Project information

Project title
FEARICE: Fate, Effect, and Risk Modelling of accidental oil spill in sea ice ecosystem
Year
2013/2014
Project leader
Lionel Camus, ApN
Participants

- ***Leader:*** Lionel Camus, Akvaplan-niva

Participants:

- Perrine Geraudie, Akvaplan-niva
- Rune Storvold, NORUT
- Jon Aars, NPI
- Per Johan Brandvik, SINTEF
- Tove Gabrielsen, UNIS

International partner: CEDRE (France) and Brest University (France)

Training and education: a PhD student (Matthieu Dussauze) and a master student (Nathalie Coquillé) financed by CEDRE/Brest University have been associated to the project.

A practical course has been conducted at APN/UiT (Ingeneering and safety department, bachelor students) on environmental monitoring, including demonstration on offshore monitoring and biomarker analysis in the lab.

Flagship

Arctic ocean, Theme: Environmental impact of shipping

Funding Source
Fram Centre
Summary of Results

APN and CEDRE

- Polar cods have been exposed to environmentally realistic concentrations of produced water (PW) for 4 weeks. The results obtained showed alteration of the gonad structure in both sexes and a diminution of oocyte number in ovaries of female polar cods. On the contrary, no effect on sex steroid concentrations, vitellogenin levels or gonad maturation were found after PW exposure.

- Recently polar cods were exposed to oil, dispersants and dispersed oil. Effects on cardiac tissular respiration were investigated. The results demonstrated that fuel oil impairs cardiac mitochondrial respiratory chain activity, confirming on a polar species the results observed on temperate or tropical animals. The results obtained give new elements on the mechanism of oil toxicity showing an inhibition of the first and the third complexes of the respiratory chain. This study is the first analysis reporting dispersant effects on mitochondrial metabolism. The dispersants tested had low effects by themselves and dispersed oil had effects comparable to those of oil alone.
- Arctic deep water amphipod, *Eurythenes gryllus*has been exposed toacute concentrations of chemically dispersed BAL oil by the Finasol® dispersant for 96 hours in order to measure the LC50 (concentration causing 50% of mortality in a population during a precise time). The LC50 obtained decreased during the time. Indeed, whereas at 24h LC50 was approximately 101mg.L $^{-1}$, it was 24mg.L $^{-1}$at 72h and 12mg.L $^{-1}$at 96h. The LC50 at 48h could not be determined because of mortalities obtained: higher mortality for the concentration 1 that for the second and third concentration and a maximal mortality of 80% (for concentrations 4 and 5).

NPI

This workpackage was a pilot study that looked at the possibilities of combining data on oil drift models with data on polar bear movement, including time in water swimming and time on sea ice, to get a more realistic model of oil exposure probabilities that earlier have been available. The aim of the full project is to develop a full risk assessment model that can be used to assess risk for polar bears in case of an oil spill in areas with partial ice cover.

SINTEFhave developed models on oil spill from an area (Storfjorden) in Svalbard based on available sea ice and weather data, showing how oil spill is likely to be dispersed spatially and temporally in two periods, May and August. For the same periods, some data on swimming of polar bears show the likelihood of bears being in the water within periods of different lengths. So far, this data indicate the

possibilities on how to combine these sources of data into a risk assessment model. As part of the project telemetry data from about 300 polar bear collars has been assessed, and initial analyses on relative densities within different areas at different seasons has been performed. The oil drift model, together with the movement and swimming data, is sufficient for some initial discussions about relative risk of exposure related to area and season, while more data and further analyses will be necessary for more detailed quantitative and conclusive studies.

NORUT and APN-Spectral response dependency of oil concentration and weathering

The aim of this study was to test new sensors that can follow the fate of oil in water and quantify the degradation rates of oil in the Arctic under controlled weathering conditions. An imaging spectrometer and IR cameras were used to monitor the behaviour of oil in experimental tanks in order to monitor the spectral effects of weathering of different oil types.

A Ramses Trios Spectrometer and Nikon 5100 camera was mounted in a waterproof box with quarts windows 1.2 meters above the water tank. Spectra and images were captured every 10 minutes. Oil was added to the tank on Januar 31 st, 2013 (Figure 1). The concentration was incrementally increased with a quarter of the oil added at the time. Figure 1 shows the increase from 0 to 100% cover. Figure 2 and 3 shows radiance spectra for different light sources and figure 3 shows radiance over time for different wavelengths.

