University of Padova // Department of Civil, Environmental and Architectural Engineering
Quality and Environmental Research Center (CESQA)

Tracing and Measuring the Plastic Footprints of Seafood Supply Chains

Past, current and future perspectives

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Cover photo reference:
https://usesilo.com/blog/issues-faced-at-each-stage-in-the-seafood-supply-chain

01 CONTEXT

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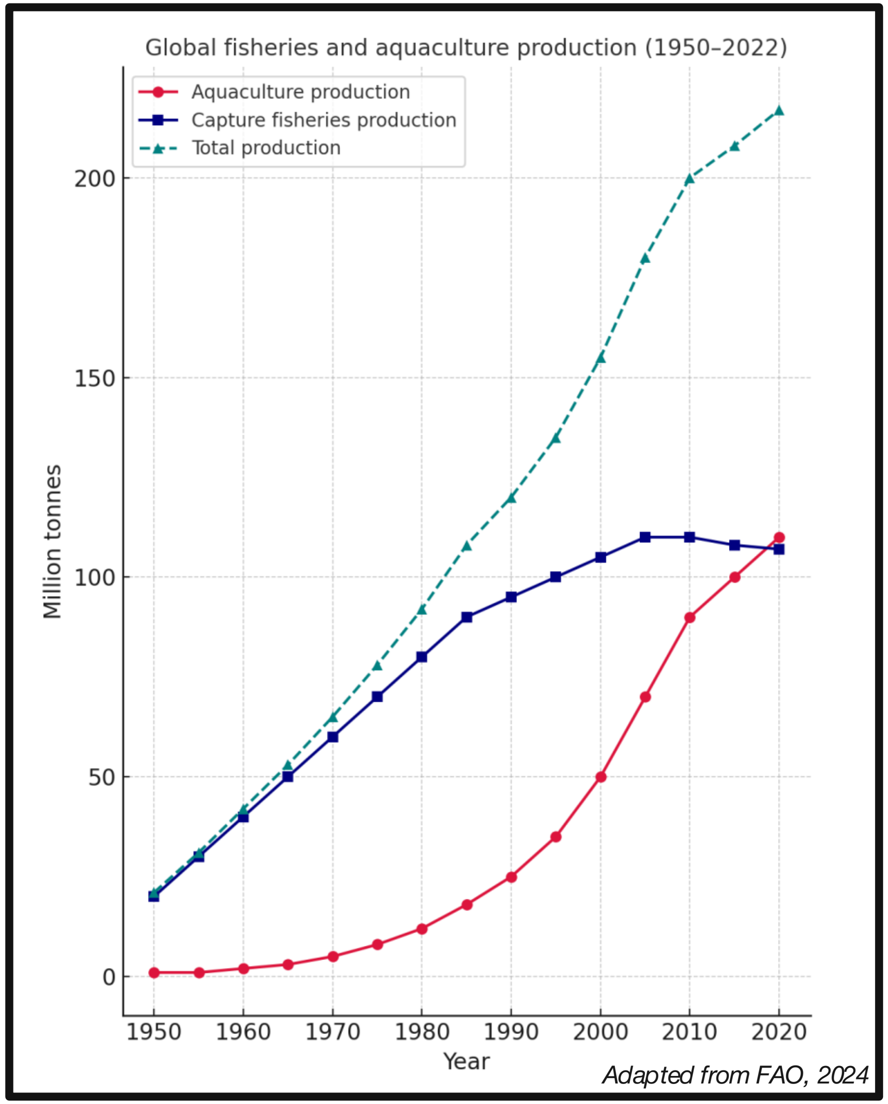
THE SEAFOOD BOOM

Global seafood demand is rising rapidly, now providing ~15% of global animal protein. It is central to future food security, providing equal access to vital nutrition for human well-being.

