Bio-based alternatives to plastic packaging for Arctic fisheries

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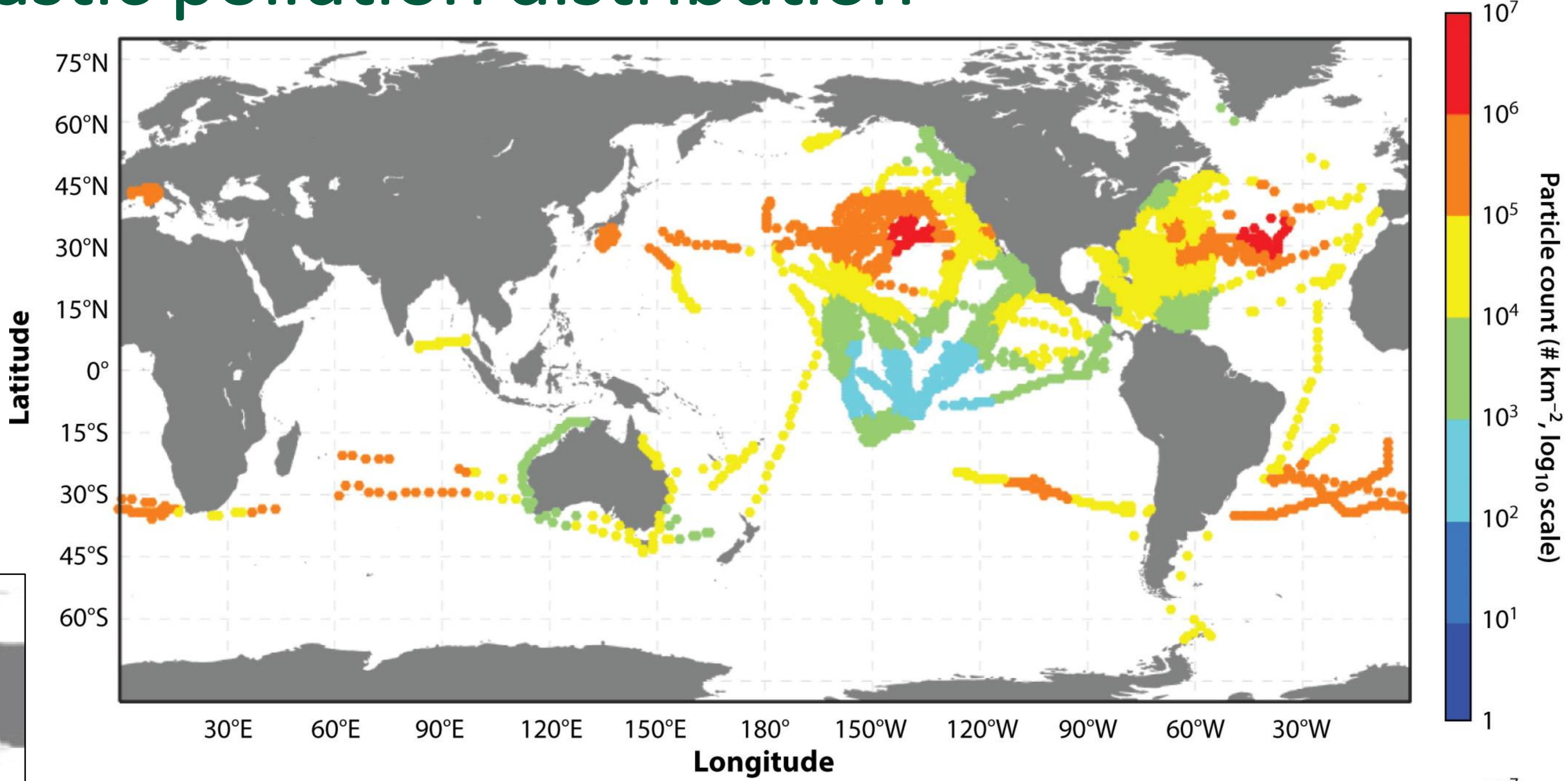
Global plastic pollution distribution



(*a*) Particle count and (*b*) particle mass of plastic samples collected from 11,854 surface-towing plankton net trawls. The data were standardized using a generalized additive model to represent no-wind conditions in the year 2014. Adapted from van Sebille et al. (2015) under the Creative Commons Attribution 3.0 Unported license (**https://creativecommons.org/licenses/by/3.0/legalcode**).

