

## **Studying adaptive processes in the changing Arctic: An application for a “Svalbard Strategic Grant” by the Kongsfjord Flagship Program**

This proposal is prepared and submitted to the Svalbard Science Forum by **Geir Wing Gabrielsen** (Norsk Polarinstitutt) and **Kai Bischof** (University of Bremen) on behalf of the Kongsfjord Flagship Program. Funding by a Svalbard Strategic Grant will enable the Kongsfjord Flagship to prepare for new project initiatives focused to the research priorities identified during the SSF funded workshop “Adaptation to environmental changes in the Arctic” held in Tromsø 10-12 October 2016. Also, this funding will enable the Kongsfjord Flagship Program to facilitate cooperation by forming smaller work groups focusing on specific scientific topics. The outcome will be the development of joint proposals, increased collaboration and joint publications.

### *Description of relevance to SSF's strategic objectives*

The Kongsfjord Flagship Program (KFP) is one of the four Ny-Ålesund flagship programs. It is currently in the process of developing a structured and integrated research agenda under the umbrella of the Ny-Ålesund Science Plan. Based on its primary task to coordinate the multiple research activities at the various stations present in Ny-Ålesund with respect to the marine ecosystem of Kongsfjorden, the KFP consortium has identified a number of essential steps to increase the level of integration and cooperation among research teams. Future research and monitoring within the flagship should therefore be fostered along the research priorities specified below.

This proposal aims to enable the Flagship to be organized in a number of topical working groups, which will have the task to further develop the research lines towards a number of integrated projects. In this way, the science within the flagship will be brought to a higher level. This initiative will also significantly contribute in the international recognition of Ny-Ålesund as the world-leading research infrastructure and monitoring site in the Arctic.

### *Relevance to existing and new collaborative networks/flagships (when relevant)*

This application for a Svalbard Strategic Grant largely builds on the SSF-funded Kongsfjord Flagship workshop on “Adaptation to environmental changes in the Arctic”. During this international and multidisciplinary workshop, a series of research priorities and measures to increase integration and data accessibility were discussed. The following three overarching research areas were identified to promote the progress of integrated research within the KFP:

1. Can Kongsfjorden function as a sentinel and model system to foresee and predict environmental change in a future Svalbard. Are current changes harbingers of the future in other fjords?
2. What will be the consequences of “Atlantification” on ecosystem processes and services such as primary and secondary production, carbon uptake and storage, source/sink of nutrients (including runoff), food-webs, energetics of marine organisms, levels of contaminants and their transfer through the food-web?
3. What are the potential acclimation processes that could mitigate these changes? What is the timescale of adaptation and its potential to maintain ecosystem services?

To address these questions we aim to organize a number of topical working groups as specified below. Steps to improve integration and data accessibility can be discussed more specifically within these topical working groups, and measures can be designed to meet the specific needs of the respective scientific themes. This will promote coordination of environmental monitoring activities as well as support in-depth data synthesis and ecosystem modelling.

Because the research topics are highly inter-disciplinary, collaboration with the atmospheric, glaciology and terrestrial flagships will be essential.

### ***Scientific justification***

The European Arctic has been identified as one of the primary regions, in which the impacts of global climate change will be manifested (see IPCC report 2013). Ny-Ålesund with adjacent Kongsfjorden is a unique study site for documenting and ultimately predicting those changes in the future Arctic. The Kongsfjord-Krossfjord system has been subject to an extensive amount of scientific investigations, which today form a unique historical multidisciplinary knowledge base present nowhere else in the Arctic. Based on an international workshop in 2014 on “Kongsfjorden Ecosystem – new views after more than a decade of research” two Special Issues of *Polar Biology* are published in 2016, and book of review papers will be published in *Advances in Polar Ecology* in 2017.

