Partial impact assessment of marine plastics

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"Plastic Pollution: Status Quo and the Way Forward"
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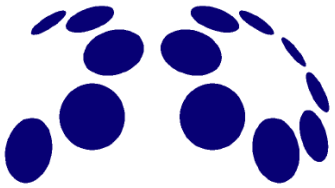
Gabor Doka
Doka Ökobilanzen, Zürich
do@doka.ch

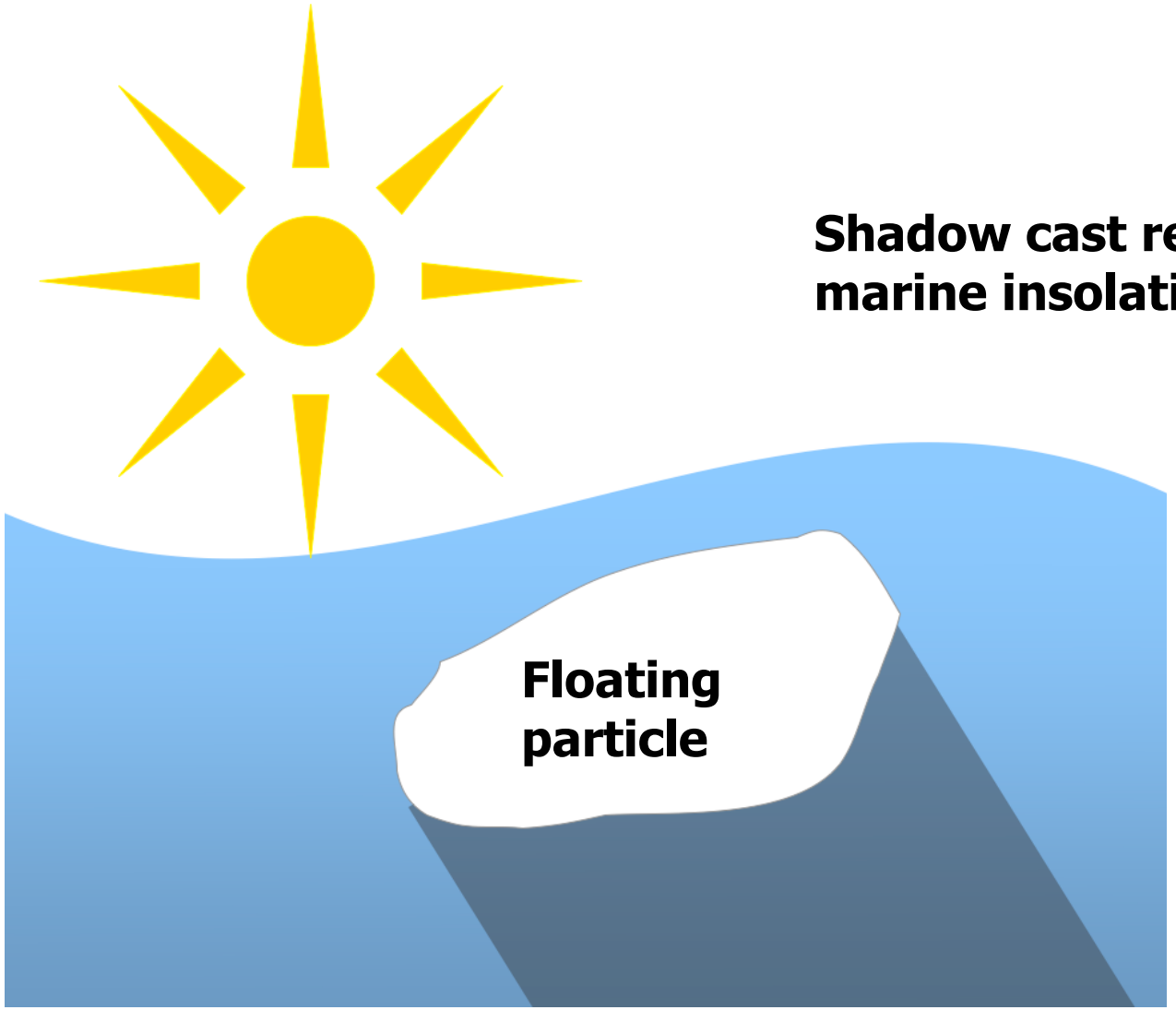


Impact Assessment

- **Damages from Microplastics (MiP) and Macroplastics (MaP): Use endpoint damages**
- **I.e. damages to safeguard subjects like biodiversity and human health**
- **Comparable/relatable to other damages already established in LCA**
- **Easier to show the real relevance of MP (= MiP + MaP).**
- **What follows is an attempt to cover a part of the endpoint damages of MP.**

