintered on the bottom since last year's bloom. These spores need to be mixed up into the water column again to germinate, which normally happens when winter convection reaches bottom depths. If this vital physical process in any way is prevented, like in 2007, there will be very few diatoms in the water masses to initiate the spring bloom. It will likely be delayed and made up of phytoplankton species surviving in the water masses, such as the flagellate *Phaeocystis pouchetii*. This species, however, has a different biochemical composition than diatoms, and its value as food for higher trophic levels is probably different. The proposed project will study the mechanisms behind the spring bloom in cooperation with physical oceanographers in order to assess whether the 2007 situation will become more common with anticipated climate change and the possible consequences for the higher trophic levels. The progression of the spring bloom in Kongsfjorden will be followed, through sampling by sediment traps on stationed moorings, as well as frequent sampling from vessels throughout the bloom period. The impact of different bloom scenarios on the benthos will be assessed by measuring the growth of filter feeding clams in the field and through lab experiments where clams are fed diets reflecting different phytoplankton communities.

Contact: Else Nøst Hegseth (else.hegseth@nfh.uit.no)

3.7 CLIM-CLAM: Clams as climate indicators and environmental monitors in Svalbard waters

Growth patterns in shells of bivalves are useful indicators of present and past climate variability, since they integrate environmental conditions over time at a particular location. Temperature and food are two major factors influencing bivalve growth, and both are likely to be influenced by climate change. Because many clam species are long-lived (decades to > 100 years) they can serve as long-term biological proxies for altered environmental conditions. Clams have been collected by divers from Kongsfjorden during the last 10-15 years, and their growth patterns can be combined into time-series.

One problem not yet resolved is to link growth patterns directly to physical factors. Regional indices (e.g. ice cover, NAO) or local conditions (e.g. local ice cover, SST, precipitation) are frequently related to bivalve growth, but the causal factors are not clear. More direct relationships between seasonal growth and physical and biological factors can be established by placing bags of clams near or on the oceanographic moorings. Effects of temperature and food supply on clam growth also need to be studied in the laboratory. Such studies should include life history aspects, which are little known for most bivalve species in Svalbard waters, as well as physiology (e.g. respiratory physiology) and behaviour. Clams cannot feed during periods when they "clam up", and they may also stop growing during weeks of unfavourable ambient conditions despite continuous filtration activity. Today, clam growth can be investigated remotely in free living animals by placing microelectrodes on the bivalve shells. These microelectrodes measure the opening and closing rates of the shells and give a daily growth index during long-term monitoring periods (12-15 months). Experiments can be set up in enclosures on the bottom and *in situ* clam behaviour could be studied by SCUBA divers.

Contact: Haakon Hop (haakon.hop@npolar.no)

3.8 Winter studies in Kongsfjorden

Winter studies are needed to characterize the adaptation of polar organisms to the dark season. The focus of this initiative will be to advance the understanding of overwintering strategies of key components of the arctic ecosystem as a major adaptive link to external forcing mechanisms. Overwintering is one of the major features of Arctic life cycles, which to a large extent define the success and the rate of productivity of most populations. Because of the delicate timing between the onset and the ending of overwintering, this period is one of the most sensitive to global changes with consequences on growth, reproduction and recruitment. The main scientific thrust of the initiative will be the development of a simultaneous and comparative approach for the different compartments ranging from macro- and micro-algae, and meiofauna to most compartments of the planktonic system. Physiological, cell biological and ultrastructural changes during darkness (polar night) occur in combination with low but variable temperatures. There are indications that higher temperatures in winter may reduce the maximum dark survival potential, i.e. global change scenarios may limit overwintering strategies in benthic diatoms with consequences for microphytobenthic structure and function. For pelagic diatom resting spores little is known about the effect of a higher temperature on dark survival. Metabolic and developmental processes in seaweeds during winter and their importance for the ecosystem also need to be studied. The overwintering strategies of shallow water benthic macrofauna are poorly known, as well as winter grazing by sea urchins on new-growth of macroalgae. For the entire marine food web, predator – prey relationships during winter are largely unknown, and this can be elucidated by means of analyses of stable isotopes. This needs to be aided by experiments to determine tissue turnover time and to investigate stable isotopes in storage lipids (based on experience from earlier experiments).