However, our understanding of the potential of organisms to acclimate and adapt to mitigate environmental change and thus maintain essential ecosystem functions is still poor and scattered. Yet, this information is vital in order to make reliable predictions including sustenance of ecosystem services. Research must be multidisciplinary, encompassing climatology, physics, chemistry and response of the biota. The approach must be integrative, including key polar and boreal species, populations, and communities in a marine-terrestrial setting.

Against the background of the above mentioned overarching research topics, the KFP is now preparing to make further steps towards an integrative, interdisciplinary and international project and to facilitate structured research activities. To address this major task, a number of working groups have been identified to move on with more specific project plans:

**WP 1: Physical, chemical and ecological observations**

**WP 2: Contaminant flow and deposition**

**WP 3: Land-sea-atmosphere interactions**

**WP 4: Seasonal control of the nutrient regime**

**WP 5: Response to key environmental drivers and potential for acclimation and adaptation**

**WP 6: Approaches in modelling the Kongsfjorden/Krossfjorden ecosystem**

Each of these working groups plans to organize joint networking meetings and initiate research activities. More details on the goals within each working group are given below. Anticipated outputs from the working group meetings are joint publications, joint proposals and increased collaboration in the field and facilitating the improved share and flow of data. During upcoming Ny-Ålesund Seminars the working groups will present their progress and results.

Apart from the establishment of new project initiatives, the KFP stresses the need for stronger coordination of monitoring activities and data accessibility. These initiatives will enable us to reach these goals. Thus, by such kind of bottom-up process from more focused research activities to the overall KFP the flow of information and data sharing will further be promoted, by making use of the RiS portal, and eventually the SIOS Data Portal.

### **WP 1: Physical, chemical and ecological observations**

Several monitoring activities are ongoing in Kongsfjorden, but several deficiencies have been identified at a recent workshop. There are four overarching objectives. First, there is no one-stop shop where all data are available. While a common database is a long-term objective, an interim solution would be to comprehensively list existing data sets and produce a small number of compiled data sets on specific variables of interest, for example, temperature and carbonate chemistry. Second, the vast majority of monitoring efforts are performed in the water column. It is critical to expand monitoring to closer to the

benthos and also throughout the western coast of Spitsbergen. This is essential to monitor the progress and magnitude of atlantification. Third, whereas ocean acidification is a driver of key importance in the Arctic, it is continuously monitored at only one location. The availability of new autonomous sensors makes it possible to considerably expand the observation network. Finally, the fourth objective is to find ways to expand observations of changes in community composition both in the water column and the benthos.

The goal of this WP is to address these deficiencies and work out strategies on how to fill the gaps highlighted above. The WP will establish an overview on monitoring activities and data repositories and elaborate on how these information could be merged and become accessible in the most efficient manner.

**Participants:** Jean-Pierre Gattuso (CNRS and UPMC, France), Finlo Cottier (SAMS, UK), Haakon HOP (NP, Norway), Philipp Fischer (AWI, Germany)

## **WP 2: Contaminant flow and deposition**

Elevated temperatures are predicted to change the atmospheric dynamics of contaminants transported to the Arctic from remote sources. Higher temperatures will also stimulate the movement of contaminants between environmental phases and increase the permeability of soil, with melting permafrost potentially leading to a release of contaminants currently sequestered in frozen land. Simultaneously, local sources such as remains from abandoned industrial activities, and discharges from transportation and sewage outfalls are becoming relevant contributors of current-use and emerging contaminants as Arctic exploitation increases in the wake of climate change.

In the light of a changing Arctic, the objectives of the working group are to

1. determine seasonal variations of targeted legacy and non-regulated/emerging organic pollutants on the ocean-atmosphere, land-water, water-ice and water to sediments interfaces;
2. explore influences of oceanographic changes on pollutant profiles in the respective water masses, the transition processes as well as possible consequences for remobilization, transformation and deposition;
3. construct potential scenarios of climatic change on regional Arctic ecosystems;
4. describe the source-to-sink dynamics of natural organic matter and anthropogenic contaminants in a rapidly changing Arctic fjord system;
5. carefully map and characterize existing local contaminant sources on land and in the sea within the Kongsfjorden-Krossfjorden system.