PLASTIC AND WATER

- **11 Million Metric Tons entering the oceans every year.**
- **A FAO study indicates that microplastics have been documented in over 800 species of fish and mollusks.**
- **A pivotal study estimated that humans ingest between 39,000 and 52,000 microplastic particles per year through food and beverages alone.**

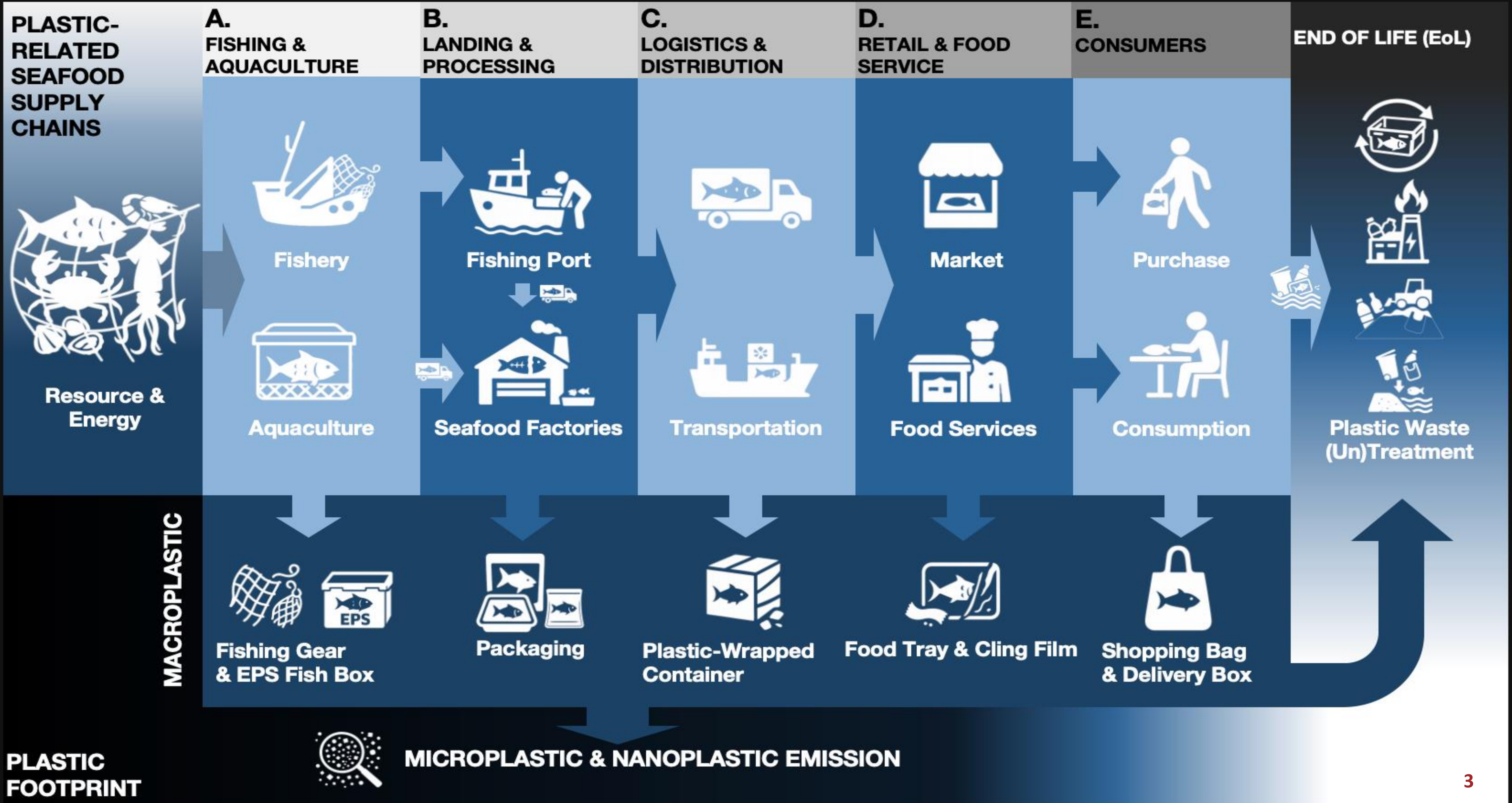
Geyer, R., et al. (2017). "Production, use, and fate of all plastics ever made". Science Advances.



Source: FAO, 2024; Lusher et al., 2017

Plastics in Seafood Supply Chain

Source: Luoqin Liu et al. 2026) (to be submitted)



Plastic is an area of concern in seafood supply chain...Plastic Footprint?

Term	Definition
Footprint	Metric used to report **life cycle assessment results** addressing an **Area of Concern**
Area of Concern	Environmental topic defined by the interest of society
Footprint profile	A list of footprints addressing different Areas of Concern

Ridoutt et al, 2016

3.1 Area of Concern

Environmental subject defined by the interest of society
[SOURCE: ISO 14044]

The plastic footprint is a metric that quantifies the potential environmental impacts of plastic use, including plastic leakage into the environment, across the entire life cycle of products or services.

