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18-19TH OF FEBRUARY 2014

BIVARC WORKSHOP

"Bivalves in the Arctic" in Tromsø, Norway

- Gathering scientists working on Arctic bivalves and benthos
- Facilitating existing research activities
- Creating synergies between activities
- Identifying gaps in knowledge

UNIVERSITY OF TROMSØ

NORWEGIAN RESEARCH COUNCIL

SVALBARD SCIENCE FORUM

18TH OF FEBRUARY

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ABSTRACTS

Blue mussels on Svalbard

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Between 10000 and 5000 years ago, *Mytilus edulis* were widely distributed around the high Arctic archipelago of Svalbard (Salvigsen *et al.* 1992; Salvigsen 2002), with a distributional pattern that is closely linked to the drift patterns of the West Spitsbergen Current (WSC) (Peacock 1989, Salvigsen *et al*. 1992, Berge *et al.* 2005). Today, we find evidence of their previous distribution pattern in elevated beach beds, as was recently shown from the Hiorthfjellet fan delta in Adventfjorden (Lønne & Nemec 2004) where deposits of 3-5000 years old blue mussel shells are in abundance in the delta's sediments. During warm intervals of the Holocene, blue mussels were at times very common and numerous along the western coast of Svalbard (e.g. Salvigsen 2002, Berge et al. 2005). Until now, no records of blue mussel remains have been reported from the northern and western side of Nordaustlandet, which has been explained by the weak influence of warm Atlantic water in these areas (Salvigsen 2002). However, in 2005 (Berge unpubl. data) remains of a 5000 year old blue mussel were collected from a lake in Rijpfjorden on the northern part of Nordaustlandet (Fig 1). This is to date the northernmost record of fossil blue mussels in the region, and further evidence of its widespread distribution during warm Holocene periods.

At present, living blue mussels are found at Arctic latitudes in western Canada and Greenland (e.g. Norton & Feder 2006), and are widely distributed in the North Atlantic, inhabiting European coastlines from the Atlantic coast of France in the South to the Barents Sea and to western Kara Sea in the North. Recently, individuals were recorded on Bjørnøya (Weslawski et al. 1997) and Spitsbergen (Berge et al. 2005) in the Eurasian part of the Arctic, where its discovery was considered as a case of re-establishment due to changes in environmental conditions such as sea surface temperature (Berge et al. 2005, 2006). Later, in 2011, a new population was discovered in Kongsfjorden on Svalbard. Here, we describe and compare its distribution with prevailing oceanographic parameters.

Climatic factors influencing population dynamics of *Mytilus edulis* in West Greenland

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The north-south orientation of the West Greenland coast provides an ideal opportunity to study the impact of natural variation in climate on marine populations. A general prediction of Arctic climate change is the northward expansion of temperate species into the Arctic. The blue mussel *Mytilus edulis* could be a species that would respond to a warmer climate by expanding northward and increasing abundance and growth rates in the Arctic. However, adequate data on current distribution is lacking and knowledge of how "climate" in a broad sense specifically influence population dynamics of this species is unknown. Here, we present data on abundance, age and mortality of *Mytilus edulis* in West Greenland combined with measurements of freezing tolerance of intertidal specimens in attempt to identify links between climate and populations dynamics in this region of the Arctic.

Blue mussels along latitudinal gradient with a special emphasis on marginal populations in the Pechora Sea

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Geographic variation in physiological functions in animals has long been of interest to biologists. Among the most intensively studied are the latitudinal clines in various life history and physiological traits such as maximal attainable body size, growth rate, age-at-maturity, development rate, longevity, standard metabolic rate, reproductive output and others. Many of the recorded latitudinal trends and patterns of geographic variation are controversial and despite significant efforts remain poorly understood (e.g., Gaston et al., 2009). Marginal species populations are considered to be especially sensitive to the environmental stresses (e.g., Sexton et al, 2009).