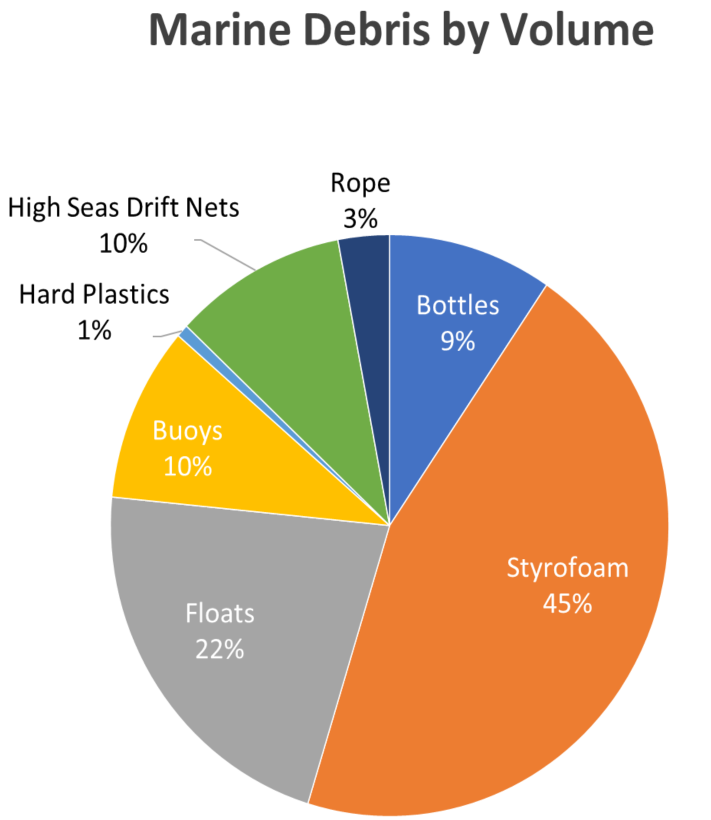
From: Law (2017) Ann Rev Mar Sci 9:205-229

A fraction of a single day’s use of expanded polystyrene (EPS) at Tokyo’s Fish Mark

In Alaska, over 1 million EPS boxes are used every year for seafood and EPS in not recycled or incinerated. It goes directly into landfills and enters water bodies.

EPS* use contributes to marine plastic pollution and CO_2 emissions

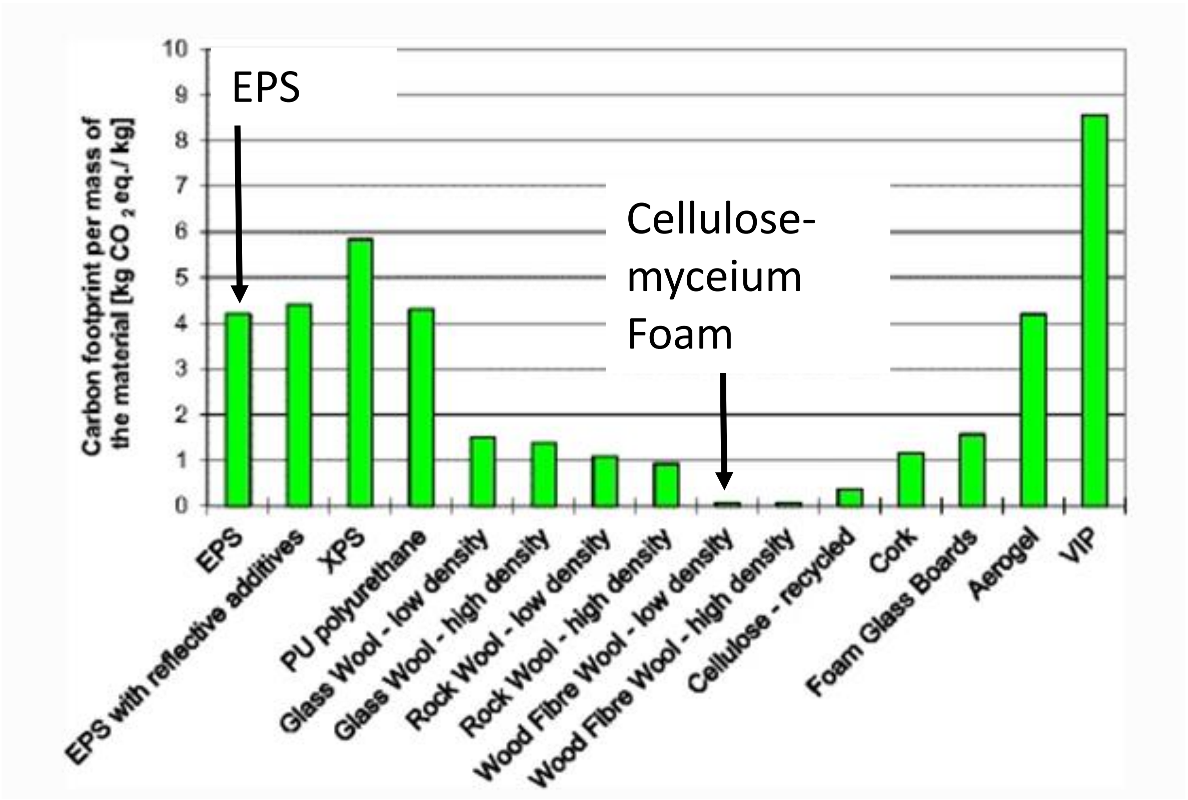
Plastic debris in Alaska



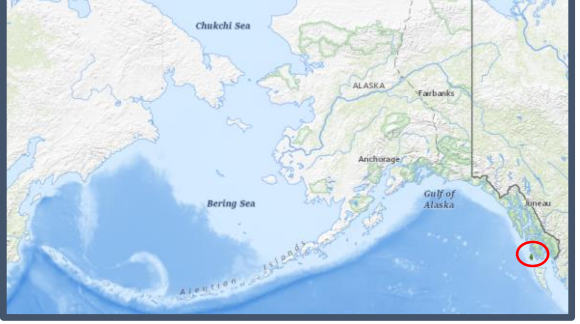
Data: Kit Cunningham, UAF, Gask̲úu/Forrester Island

