Anthropogenic footprints: litter and microplastic pollution in the Fram Strait

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Litter figures

- Plastic often accounts for the majority of marine litter as it is very durable
- Global plastic demand 1.7 mio t in 1950 $\rightarrow$ 311 mio t in 2014, increases $\sim$4% p.a. (PlasticsEurope 2015)
- < 13 million t of plastic entered the ocean in 2010 $\approx$ 5% (Jambeck et al. 2015)
- Empirical evidence is 1-3 orders of magnitude lower (Cózar et al. 2014; Eriksen et al. 2014; van Sebille et al. 2015)

Where is all the plastic? (Thompson et al. 2004)
Why study litter?

- Entanglement: suffocation, starvation, injury
- Ingestion: blockage of digestive tract, reduced food uptake, starvation, internal injury
- Microplastics: widespread but big unknown
- Plastics are vectors for dispersal
- Plastics carry added and absorbed toxins: affect organism health
- Litter on seabed biota: shading, damage, reduced food uptake and gas exchange
- Litter on seafloor: anoxia, community change

343 species (Kühn et al. 2015)
331 species (Kühn et al. 2015)
172 species (Lusher 2015)
387 species (Kiessling et al. 2015)
22 species (Kühn et al. 2015)
1 study (Green et al. 2015)
Litter pathways

- Estimated: 80% from land-bourne, 20% from marine sources
- 50% of plastic from municipal waste is heavier than seawater → sinks directly to seafloor
The visible part: sea surface

- 5,570 km surveyed
- 31 plastic items
- 0 - 0.22 (mean 0.001) items km$^{-1}$

- Similar to Antarctica
- Not so much, but probably underestimate: high survey altitude

Bergmann et al. 2015
Invisible part: microplastics at the sea surface

- 95% manta trawls contained mean: 0.34 particles m\(^{-3}\)
- 93% sub-surface samples contained mean: 2.68 particles m\(^{-3}\)
- Same order of magnitude as in the North Pacific

- 95% of the MPs were fibres!

Lusher et al. 2015
Microplastic concentrations in Arctic sea ice are 4 orders of magnitude higher than Lusher *et al.* or North Pacific Garbage Patch (Goldstein *et al.* 2012)
The invisible part: sea ice

- Pack ice: mean of $2,000,000$ particles $m^{-3}$
- Land-fast ice: $600,000$ particles $m^{-3}$
- 11 different polymers, polyethylene (PE) most abundant
  - 6-20 times > Obbards et al. 2015
  - 5-6 orders of magnitude > Lusher et al. 2015

Fibers not yet included!
More litter was caught by pelagic trawls in 2015 but analysis is pending

- Pelagic trawls yielded a number of litter items, primarily plastic, but no unit was provided
- Data unfortunately not quantitative
The invisible part: deep sea

- Annual HAUSGARTEN missions: OFOS for megafauna time series
- 7,058 images = 28,161 m² analysed
Deep sea: litter densities

- Amount of litter at HG increased significantly between 2002 and 2014 at both stations
- Litter on seafloor (2.24 - 18.47 items km$^{-1}$) exceeds neustonic litter (0 - 0.22 items km$^{-1}$)

→ seafloor = sink?
Majority of litter was plastic (>55%)  
Glass was also important (26%), indicates local disposal  
Sign. differences between stations and years
Litter type

- HG IV: more and increasing numbers of plastic items
- N3: more and increasing numbers of glass items
- More rope material in recent years, especially at HG IV

Local input!
Plastic litter size

- Significant differences between stations and years:
  - At N 3 more small (80%), at HG IV more medium-sized plastic items
- Increasing nos. of small plastic items over time
  - Fragmentation? Release from melting sea ice?
Megafaunal encounters

- 53% of litter encountered megafauna

- Mostly entangled by sponges *Cladorhiza gelida*, *Caulopacus arcticus*, or colonised by actinians
88% of the northern fulmars caught at Svalbard had ingested plastic litter → exceeds ecological quality objective (OSPAR) (Trevail et al. 2015)

3-8% of Greenland sharks had ingested plastic (Leclerc et al. 2012; Nielsen et al. 2014)

Other species: polar bear, bearded seal, sperm whales, black-throated loon, little auk, Atlantic puffin, black-legged, thick-billed murre, ...?
Passive Polyethylene samplers collected POPs (PCBs, OCPs, PAHs, PBDEs) over one year → plastic are vector for toxins, also to the deep sea.
Possible causes: sea ice extent

- Steady decrease in the extent of Arctic sea ice
- Opens the area to human activity → Footprints
Possible causes: tourism

- Strong increase in ship calls at Longyearbyen
- Strong increase in cruise tourism on Svalbard
Possible causes: fisheries

- Fishing effort is already widely spread
- Increasing fishing intensity
- Trawl marks on the seabed around Svalbard at all stations >300m depth (Sswat et al 2015)
- Beach clean-ups yield mostly fisheries debris
Possible paths: water currents

- Long-distance transport with oceanic currents?
- Advanced state of weathering of many plastic items

(From: Beszczynska-Möller et al. 2012)
**Possible paths: water currents**

- 6th garbage patch projected for the Barents Sea
- May leak to the north (Fram Strait)

*Van Sebille et al. 2012*
Summary

- Litter and MPs in surface waters
- Extremely high MP concentrations in sea ice
- Unknown quantities in the water column
- Strong increase of litter on the seafloor between 2002 and 2014
- Increase in small plastics → fragmentation?
- Seafloor may be a sink for marine litter and its toxins
- Result of increased fishing and tourism due to ice shrinkage and continuous supply of litter from northern Europe
Outlook

- Quantification of litter and microplastic in different ecosystem compartments
- Temporal trends through repeated sampling/deployments
- Effects of litter on benthic biota and community

Where is all the plastic?
Online litter data portal
‘LITTERBASE’

Effects on biota  Litter reports

No. of species affected  Global litter distribution

Outreach products

Data entry

LITTERBASE

Data base concept

Scientific meta-analysis

Citizen scientists

Tekman  Gutow  Bergmann
Thank you!

And: Harbourmaster of Svalbard, Governor of Svalbard, Svalbard coastguard