Source: Quantis & EA, 2020; Loubet et al., 2022

02 RESEARCH QUESTIONS

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RQ1.

DATA AVAILABILITY & ROBUSTNESS

What is the current state of knowledge regarding plastic consumption and pollution in seafood supply chains, and where are the critical data gaps?

RQ2.

METHODOLOGY

How do current Life Cycle Assessment (LCA) methodological choices affect the visibility of plastic related impacts?

RQ3.

ROADMAP

What should be prioritized to support closing eventual of data gaps and potential methodological flaws?

02 METHODOLOGY: PSALSAR

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We employed the PSALSAR framework (Protocol, Search, Appraisal, Synthesis, Analysis, Report) to filter literature.

1. SCREENING

Started with **497 records**. Applied strict inclusion criteria: quantitative assessment of plastics.

2. SELECTION

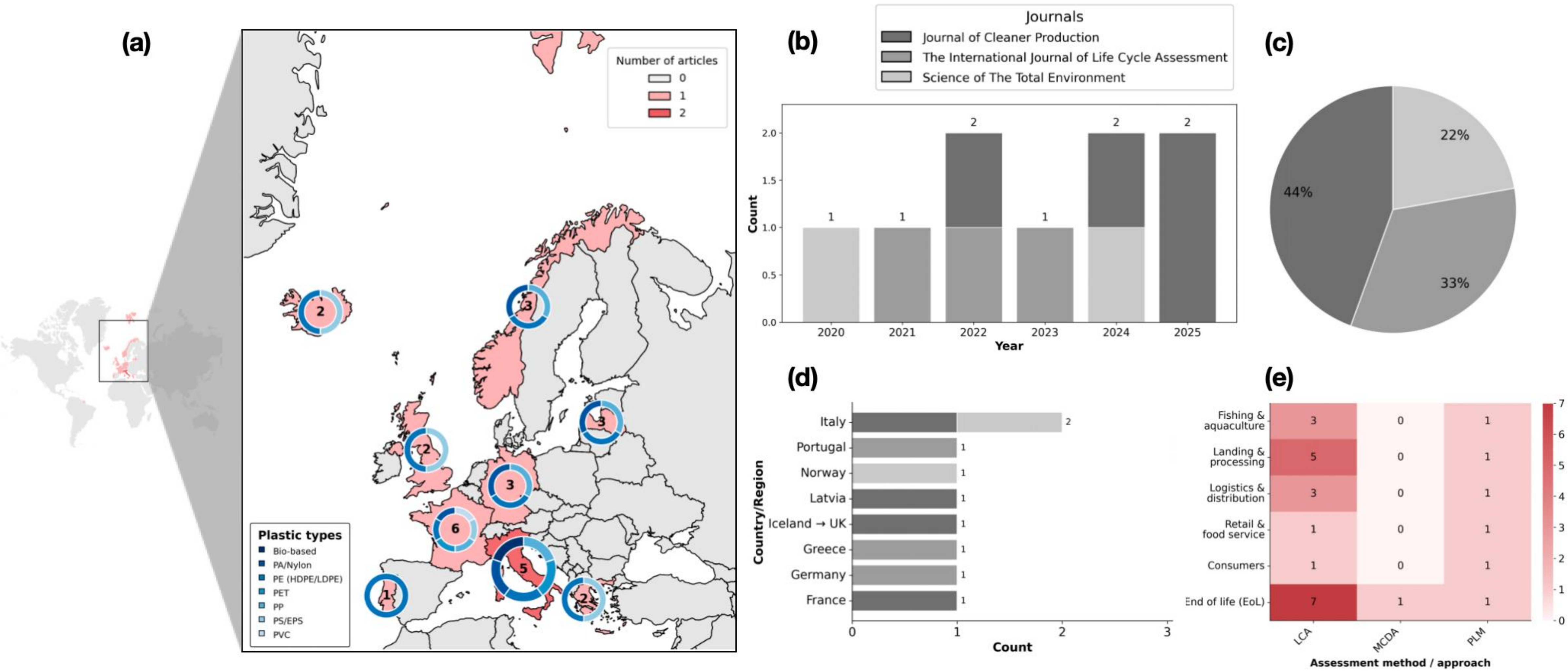
Refined to **9 robust studies**. Excluded studies that didn't quantify impacts.

