

Project information

Keywords

plastic litter, ingestion, biofouling, northern fulmar, zooplankton, contaminant

Project title

Microplastics in arctic marine food chains; biological uptake pathways and socio-economic consequences

Year

2015

Project leader

Claudia Halsband, Dorte Herzke

Participants

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Bo Eide (Tromsø Kommune)

Flagship

Hazardous Substances

Funding Source

Flagship: 490 kNOK

in kind: 250 kNOK Havet & Kysten (NFR), 200 kNOK Framsenteret (insentiv), 100 kNOK CLEANSEA, 200 kNOK MIME

Plastic pollution in the Norwegian Arctic is worse than expected, 87.5% of northern fulmars examined had ingested plastic (Trevail et al. 2015), and this may result in some contaminant uptake into tissues. An average of 15 plastic pieces were found and 23 % of the birds exceeded the EcoQO for plastic ingestion in fulmars.

In 2012, 8 fulmars and in 2013, 76 fulmars were unintentionally caught as by-catch on long-lines off the coast of Northern Norway and delivered to the Norwegian Institute of Nature Research. Liver and muscle samples were collected together with plastic particles found in the stomach of each individual. Plastic particles were found in every bird collected in 2012, ranging from 1 to 27 pieces (0.002 - 0.725 g). In 2013, 72% of the collected birds contained ingested plastic. The EcoQO for birds from northern Norway was 38%. Both plastic pieces as well as threads were found in the stomachs. Liver, muscle and plastic pieces were analysed for persistent organic pollutants in selected individuals (2012: n=8; 2013: n=30). Birds with a high, medium and no load of ingested plastic were selected for comparison. Beached plastic litter was investigated in a similar way, including DART-MS-TOF experiments to identify the type of plastic. For the 2012 samples, liver and muscle tissue concentrations of sumPCB, sumPesticide and sumDDT correlated well with r^2 ranging between 0.48 and 0.78. Plastic concentrations of POPs correlated with the respective muscle and liver samples too, with muscle correlating better than liver tissue for PCBs and DDTs, reflecting long-term exposure (sumPCB in muscle: $r^2 = 0.4$, in liver $r^2 = 0.25$; sumDDT in muscle: $r^2 = 0.81$, in liver $r^2 = 0.20$). Pesticides however, showed the opposite, with sumPest in muscle: $r^2 = 0.19$, in liver $r^2 = 0.31$, indicating a fresh exposure.

Implementation of suitable sampling methods for microplastics pollution began in autumn 2014 with a view to start assessing the extent of the problem in the vicinity of Tromsø (an area with increasing human population), and in coastal systems of Svalbard (little local human impact). Water and zooplankton samples were taken locally in Balsfjorden and Håkøybotn, as well as Adventfjorden (Svalbard) in summer 2015 and along western Spitsbergen in September/October 2014 and 2015 based on a method by Lusher et al. (2014). Microscopic analysis of microplastics on filters began in autumn 2015 and will continue in 2016. While a protocol for a proteinase digest has been published recently (Cole et al. 2014), a

chitinase-based method will be evaluated in 2016, since many planktonic crustaceans have chitin exoskeletons.

In MIME the experimental results showed ingestion of microplastics from tooth pastes in blue mussels. Similarly, species-specific ingestion of microplastics was investigated in a MSc thesis conducted at Akvaplan-niva. Both studies showed that biofouling increases the ingestion of microplastics, regardless of food conditions.

The project has been contributing to a PhD thesis (Inger Lise Nerland, UiO/NIVA) and a MSc thesis (Renske Vroom, U Wageningen, NL/Akvaplan-niva).

A review paper on socio-economic effects of microplastics in the marine environment will use expert opinions on the certainties and knowledge gaps of current research, collected during the workshop in May. The current knowledge is very limited, and the paper includes a discussion of possible effects and methods to investigate them given future availability of relevant data, focusing on the seafood industry, human health and cultural ecosystem services. The paper proposes a research agenda and also discusses policy approaches given the current poor level of knowledge about socio-economic effects of marine microplastics.

In total, 6 applications for further research funding were submitted by consortium members in 2015: PArC (NordForsk Arctic Center of Excellence, pending), 3x JPI-Oceans program on ecological aspects of microplastics, 2 funded), ArcPlast (NFR MarinForsk, pending) and one to the Svalbard Miljøvernfond (funded). These will pave the way for continued collaborative research on plastic as an emerging contaminant in the Arctic.

Several members of the consortium attended national and international workshops relating to marine litter. Here, contacts were established and fostered with relevant stakeholders within governmental authorities, industry and the science community. Research results, methodological challenges and needs for future research and legislation were discussed.

NIVA and Akvaplan-niva have prepared a comprehensive literature review for Miljødirektoratet on "Eksisterende kunnskap om egenskaper spredning og effekter av mikroplast i marint miljø (Delprosjekt 2)". The report was published by NIVA (no. 6754-2014).

Akvaplan-niva and NILU prepared a chapter on marine plastic in the Arctic for the forthcoming AMAP report on emerging contaminants in the Arctic.