We studied variation in abundance, growth patterns, fecundity, longevity, tissue biochemical composition and metabolic rates in European populations of blue mussels *Mytilus* with the main focus on the populations in Pechora Sea. In this area mussels reach the NE boundary of their amphi-boreal distribution range.

Longevity and maximal body size did not show any latitudinal trends but were determined mostly by the local factors such as depth or hydrodynamic regimes. Abundance, individual growth rates and fecundity declined towards the edge of the species distribution range and were minimal in the Pechora Sea populations. Metabolic rates in *M. edulis* progressively increased in animals living at high latitudes which possibly led to reduced energy investment in growth and reproduction in colder environments. Age frequency distributions in the Pechora Sea mussel populations indicate that successful recruitment occurs once in 3-4 years in this part of the range. Taking into account slow growth and low fecundity mussel beds in Pechora Sea may be particularly vulnerable to stress factors both natural and anthropogenic.

Are blue mussels *Mytilus edulis* and *M. trossulus* genetically, ecologically and morphologically distinct entities in the White Sea?

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Two blue mussel species *Mytilus trossulus* and *M. edulis* co-exist in Northern Europe, in particular in Northern Russia and along the Norwegian coast (in the latter area the minor presence of the third species *M. galloprovincialis* was recently reported). These species ultimately are separate genetic forms that have distinct evolutionary histories. On the other hand, according to the conventional knowledge *M. trossulus* and *M. edulis* has no clear morphological differences (yet multivariate morphometric analysis permits to discriminate them probabilistically), has no clear ecological differences in the areas of co-existence (data on habitat segregation is limited and controversial) and hybridize easily while the extent of hybridization is usually reported in relative, not absolute terms in genetic papers. Therefore marine biologists quite often (and quite reasonably) regard *M. trossulus* and *M. edulis* as intangible, virtual entities that are of importance for geneticists only. Here, on the example of the White Sea hybrid zone between *M. trossulus* and *M. edulis* we ask: what are the actual frequencies of hybrids in mixed populations, how easily individuals of the two species could be discriminated by a simple conchological character suggested by Zolotarev & Shurova (1997) and are there any differences between species in their substrate preferences. Mean frequency of hybrids in populations is 23% (range 33-43%); on average 85% of *M. trossulus* in populations (range 33 - 93%) bears a prismatic layer under ligament (i.e. has a distinct blue stripe under the ligament) while most of *M. edulis* bears a nacreous layer (0-78%); frequency of *M. trossulus* is universally higher in samples collected from algal substrate than in samples collected from the ground. We conclude that *M. trossulus* and *M. edulis* “behave” as rather distinct biological entities in the White Sea.

Comparative study of hemocytes concentration in mussel (*Mytilus edulis*) hemolymph and extrapallial fluid under the different environment conditions

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The hemopoesis of extrapallial hemocytes, its lifecycle, renewal rate and reaction to environmental stimuli are still insufficiently explored questions. The study of total hemocyte number (THN) was made for White Sea mussels taken in August 2012 from different environmental conditions (tidal, subtidal and mussels from estuary sills). The hemocyte number was measured in both hemolymph and extrapallial fluid (EPF) for each mussel.

When temperature has been elevated from 12˚C to 28˚C the THN in hemolymph was increase three-times, but EPF THN was not changed. Tidal mussels had 2-3 times THN in hemolymph than in EPF THN, and subtidal ones had similar THN in hemolymph and EPF equal to medium tidal mussels THN. Thus the THN in mussels' hemolymph is more reactive parameter than EPF THN.

50 shades of blue: underwater light as an environmental factor and potential implications for bivalves studies

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Photosynthetically active radiation (PAR) is a common environmental parameter that has been considered in ecosystem studies over several past decades. Recent advances in instrumentation allow looking into spectral composition of underwater light field. Therefore, it seems essential for marine ecologists to incorporate this kind of data on underwater spectral radiation in their studies and models. Especially, such data will be relevant in coastal environments with potentially strong gradients in optically active substances such as particulate matter, colored dissolved organic matter (CDOM) and chlorophyll. We present several examples of underwater light profiles that can stimulate discussion on importance of underwater light spectral composition for bivalve studies in two contrasting regions – Svalbard fjords and the White Sea.

