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Norwegian Institute for Sustainability Research

- Nov 2022 LCA Discussion Forum. B. Fate: Transport, degradation, fragmentation and sinks of plastic litter in the environment

LCA modelling of biodegradable plastic products in soil and sea environments – what data and fate information do we have vs what we need?

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Norwegian Institute for Sustainability Research

Private research institute

Not-for-profit

30 researchers

Fredrikstad & Oslo, Norway

Examples for today: Dgrade & Dsolve

Financed by The Research Council of Norway and project partners

Dsolve

SFI Biodegradable Plastics for Marine Applications

https://uit.no/research/dsolve

https://www.nibio.no/en/projects/dgrade-constraints-to-degradation-of-biodegradable-plastics-in-terrestrial-systems

The Research Council of Norway

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Dgrade – research work

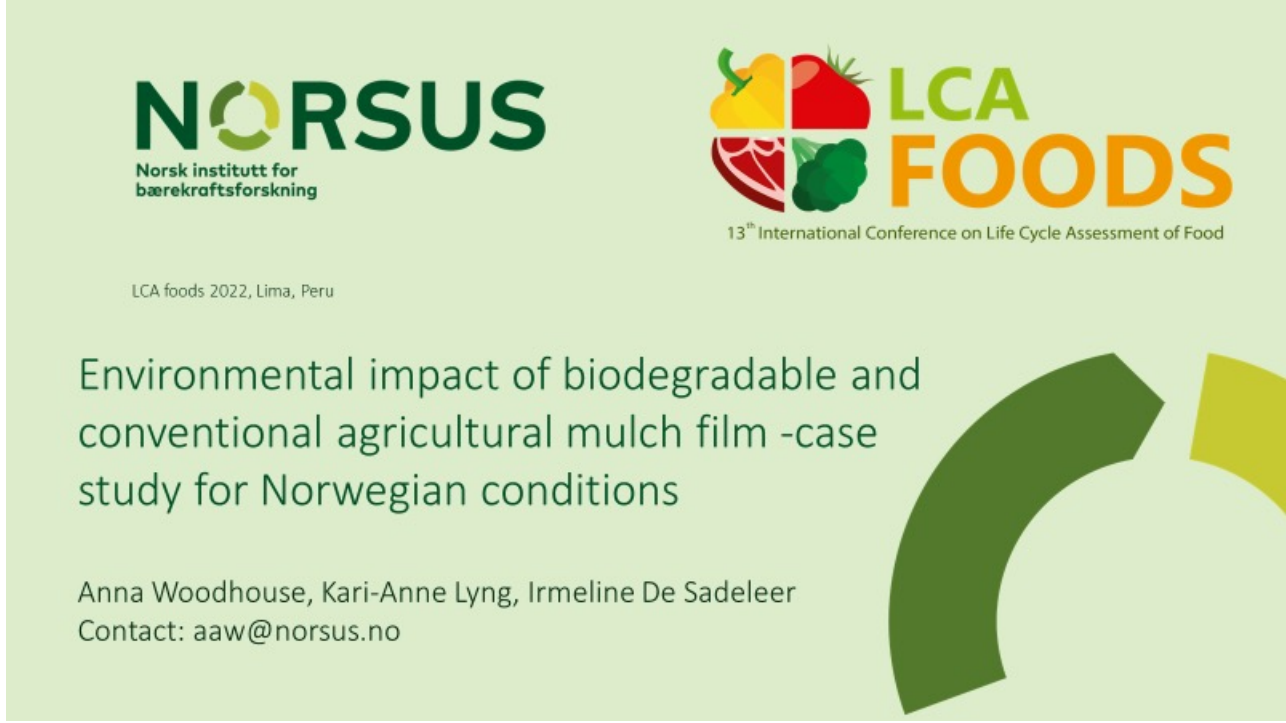
3 Work packages

- Degradation of biodegradable mulch films in soils under Nordic conditions
  NIBIO
- Fate of biodegradable and compostable plastic material streams, with a focus on those entering composting and facilities
  NIBIO
- Life-cycle assessment of biodegradable plastic materials
  NORSUS

Note: Fate ≠ FF, but data for the LCI

LCA cases - DGrade

- biodegradable mulch films for the agricultural sector,
- biodegradable waste bags for the biogas sector,
- compostable food and beverage containers and
- cutlery for the industrial composting sector.