Published Results/Planned Publications

Published:

- Trevail, A.M., Gabrielsen, G.W., Kühn, S., Bock, A., van Franeker, J.A. (2014) Plastic Ingestion by Northern Fulmars, *Fulmarus glacialis*, in Svalbard and Iceland, and Relationships between Plastic Ingestion and Contaminant Uptake. Brief Report Series 29, Norwegian Polar Institute
- Cole, M., Lindeque, P.K.; Fileman, E.S., Halsband, C., Galloway, T. (2015). The Impact of Polystyrene Microplastics on Feeding, Function and Fecundity in the Marine Copepod *Calanus helgolandicus*. *Env Sci & Tech* 49(2), 1130-1137
- Wright, S. L., Rowe, D., Reid, M.J., Thomas, K.V., Galloway, T.S. (2015) Bioaccumulation and biological effects of cigarette litter in marine worms. *Sci Rep* 5, 14119
- Trevail, A.M., Gabrielsen, G.W., Kühn, S., Van Franeker, J. A. (2015). Elevated levels of ingested plastic in a high Arctic seabird, the northern fulmar (*Fulmarus glacialis*). *Pol Biol* 38, 975-981
- Herzke, D., Anker-Nielsen, T., Koelmans, A., et al., (in press). Negligible Impact of Ingested Microplastics on Tissue Concentrations of Persistent Organic Pollutants in Northern Fulmars off Coastal Norway, *Env Sci & Tech*
- Halsband, C., Herzke, D. (subm). AMAP report on emerging contaminants 2015: chapter 2.17: Marine Plastics and Microplastics.
- Nerland, I. L., Halsband, C., Allan, I., Thomas, K. (2014). Microplastics in marine environments: Occurrence, distribution and effects. Report no. 6754-2014, NIVA (på oppdrag fra Miljødirektoratet)

Planned:

- Vroom, R., Halsband, C., Koelmans, B., Besseling, E. (in prep). Microplastic ingestion by zooplankton: the role of taste (Msc thesis Renske Vroom)
- Herzke, D., Halsband, C., Fuhrmann, M., Sundet, J. (in prep). Microplastics distribution and composition

in Norwegian coastal systems.

- Herzke, D. (in prep). Plastic loading and related pollutants in beach litter.
- Mikkelsen, E., Nielsen, H. (in prep). Potential effects of microplastics on seafood safety and economic losses in seafood production in northern Norway

Communicated Results

- Workshop in Oslo, funded by NFR and Framsenderet. Organizers: C. Halsband & K.V. Thomas
- presentation at Polaria for Tekna Familiedag (APN)
- Senioruniversitet, Polaria, (NILU)
- Forskningsdager i Oslo (NILU)
- Display at Norwegian Maritime Museum, opening in 2016 (NIVA)
- Book in prep. about plastics in fulmars for children aged 10-14 years (NPI)
- Book in prep. about Mattea and her water bottle for children 4-6 years old (SALT)

Interdisciplinary Cooperation

Our consortium consists of biologists, ecotoxicologists, chemists and socio-economists, but has a rich portfolio of collaborations with other disciplines through our national and international networks. Connecting the socio-economics with the natural science part is at present challenging due to a lack of suitable and comparable data sets.

Microplastics is a very young field of science, but interdisciplinarity is warranted here more than elsewhere, due to the multi-faceted aspects of the problem. We strive to enhance interdisciplinarity further as the projects develop and have found the Fram Centre project an essential tool to start communication and collaboration across the disciplines involved at the local (Fram) level. It is, however, desirable to broaden interdisciplinarity even further and include, for example, oceanographic modelling of microplastic particle transport and distribution, as well as ecotoxicological and ecological modelling to inform the socio-economics component more effectively. Communications with other flagships (Polhavet, F&K) have been initiated accordingly, with a view to develop 'tverfaglige' projects with other FRAM groups.

Budget in accordance to results

The funding enabled the consortium to meet, exchange information of mutual interest, discuss ongoing and planned activities and submit proposals developed by several project participants. The funding was also used to take samples and perform chemical analysis, as well as participation at international conferences and outreach activities.

We have applied for funding from the Norwegian Research Council to expand the work

on plastic in arctic marine food webs, as well as for a Nordic Center of Excellence (NordForsk) to bring together Nordic international experts and address interdisciplinary research questions and the urgent need for standardized sampling and analysis protocols.

We consider an outreach initiative through the Fram Centre's "gjennomgående midler" program to involve more relevant research groups in the flagships Polhavet and Fjord & Kyst.

Could results from the project be subject for any commercial utilization

No

Conclusions

The project successfully continued the activities initiated since 2013. The new collaborations were further developed and generated proposals for high profile national and international projects. The interest from stakeholders such as Miljødirektoratet, Troms fylke, the media and others was high.

The work on fulmars showed that plastic litter and associated chemical contamination is a problem also in the high North. It is expected that this is also the case for the pelagic environment and the smaller, less well studied microplastics. A MSc thesis studied the role of biofouling for the bioavailability of microplastics and found enhanced ingestion by herbivorous zooplankton, indicating that microplastics are bioavailable at the base of arctic marine food chains. Further research is needed to implement standardized methods for the collection of meso- and microplastics as well as impact studies on biota from different trophic levels. How the lipid-rich Arctic food web in particular is affected by this type of pollution in contrast to more boreal communities, remains a topic of future study, including for human populations.