Read my lips told us the scallop in Arctic waters: a 1st assessment.

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To understand and inform of ongoing challenges facing the Arctic is a major problem for the scientific community. A continuous monitoring in the Arctic is very tricky due to the climate, the polar night, all technical difficulties and logistic costs. A solution is to develop unmanned systems, able to work without human intervention over long periods of time. One part of these systems must show integration capacities. In the aquatic environment the ability of clams to permanently 'taste' their environment is a way to monitor the quality of the Arctic waters. Monitoring their natural and/or abnormal opening/closing activity, their biological rhythms, their spawning activity and their growth rate is a way to read, through "molluscan eyes", the health of their environment. We are working in the Arctic since 2012. We will recall you what we are doing and we will present a short review of some main observations. The MolluSCAN eye website where one have direct insights, 24/7, all year round, into the behavior of bivalves in their natural environment: molluscan-eye.epoc.u-bordeaux1.fr

Pan-Arctic Bivalves as polar bioarchives

L. Chauvaud

Cardiac responses of two different zones blue mussels (*Mytilus edulis*) and horse mussels (*Modiolus modiolus*) to seasonal in temperature and phytoplankton concentrations

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In according with the aims of our project we monitored over a full year cycle the physiological (heart activity), biochemical (lipid composition), biological (reproductive status) and morphological (condition index) characteristics of the indicator species – blue and horse mussels - affected by specific physical (light, temperature, ice cover, salinity) and biological (food availability) conditions. We used cardiac activity of Bivalvia because it is usually fast and thus potentially suitable for a fast response in continuous biological monitoring. Further, the response of the mussels to petroleum related pollution jointly with changes of salinity was studied.

The high significant correlation of temperature and cardiac activity (heart rate and amplitude of heart contraction) from February to January was shown. However, in some points – start of May and July-August – that relationship was not obviously. We suppose that such changes in correlations may be based on the effect of food availability, i.e. phytoplankton concentrations. That biological index was changed drastically with two high peaks on May and July.

The comparative analysis of the lipid composition revealed the considerable changes of the general lipid one (structural and reserve forms), some fractions of phospholipids and fatty acids. We think that reproductive status is the main factor which connected with those changes.

Mytilus species in Norway, differences in distribution, chemical bioaccumulation and biomarker responses

S. Brooks

Combined effects of petroleum and the Environment in bivalves

J. Nahrgang

Effect of latitude on the antioxidant defences in an Arctic bivalve

L. Camus

Biological effects of mechanically and chemically dispersed oil on the Icelandic Scallop (*Chlamys islandica)*

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The aim of this study was to examine short- and long-term effects of mechanically and chemically dispersed crude oil on the Arctic filter feeding bivalve *Chlamys islandica.* In order to investigate if chemically dispersed oil is more toxic than mechanically dispersed oil, scallops were exposed for 48 hours to a range of concentrations of mechanically and chemically dispersed oil: (i) Total hydrocarbon content (THC) <1 mg/L representative of a small oil spills scenario; (ii) THC 10-20 mg/L as a severe oil spill scenario; (iii) THC >50 mg/L as worst case/ environmentally improbable scenario. Short-term effects of 48 hours exposures were assessed in terms of lysosomal membrane stability, and oxidative stress and peroxisomal proliferation biomarkers (superoxide dismutase, catalase, gluthatione S-transferases, glutathione peroxidases, glutathione reductase, glutathione, total oxyradical scavenging capacity, lipid peroxidation and peroxisomal proliferation). Post-exposure survival, growth and reproductive investment were also followed for 2 months to evaluate any long-term consequence of exposure. Despite a significant accumulation of PAHs in scallops exposed to both chemically and mechanically dispersed oil, quite limited effects were observed on cellular and oxidative stress responses after 48 hours, suggesting that a different timing would be required for measuring these biomarkers. There was a concentration dependent increase in cumulative post-exposure mortality, but long-term effects on gonadosomatic index, somatic growth/condition factor and shell growth did not differ among treatments, indicating that chemically dispersed oil would be no more toxic to Icelandic scallops than mechanically dispersed oil. Potential effects on reproductive development and success require further investigation.

