

Project information

Keywords

oil, polar cod, temperature, early life stages

Project title

Sensitivity of polar cod early life stages to a changing Arctic: A study of the impact of petroleum and elevated temperature (Sens2change)

Year

2018

Project leader

Jasmine Nahrgang

Geographical localization of the research project in decimal degrees (max 5 per project, ex. 70,662°N and 23,707°E)

Fieldwork on Svalbard and analyses at UNIS (79°N, 18°E), experimental work and analyses at UiT and APN (69°N 18°E), and analyses at NORD (67°N 14°E) and SINTEF (63°N 10°E)

Participants

UiT (Morgan Bender, Julia Gossa, Jennifer Laurent, Ragnar Teisrud, Connie Jones),
Akvaplan-niva (Starrlight Augustine, Marianne Frantzen),
SINTEF (Bjørn Henrik Hansen, Lisbet Sørensen),
University Centre In Svalbard (Helena C. Reinardy)
NIFES (Paul Whatmore),
Nord University (Pål A. Olsvik, Jorge M. Fernandes),
NOAA, USA (James P. Meador, Ben Laurel),
IFREMER, France (Carole Di Poi Broussard)

Flagship

MIKON

Funding Source

MIKON

Summary of Results

The Arctic has experienced drastic climatic changes within the past years, accompanied by an increase in temperature, multi-year sea ice loss and sea ice retreat. With increasing global temperatures, the Arctic might be seasonally ice-free within the next two decades, which opens new possibilities for industrial development in the high north. It also enhances the risk of an accidental oil spill and could thus add another stressor to the already changing Arctic and its inhabitants. Particularly ice-associated marine organisms, like the early life stages (ELS) of the polar cod (*Boreogadus saida*), which remain in the upper water layer during their embryonic and larval development, could be at risk of exposure to spilled crude oil and its water-soluble fraction (WSF). In our experiment polar cod eggs and larvae were exposed to extremely low, environmentally realistic concentrations of the crude oil WSF, at two different temperatures (0 and 3 degree °C). Oiled-gravel was used to mimic the exposure of positively buoyant eggs and larvae to the crude oil WSF under the sea-ice with an exponential decrease in water-soluble oil components. Levels of $\Sigma 44$ PAHs in the water were below 250 ng L⁻¹ and decreased exponentially over time as expected. Body burden analysis showed a dose-dependent PAH accumulation in embryos tissues (50.4-852.9 ng.g⁻¹ at 4 dpf for exposed embryos), which decreased over time (44.4-337.7 ng.g⁻¹ at 18 dpf for exposed embryos). A CYP1A immunohistochemical methodology on larval sections was implemented to assess the biotransformation capacity of polar cod early life stages. Larvae exposed to oil treatments showed baseline levels of CYP1A in all tissues but did not show dose-dependent CYP1A increases in brain, eye nor liver. In contrast, CYP1A levels showed a dose-dependent decrease in the heart (819.4 - 657.3 a.u.) that may indicate cellular damage to cardiac cells, preventing the expression of CYP1A. mRNA expression analyses showed dose dependent and temperature dependent increases in *cyp1a1* and *cyp1c1* transcription levels in embryos close to the hatching stage.

At increased temperature, the development of the embryos was accelerated, resulting in an earlier hatching date. Embryos and larvae at 3°C suffered from an increased mortality, smaller size at hatch, but an increased feeding success compared to the 0°C group. Exposure to the WSF of crude oil led to a dose-dependent increase in mortality, decreased size at hatch, severe deformities including spine curvature, yolk-sac and pericardial edema as well as jaw malformations. Heart rate was reduced and arrhythmia increased in oil exposed specimens.

At yolk sac resorption, oil exposed larvae showed a reduced feeding success, reduced length and eye-area.

Normal looking individuals that had been exposed to oil showed trends of altered locomotor activity in response to changing light levels suggesting behavioural alterations not directly caused by deformities. The data analysis is still in progress and behavioural data analysis, histological analysis and respirometry needs to be further processed.

Samples for epigenome analyses are under progress and sent to China for DNA sequencing. Bioinformatic analysis will be done in 2019. Single genes (15 genes implicated in DNA methylation, genotoxicity, DNA repair and heat shock proteins) have been analysed with real time qPCR and show clear temperature dependent transcription levels with in general higher levels of expression at 0 degrees compared to 3 degrees. Oil exposure did also lead to some alterations but in a less clear pattern than for the biotransformation genes (*cyp1a1* and *cyp1c1*). Finally, all data has been compiled and the development of a DEB model is ongoing (APN).

The study has led to two delivered Master theses (University of UBO, France and University of Dusseldorf) in the fall 2018. Two more master theses are planned for May 2019 at UiT.

3 highschool classes visited the marine biological station in the spring of 2018, were introduced to the project by a 45min presentation (M. L. Bender) and participated in demo sessions (cardiotoxicity, behavioural assay, egg buoyancy analysis and cultivation of live feed) ran by PhD and master students.

The study and its results have been presented at multiple national and international meetings. The team has met on several occasions such as during the ARCEX conference (Tromsø team with JP Meador). In addition, C. Broussard from IFREMER visited Tromsø in June 2018 and Bjørn Henrik Hansen and Lisbet Sørensen (SINTEF) will visit Tromsø to discuss results and future proposals in November 2018.