* EPS (Expanded Polystyrene)

Carbon footprint of thermal insulation materials



Adapted from Kunic R., Carbon footprint of thermal insulation materials in building envelopes. Energy Efficiency 10 (2017), 1511-1528.



Forrester Island

EPS

7(other): Polyurethane PUR

2: High Density Polyethylene (HDPE)
7(other): Acrylonitrile Butadiene Styrene (ABS)

7 (other): Styrene-butadiene (SBR) rubber, butadiene rubber, natural rubber, etc.

Polyethylene Terephthalate PET

High Density Polyethylene HDPE

Plastic debris in SouthEast Alaska

Data: Kit Cunningham, UAF, Gask̲úu/Forrester Island

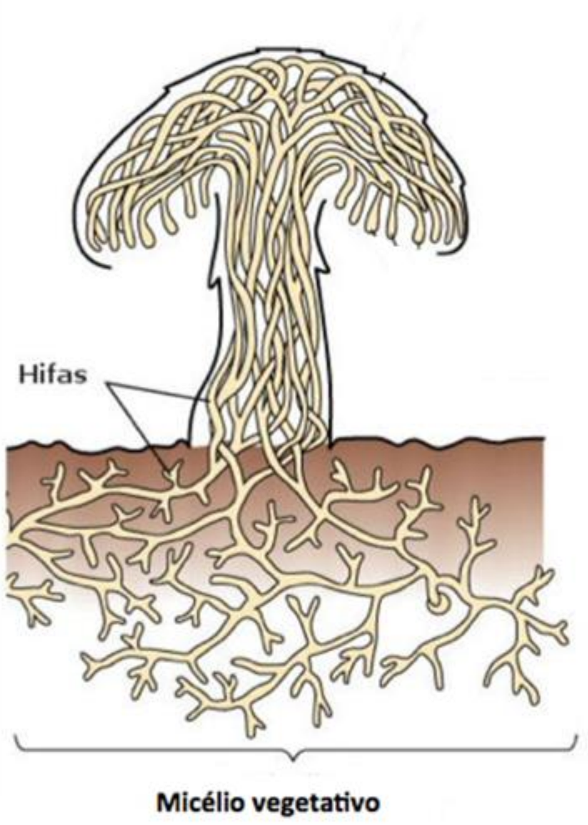
Village of Nulato

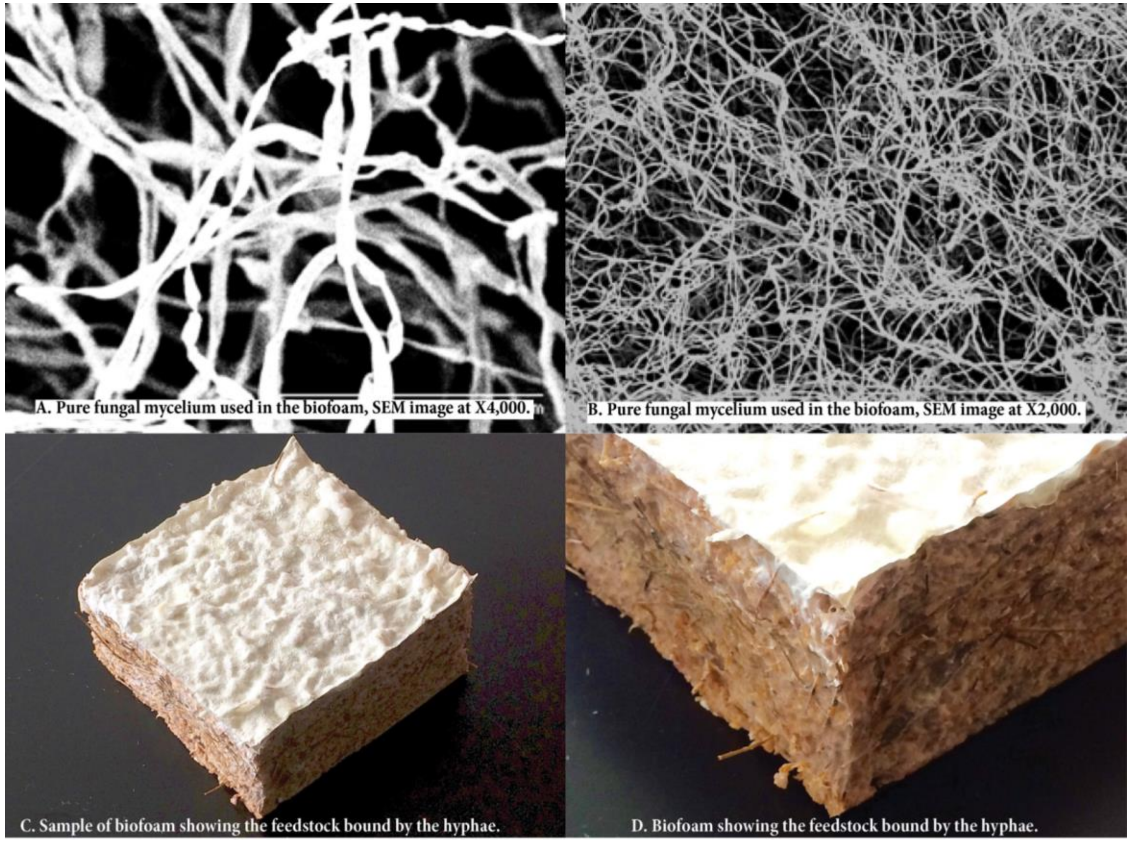
Landfill of Shishmaref Village

Shishmaref Village

EPS beads in Kachemak Bay, Alaska

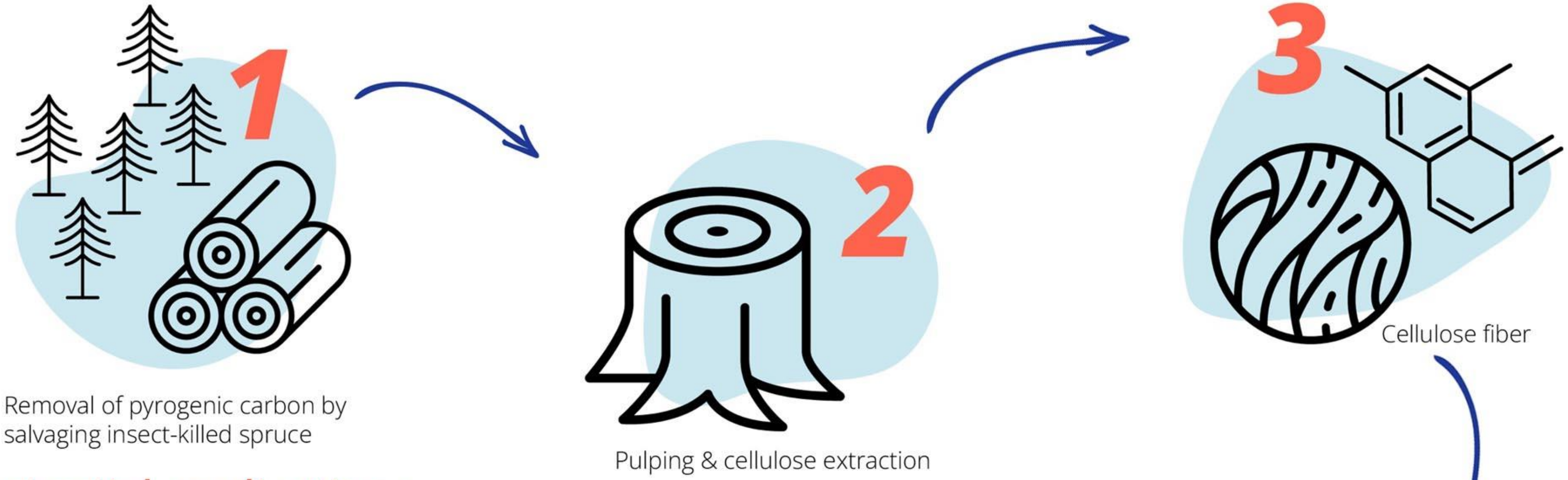
Bio-based alternative to EPS?