Bivalve growth and mineral proxies: indicators of annual routines and variable physical environments?

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Calcified skeletons of bivalves and other taxa can offer a variety of insights into spatial and temporal variability in growth rates and environmental conditions. A series of deployments of marked bivalves of several taxa have confirmed annual growth bands in high Arctic species, as has been observed in more southern latitudes. Furthermore, shell mineralogy along the growth axis appears to indicate the potential for linking patterns of growth with interannual variability in water column fluorescence. Coordination of clam deployments and measurements on oceanographic moorings has been a powerful tool in studying clam growth and identifying potential mineral proxies for environmental conditions in the past. Finally, a new project will investigate variability in mineralogy of bivalves and bryozoans relative to changes in carbonate saturation state due to ocean acidification. These, and a growing number of related studies, suggest that the environmental signals preserved in carbonate skeletons may be valuable in both reconstructing historical conditions and predicting ecological changes due to climatic shifts in the future.

Sclerochronology of Arctic bivalves in Svalbard: patterns and drivers

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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.

Variable individual- and species-level responses to ocean acidification and warming

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Ocean acidification (OA) will cause dramatic and abrupt changes to the physical environment of marine taxa. These changes are likely too fast for adaptation through genetic mutation. Hence the adaptability of a population to the future OA is determined by the already existing genetic variability within the population and by the magnitude of selection pressure caused by OA related processes. Most calcifying marine taxa undergo several different life-stages for which the selection pressure by OA might act differently. If OA causes a substantial selection at an early life stage, the genetic variability of a population might decrease, even though some of this variability would be beneficial at later life-stages. Fertilization is an important and complex process in marine broadcast spawners, such as bivalves, and its success depends on gametes being released into an environment favourable for the gametes to remain viable, meet, and fertilize. Changes in the physical environment, such as reduced pH, which may influence cellular and sub-cellular processes, are therefore expected to influence the fertilization process. We tested the effect of increased pCO_2 and temperature on sperm activity (swimming speed and percent motility) and longevity of the three bivalve species, the mussel *Mytilus galloprovincialis,* the scallop *Chlamys islandica*, and the mud clam *Macoma calcarea*. Our results suggest that the sensitivity to ocean acidification and warming is variable among individuals and species. As sperm quality is an important driver of fertilization, we predict that selection by OA will favour fertilization by sperm that are more OA-resistant, and, hence, that populations may be able to adapt to near-future OA, but with a potential reduction in genetic variability in the population.

ECOTAB project: Effect of Climate change On The Arctic Benthos

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It is now generally admitted that effects of climate change are enhanced in the Arctic. These changes will have repercussions on the entire ecosystem functioning and carbon cycling, although it is yet unclear how benthic organisms will respond to these changes in food sources and environmental conditions. The overarching goal of the ECOTAB project was to investigate how climate-induced changes in biological (food sources) and environmental (temperature, pH, salinity) conditions will impact the Arctic benthos. In 2012/2013, during 4 field campaigns (May, August, October and January), organic matter fluxes from the water column to the sea floor and the benthic response to these inputs were studied as a function of biological and environmental factors, at 3 stations along a gradient glacier-outer fjord in Kongsfjorden. During the second phase, the impact of changes in food and environmental parameters will be studied experimentally on the key bivalve species *Chlamys islandica.*

An overview of the bioturbation activities in arctic sediments

E. Michaud

Ecophysiological study of the bivalve *Chlamys islandica*, *in situ* versus *ex situ*

