

Project information

Project title

Giants of the ocean – affected by anthropogenic pollutants?

Year

2019

Project leader

Heli Routti

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

Svalbard: 77-80N, 12-18E and Skjervøy 70N, 21E

Participants

Arntraut Götsch, Mikael Harju/NILU

Jenny Bytingsvik, Pierre Blevin/Akvaplan-Niva

Anders Goksøyr, Roger Lille-Langøy/UiB

Christian Lydersen, Kit M. Kovacs, Katharina Luhmann/NPI

Cristina Panti, Maria Cristina Fossi/Univ. of Siena, Italy

Martin Hansen/ University of Aarhus, Denmark

Flagship

Hazardous Substances

Funding Source

Funding sources	2017	2018	2019
Own funding NPI	652200	294399	385394
NFR (ICE-whales K.Kovacs)	121325	168790	105929
FRAM	500000	600000	700000

Summary of Results

Levels of contaminants in relation to biological and ecological factors

We have analyzed blubber levels PCBs, organochlorine pesticides and PBDEs in 30 fin/blue whale samples, organophosphorous flame retardants in 27 samples and current-used brominated flame retardants in 17 samples. In addition, we have analysed phthalates in 17 blue/fin/bowhead whales. Sex determination and stable isotope analyses have also been done for fin and blue whales. Levels of legacy POPs were higher in fin whales than blue whales, which is likely related to the higher trophic level diet of fin whales. Carbon isotope values suggest that fin whales feed at higher latitudes than blue whales. Twice as high pollutant levels in males as females indicates that females offload pollutants to their offspring. Finally, pollutant levels in baleen whales show large global scale geographical differences.

We have compiled data on POP levels in blubber, and stable isotopes in skin, from 10 marine mammal species from the Barents Sea. We are soon finishing a manuscript, which aims to investigate species-differences in POP levels in relation to diet and feeding habitat, migration patterns, taxonomy and biotransformation.

Assess cause-effect relationships between chemical exposure and effects

We have sequenced and cloned fin and blue whale nuclear receptors peroxisome proliferator-activated receptor gamma (PPARG),

glucocorticoid receptor (GR) and thyroid hormone receptor beta (THRβ), and aryl hydrocarbon receptor (AhR). We successfully established in vitro reporter gene assays for PPARγ, GR and THRβ to assess the agonistic and antagonistic effects of 14 POPs and 2 phthalates present in blubber of fin and blue whales, as well as a synthetic mixture POPs. We also attempted to establish an assay for AhR, but without success. POPs had both agonistic and antagonistic effects on PPARγ, GR and THRβ. The results are also relevant for other mammalian species, because the similarity of the ligand binding domain of one of several receptors with other mammal species including killer whales, minke whales, polar bears and humans. Several pollutants modulated the transcriptional activity of the nuclear receptors at concentrations, which are environmentally relevant for whales and polar bears.

We have successfully established a culture of fin whale fibroblasts. We have exposed the cells with mixtures of POPs and phthalates after which they will be analysed for exposome (metabolome + pollutants).

Correlative field studies on pollutant effects

We are working with a correlative study looking at transcript levels of genes related in endocrine disruption in fin whale biopsies from low-polluted Svalbard and highly polluted Mediterranean Sea.

Highlights:

- We provide knowledge on levels and fate of legacy and emerging contaminants in world's largest animals
- We provide cause-effect relationships between chemical exposure and toxic outcomes in whales at molecular and cellular level

Master and PhD-students involved in the project

MSc-thesis:

Katharina Luhmann: Activation of the thyroid hormone receptor of fin whales by environmental pollutants, University of Landau (2018)

Karoline Viberg: In vitro modulation of transcriptional activity of nuclear receptors in blue whale (*Balaenoptera musculus*) and fin whale (*Balaenoptera physalus*) by environmental contaminants. University of Bergen (2019)

For the Management

- We provide knowledge on levels and fate of legacy and emerging contaminants in world's largest animals, which are both classified as endangered species
- We provide cause-effect relationships between chemical exposure and toxic outcomes in whales at molecular and cellular level

Published Results/Planned Publications

Submitted manuscripts:

Tartu S, Fisk AT, Götsch A, Kovacs KM, Lydersen C, Routti H. First assessment of pollutant exposure in the North-East Atlantic populations of Balaenopterid whales off Svalbard coast, Norway. *Science of Total Environment*. In revision

Lühmann K, Lille-Langøy R, Øygaard L, Kovacs KM, Lydersen C, Goksøyr A, Routti H. Environmental pollutants modulate transcriptional activity of nuclear receptors of whales in vitro. *Environmental Science and Technology*. Submitted

Manuscripts in preparation:

Lühmann K/Routti H, Harju M, Lille-Langøy R, Goksøyr A, Aars J, Kovacs K, Lydersen C. Concentrations of phthalates and their effects on transcriptional activity of nuclear receptors in marine mammals.

Blevin P, Aars J, Bytingsvik J, Fisk AT, Götsch A, Hansen L, Herzke D, Kovacs KM, Lydersen C, Rikardsen A, Routti H. Legacy POPs

in marine mammals from the Barents Sea.