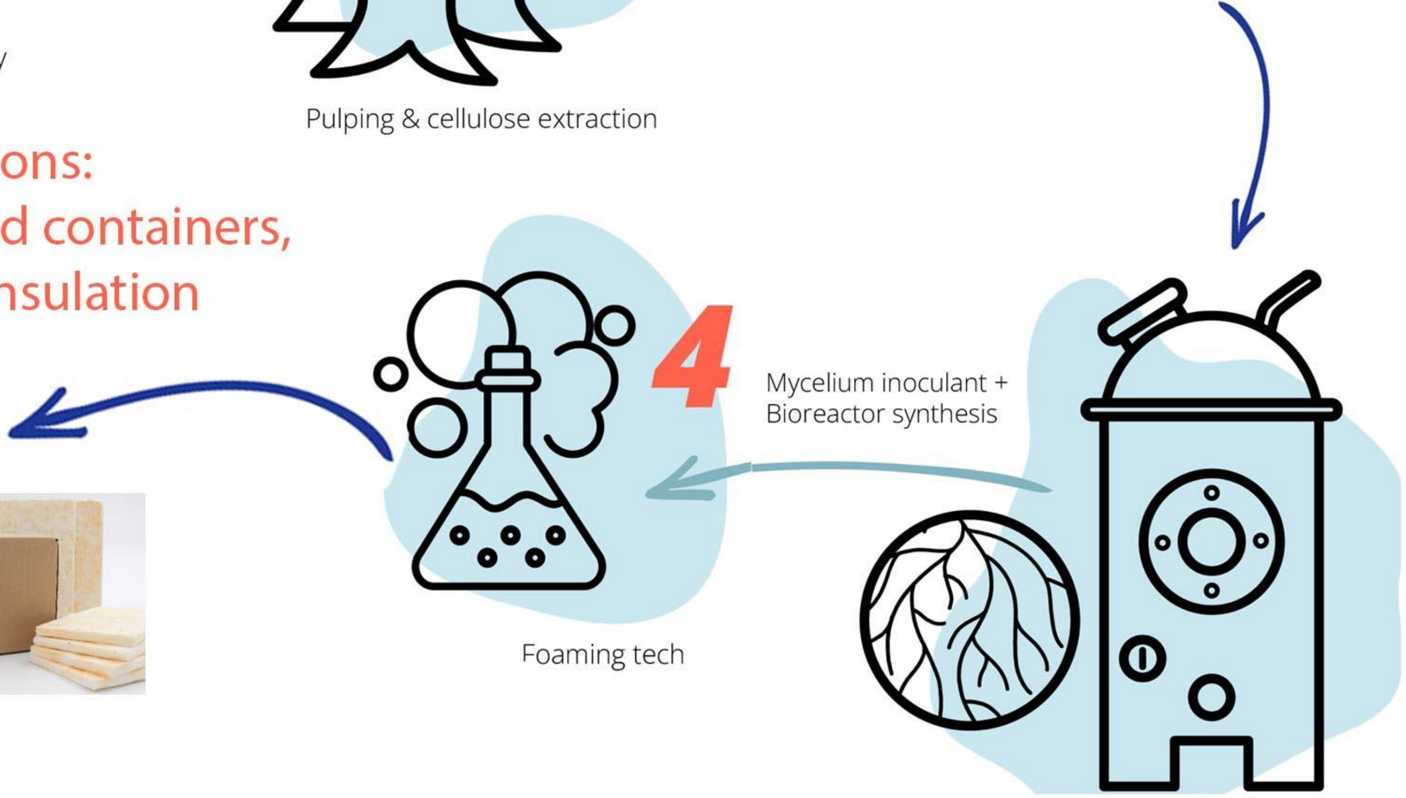



A. Pure fungal mycelium used in the biofoam, SEM image at X4,000.
B. Pure fungal mycelium used in the biofoam, SEM image at X2,000.
C. Sample of biofoam showing the feedstock bound by the hyphae.
D. Biofoam showing the feedstock bound by the hyphae.

Cellulose-mycelium composites: 3-d matrix consisting of cellulose fibers and nutritive substrate bound together by hyphae.