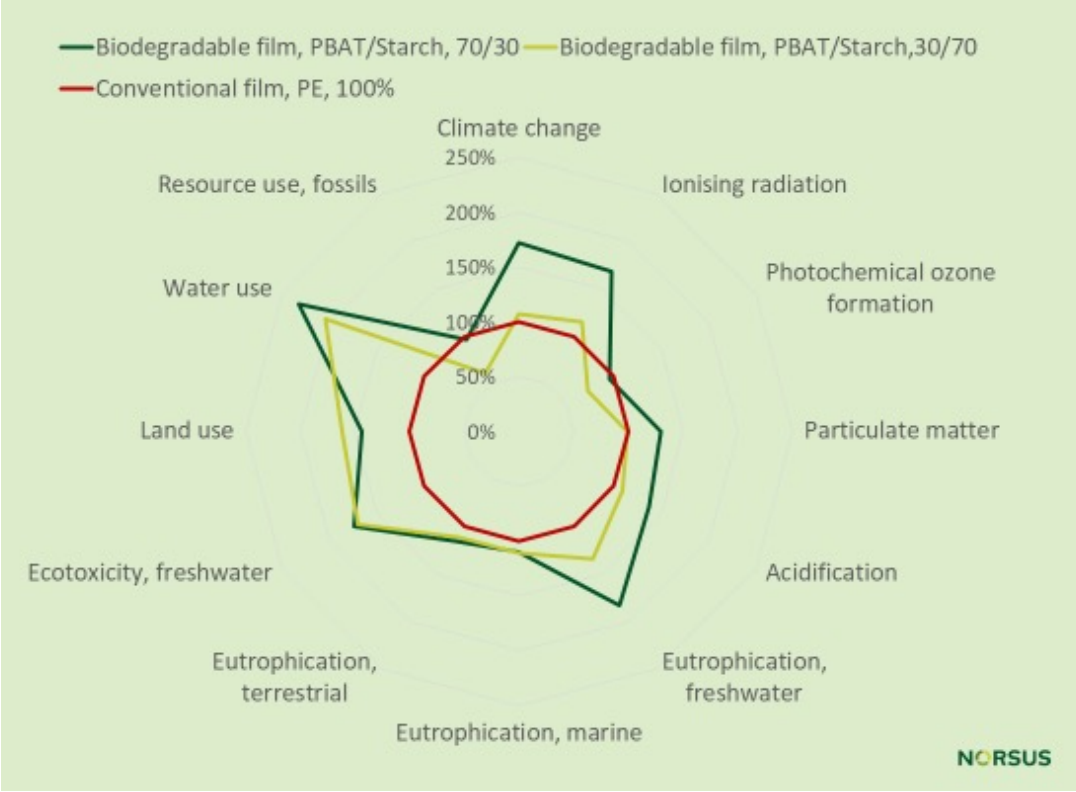


DGRADE

DGrade

Research question for mulch film:

What is better for the environment: conventional plastic or biodegradable?



The field studies (NIBIO) showed that the biodegradable films do not degrade fast enough in Nordic conditions – collection and industrial composting?

Non-degradable plastic – collection & recycling? (As in Sweden)

Plastic lost & microplastics generated not included in inventory, or in LCIA in this assessment

Field work –mulch films

- Different films
- 2 depths
- 4 time intervals – up to 2 years
- 3 replicates on each farm

What information was measured? & what do we need in LCA?

- Change in mass
- Temperature in the soil and soil characteristics
- Presence of soil particles, roots and organisms

- Quantification of loss in mass → LCI (plastic loss to soil)
- Evidence of fragmentation and time scale in given conditions → can provide information for FF work

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Dsolve

Biodegradable fishing gear as a technology solution to the environmental impacts of ghost fishing.