Contact: Martin Graeve (martin.graeve@awi.de)

3.9 Climate and environmental development of the Kongsfjorden system during the last 13 000 years

The ongoing warming of the Arctic is unusual for the past century, but in order to assess the significance of this warming in the context of the Holocene and to produce more reliable predictions for future climate, climate data on longer time-scales than the instrumental records are needed. By mapping the surface sediment distribution of sediment properties and microfossil assemblages in Kongsfjorden, and by reconstructing the climatic and environmental changes taking place in the fjord during the last 13 000 years from a series of sediment cores, the mechanisms behind natural variability of the system can be investigated. Additionally, information contained in the calcitic skeleton of long-lived crustose coralline red algae can be used as climate archive of the Kongsfjorden system. The proposed project aims to assess the natural variability of climatic, biological and oceanographical parameters, the changes of calving and melting of glaciers through time and the linkages between atmosphere, ocean and cryosphere in the Kongsfjorden system.

Contact: Nalân Koç (nalan.koc@npolar.no)

4. Funding needs

In order to promote national and international research on the Kongsfjorden system, specific funding sources need to be made available on national and international level. This is particularly important for projects involving students or young researchers in the Kings Bay Marine Laboratory due to the high costs of laboratory use and stay in Ny-Ålesund, but also funding is needed for networking activities to promote closer collaboration amongst the investigators for larger measurement campaigns on site. Ny-Ålesund has the outstanding and unique feature of being a ***global*** research platform. Funding processes are characterized by being national or regional (e.g. European in the case of European Union grants) whereas the collaboration promoted in this report brings together the entire Ny-Ålesund community including presumptive future nationalities. There is a pressing need for a funding mechanism to promote the development of Ny-Ålesund science. Such a funding mechanism must be coordinated with national and regional granting mechanisms but focused on resolving the special challenges involved with enticing global creativity.

The European Strategy Forum for Research Infrastructures endorsed the project SIAEOS in December 2008. SIAEOS will contribute to improved infrastructure and data proliferation. This document should be considered an important guideline for the process of defining the investments of SIAEOS to further develop the infrastructure of Ny-Ålesund and Svalbard. For more information see http://www.unis.no/20_RESEARCH/2080_SIAEOS/default.htm.

5. Summary of the workshop sessions

5.1 Session "Atmospheric research & environmental pollutants"

Geir Wing Gabrielsen – session chairman
30 March, 09:30 – 12:00

Johan Ström (ITM, Sweden) – *Aerosols and water*; **Markus Rex (AWI, Germany) –** *The Arctic ozone layer: Current understanding and relation to climate change*; **Ove Hermansen (NILU, Norway) –** *Monitoring of airborne pollutants at the Zeppelin Mountain*; **Roland Kallenborn (UNIS, Norway) –** *Atmospheric transport of persistent organic pollutants to the Kongsfjorden region*; **Torunn Berg (NTNU, Norway) –** *Occurrence and fate of springtime atmospheric deposition of mercury at Ny-Ålesund.*
Presentations were made on measurements of aerosols, ozone, POPs, heavy metals and climate gases at the Zeppelin Station. Measurements, which include new contaminants

(brominated and fluorinated compounds), will start in 2008. Measurements of contaminants in the settlement of Ny-Ålesund will also start in 2008.

Trend data were presented from measurements of different POPs (HCB, HCH and PCBs) at the Zeppelin Station. There was a steady decrease of these pollutants until 2002/2003, since then there has been an increase in the contaminant levels. The question was raised if this recent increase is due to climate change?

Data related to research campaigns on ozone and mercury performed at the Zeppelin station was presented. The results show that mercury increases both in the snow and in the biota in Kongsfjorden due to mercury deposition in spring.

Geir Wing Gabrielsen (NPI, Norway) – *Contaminants in the marine food web*. **Sveinn Are Hanssen (NINA, Norway) –** *BirdHealth – a three year IPY study in Kongsfjorden.*
Data on the POP levels in the marine food web were presented. POP levels are related to trophic positions and the highest levels are found in species at higher trophic levels (polar bear, Arctic fox, glaucous gull, great skua and ivory gull). In some of these species POP levels exceed levels of effects on health and reproduction. For polar bears and glaucous gulls in Svalbard, effects on the immune, hormone and the enzyme system have been documented. The contaminant level is declining for PCBs and DDTs while we see an increase in the levels of new contaminants (brominated and fluorinated compounds).