This working group will: (1) organize an international workshop related to contaminant dynamics in the Arctic, and (2) aims to establish an international expert group under the framework of the flagship program to unify the related research works in the future. Furthermore, it will (3) promote joint master or PhD degree programs in this international framework.

**Participants:** Geir Wing Gabrielsen (NP, Norway), Maria Granberg (SERI, Sweden), Roland Kallenborn (NULS, Norway), Leonid Lisitsyn, Anna Nikulina and Sergei Vlasov (Typhoon, Barentsburg), Lu Zhibo, Huang Qinghui (Tongji University), Cai Minggang, Liu Mengyang (Xiamen University), Cai Minghong, Zhang Jie, Yu Yong (PRIC, China), Mahesh Mohan (Mahatma Gandhi University, India), K.T. Kim, J.H. Kang (KOPRI, Korea)

## **WP 3: Land-sea-atmosphere interactions**

Climate change will exert considerable changes in the continuum of interactions between atmosphere-land-sea. The research fostered within this working group will focus on the impact of increased terrestrial, glacial and fluvial inputs into the fjord system. By interaction of scientists from all four of the flagship programs, we aim to link climate signals and glacial mass balances to ecosystem functioning. We will address how temperature increase, black carbon deposition and changes in precipitation will result in increasing glacial and terrestrial run-off. From these sources, we will quantify sediment and freshwater

input to the Kongsfjord-Krossfjord system and address resultant changes to the underwater radiation and salinity regime, and potential implications to primary production and trophic interactions. In addition, this working group will also aim to characterize the modulation of trophic interactions between terrestrial and marine ecosystems and climate variation (i.e. transfer of marine biomass to terrestrial systems and vice versa).

Within this working group, an attempt will be made to address prime ecological questions by a transfer of expertise between all four flagship programs. In order to achieve this, a workshop meeting directed to specify land-sea-atmosphere interactions in the Kongsfjord-Krossfjord system will be organized. Existing data will be screened, collected and used for predictions of sediment input and its implications to the underwater radiation climate.

**Participants:** Kai Bischof (Bremen University, Germany), Jack Kohler, Katrine Husum, Haakon Hop, Sebastian Gerland (NP Norway), Marion Maturilli, Inka Bartsch (AWI, Germany), Michael Roleda (NIBIO, Norway), Nuncio Murukesh (ESSO-NCAOR, India)

#### **WP 4: Seasonal control of the nutrient regime**

Our understanding on the effects of increased CO<sub>2</sub>, temperature and UV radiation on Arctic marine primary producers is mainly restricted to the summer months. During this time, continuous solar irradiation coincides with a nutrient-depleted and strongly stratified environment. Due to the combination of these factors, Arctic algae in summer are prone to regular or even chronic photoinhibition, that only disappears as the darkness progressively increases towards the autumn. However, increasing global temperature may lead to the release of different forms of inorganic N and P, mainly from terrestrial sources. We hypothesise that increased contribution to the N and P pools in the fjord in summer may affect growth and metabolic performances of phytoplankton as well as benthic micro- and macrophytes. Conclusive data on the effects of N and P enrichment in summer on growth and physiological performance of other macrophytes, associated benthic microalgae, and pelagic phytoplankton are, particularly in this area, not available. Given the strong interactive effects of nutrient limitation and other environmental drivers (e.g. temperature, CO<sub>2</sub>) on the competition between photosynthetic organisms, such knowledge is indispensable when assessing the potential for climate change adaptation of the Kongsfjord ecosystem.

The research will be carried out both on site in Ny-Ålesund (Svalbard), as well as through laboratory experiments in the home institutions. The working group will organize common research activities by means of visits of several weeks of duration of both senior and junior researchers. In addition, joint project meetings will be carried out for data analysis, experimental design and group discussions.