5. NORSUS: LCA of biodegradable fishing gear cases

Biodegradable polymer development and optimization

Assessment of biodegradability

Gear development, tests and demonstrations at sea

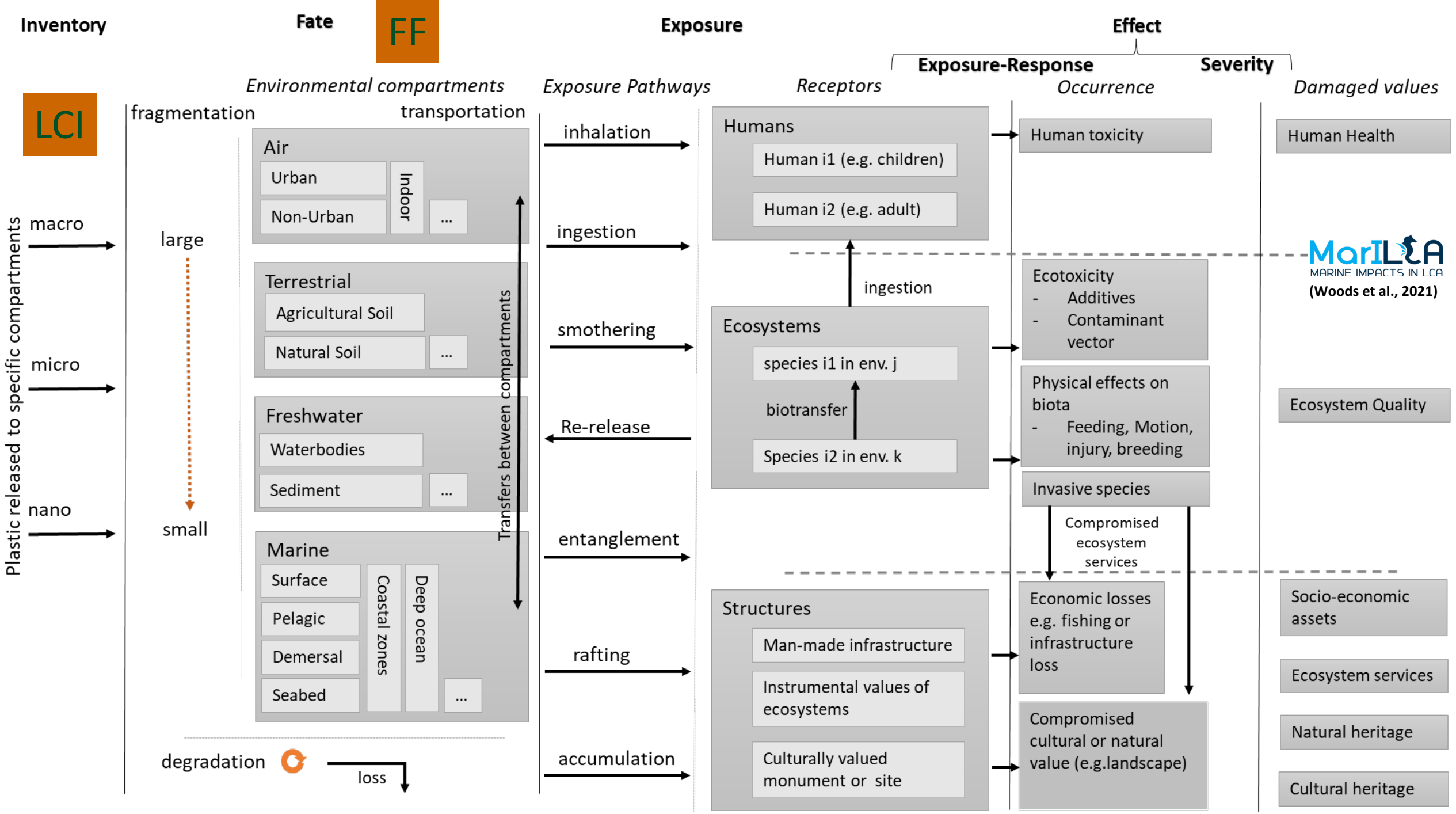
UiT Norges arktiske universitet

norner The Polymer Explorers

SINTEF

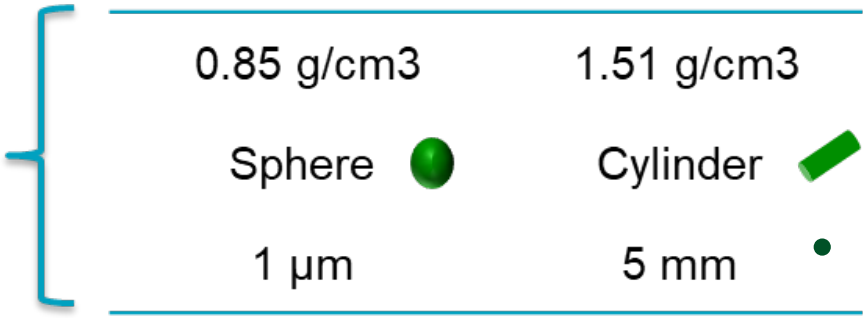
NORSUS Norsk institutt for bærekraftsforskning

