Timing of ecological processes in Spitsbergen fjords - SpitsEco

1. Scientific relevance and background

High latitude marine systems are characterized by low and stable temperatures, large seasonal variability in the light regime (Falk-Petersen et al. 2007) and high annual and interannual fluctuations in ice thickness, extent and duration. However, the accelerating increase in global temperatures is leading to rapid shifts in Arctic ecosystem structure and function (Popova et al. 2010; Wassmann et al. 2011). In recent years sea ice has declined rapidly, air and ocean temperatures as well as water column stratification and river runoff have increased, and multiple physical, dynamic and chemical changes have significantly alter the patterns of productivity at the base of marine food webs (Walsh 2008). Such changes are anticipated to affect ecosystem structure and productivity higher up in the food web, but at present. the consequences on pelagic ecosystems in Arctic and sub-arctic regions are poorly understood. Changes in water column stratification, sedimentation and sea ice extent and duration will for example have consequences for the underwater light climate and the nutrient supply. This will affect the timing and productivity of ice algae and phytoplankton blooms with far fetching consequences for higher trophic levels (Søreide et al. 2010; Leu et al. 2011). About 50% of the Arctic Ocean area is located over the shallow continental shelf which plays significant role in transformation of water masses (Aagaard et al. 1981) and the biogeochemical carbon cycle in the Arctic (Carmack and Wassmann 2006). Largest changes in sea ice cover extent and thickness are found in Arctic shelf seas, which are five times more productive than the deep Arctic Ocean (Sakshaug 2004). It is therefore of particular interest to study ecosystem function of these seas. Daubed shanny, *Leptoclinus maculatus*, is a key organism transferring energy-rich lipids originating from primarily diatoms through *Calanus* (see Falk-Petersen et al. 2007) to higher trophic levels animals as seals and seabirds. However, except for a few studies (Falk-Petersen et al., 1986; Meyer Ottesen et al. 2011; Murzina et al. 2012), little is known about daubed shanny's growth, distribution and life cycle strategy in Svalbard waters. Daubed shanny develops from pelagic larvae to bottom adult via a semi-adult stage. During the change from pelagic to bottom environment, daubed shanny faces changes in abiotic factors such as temperature, light, salinity, water currencies and pressure and biotic factors as food abundance and presence of predators. These changes should be reflected on fish biology and ecology. One of the more important periods of life of adults is reproduction, characterized by total modification of the metabolism, in particular lipid utilization. Lipid metabolism play a key role in oogenesis and spermatogenesis of fishes, and particularly the Arctic daubed shanny is known to produce very lipid-rich eggs. However, embryos and larvae of daubed shanny have not been described and information is lacking about how the embryos uses its lipid storages, during embryogenesis and after hatching.

A key element of our approach is the network of ocean observatories currently being operated around Svalbard. Some of these have been operated by Arctos institutions and AWI since 2002, whereas others have been established only recently. In common to all of them, is that they are all perfectly equipped to study pelagic biological processes while at the same time providing state-of-the-art physical background data. Both Circa and Cleopatra II will base much of their work on the data provided by these observatories, and data will be made fully available also for the SpitsEco scientists.

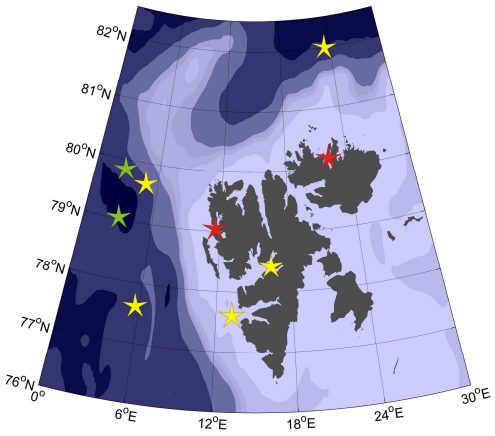


Figure 1: The network of established observatories around Svalbard. The green stars indicate locations of moorings operated by AWI in the HAUSGARTEN project. The red and yellow stars indicate observatories that are operated by ARCTOS institutions (Kongsfjorden since 2002).