**Participants:** Carlos Jimenez, Franciso Gordillo (Malaga University, Spain), Angela Wulff (Gothenburg University, Sweden), Willem van de Poll (Groningen University, The Netherlands), Clara Hoppe (AWI, Germany), Haakon Hop (NP, Norway), Michael Roleda (NIBIO, Norway), K. P. Krishnan (ESSO-NCAOR, India), J. Y. Jung (KOPRI, Korea)

#### **WP 5: Response to key environmental drivers, acclimation and adaptation**

The response of biological communities to on-going and futures changes in the Arctic is very poor, especially the capabilities for acclimation and adaptation. This major gap could be addressed using a two-pronged approach. First, time-series observations of the physical, chemical and ecological parameters addressed in WP1 should be put together and analysed in terms of bioclimatic envelopes and responses to continuous and abrupt events. Second, perturbation experiments should be planned with three objectives in mind: (1) investigate communities rather than isolated species, (2) manipulate more than one driver to understand the combined response to multiple drivers and (3) look at long term perturbations (weeks to months at least) to assess potential for adaptation.

This WP will arrange a workshop meeting focussed to the conceptualisation of multifactorial experiments. In this way WP 5 will create the biological link between the environmental observations (WP 1) and ecosystem modelling (WP 6).

**Participants:** Jean-Pierre Gattuso (CNRS and UPMC, France), Kai Bischof (Bremen University, Germany), Carlos Jimenez (Malaga University, Spain), Michael Roleda (NIBIO, Norway), Brezo Martinez (University Rey Juan Carlos, Spain), Geir Wing Gabrielsen, Haakon Hop (NP, Norway), Clara Hoppe (AWI, Germany)

### **WP 6: Approaches in modelling the Kongsfjord/Krossfjord ecosystem**

The aim of this working group is to synthesize available knowledge and data relevant for Kongsfjorden/Krossfjorden ecosystem modelling and debate with specialists the main processes and trophic/functional groups that should be considered in an ecosystem model of this system. In parallel, models for defined indicator species, such as Species Distribution Models (SDMs), shall be discussed. SDMs may be used to predict the shifts of the geographic distribution of the target species as a result of warming and other stressors, and physiology and population dynamics models that may be linked to the former and also feedback ecosystem modeling efforts. The final aim of this workgroup is to take full advantage of the wealth of information and data available for Kongsfjorden/Krossfjorden and to design a solid project that will allow synthesizing it in formal predictive tools.

This work group will organize a meeting with researchers with a significant publication record on the topics mentioned above, based on studies conducted in Kongsfjorden, and also with physical modelers that are currently implementing a circulation model for Kongsfjorden within the projects “Effects of oceanic inflow and glacial runoff on fjord circulation in Kongsfjorden, Svalbard; establishment of a high resolution ocean circulation model system (KongHiro)”, financed by the Fram Centre, and “Tidewater Glacier Retreat Impact on Fjord circulation and ecosystems (TIGRIF)” financed by the Norwegian Research Council. This interaction between ecologists and physicists will allow the proper planning of the coupling methodology between physical, chemical and biological processes in the ecosystem model mentioned above. It will also be useful to plan how to define the physical context for SDM models by providing the spatial distribution of relevant physical properties in present and future scenarios that may force changes in the geographic ranges of selected species.

**Participants:** Pedro Duarte, Arild Sundfjord (NP, Norway), Brezo Martinez (University Rey Juan Carlos, Spain), Jon Albretsen, Jofrid Skardhamar (Havforskningsinstituttet, Norway), Divya David (ESSO-NCAOR, India)

#### ***Budget:***

##### *Direct costs*

One workgroup meeting within each group. Six work group meetings: 6 WG x 60 kNOK= 360 kNOK  
This will cover: lunches, coffee, dinner, and some funds for travel

Each group also applies for funding for an undergraduate student for up to three months to screen, collect and assemble relevant data to project-specific data sets allowing for meta-analyses and model preparation:  
Six students x 3 months: 40 kNOK

**Total costs applied for in this application: 400 kNOK**