Two Kongsfjorden projects related to IPY (COPOL and BirdHealth) provide new data related to the contaminant levels in the marine food web in Kongsfjorden. These projects also include studies of effects in eiders, kittiwakes, great skuas and glaucous gulls.

Angela Köhler (AWI, Germany) – *The biomarker approach to identify contaminant effects in key species of various climate zones.*
At the end of the session the use of biomarkers as tool to study the health of marine ecosystems was presented. For Arctic organisms, the use of biomarkers is urgently recommended for studies of physiological responses towards seasonality and climate change. Biomarkers can also be used to identify point source input of contaminants and input of terrestrial particles to the marine ecosystem.

5.2 Session "The pelagic environment"

Haakon Hop – session chairman
30 March, 13:00 – 15:30

Harald Svendsen (UoB, Norway) – *Impact of topography, wind and tide on circulation and exchange.*
This was a presentation of oceanographic characteristics of Kongsfjorden, showing the exchange of water masses from shelf to fjord. The currents are topographically steered, but the current pattern in the fjord is driven by Coriolis, with influxes on the southern side of the fjord and fluxes out on the northern side. In addition the circulation is locally influenced by wind and tides and models have been used to show how the wind direction and force influence currents and exchange. A gyre appears in the middle of Kongsfjorden, and may have consequences for keeping planktonic organisms in the fjord.

Mark Inall (SAMS, UK) – *Water mass distributions in Kongsfjorden: Variability and consequences for ice cover and ecosystem function on the shelf off West-Spitsbergen.*
Mark presented data from the stationary underwater observatory (mooring) in Kongsfjorden, which has been in different locations in the fjord since 2002. The continuously recorded data nicely show the influx of Atlantic water into the system during early winter, which was partly responsible for the lack of ice in the fjord in the winter of 2006. The mooring also collects biological data of sediment flux and swimmers (zooplankton), and the ADCP can show vertical migration of zooplankton in the fjord. A similar mooring was installed in Rijpfjorden in 2006. SAMS wishes to continue with the mooring project in Kongsfjorden, and has funding to do so until 2010.

Stefano Aliani (CNR, Italy) – *Multidisciplinary oceanographic investigations in the inner Kongsfjorden: data available at present.*
Italian research in Kongsfjorden has particularly focused on the inner fjord basin. The disappearance of the Blomstrand glacier opened up a channel on the north side of Blomstrand, and this has affected the circulation in the inner bay somewhat, but mainly in the upper part of the water column. The Italians would like to continue with oceanographic research in Kongsfjorden, but will rely on collaboration with others in order to obtain funding.

Andrea Bergamasco (CNR, Italy) – *Polar oceanography of CNR-ISMAR: research activity & future perspective.*
Bergamasco presented polar oceanography of CNR-ISMAR, which has included much research in the Antarctic. Modelling has been extensively used to determine distribution of Antarctic water masses, and some examples of what the models can do and show were included in this presentation.

Vigdis Tverberg (NPI, Norway) – *Mechanisms for Atlantic Water influence in Kongsfjorden.*
Tverberg presented new data for Atlantic water influence in Kongsfjorden. The Atlantic water, which has increased in magnitude, generally is separated from the cold fjord water during winter by strong fronts, but in the later years this front has become much less apparent. In May 2007 there was no observable front in Kongsfjorden and most of the influx of Atlantic water was close to the surface. The exchange of water massed between shelf and fjord is now very strong. Modelling has been used to determine interactions between water masses in the West-Spitsbergen Current and Arctic water on the shelf. Much of the oceanographic data are based on the standard stations of the fjord transect, but Tverberg has also assembled older oceanographic data from the Kongsfjorden area in order to look for trends in temperature and salinity over time.

