

## Project information

### Project title

Effects of Ocean Acidification and temperature on Arctic vs. boreal zooplankton species and populations

### Year

2012/2013

### Project leader

Haakon Hop, NPI

### Participants

- Haakon Hop (NPI)-Leader
- Howard Browman (IMR)-Co-leader
- Anne Berit Skiftesvik (IMR - researcher)
- Caroline Durif (IMR - researcher)
- Reidun Bjelland (IMR – senior engineer)
- David Fields (IMR and Bigelow Laboratory for Ocean Science - researcher)
- Jeffrey Runge (Gulf of Maine Research Institute - researcher)
- Claudia Halsband (Akvaplan-niva)
- Peter Thor (NPI-post doc)
- Erik Sperfeld (IMR-post doc)
- Padmini Dalpadado (IMR)
- Stig Falk-Petersen (NPI)

### Flagship

Ocean acidification, Theme: Ocean acidification effects on key components of the Arctic marine ecosystem

### Funding Source

Fram Centre, internal

### Summary of Results

Several meetings and visits to stations were conducted in order to start up collaborative research on experiments on ocean acidification with marine organisms. The sites included:

- Institute of Marine Research, Austevoll Station (May)
- Troms Marin Yngel (June)
- Havbruksstasjonen in Tromsø, Kårvika (June)
- Troms Kråkebolle (June)
- Kings Bay Marine Laboratory (October)
- The Sven Lovén Centre for Marine Sciences, Kristineberg (SLC-K), Sweden, (Peter Thor is currently conducting experiments this location)

Project participants attended all flagship meetings and contributed to the collation of the flagship description, and to the project description of project WP2-OA-3. Participants from Apn and NPI visited IMR-Austevoll, TMY and Kårvika, and NPI representatives visited Troms Kråkebolle and KB Marine Laboratory. The meeting at Austevoll (31.05.12) included 20 participants, of which 10 were WP2-OA-3-project participants.

**Peter Thor** is currently running experiments on *Pseudocalanus* sp. at SLC-K, Sweden in collaboration with Sam Dupont and Pierre De Witt, University of Gothenburg. This study investigates effects of OA on phenotypic plasticity in several life cycle and metabolic traits as well as effects on gene expression (transcriptomics). The *Pseudocalanus* sp. were collected in October from Kongsfjorden with RV *Teisten* and successfully brought live to Kristineberg for these experiments. One master student at Kristineberg is involved in these studies. **Thor** also went to Ny-Ålesund to assess possibilities for copepod experiments at the Kings Bay Marine Lab. He has further initiated practical planning of the collaboration with **Erik Sperfeld** (post doc. at IMR) at Austevoll. He is currently discussing possible collaboration with Maarten Boersma, Alfred Wegener Institute, Germany on OA effects on copepods.

**Claudia Halsband** has advised on the choice of study animals and experimental study at SLC-K. She also submitted two papers to a special issue in the *Marine Pollution Bulletin*, which are accepted for publication pending revisions, and joined the ICES Study Group on Ocean Acidification (SGOA).

**Haakon Hop** took care of organizational aspects. He also took some action to enhance Ocean Acidification project and collaboration at IMR-Austevoll. This cold-water facility needed for experimental research on arctic zooplankton at 0°C is currently being built and should be completed by early 2013. The water system also needs to be upgraded to deliver constant temperature and environmentally correct pH. This will make it possible to conduct comparative OA experiments on boreal and Arctic zooplankton at IMR-Austevoll with both post docs (IMR/NPI) involved as well as the other project participants. We are also planning some smaller experiments at the Kings Bay Marine Laboratory in Ny-Ålesund. Haakon participated in the 3. Pan-Arctic symposium in Motovon, Istria, Croatia in October. Based on this symposium, participants have agreed to write pan-Arctic papers for a special volume in *Progress in Oceanography*, and he will be co-author on a paper on: “Arctic Ocean acidification and its biological and physiological consequences.

**Erik Sperfeld** (IMR-post doc) and **Padmini Dalpadado** are currently developing several aspects in the methodology regarding the ocean

acidification experiments with krill, which have been regularly caught near Austevoll research station using light traps, developed by **Anders Mangor-Jensen**. They are using containers as traps in order to avoid any injuries of krill potentially caused by net-based light traps. The caught krill have been transferred to a big stock tank (700 L) to collect the animals for later experiments. Subsamples of the krill were analysed to determine species composition and size structure. Two species in varying age/size classes were caught: *Meganyctiphanes norvegica* (the current focal species) and *Nyctiphanes couchii* (a smaller krill species). Recently, short-term feeding experiments were carried out to investigate the nutritional requirements of krill of different sizes. Preliminary results show that krill fed on large amounts of freshly hatched *Artemia salina* nauplii as well as algae. This information is essential for the intended long-term OA experiments in order to keep the animals in a good condition and allow for growth and consequently moulting. The krill will be fed with a food mixture comprised of an algal mixture, freshly hatched *Artemia* nauplii and commercial shrimp food.

The OA facility is in final preparation to start soon with krill experiments at about 10°C, which are intended to run for several weeks. Krill are kept individually in jars in order to observe moulting/growth, mortality and feeding behaviour. They intend to expose the krill to three different pCO<sub>2</sub>/pH levels and keep them on low and high food availability. The development of methods for measuring other end points (e.g. metabolic rates, lipid content and composition, calcium content) is planned for 2013.