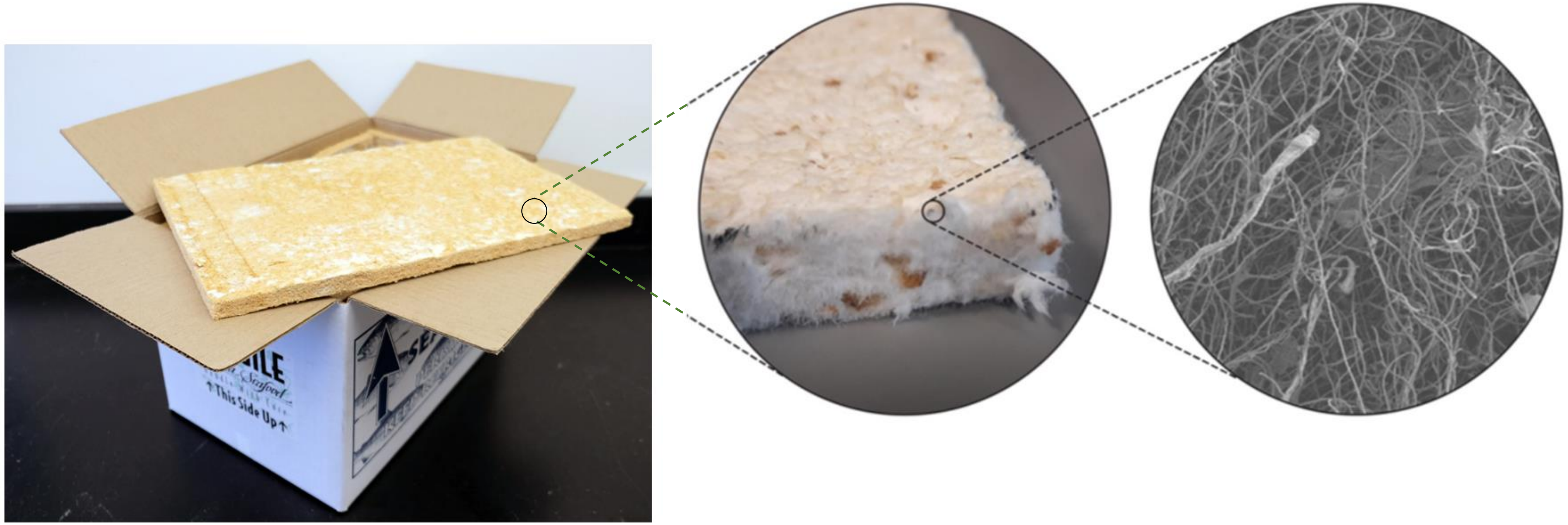
Bio-based fabrication





Potential applications:
zero-waste seafood containers, fishing gear, and insulation

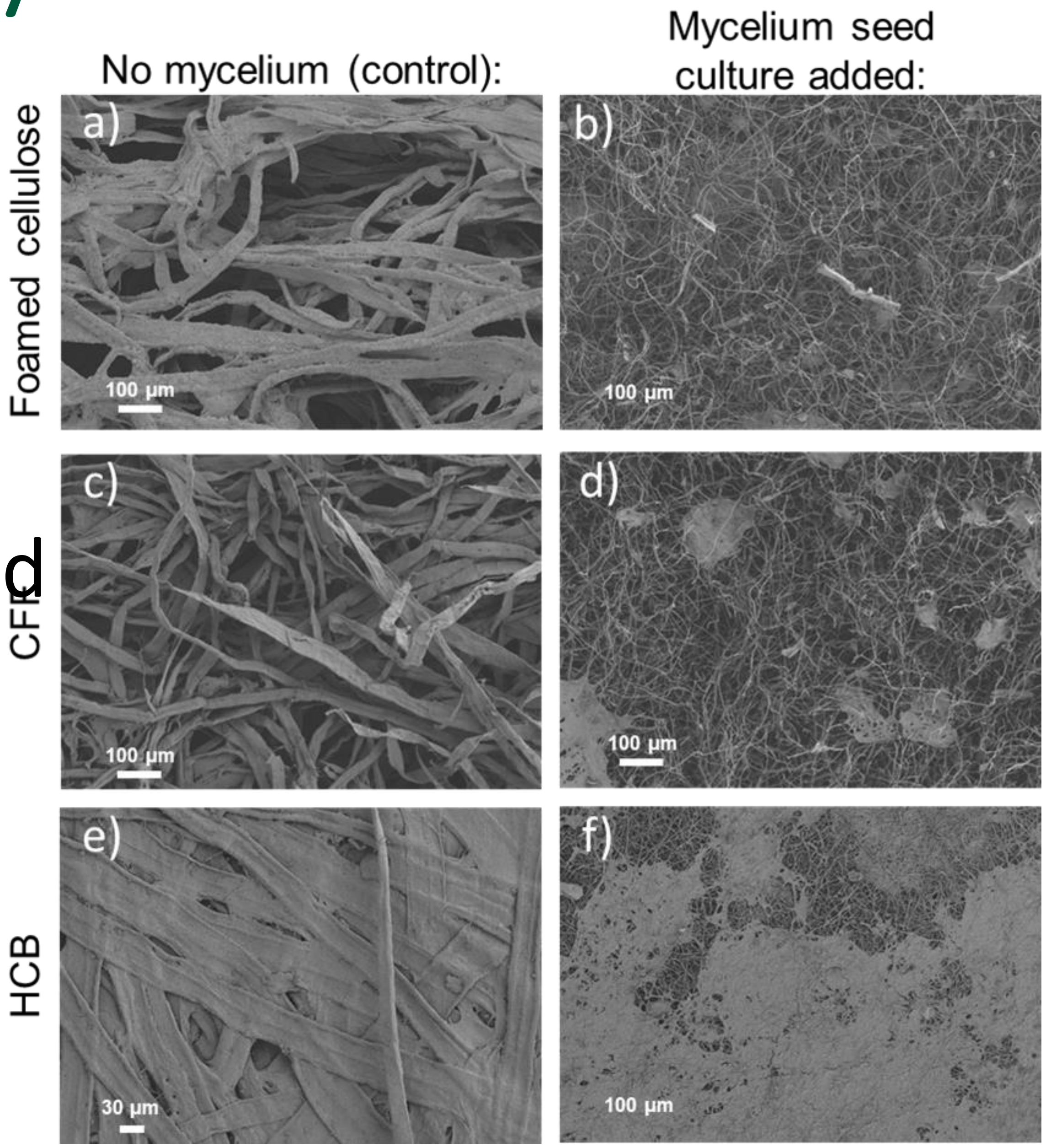
Development of cellulose-mycelium fish boxes