Figure 1. Oil concentration from left, 0%, 25%,50% and 100%. Time of capture:13:10, 13:20, 14:30, 16:40 respectively, after adding oil.

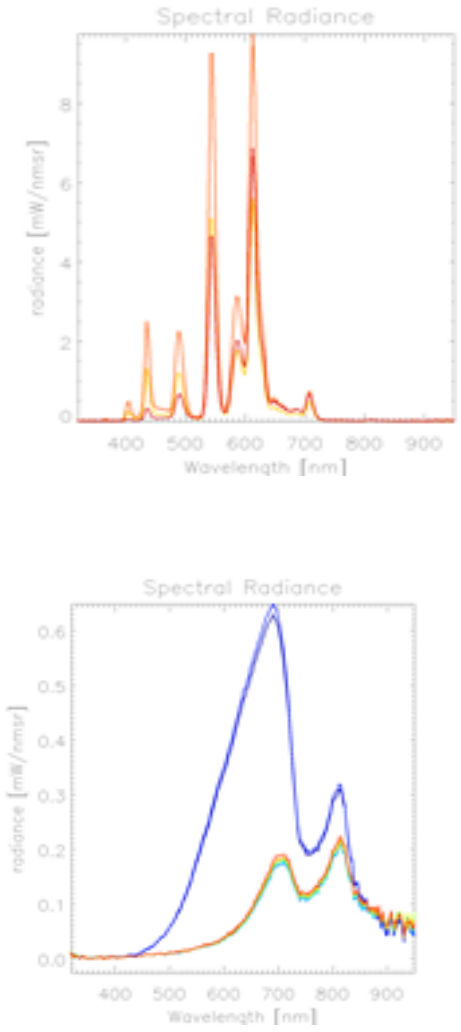

Figure 2. Radiance spectra. Left fluorescent Right, center incandescent light.

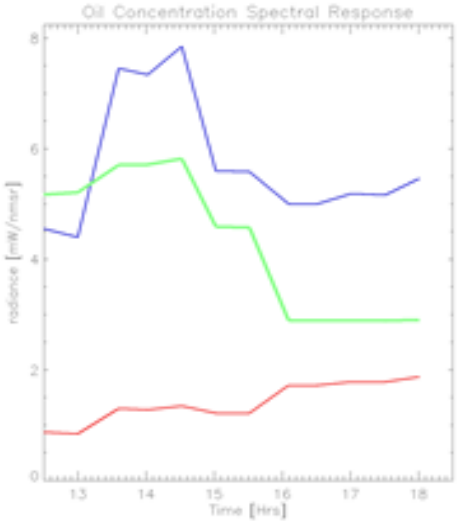

Figure 3. Time series of 615 nm (blue) and 710 nm (red) wavelength. With 25% oil added at 13:15, 50% at 1430 and 100% at 16:40 UTC. Green is ratio 615/710 radiances. Absolute value depends on light source.

Weathering of oil -The oil on water was kept still in the tanks until February 11 thwhen it was mechanically dispersed 25%, 50% on feb 13 thand 100% feb 15 th, at about noon each day. There is a very slow weathering when the oil stands still in the tanks. Mechanical dispersion in the tank abruptly increases the radiance and more for the NIR wavelengths than the red, which showed low response. This could possibly be used to assess effectiveness in mechanical dispersion.

For the Management

The petroleum industry is moving north, and this will increase the risk for oil spills in regions with sea ice. In order to select the best respons in case of an accident it is important to aquire knowledge about effects of different remedial actions. Today little is known about effects of different dispersants and dispersed oil on Arctic organisms. In FEARICE it has been shown that fuel oil exposure impairs cardiac mitochondrial respiratory chain activity in polar cod. The study also documented that selected dispersants had low effects polar cod by themselves and that the use of dispersants did not worsen the effects of oil contamination. Throgh FEARICE it was also shown that the LC50-concentration of dispersed oil decreased with increasing exposure time. This means that short-term exposure experiments/test may not give a sufficient picture of the actual risk for amphipods.

The results from the project indicate that use of chemical dispersants can be a remedial action that should be considered in Arctic areas.