3. ANALYSIS

Findings led to the conceptualization of a '**Service Lens**' to align conflicting supply chain scopes.

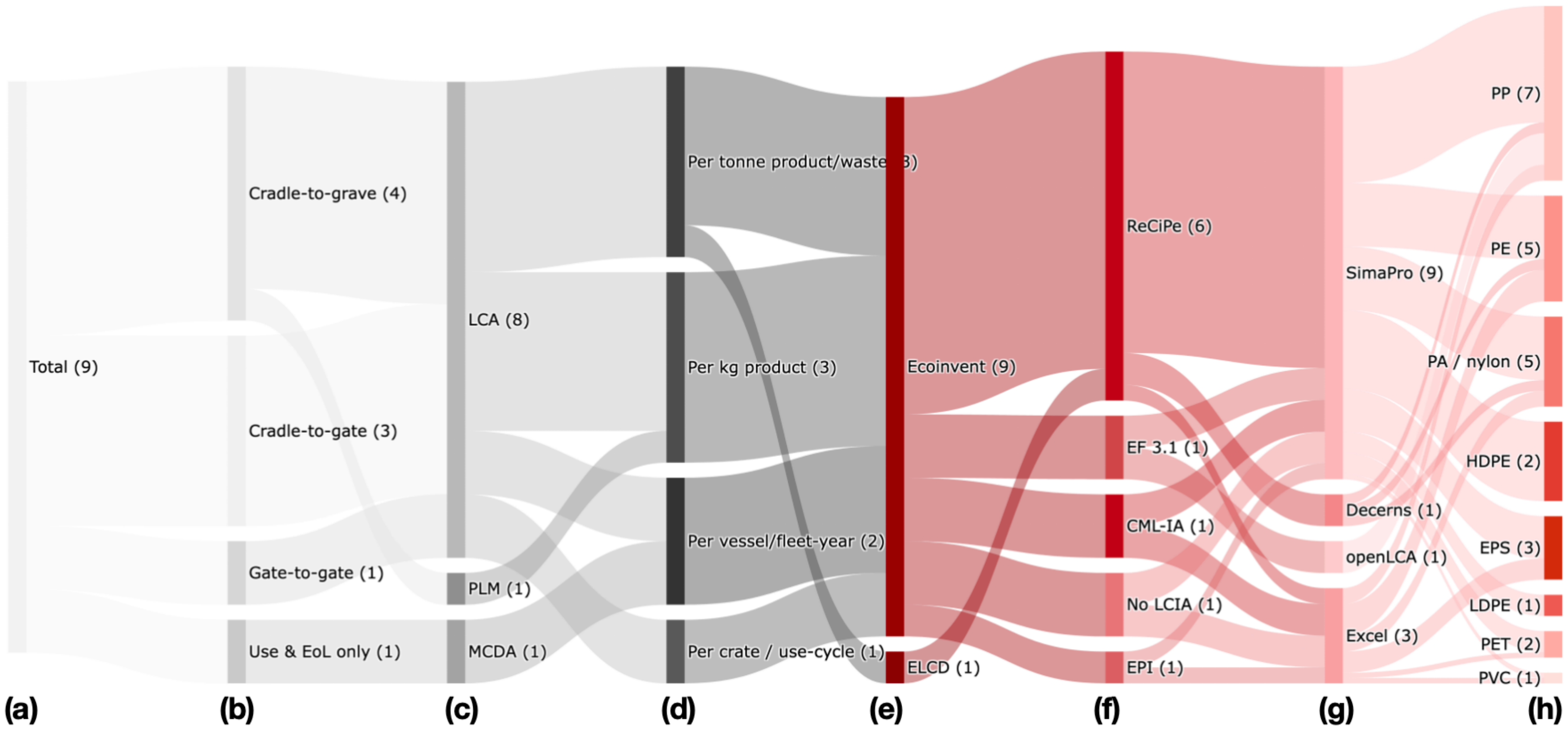
Adapted from Tranfield et al. (2003)

03 RQ1: Descriptive Analysis



Source: Luoqin Liu et al. 2026)
(to be submitted)

03 RQ1: Descriptive Analysis



Goal and boundaries present general inconsistency among studies:

Different papers model different “services” catching fish efficiently (gear), keeping it safe and fresh (packaging + cold chain), and avoiding leakage at end-of-life.), so they choose different boundaries and plastics can look “invisible” or become a hotspot depending on the service and functional unit