Non-plastic cold-chain packaging could transform fish coolers into carbon sinks

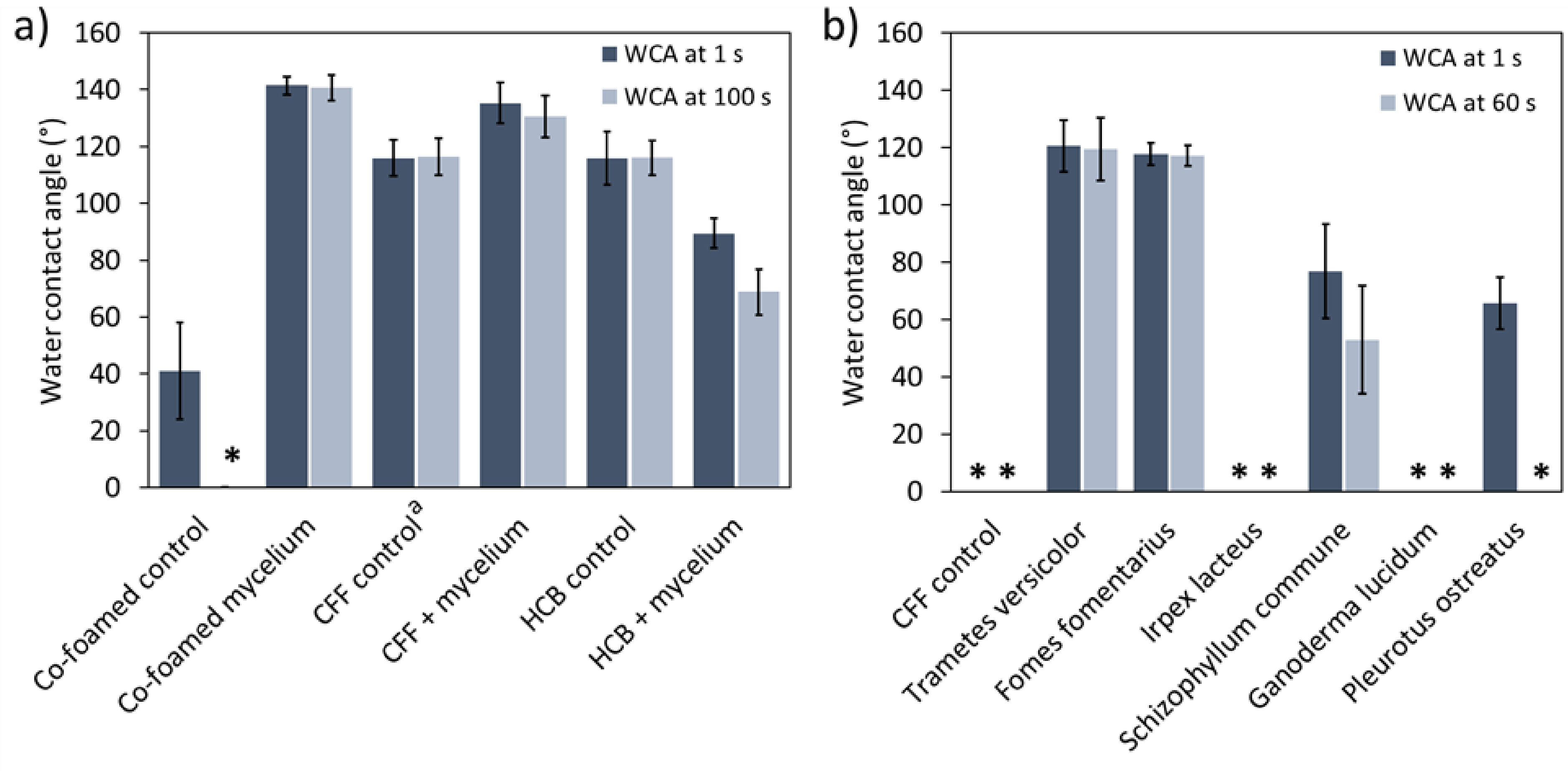
Key properties of mycelium foams

- Hydrophobins provide water repellence
- Mycelium consumes cellulose and forms a strong 3-D scaffold
- Incubation time is required
- Material can be poured into a mould and then incubated