Technology that can be used to detect oil using remote sensors has been tested.

The first steps towards developing a method for assessing risk for the polar bear population in case of an oil spill in the Marginal Ice Zone has been taken through FEARICE. When such a model is in place it will be a very useful tool for environmental managers.

The results from FEARICE will form the basis for future work assessing the risk for Arctic species in case of oil spills.

Published Results/Planned Publications

FearIce allocated some funding to Perrine Geraudie (APN) to write a paper following a study she did at APN with an Yggdrasil NFR grant (2009-2010) to investigate the biological effects of produced water on the polar cod. The work has been presented at the National Ecotox Symposium (Tromsø, October 2012) and the manuscript has been submitted to a peer reviewed journal, "Journal of Toxicology and Environmental Health, Part A":

- P., Geraudie, J., Nahrgang, J., Leray, C. Minier, L., **Camus** (submitted) *In vivo* effects of environmental concentrations of produced water on the reproductive function of polar cod (*Boreogadus saida*)

A manuscript reported the effects of dispersed oil on cardiac respiration in polar cods (*Boreogadus saida*) have been submitted to Environmental Science and Pollution Research earlier this month:

- M Dussauze, S Le Floch, K Pichavant-Rafini, L **Camus**, P Geraudie, N Coquillé, A Amérand, P Lemaire, M Theron (submitted). Impact of dispersed oil on cardiac mitochondrial function in polar cod *Boreogadus saida*.

Communicated Results

FearIce was presented at the First Nordic-China Symposium, organized by the Chinese polar institute, Shanghai, May 2013

FearIce was presented at the EPPR working group of the Arctic Council on "dispersant use in the Arctic" October 2013

FearIce will be presented in France to the public in Paris at the La Villette la Cite des Sciences in the Auditorium la "Geode"

FearIce will be presented in Poitiers (France) to a Science Festival through two conferences at the University of Poitiers, to international students and later to a large public.

Interdisciplinary Cooperation

Good inter-disciplinary cooperation between APN and NORUT for testing sensors while doing biological testing with Arctic species, i.e., polar cod and amphipods, exposed to crude oil.

Budget in accordance to results

APN

The budget has being used for developing collaboration with Total Fluids, CEDRE and Brest University who provided a student and oil industry provided additional funding. The money provided by Total Fluids and FearIce has allowed us to accommodate the student and to also contribute scientifically to the PhD program of the student by complementing his research.

FearIce has led to the establishement of an international consortium coordinated by Akvaplan-niva for responding to a call for projects from the International Oil and gas association (OGP) to study the impact of oil spill in the ice. The Expression of Interest was accepted (October 2013) and the large proposal was been submitted 18.Nov 2013 (APN, UiT, NP and NORUT are part of the application). In February 2014 the consortium led by Akvaplan-niva received notification from OGP that three projects had been awarded.

Additionaly, APN CEDRE and Brest university with support from Total Fluids submitted an application to the NFR Petromaks program to continue working on dispersant impact at a much larger scale. Unfortunately the project was not funded through NFR, but Total Fluids has indicated that they plan to fund parts of the work.

NORUT

The money allowed to test and calibrates the sensors for oil detection in the lab so the sensors later can be deployed in remote operated planes for oil tracking.

NPI/SINTEF

The Fram money allowed to get started on the idea to combine oil drift model/ice drift model and bear movement.

If Yes

APN:

The study on the polar cods will help the responders, regulators and the oil industry to select the most appropriate chemical dispersant to be used in Arctic waters.

NORUT:

When the sensors are calibrated, NORUT will be able to market his technology towards the responders are a tool for oil detection and tracking

NPI/SINTEF:

When the oil drift model and bear population data is coupled, a model estimating risk for the polar bear population in case of an oil spill can be offered to the operators, responders and regulators.

Conclusions

The project has combined innovative approaches and methods among partners exhibiting complementary expertise to increase the

knowledge on the use of dispersant in Arctic and the effects of dispersed oil on key Arctic species. The results from FEARICE will form the basis for future work assessing the risk for Arctic species in case of oil spills. Through a project awarded from the OGP several Fram Centre Institutions will continue the work with effects of oil and dispersants on Arctic organisms and ecosystems.