Else Nøst Hegseth (NCFS, UoT, Norway) – *Changing of the spring bloom timing? Kongsfjorden as a natural laboratory.*
This presentation focussed upon data from the spring blooms of 2006 and 2007, showing how the changed inflow of Atlantic water had delayed the bloom in 2007, and led to less biomass and a changed species composition as diatoms now occurred in significantly less

numbers, being replaced by the flagellate *Phaeocystis*. Both these years had no ice, hence the spring bloom is not dependent of ice cover in Kongsfjorden, but on the physical conditions of the water masses, particularly the winter convection. This is the only process bringing up the spores from the bottom, which formes the diatom bloom. A change in timing and composition of the spring bloom may have consequences for higher trophic levels. In a highly dynamic system where the sampling is cruise dependent (time/year), timing of blooms may be difficult to determine, and for future studies more regular sampling or continuous monitoring should be performed in Kongsfjorden

Young-Nam-Kim (KOPRI, Korea) – *The phytoplankton community structure in Kongsfjorden; sampling strategy and future plan.*
The phytoplankton community structure in Kongsfjorden was presented, including genetical aspects of the plankton. The project sampling campaigns have covered several stations in both Kongsfjorden and Krossfjorden. Samples have been taken on some of the established stations in Kongsfjorden, but also on their own sampling stations in these fjords.

Anita G. J. Buma (CEES, Univ. Groningen, Netherlands) *Past and future studies on microbial community performance in Kong- and Krossfjorden, in response to climate change.*
Aspects of the microbial community in Kongsfjorden were presented, including a genetical survey of the community. The sampling campaigns covered several stations in both Kongsfjorden and Krossfjorden. Comparison of both fjords revealed significant differences in the prokaryotic and eukaryotic communities probably related to differences in fjord bathymetry. The input of turbid melt water through predicted increased glacial melting in the fjord systems will strongly influence the communities.

Hak Jun Kim (KOPRI, Korea) – *Biodiversity and cold adaptation of polar marine microorganisms and microalgae.*
This presentation included fundamental aspects of biodiversity and cold adaptation of polar microorganisms and microalgae. Genetical aspects were also discussed.

5.3 Session "From pelagic to benthic"

Jan Marcin Weslawski – session chairman
30 March, 16:00 - 18:30

Marek Zajaczkowski (IOPAS, Poland) – *Sedimentation and zooplankton mortality*.
Glaciers calving into Kongsfjorden are suspensions transporters, resulting in large sedimentation rates in the inner fjord basin. Marine plankton mortality is connected with the freshwater outflow from tidal glaciers.

Carlo Papucci (ENEA, Italy) – *Particle dynamics in Kongsfjorden and in the outer continental shelf.*

Papucci reviewed 11 Arctic campaigns, including Pb-210 dating, inventories of anthropogenic radioactivity, sedimentation rates established for the outer fjord (0.1 cm y^{-1}), central fjord (0.5 cm y^{-1}) and the innermost basin (10 cm y^{-1}).

Laura de Santis (OGS, Italy) – *OGS past and ongoing polar research and Italian IPY proposals*.
OGS has long-term Antarctic experience, including the use of RV *OGS Explora* for multi-seismic and magnetic profiling. In the Arctic, OGS discovered gas hydrates on the West Spitsbergen Shelf.

Prakash Kumar (NCAOR, India) – *NCAOR and planned Indian scientific initiatives.*
India has a long research experience in the Antarctic, including a wide range of Antarctic monitoring projects. About 20 new bacteria species were discovered in Antarctica by Indian scientists. New plans for Kongsfjorden include comparative studies with regard to monsoon understanding. The First Indian Arctic Expedition will work with microbiology, carbon cycling in near-shore sediments, dynamic and mass balance of Kongsfjorden glaciers.

Luo Wei (PRIC, China) – *The microbial ecology study in Kongsfjorden (CAAA report).*
Estimates for Kongsfjorden microbial biomass: heteronanoplankton 37%, bacteria 15%. China supports 2-3 scientists every summer in Ny-Ålesund.