Master and PhD-students involved in the project

PhD candidate Morgan Bender (UiT), Master students: Jennifer Laurent (UBO, FR), Julia Gossa (U. Dusseldorf, DE), Ragnar Teisrud (UiT), Connie Jones (UiT)

For the Management

This work is directly relevant to the Fram Centre, stakeholders and the general public by increasing the knowledge base for a sustainable management of marine resources in the Arctic. Through a multifactorial experiment combining the effects of oil and temperature, the study brings a level of complexity not existing from before for this species. The endpoints measured are highly relevant for the development of population models that could help predicting the effects of oil spill on populations of this species. The use of DEB models is a first stage in this direction, as it can be coupled to ecological risk-based frameworks for the industry. This project will serve as the base for the development of a larger proposal to be submitted to the NRC in April 2019.

Published Results/Planned Publications

- Bender, Gossa, Laurent, Teisrud, Nahrgang et al. 2019. In prep. Effects of increased water temperature and water-soluble crude oil exposure on survival, biotransformation capacity, cardiac activity and development of early life stages of polar cod (*Boreogadus saida*)
- Gossa, Bender, Nahrgang et al. 2019. In prep. Effects of increased water temperature and water-soluble crude oil exposure on growth, respiration, feeding success and behavior of polar cod larvae (*Boreogadus saida*)

Communicated Results

International conferences and scientific presentations

- Bender, ML, Gossa, J, Laurent, J, Teisrud, R, Jones, C, Frantzen, M, Hansen, BH, Laurel, B, Meador, J, Nahrgang, J. "Effects of increased water temperature and water-soluble crude oil exposure on survival, growth, and feeding success of early life stages of polar cod (*Boreogadus saida*)". ESSAS Conference June 10-12 Fairbanks Alaska. Platform Presentation
- Morgan Bender, Nahrgang J, Frantzen M, Meador JP. "How sensitive are polar cod to oil pollution?". ARCTOS Research School August 2018, Presentation
- Bender, ML, Gossa, J, Laurent, J, Teisrud, R, Jones, C, Frantzen, M, Hansen, BH, H Reinardy, Laurel, B, Meador, J, Nahrgang, J. "How sensitive are polar cod to a changing Arctic?". Framdagen August 2018,

poster presentation

- Bender, ML, Gossa, J, Laurent, J, Teisrud, R, Jones, C, Frantzen, M, Hansen, BH, H Reinardy, Laurel, B, Meador, J, Nahrgang, J. "Effects of increased water temperature and water-soluble crude oil exposure on early life stages of polar cod (*Boreogadus saida*)". ARCEX Conference, Oct 9-11 Longyearbyen, Svalbard, Presentation
- Gossa J, Carole Di Poi Broussard, Morgan Lizabeth Bender, Jennifer Laurent, Ragnar Teisrud, Paul Dubourg, Marianne Frantzen, Bjørn Henrik Hansen, James Meador, Jasmine Nahrgang. Behavioral response of Polar cod (*Boreogadus saida*) Larvae Exposed to the Water-Soluble Fraction of Crude Oil at Two Different Temperatures. ARCEX Conference, Oct 9-11 Longyearbyen, Svalbard, poster
- Bender ML. "Polar cod larvae in an oil spill". Center for Biodiversity at NTNU PhD student meeting, Oct 2018, Presentation
- Bender ML. Effects of increased water temperature and water-soluble crude oil exposure on early life stages of polar cod (*Boreogadus saida*)". AMSE Group seminar, Oct 11, Tønsvik.

Popular science/School pupil outreach

- [Interview with Swiss radio](#) on collection cruise Nov 2017 "Everything you love about the Arctic comes down to Polar cod"
- Photography and filming on Polar night cruise 2018 by Mike O Snyder Film titled "[Into the Dark](#)"
- School Classes visiting experiment (Kongsbakken, 2 groups and Tromsdalen vgs 1 group), Spring 2018, all involved
- Courses / classes visiting experiment (aquaculture students, animal welfare students), Spring 2018, Morgan
- UiT Biology recruiting Cruise Presentation and Discussion, March 2018, Morgan
- Alaskan Conservation High Schooler Crew Outreach through Presentation and Discussion, June 2018, Morgan presented
- Nahrgang, Jasmine; Bender, Morgan. Polartorskens usikre oppvekst i fremtidens Arktis. Nordlys 2018. ISSN 0805-5440.s 5
- Researcher Grand Prix Presentation Sept 2018, Morgan presented
- UiT Open Day, Nov 2018, Polartorsk i et oljeutslipp, Morgan presented to high school students from Tromsø
- Instagram page Sens2change
- Facebook page sens2change

Interdisciplinary Cooperation

The project works within the field of ecotoxicology/biology. SINTEF has provided expertise in the field of petroleum chemistry. UNIS and NORD contributed on epigenetics, Akvaplan-niva contributes on modelling (DEB) and IFREMER contributes with expertise on behavioral biology.

Budget in accordance to results

yes.

Could results from the project be subject for any commercial utilization

No

Conclusions

This present study offers important data on the sensitivity of polar cod ELS to a water-soluble fraction of crude oil in combination to suboptimal temperature. It is the first time that such a study is performed on this species, using a multifactorial design and investigating sublethal effects past the yolk-sac resorption stage. The work has brought together a team of experts and multiple fields of science including petroleum chemistry, epigenetics and behavioral biology. The study shows that even normal looking larvae that were exposed to oil related contaminants, show alteration in their responsiveness to additional light stresses. This could have important long-term implications for the fitness of surviving polar cod.