Marine Dimming

insolation



Shadow cast reduces marine insolation

Calculation of Dimming

- **Shadow cast per kg of MP depends on:** **Model assumptions**
- **Particle geometry and size (surface-to-volume ratio)** **variable**
- **Density of plastic** **900 kg/m^3**
- **Translucence/reflectance** **100% opaque and non-reflective**
- **Dilution/saturation** **Dilute = no cumulative shadowing**

Working point conditions

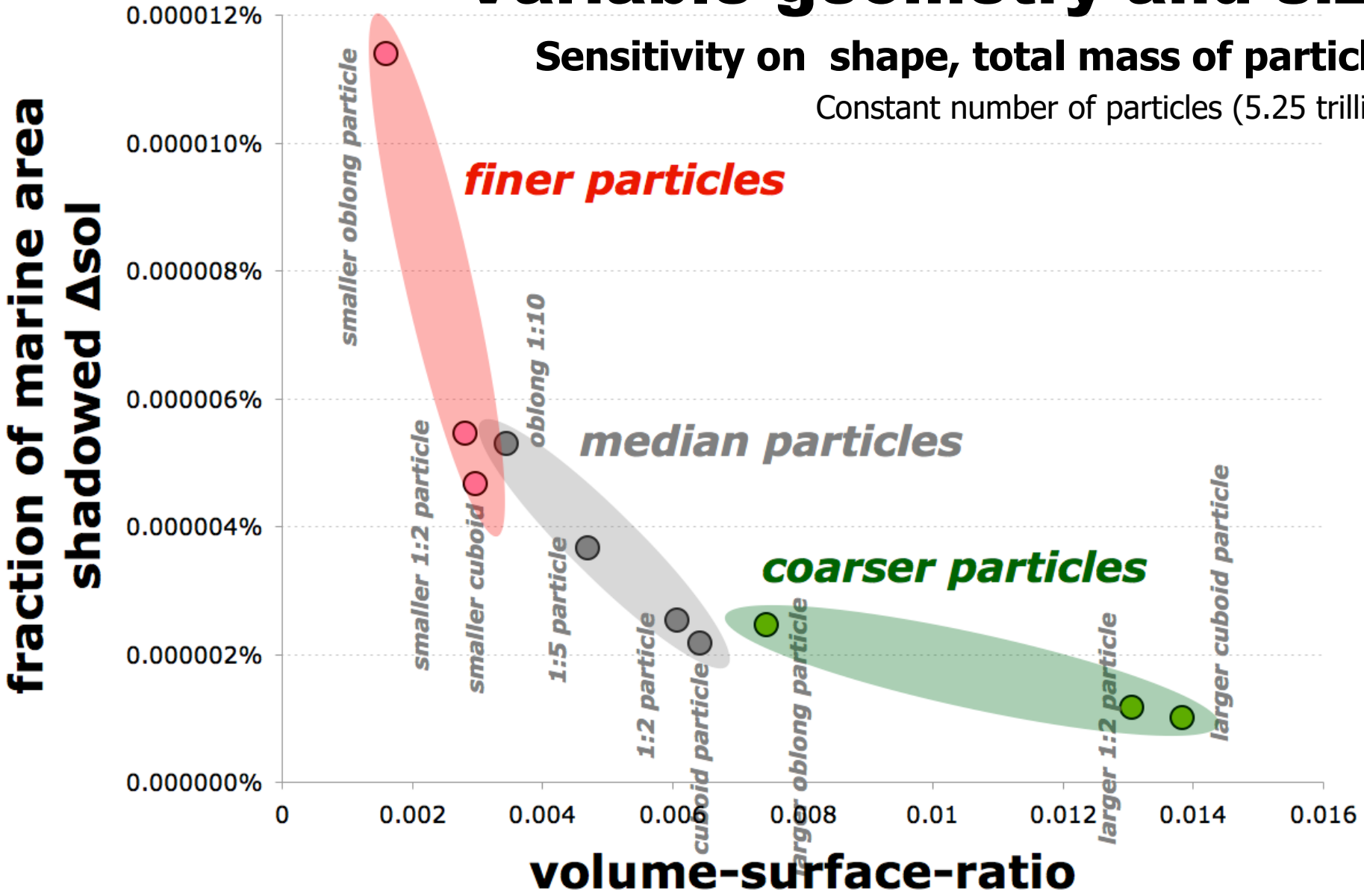
- **To estimate typical magnitude of marine particle:**
- **5.25 trillion marine particles globally ***
- **Total weight of circa 270'000 tons** (Eriksen et al. 2014)
- **Thus average particle is ~50 grams**
- **Assuming a 10:1 oblong particle**
- **Marine area 360 million km^2 ***
- **Shadow area of all marine particles: 19 km^2 (0.000005%)**