Tron Frede Thingstad (UoB, Norway) – *Mesocosm experiments in Ny-Ålesund. Results from 2007 and future plans.*
The project investigates microbiology, microbial food loop, and links to the CO_2 sequestration. Nutrient recycling can go the fast lane from flagellates to ciliates and slow from diatoms to copepods. Heterotrophic flagellates feeding on bacteria were fed artificially with glucose to manipulate energy transfer. The experiments in Ny-Ålesund consist of 10 mesocosms arranged in two silica modes – deficit and saturation. Less chlorophyll with increasing glucose showed that bacteria are winning the competition with diatoms (even those fed with Silicium). In low chlorophyll mesocosms, the diatoms were very small – below 7 microns. Bacteria perform well in any temperature, provided that food is available.

Haakon Hop (NPI, Norway) – *Key players in the marine food web of Kongsfjorden.*
Calanus is converting low energy sugars to high energy lipids. Relatively large herbivores allow for shortened Arctic food chains. Ctenophores are not dead ends; they are fed on by seabirds and fish. Stable isotopes of nitrogen can be used to assign trophic levels and stable carbon can be used to trace carbon sources (e.g. phytoplankton, ice algae or terrestrial). POP levels against stable isotopes show biomagnification of contaminants in the marine food web.

5.4 Session “Benthos it is”

Christian Wiencke – session chairman
30 March, 19:30 - 21:00

Christian Wiencke (AWI, Germany) – *Possible common themes for research in Kongsfjorden, the perspective of a seaweed biologist.*
In particular winter studies are needed to characterize the adaptation of polar organisms to the dark season. Only very few data are available on seaweeds, benthic microalgae, ice algae and invertebrates from all trophic levels. With respect to global changes various aspects demand intense research, in particular on the interactive effects of rising temperatures and enhanced UV-radiation on organisms and communities. Global warming does not only lead to higher temperatures but also to an increased input of turbid meltwater, dissolved and particulate organic matter into Kongsfjorden. This has implications on the depth distribution and succession of benthic organisms as well as for biogeochemistry. To allow predictions for the future development of the ecosystem under different global change scenarios, the past history of the ecosystem must be described using long-term monitoring. Another aspect is feed-back mechanisms from the biosphere to the atmosphere. Seaweeds produce volatile organohalogenic compounds such as bromoform, which are released in the atmosphere. The production of these compounds under changing external conditions and their fate in the atmosphere are unknown prompting for further collaborative studies between biologists and atmospheric scientists.

Jaroslaw Tegowski (IOPAS, Poland) – *Estimation of macrophytes using underwater acoustics for the evaluation of fjord environmental state (Kongsfjorden, West Spitsbergen).*
This was a study on the distribution of seaweeds in Kongsfjorden using acoustical surveys. Large parts of the coastline between Kvadehuken and Kongsvegen, on Blomstrand between Hansneset and New London and around Lovénøyane were studied down to depths of about 25 m. The whole coastline was densely covered with seaweeds. The seaweed forest attained a height of 1.2 m along Blomstrand, in the western parts of Lovénøyane and in “Nansen-Bay” between Brandalpynten and Gludneset. The future plans are the assessment of the seaweed biomasses.

Hiroshi Kawai (Kobe University, Japan) – *Biodiversity studies of marine macroalgae, with special reference to the evolution.*
Kawai showed important data on the phylogeny and geographical origin of the brown algal order Laminariales (kelps). According to taxonomic (including molecular) studies, the Laminariales s.s. most probably originated in the NW Pacific and spread from there into NE Pacific and Atlantic. In contrast, the *Phyllariaceae* and *Halosiphonaceae*, the so-called pseudo-kelps, developed in the Atlantic. The present circum-Arctic distribution of the brown algal genera Chorda and Chordaria is the result of either vicariance or dispersal, respectively. Further collections of the latter species are planned in Kongsfjorden.

Jean-Charles Massabuau (CNRS, Arcachon, France) – *New developments of in situ monitoring of molluscan bivalve behaviour to detect water quality change in the field.*
This group is interested in the behaviour of oysters as well as other bivalves, in particular in the monitoring of the times during which oysters open their valves *in situ.* In addition to continuous raw recordings, a variety of parameters can be measured, e.g. the time at which the oysters open their valves for more than 5 min, the number of movements and the velocity. The data can be recorded for different periods up to 1.5 years, without manipulation in the field, and are presented online on a website. Using this method the animal behaviour can be described quantitatively and biological rhythms related to tide, night and day, sunrise and sunset can be identified. Moreover, using the data obtained by this method, the water quality in which the mussels live can be estimated. The next step will be the development of an automated index of the growth rate. A detailed collaborative study on the behaviour and the biological rhythms of *Serripes groenlandicus* with special emphasis on the dark season was proposed. The obtained data can be related to local changes of environmental conditions (climate, turbidity and associated changes, contaminants, phytoplankton) and can be an important mosaic stone for long-term monitoring.