Source: Luoqin Liu

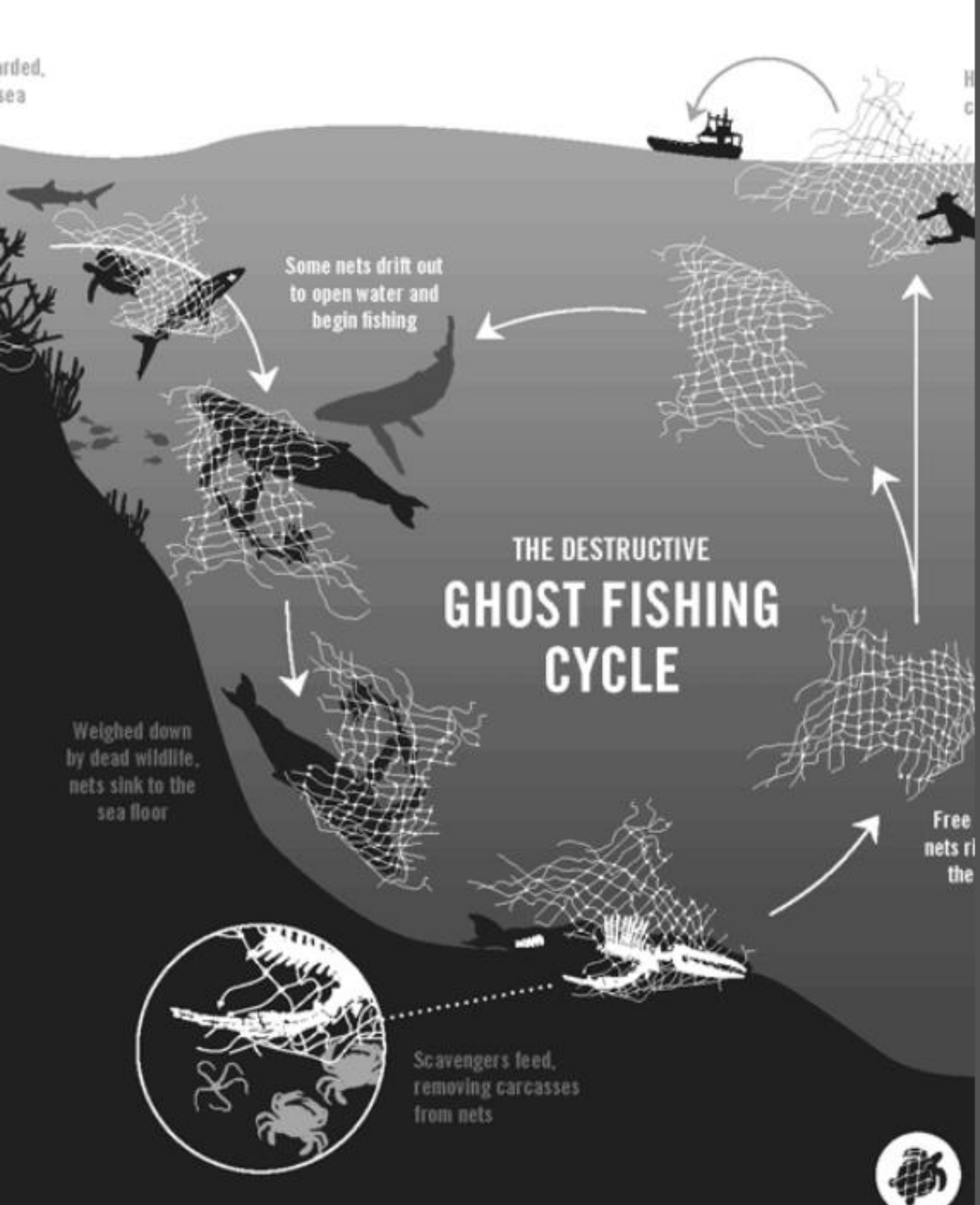


Image credit: Olive Ridley Project

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03 RQ1: THE LEAKAGE GAP

Plastic ignored as an elementary flow and ignored in Inventories

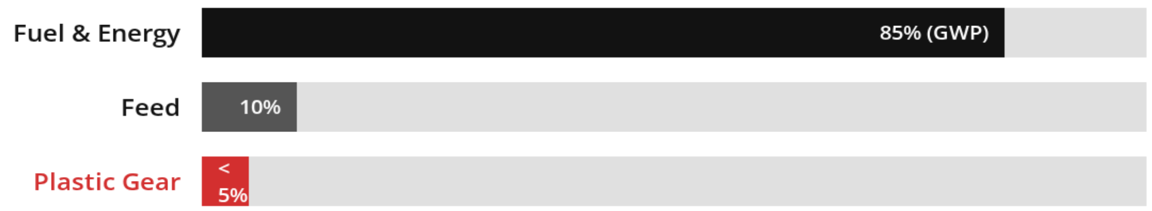
Ghost Gear: Major pollutant, often excluded from inventory.

Microplastics: Chronic abrasion creates invisible flows unquantified in models.

Consequence: LCAs systematically underestimate the ecological risks of leakage.

Source: Loubet et al., 2022; Schneider et al., 2023

03 RQ2: PLASTIC VS GWP



- **Evidence**: **In 8 out of 9 studies, plastic equipment contributed <5% to the Global Warming Potential (GWP).**

- **Consequence**: **NOT PRIORITIZED IN ENVIRONMENTAL POLICIES Since standard environmental policies prioritize Carbon Footprint, the mathematical insignificance of plastics in GWP leads to their neglect in sustainability agendas. THE FOCUS OF INTERVENTION IS UPSTREAM AND IN THE CORE PROCESSES**

➢ **Consequence - Masked Trade-offs: Low carbon impact ≠ Low ecological risk. Current LCAs lack robust Impact Categories for marine litter, leaving physical risks (entanglement, ingestion) unquantified and "invisible."**

03 RQ3: ADOPT A "SERVICE LENS"

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PROVISION-CENTRIC

Focus: Production (Fisheries).
Blind Spot: Energy dominates; plastic is "invisible".

SERVICE

Focus: Logistics & Packaging.
Trade-off: Material intensity vs. Transport energy.

WASTE

Focus: End-of-Life (EoL).
Limit: Ignores upstream burdens.

LEAKAGE

Focus: Pollution flows.
Gap: Quantifies mass, but lacks impact factors.