* Average distance between two individual floating particles is ~260m;
so indeed very dilute (=√(360 M km^2/5.25 10^9))
and at GPGP ~2 m (=√(1 km2/334'271))

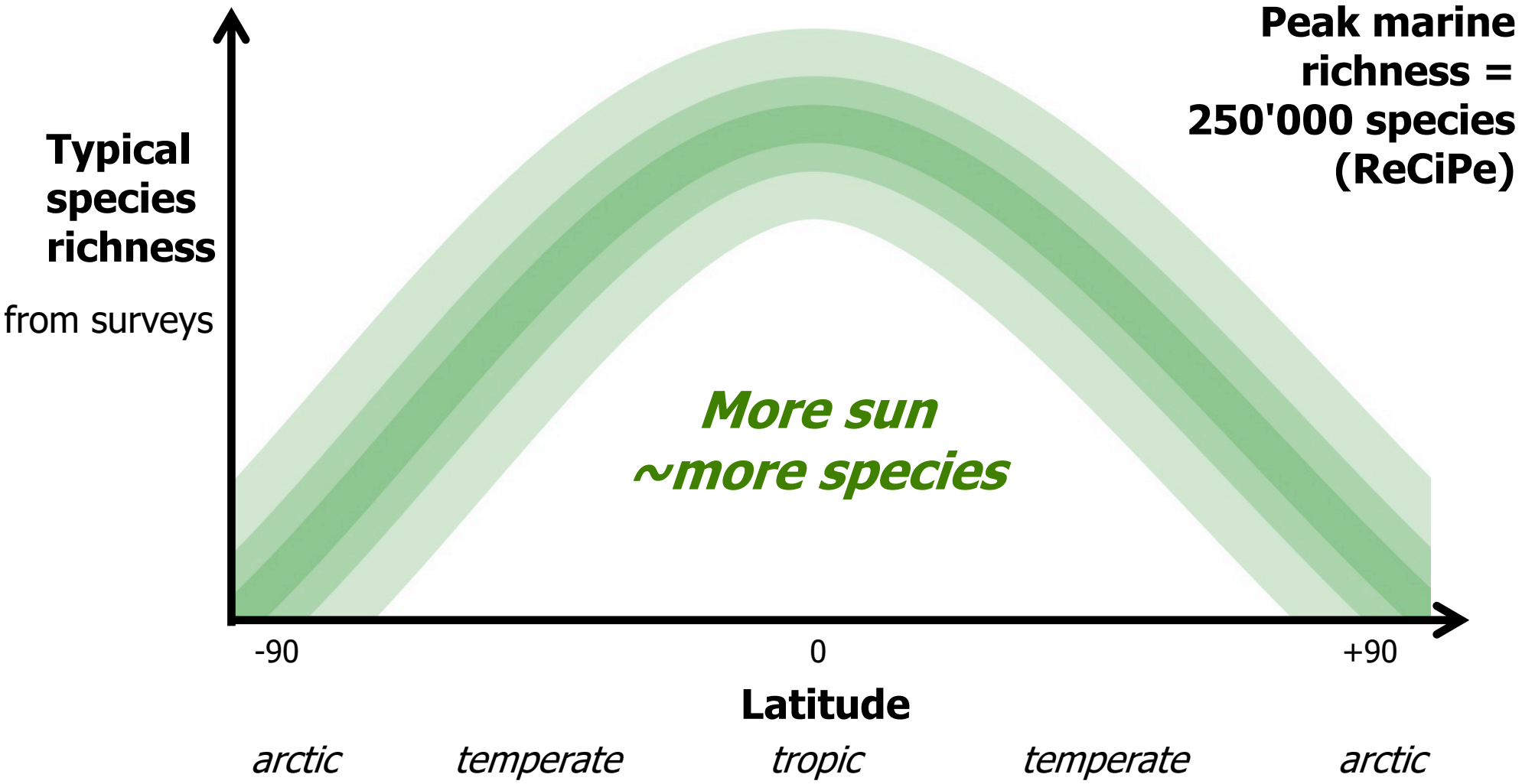
Variable geometry and size

Sensitivity on shape, total mass of particles

Constant number of particles (5.25 trillion)