Comparison of cellulose to mycelium foam

WCA analysis

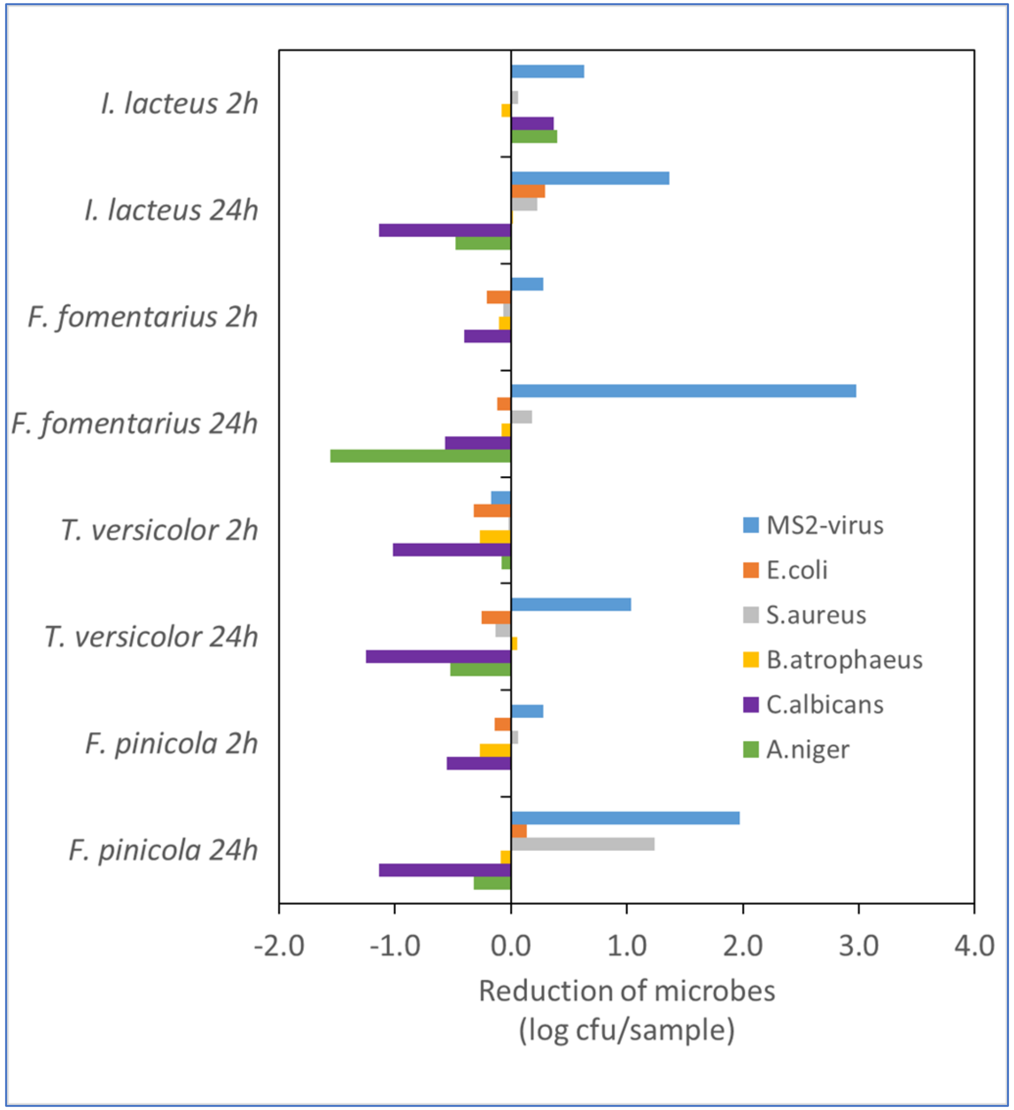


Water contact angle (WCA) values on material surface. a) Measurements of WCA on materials prepared using *T. versicolor*. b) WCA values on CFF+Mycelium and control materials using various fungal species. The WCA was not measured on samples where the water droplet penetrated into the material and these measurements were marked with an asterisk (*) and the materials defined as hydrophilic. The CFF control sample contained a hydrophobic sizing agent (Fennosize KD364M).

Tests on antiviral and antimicrobial properties

- Tests of antimicrobial activity of homogenized cellulose-mycelium foam produced with strains of *Irpex lacteus, Fomes fomentarius, Trametes versicolor* and *Fomitopsis pinicola*

(modified standard EN 1276: 2019 "EU Chemical disinfectants and antiseptics").



Antimicrobial activity analysis

Cellulose feedstock from insect-killed conifers, cardboard, or agricultural waste (i.e., corn stover)

Beetle killed spruce in Kenai Alaska

Dendroctonus rufipennis outbreak in Central Alaska
Source https://www.fs.usda.gov/inside-fs/delivering-mission/sustain/alaska-impacted-most-recent-spruce-beetle-outbreak

Harvested beetle killed spruce for sample production

Properties of mycelium-cellulose foam

Water repellent

(EPS 90°, CoFoam 140°, CoFoam performs better)

Insulative

(comparable thermal performance with EPS)

Physically strong

(mycelium chitin structures partially stronger than steel)

Compostable

Selective antimicrobiality

(reduces the amount of time viruses and bacteria are viable on surfaces, arising from the natural features of mycelium)

Main Findings:

- **100% biodegradable in nature**
- **0% petroleum based**
- **Water repellent surface (contact angle 140°)**
- **Comparable thermal performance with EPS**
- **Microbial resistance arising from mycelium**


Forest soil cores 6 months after mixing with
Mycelium-cellulose Board. EBL Research site, Central Alaska

Thank you the fishing communities of Nulato, Galena, & Homer, Alaska!

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