RQ 3: A Methodological Framework: Inventory

Refining the LCI: From Generic Waste to Gear-Specific Loss

The Gap: Static Inventories

- **Generic Approach:** Most seafood LCAs treat fishing gear as "Capital Goods" with generic depreciation rates.
- **Blind Spot:** Fails to distinguish between managed waste (landfill) and unmanaged leakage (ocean).

The Solution: "Loss-Driven" Inventory

- **Activity-Specific Rates:** Applying fishery-specific loss probabilities (e.g., Trawl vs. Gillnet abrasion).
- **Flow Distinction:** Separating *Macro-leakage* (lost nets/ALDFG) from *Micro-emissions* (wear & tear).

Source: Maranghi, S., et al. (2020), Ryberg, M., et al. (2019), https://www.whoi.edu

RQ 3: Methodological Framework: From Leakage to Damage

Supporting development of the MarILCA Framework

From Mass Leakage to Ecological Damage

To move beyond simple mass-based accounting (kg leaked), we could adopt the MarILCA consensus framework, which links leakage/emissions to potential ecological damage.

1. **Fate Factor (FF)** Residence time in ocean compartments (e.g., surface vs. sediment).
2. **Exposure Factor (XF)** Probability of biota encountering the debris.
3. **Effect Factor (EF)** Physical harm to organisms (e.g., physical effects) leading to biodiversity loss.

Source: Boulay, A.-M., et al. (2021), Woods, J. S., Boulay, A.-M., et al. (2021), Corella-Puertas, E., et al. (2023), dmc.umaine.edu

Target Metric:

PAF (Potentially Affected Fraction of Species)

Here, we could use the fate–exposure–effect logic to show how future seafood supply-chain studies could translate leakage (including ALDFG) into biodiversity-relevant endpoints as characterization factors mature.