Marine species distribution by latitude



Species loss from dimming

Chronic shadow cast leads to change in insolation Δsol

↓

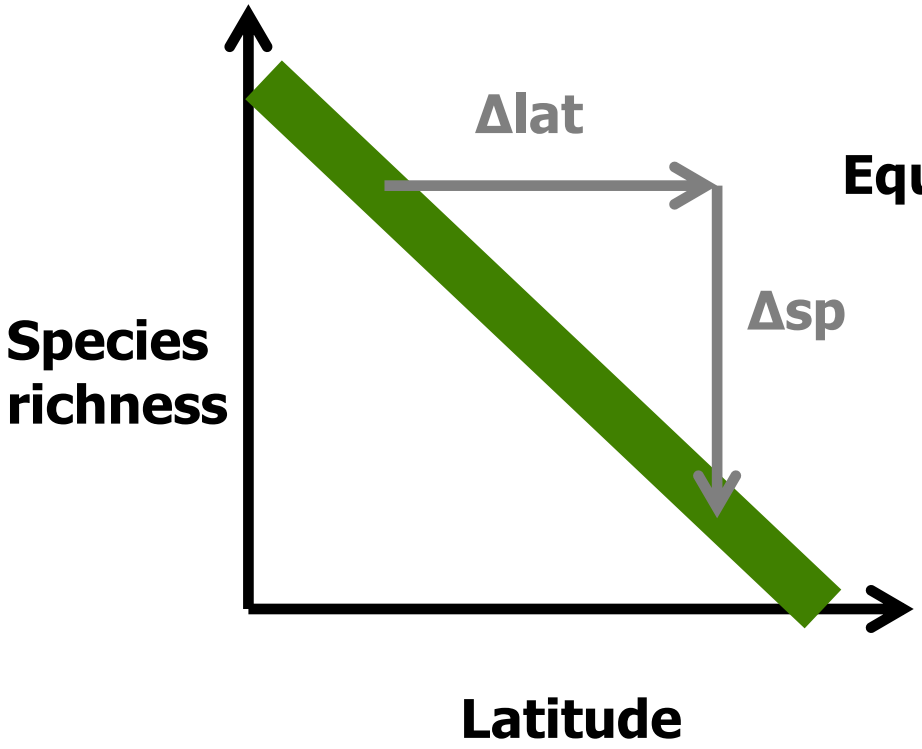
Change in habitat conditions

↓

Equivalent to a shift in latitude Δlat

↓

Which results in a **chronic reduction of species richness** Δsp



Species loss per kg of marine plastics

- Average particle: $8.58 \cdot 10^{-11}$ species/kg MP
- Finer particles: $1.85 \cdot 10^{-10}$ species/kg MP
- Coarser particles: $3.98 \cdot 10^{-11}$ species/kg MP
- (all independent of latitude!)

- But LCA damages are in lost species-years
- Assumption: floating residence time = 5 years
- Average particle: $4.29 \cdot 10^{-10}$ species.yr/kg MP
- Finer particles: $9.24 \cdot 10^{-10}$ species.yr/kg MP
- Coarser particles: $1.99 \cdot 10^{-10}$ species.yr/kg MP

Relevance of Marine Dimming

- **Worst case:**
  1 kg of PE dumped directly in ocean (no land based fate) and remaining floating for 5 years

- **Marine Dimming damage:**
  $2 - 9 \cdot 10^{-10}$ species.yr/kg PE

- **Common LCA damage of plastic production:**
  $3 \cdot 10^{-8}$ species.yr/kg PE

- **Marine dimming increases LCA damage of plastics by 0.6 – 2.7% (in the worst case of direct marine disposal)**

Conclusions

- **Marine Dimming damages of marine floating plastics can shown to be overall rather negligible.**
- **But quantification is essential in impact assessment of MP – also for other effects not considered here, like toxic effects or ingestion**
- **Please strive to show relevance or irrelevance of actually occurring endpoint damages. Do not presuppose relevance.**