Planned manuscripts:

- Emerging flame retardants in marine mammals from Svalbard
- Screening of toxic outcomes in fin whale fibroblasts exposed to contaminant mixtures – exposome as a tool
- Relationships between pollutants and transcript levels of genes in fin whales from the Arctic and Mediterranean Sea

International and national scientific conferences:

Lille-Langøy R, Øygaarden L, Lühmann K, Kovacs KM, Lydersen C, Goksøyr A, Routti H. Effects of environmental pollutants on the activity of transcription factors in blue and fin whales in vitro. 19th International symposium on Pollutant Responses in Marine Organisms. Matsuyama, Japan 30.6-3.7.2017. Poster.

Lühmann K, Lille-Langøy R, Øygaarden L, Kovacs KM, Lydersen C, Goksøyr A, Routti H. Activation of the thyroid receptor of fin and blue whales by environmental pollutants. 7th Norwegian Environmental Toxicology Symposium (NETS), Svalbard, Norway. 14-16.3.2018. Talk.

Viberg K, Goksøyr A, Lille-Langøy R, Kovacs KM, Lydersen C, Routti H. Do environmental contaminants alter the activity of transcriptional factors in blue whales (*Balaenoptera musculus*) Vintermøte til Norsk Selskap for Farmakologi og Toksikologi 24-26.1.2019. Beitostølen. Poster

Viberg K, Lühmann K, Lille-Langøy R, Øygaarden L, Kovacs KM, Lydersen C, Karlsen OA, Routti H, Goksøyr A. In vitro modulation of transcriptional activity in nuclear receptors of fin and blue whales by environmental pollutants. Primo, 19-22.5.2019 Charleston. Poster and talk.

Lühmann K, Lille-Langøy R, Øygaarden L, Götsch A, Kovacs KM, Lydersen C, Tartu S, Goksøyr A, Routti H. In vitro modulation of transcriptional activity of nuclear receptors of whales by environmental pollutants. SETAC 26-30.5.2019 Helsinki. Poster and short talk.

Communicated Results

The project has been shortly presented by Anders Goksøyr and Heli Routti at eleven faculty seminars held at North-American or European universities/ research institutes in 2017-2018.

1. Anders Goksøyr, From cod to polar bear: Toxicogenomics and ecotoxicology, Ocean Sciences Centre, Memorial University, St. John's, Newfoundland, Canada, 5.9.2017
2. Anders Goksøyr, Cod as canaries - and polar bear in a petri dish, Ocean Sciences Centre, McMaster University, Hamilton, Ontario, Canada, 7.9.2017
3. Anders Goksøyr, Cod as canaries - and polar bear in a petri dish, Woods Hole Oceanographic Institution, USA, 15.9.2017
4. Anders Goksøyr, Cod as canaries - and polar bear in a petri dish, Stony Brook University New York, Long Island Seminar, Dept. of Marine and Oceanographic Sciences, USA, 21.9.2017
5. Anders Goksøyr, Cod as canaries - and polar bear in a petri dish (ecotoxicological explorations), University of Minnesota, Minneapolis-St. Paul, School of Biological Sciences, USA, 3.10.2017
6. Anders Goksøyr, Cod as canaries - and polar bear in a petri dish, US EPA, Duluth, MN, USA, 5.10.2017
7. Anders Goksøyr, From cod to polar bear: seeking ecotoxicological insight through toxicogenomic and ex situ approaches, UC Berkeley, Department of Integrative Biology, USA, 12.10.2017
8. Anders Goksøyr, Cod as canaries - and polar bear in a petri dish, UC Riverside, Department of Environmental Science, USA, 25.10.2017
9. Heli Routti, Effects of pollutants in Arctic marine mammals, University of Siena, Italy, 23.11.2017
10. Heli Routti, Exposure and effects of pollutants in Arctic marine mammals, University of Quebec in Montreal, Canada 5.9.2018

11. Heli Routti, Exposure and effects of pollutants in Arctic marine mammals, University of Laval, Quebec, Canada, 5.9.2018

Media:

Interview: Radio France 24, 1/2019

Interdisciplinary Cooperation

This project absolutely benefits of the inter-disciplinary cooperation. We combine information from analytical chemistry, ecology, physiology and molecular biology.

Budget in accordance to results

Fram Centre 2019 funding has covered all costs for exposome analyse (Univ. Aarhus), gene transcript analyses (Univ. Siena) and compiling the POP and isotope data in marine mammals (APN). The FRAM funding has also covered the majority of the costs employing K. Luhmann (NPI). Part of the field costs as well as part of Katharina's participation to SETAC was also covered by the FRAM. The remaining costs of K.Luhmann and field work have been covered NFR funding (K. Kovacs) and by NPI internal funding. The latter has also covered salary for HR (NPI). Field costs, other than participation of K. Luhmann and H. Routti, have been covered by NPI-projects led by C. Lydersen and K. Kovacs.

Fram Centre has covered 59% of the costs in 2019.

Could results from the project be subject for any commercial utilization

No

Conclusions

For the first time, we provide knowledge on levels and fate of legacy and emerging contaminants in blue and fin whales from the Northeast Atlantic. We also show cause-effect relationships between chemical exposure and toxic outcomes in whales at molecular level. We have established a cell culture of fin whale cells that gives numerous future opportunities. Future studies should focus on effects of pollutants in whales using cellular in vitro methods and correlative studies.

We have developed methods to study in vitro activation of three different nuclear receptors from blue/fin whales. NILU has also developed a method for phthalate analyses. We have established a cell culture of fin whale cells. These methods are valuable tools to assess emerging compounds and endocrine disruptive potential of pollutants in wildlife.