Pelagic juveniles of daubed shanny has an unusual developmental feature, the tiny, translucent pelagic larvae contains a “lipid sac” situated in a ventral part of the body. This lipid sac consists of globules filled by lipids originating from feeding on the lipid-rich copepod *Calanus* spp.. The lipid sac is an evolutionary adaptation enabling daubed shanny larvae to survive as a pelagic larvae up-to 3 - 5 years. The pelagic larvae might overwinter and develop under the ice cover during winter. Lipids are multifunctional but the most general functions are energy producers, structural (biomembrane) components and bioactive elements (cellular messengers, vitamins, steroids etc.) which are important for the development of larvae. We work out of the hypothesis that the hatching of the eggs, which we believe is spawned in burrow in muddy substrate, are timed with the seasonal migration and spawning of *Calanus glacialis.*

SpitsEco is built as an affiliated but separate subproject on top of ongoing mare-incognitum projects that both carry out field campaigns within Svalbard waters:

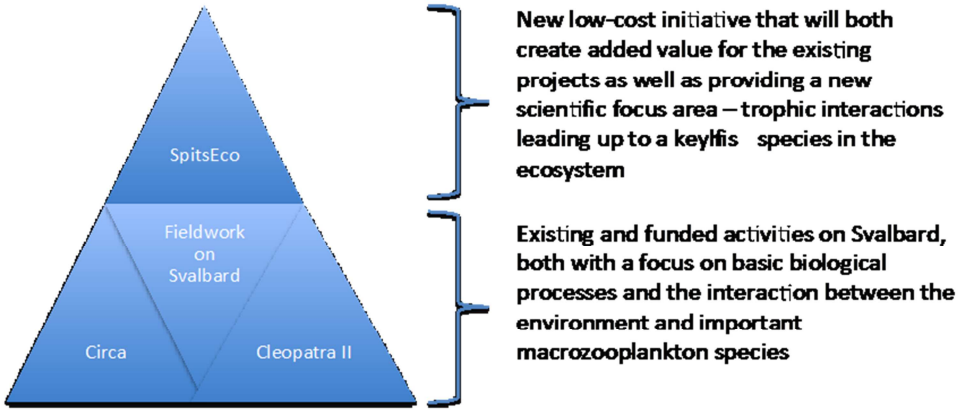
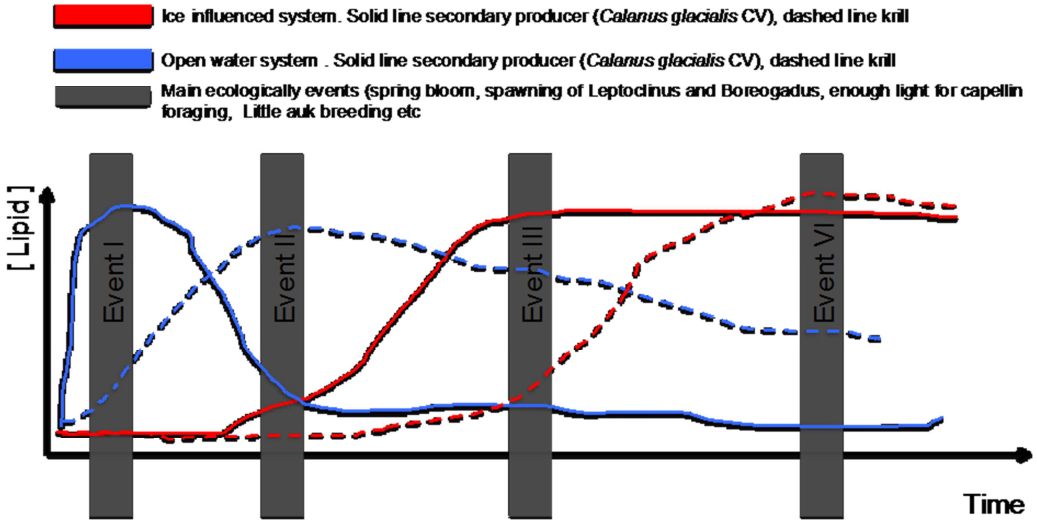