SALT


Inventory
Fate
FF
Exposure
Effect
Exposure-Response
Severity
LCI
Environmental compartments
Exposure Pathways
Receptors
Occurrence
Damaged values
fragmentation
transportation
Plastic released to specific compartments
macro
micro
nano
large
small
Air
Urban
Non-Urban
Indoor
...
Terrestrial
Agricultural Soil
Natural Soil
...
Freshwater
Waterbodies
Sediment
...
Marine
Surface
Pelagic
Demersal
Seabed
Coastal zones
Deep ocean
...
Transfers between compartments
degradation
loss
inhalation
ingestion
smothering
Re-release
entanglement
rafting
accumulation
Humans
Human i1 (e.g. children)
Human i2 (e.g. adult)
ingestion
Ecosystems
species i1 in env. j
biotransfer
Species i2 in env. k
Structures
Man-made infrastructure
Instrumental values of ecosystems
Culturally valued monument or site
Human toxicity
Ecotoxicity
- Additives
- Contaminant vector
Physical effects on biota
- Feeding, Motion, injury, breeding
Invasive species
Compromised ecosystem services
Economic losses e.g. fishing or infrastructure loss
Compromised cultural or natural value (e.g.landscape)
Human Health
Ecosystem Quality
Socio-economic assets
Ecosystem services
Natural heritage
Cultural heritage
MarILCA
MARINE IMPACTS IN LCA
(Woods et al., 2021)

LCIA data needs are important input to experimental design for Dsolve

1- Horizontal dispersion
2- Vertical dispersion
3- Biofouling density
4- Biofouling rate
5- Water density
6- Particle density
7- Particle shape
8 - Particle size



Ref: Carla Hajjar

- We will need the research partners to record environmental conditions and data on fragmentation and degradation in relevant units and related to the mass of the product plastic being assessed.
- Also data for traditional alternatives

e.g. Elena Corella-Puertas

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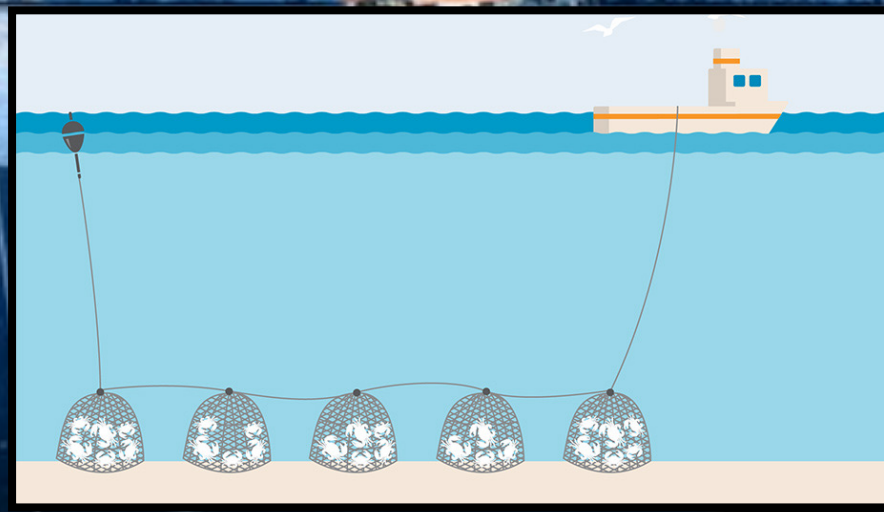
PURSE SEINE

TRAWL NET

DANISH SEINE

LONG LINE



We will make LCA case studies for these gear types

Illustrations from: www.msc.org/what-we-are-doing/our-approach/fishing-methods-and-gear-types/pots-and-traps
https://cod.fromnorway.com/globalassets/cod/images/illustrations/catch-methods-full.png?preset=width-700

To include microplastics effects we need data for Life Cycle Inventory (LCI) data and Characterisation factors (CFs)

- Wear and tear data
- Amounts of gear lost
- Fate models for transport, degradation, fragmentation and sinks of the plastic (both macro and micro) over time
- As well as exposure / intake and effect data.

Which plastics?

- The biodegradable plastic(s)
- Polyester
- Nylon 6.6
- LDPE
- HDPE
- EPS

N.b. also catch efficiency differences where relevant (some data already published, Cerbule et al. 2022: Marine Pollution Bulletin 178 (2022) 113618 + Marine Pollution Bulletin 178 (2022) 113577)

Practioner perspective

- There is a lot of interest in incorporating plastic littering and impacts associated with microplastics into LCAs.
- Functional unit focus - would like CFs to exist already
- We can often find “pre-fate” data contributing to the LCI (e.g. plastic leak project, or country specific litter rates), but not enough knowledge for many products and regions, e.g. discarded fishing gear – undocumented losses in particular.
- Biodegradable plastics - lack of LCI data and transparency. Referring to biodegradability standards is not adequate – we need both LCI data and data for fragmentation, degradation, biodegradation + emission products of these processes to add to our LCI + contribute to CF development
- The marine compartment isn’t a simple box, the products aren’t simple, or one-size; temporal scale to include? Gillnets → → → microplastic


Thank you