William Ambrose Jr. (Akvaplan-niva, Norway & Bates College USA) – *Kongsfjorden as a test site for new Arctic bio-monitoring tools and procedures.*
For this purpose, pelagic-benthic mollusc genera, e.g. *Serripes*, *Clinocardium*, *Hiatella*, *Arctica*, *Mya* and *Macoma*, are well suited as they are sessile and long-lived. Bivalve growth reflects tight pelago-benthic coupling and integrates environmental conditions over time. By use of sclerochonology it is possible to monitor current environmental conditions, reconstruct past climate and evaluate climate impacts on the benthos.

Jan Marcin Weslawski (IOPAS, Poland) – *Long term studies on the Kongsfjorden benthos - opportunities and limitations of the monitoring system.*
Between 1996 and 2006, benthic and zooplankton samples were taken annually at an inner, outer and central station in Kongsfjorden. The biodiversity was described with relation to the changing environmental conditions. 2003 was a year with cold Arctic waters of low salinity at the surface and the presence of ice, whereas 2002 was a warm year with a vast amount of Atlantic water present in the main fjord, warmer air temperature and increased glacial discharge. Bottom seawater temperature increased from 0.5 °C to 3 °C between 1996 and 2006. In the inner fjord, increased densities of two bivalves and some polychaete species were observed with a two-year time lag after the ‘cold’ event. An increasing abundance of opportunistic species of the family Cirratulidae has been observed since 2002. In the central fjord, the most prominent change in species composition was the change in abundance of Cirratulidae, which continuously increased in number since 1998 and decreased since 2003. The bivalvia *Axinopsida orbiculata* and *Ennucula tenuis* exhibited an increased abundance 1-2 years after the ‘cold’ event. Overall, the inner fjord station was characterized by significant differences in density, species richness as well as in species diversity. The central fjord station was the most changeable, whereas the outer station was the most stable from all three monitoring stations. The study clearly shows the value of long-term monitoring during times of environmental change.

Appendix 1: Marine Laboratory meeting with Kings Bay AS

During the Kongsfjorden System Workshop, representatives from institutions with interest in the Kings Bay Marine Laboratory met with Kings Bay AS to discuss laboratory concerns and plans for expansion of the laboratory facility, as well as the use of the Kings Bay vessel *Teisten*.

The Marine Laboratory interests were represented by: Mark Inall – SAMS (UK), K.P Krishnan – India (National Centre for Antarctic and Ocean Research), William Ambrose Jr. – NSF (USA), Hak Jun Kim – KORDI (Korea), Christian Wiencke – AWI (Germany), Stefano Aliani – CNR (Italy), Lou Wei – PRIC (China), Haakon Hop – NPI (Norway)

Kings Bay AS: Oddvar Midtkandal (Director), Elin Austerheim (Marine Lab Manager), Bendik E. Halgunset (Research Advisor).

The Marine Laboratory interest group brought up the following items for discussion:
Cabled physical/biological mooring to marine lab (real-time data transmission); gear storage (particularly batteries), small-boat use, microbial study needs (autoclave, ultra-speed centrifuge), chemical store (supply), shared space use, diving assistance (KORDI), laboratory expansion (basement plans).

An AWI proposal for installing a wet lab with more lab benches and tank/rinsing facility for receiving of marine organisms was presented, as well as an NPI proposal of increasing the water facility. The wet lab will be located adjacent to the new diving facility in the basement. The improvement of the water supply can possibly be done with a recirculation unit. It was pointed out, however, that this can be only an interim (quick) solution. Within three years there is a need for an additional water system with ambient water (pipeline, pump, filtration, aeration). The recirculation unit may then become a back-up or additional system. For clam research it should be possible to deliver unfiltered water, by circumventing the filtration system.