Figure 1. SpitsEco has three main pillars on which the scientific objective is built; two ongoing research projects (Circa and Cleopatra II) that both are aimed at pelagic processes and connection between the physical environment and important biological elements within the Arctic food chain, and joint field activities in the fjords on Svalbard (Isfjorden, Kongsfjorden and Rijpfjorden).

2. Project description

The project is focused on the timing of energy transfer in arctic pelagic ecosystems, with special emphasis on the life history adaptations in the key high Arctic species. We propose a joint Russian – Norwegian project on adaption to high latitude environmental cycles and energy transfer through pelagic food webs in Svalbard, utilizing existing infrastructure (observatories) and activities (Mare-incognitum projects, see www.mare-incognitum.no). We will utilize the strong knowledge on polar marine ecosystems by both the Norwegian and Russian partners. The Russian group has its strength in their analytical capacity in histology and lipid chemistry and biochemical adaptations of high latitude fish species.

Project outline:



Task 1: Assign time-frames for main events

Task 2: Develop energy curves for *Calanus* and krill

Main objective: Predict physical and biological forcing of community structure (which system will match which events?)

Example: If Event 1 is *Leptoclinus* spawning, the the red system does not match a build up of energy required to sustain the feeding larvae

Changes in timing of physical and biological processes will have cascading effects throughout the food web (Winder and Schindler 2004). The life history and annual routines of central actors in Arctic pelagic ecosystems are surprisingly poorly known, maybe with the exception of *Calanus* copepods (Falk-Petersen et al. 2009). CLEOPATRA II will study sea ice phenology and timing of blooms and zooplankton dynamics. In this project we will study how the timing of the seasonal migration of *Calanus* will affect growth and development (timing of reproduction) of daubed shanny.

Hypothesis: Reproductive success and recruitment of key carnivorous species is indirectly related to timing of blooms through recruitment of *Calanus* spp. and krill. Changes in sea ice and bloom phenology will alter the potential for a match between annual routines and timing of reproduction in important predators such as *Boreogadus saida*, *Leptoclinus maculatus*, and *Alle alle.*

Approach and methods: By aligning SpitsEco with Marine Night and other mare-incognitum projects, we will utilize existing platforms for defining main events and follow the ecologically available buold-up of energy in *Calanus* spp and krill. This include sampling of *Leptoclinus maculatus* and *Boreogadus saida* during winter (November-March) to unequivocally define spawning periods. Sampling will be conducted by the trawler RV Helmer Hansen and UNIS smaller RV Viking Explorer, from the shallow muddy flats with nets and dredges. Basic data of total fish community, including species composition, length frequency distribution will be collected. For these species, basic parameters on length, weight, age (otholites) and maturity, gonads developmental stage will be measured and documented, respectively. Seasonal stomach content will be analyzed. Lipid and fatty acid profile as well as measuring in addition to membrane connected enzymes (Na+, K+-ATP-ase, in particular) to increase our understanding of the activity of adult fishes in regard to physiology (age, sex, maturity) and seasonal changes in the environment.

Sampling plan (in red new activity):
January 2014: Kongsfjorden and Rijpfjorden onboard HH
March 2014: Kongsfjorden using *Teisten*
April 2014: Billefjorden together with AB330
June 2014: Kongsfjorden using *Teisten*
August 2014: Isfjorden, Kongsfjorden and Rijpfjorden on HH with UNIS-HI course
September 2014: Isfjorden, Billefjorden, Kongsfjorden and Rijpfjorden on HH with AB321