05 CONCLUSIONS

- Plastic ignored as an elementary flow and ignored in Inventories
- General inconsistency in current study that deviates the focus from plastics
- Lack of Inventory methods to specifically tackle seafood supply chains
- Impact Categories for marine litter, leaving physical risks (entanglement, ingestion) needs to be further developed

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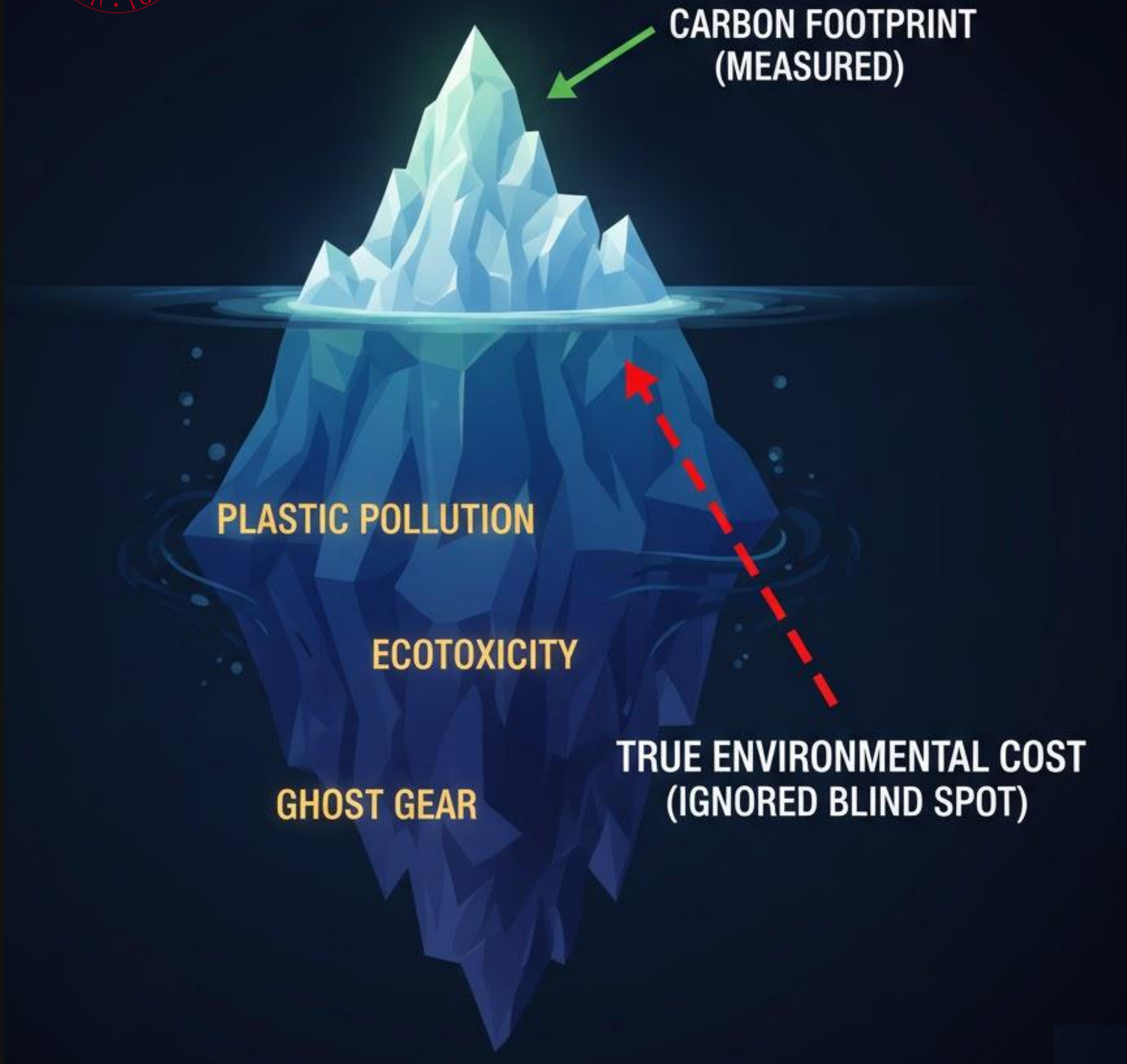

Source: Quantis & EA, 2020; Plastic Leak Project; Boucher et al., 2020; Luoqin Liu

05 ROADMAP

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1) **EXPAND BOUNDARIES**
Adoption of a “service lens approach” Mandate EoL inclusion in LCAs.

2) **EXPLICIT INVENTORIES**
Track "Managed Waste" and "Leakage" as distinct flows.

3) **DEVELOP CFS**
Create Characterization Factors for entanglement & ingestion.

4) **HARMONIZE**
Integrate Carbon and Plastic footprints into a unified framework.

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THANKS FOR YOUR ATTENTION!

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