**Howard Browman's team** at IMR-Austevoll, in collaboration with David Fields and Jeffrey Runge in the USA and V. Thiyagarajan in Hong Kong, have been investigating the influence of three different pCO<sub>2</sub>/pH levels on the boreal copepod *Calanus finmarchicus*. Various biological end-points are being measured, specifically, egg production rate, larval viability, survivorship, fat storage, gut pH, metabolic rate, protein expression and escape responses to a simulated predator. In 2012, an experiment on *C. finmarchicus* was completed, and samples from this experiment are being analysed. In addition, **Browman** and **Skiftesvik** from IMR participated in the *Oceans in a High CO<sub>2</sub> World* conference. Browman and Thiyagarajan are also organizing the *Interdisciplinary Symposium on Ocean Acidification and Climate Change* to be held 11-14 December, 2012, in Hong Kong. The Fram Centre is a co-sponsor of this event (see: <http://www.biosch.hku.hk/ecology/isoacc/index.htm>).

#### Published Results/Planned Publications

**Browman, H.I.**, V. Thiyagarajan *et al.* Effects of elevated pCO<sub>2</sub> on the global proteomic expression of *Calanus* spp. (in prep.).

**Halsband, C.** and H. Kurihara. Potential acidification impacts on zooplankton in Carbon Capture & Storage leakage scenarios. *Marine Pollution Bulletin, Special Issue* (in revision).

Maneja, R.H., A.Y. Frommel, **H.I. Browman**, C. Clemmesen, A.J. Geffen, A. Folkvord, U. Piatkowski, C.M.F. Durif, R. Bjelland, and **A.B. Skiftesvik**. 2012. Effect of ocean acidification on the swimming kinematics of larval Atlantic cod, *Gadus morhua*. *Marine Biology* (in press).

Maneja, R.H., A.Y. Frommel, **H.I. Browman**, C. Clemmesen, A.J. Geffen, A. Folkvord, U. Piatkowski, **A.B. Skiftesvik**, and V. Thiyagarajan. Effects of elevated pCO<sub>2</sub> on the global proteomic expression of Atlantic herring, *Clupea harengus*, larvae. (in prep.).

Maneja, R.H., A.Y. Frommel, **H.I. Browman**, C. Clemmesen, A.J. Geffen, A. Folkvord, U. Piatkowski, **A.B. Skiftesvik**, and V. Thiyagarajan. Effects of elevated pCO<sub>2</sub> on the global proteomic expression of Atlantic cod, *Gadus morhua*, larvae. (in prep.).

McConville, K., **C. Halsband**, E. Fileman, P.J. Somerfield, H.S. Findlay, and J.I. Spicer. Effect of elevated CO<sub>2</sub> on the reproduction of two calanoid copepods. *Marine Pollution Bulletin, Special Issue* (in revision)

Yamamoto-Kawai, M., J. Mathis, L. Anderson, and **H. Hop**. Arctic Ocean Acidification and its biological and physiological consequences. *Progress in Oceanography* (in prep.)

#### Communicated Results

**Browman, H.I.**, R.H. Maneja, **C.M.F. Durif**, **R.M. Bjelland**, **A.B. Skiftesvik**, **D.M. Fields**, S. Shema, and **J.A. Runge**. Effects of ocean acidification on boreal and sub-Arctic fish larvae and zooplankton. Interdisciplinary Symposium on Ocean Acidification and Climate Change. The Swire Institute of Marine Science, Hong Kong (oral presentation).

**Sperfeld, E.**, Mangor-Jensen, A., **Dalpadado, P.** 2012. How will ocean acidification affect northern krill? - Experimental investigations. CeMEB Advanced Course on Marine Evolution under Climate Change, Kristineberg, Sweden (poster).

#### Interdisciplinary Cooperation

Studies of effects OA are always inter-disciplinary. In our projects this involves carbon chemistry, zooplankton physiology, enzymatics, genetics and behaviour. Not always easy to work across research fields, but to advance the OA-research, one basically has to. There are of course also mutual advantages of such collaboration, such as new and exciting scientific collaborators and good inter-disciplinary papers.

#### Budget in accordance to results

- **In which way has the funding from the Fram Centre helped the project?**

Funding was used more or less as outlined in the budget. It has grandly helped initiation of the OA experiments on *Pseudocalanus* sp. and has facilitated collaboration between IMR/Apn and NPI on OA. Part of the funding was used to attend the meeting at IMR-Austevoll. It has also been vital for funding the NPI post doc to initiate and conduct some of this research.

- **Did the Fram Centre funding act as a sufficient boost for completing the project through other sources of funding?**

Other funding has included in-kind funding from IMR and Kristineberg (see above) for conducting OA experiments and building a cold-water facility at IMR-Austevoll. This was then only indirectly linked to a Fram Centre boost.

Could results from the project be subject for any commercial utilization

No

Conclusions

1. **Indicate future research and/or perspectives which the project results have led to**

Too early for results, since the projects have barely started, but some of the project researchers have brought in ongoing OA-research, which has resulted in publications in review/press. We do anticipate enhanced collaboration, particularly between post docs at IMR and NPI, but also with Apn more involved.

1. **List and describe new methods or techniques that have been developed during the project or that the project has revealed a need for**

Novel genetic techniques involving RNA sequencing for transcriptomic analysis and PCR with *Pseudocalanus*-specific primers to identify species.