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Bivalves dominate the benthic biomass of many Arctic shelves (Gulliksen *et al*., 1985; Dayton, 1990). These organisms form their external calcium carbonate skeleton periodically, controlled by the organism and function of environmental conditions. It leads to the formation of growth lines that can be used as chronological landmarks (sclerochronology). High latitude bivalves have life spans of decades (Ambrose *et al*., 2006; Sejr & Christensen, 2007; Carroll *et al*., 2009, 2011a) to centuries (Schöne *et al*., 2005, 2011a; Witbaard *et al*., 1999; Wanamaker et al., 2011). Deciphering environmental proxies incorporated within biogenic archives during their growth thus provide records of environmental conditions over decades to centuries, which are critical to understand the response of Arctic benthic communities to climate change given the paucity, in this region, of long-term data on community structure and dynamics. The studies cited above produced intriguing results suggesting that inter-annual variations in bivalve shell growth indeed reflects variability in local ecological conditions, with potential for retrospectively examining ecologically relevant effects of climatic variations over decades to even thousands of years. The important link between climate and ecosystem processes suggested by clam growth patterns however depends on uninvestigated direct links between growth and simultaneously collected environmental data (Ambrose et al., 2012). The approach used till now to address these questions focused on two species in the Svalbard Archipelago (*Serripes groenlandicus* and *Clinocardium ciliatum*) and consisted in looking at the inter-annual variations in shell growth to explore the relationship between benthic communities and environmental variations associated with decadal climate oscillations in the Arctic as the Arctic Oscillation (AO) and the Arctic Climate Regime Index (ACRI) (Ambrose et al., 2006, 2012; Carroll et al., 2009, 2011a, 2011b). The last conclusions in Ambrose et al. (2012) called for the need: i) to understand the factors affecting growth in bivalves and what they may tell us about the influence of climate change on benthic communities in general, ii) to determine the relative importance of biotic and abiotic factors on the bivalves' growth and iii) to understand taxon-specific responses to environmental variables before bivalves can be used to their full potential as bioarchives for high-latitude environmental conditions.

Data concerning growth, filtration rate and respiration for *Chlamys islandica* were collected *in situ* in Kongsfjorden during spring bloom and autumn. Moreover, in spring 2014, we will made perturbation experiment using the Ny-Ålesund Marine Laboratory facilities to study the impact of temperature, food and light on the *Chlamys ilsandica* physiology. This experiment will be explained with respect to an experiment realized in Brest on *Pecten maximus*.

Bivalves in west Spitsbergen fjords: distribution, diversity and trophic ecology

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Bivalvia are dominant taxa in Arctic benthic communities, both in terms of diversity and standing stocks. Thus they are in focus of the ecological studies of IO PAN in west Spitsbergen fjords. The assessment of the mollusc diversity and distribution patterns in an Arctic glacial fjord – Kongsfjorden was based on materials collected throughout the fjord, in 5 years, across the variety of habitats and depths ranging from 5 to 390 m. The patterns of bivalve diversity and density are not consistent with those of the other macrobenthic groups - e.g. some species (Yoldiidae and Thyasiridae) can occur in large numbers in near-glacier areas that are subjected to strong sedimentation of minerals transported with glacial meltwaters. The feeding of the selected bivalve species was investigated with use of biochemical markers (isotopes and lipids) in Kongsfjorden and Hornsund. Stable isoptope analysis proved that their trophic position within local food webs is low (ca. 2 TL) and it does not change between seasons. Bivalves do not accumulate high lipid reserves, total lipid content reaches up to 4.7% of DW in summer and up to 4.4% of DW in winter. Based on their fatty acid composition bivalves seem to be quite selective feeders. High amounts of 22:6n-3 and C18 fatty acids indicate flagellate-based nutrition of the suspension-feeding bivalves both in winter and summer.

Bivalve molluscs on hard-bottom in Kongsfjorden, Svalbard

A. Voronkov