Kings Bay AS presented different aspects of running the marine laboratory and gave an overview of the use of the laboratory by the different user groups and nations. Kings Bay AS has updated their web page (www.kingsbay.no) and much of the information needed can now be found there.

Expansion of the laboratory to the basement of the laboratory was presented. A new dive facility has been constructed. The participants were given a tour of the construction area in the basement. Kings Bay AS will suggest a plan for the upgrade, which will be circulated for comments from the *Marine Lab Advisory Group*.

Appendix 2: List of abbreviations

Institutions:

AWI – Alfred-Wegener Institute, Germany
CEES – Centre for Ecological and Evolutionary Studies, University of Groningen, The Netherlands
CNR – National Research Council, Italy
CNR-ISMAR – Marine Science Institute, National Research Council, Italy
CNRS – National Centre for Scientific Research, France
ENEA – Marine Environment Research Centre, Italy
IOPAS – Institute of Oceanography, Polish Academy of Science
ITM – Department of Applied Environmental Science, Stockholm University, Sweden
KOPRI – Korea Polar Research Institute
KORDI – Korea Ocean Research & Development Institute
NCAOR – National Centre for Antarctic and Ocean Research, India
NCFS – Norwegian College of Fishery Science
NILU – Norwegian Institute for Air Research
NPI – Norwegian Polar Institute
NTNU – The Norwegian University of Science and Technology
OGS – National Institute of Oceanography and Experimental Geophysics, Italy
PRIC – Polar Research Institute of China
SAMS – Scottish Association for Marine Science
UNIS – The University Centre in Svalbard, Norway
UoB – University of Bergen, Norway
UoT – University of Tromsø, Norway

Others:

ADCP – Acoustic Doppler Current Profiler
ADV – Acoustic Doppler Velocimeter
CTD – Conductivity, Temperature, Depth
DDT – Dichloro-Diphenyl-Trichloroethane
EMBS – European Marine Biodiversity Sites
ESFRI – European Strategy Forum on Research Infrastructures
HCB – Hexachlorobenzene
HCH – Hexachlorocyclohexane
IPY – International Polar Year
MAAs – Mycosporine-like amino acids
MariClim – Project funded by the RCN: 'Marine ecosystem consequences of climate induced changes in water masses off West-Spitsbergen'
NAO – North Atlantic Oscillation
RCN – Research Council of Norway
OC – Organic carbon
PAR – Photosynthetic Active Radiation
PCB – Polychlorinated biphenyl
POPs – Persistent Organic Pollutants
ROS – Reactive oxygen species

ROV – Remotely operated underwater vehicle
SIAEOS – Svalbard Integrated Arctic Earth Observing System
SST – Sea surface temperature
TAW – Transformed Atlantic Water
UVBR – UV-B radiation

1) Youngnam Kim (KOPRI)
2) Else Nøst Hegseth (NCFS, Univ. Tromsø)
3) Markus Rex (AWI)
4) Roland Kallenborn (UNIS)
5) Vigdis Tverberg NPI)
6) Hiroshi Kawai (Kobe Univ. Res. Cent)
7) Ove Hermansen (NILU)
8) Hak Jun Kim (KOPRI)
9) Prakash Kumar (NCAOR)
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11) Geir Wing Gabrielsen (NPI)
12) Johan Strøm (ITM)
13) Luo Wie (PRIC)
14) William Ambrose Jr. (Bates College, USA)
15) Nalan Koc (NPI)
16) Sveinn Are Hansen (NINA)
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19) Anita G C Buma (CEES, Univ. Groningen)
20) Carlo Papucci (ENEA)
21) Tron Frede Thingstad (Univ. Bergen)
22) Marek Zajaczkowski (IOPAS)
23) Stefano Alanini (CNR)
24) Jaroslaw Tegowski (IOPAS)
25) Torunn Berg (NTNU)
26) Laura de Santis (OGS)
27) Angela Köhler (AWI)
28) Haakon Hop (NPI)
29) Andrea Bergamasco (CNR-ISMAR)
30) Bendik Halgunset (Kings Bay AS)
31) Elin Austerheim (Kings Bay AS)
32) Christian Wiencke (AWI)
33) Christiane Hübner (SSF)