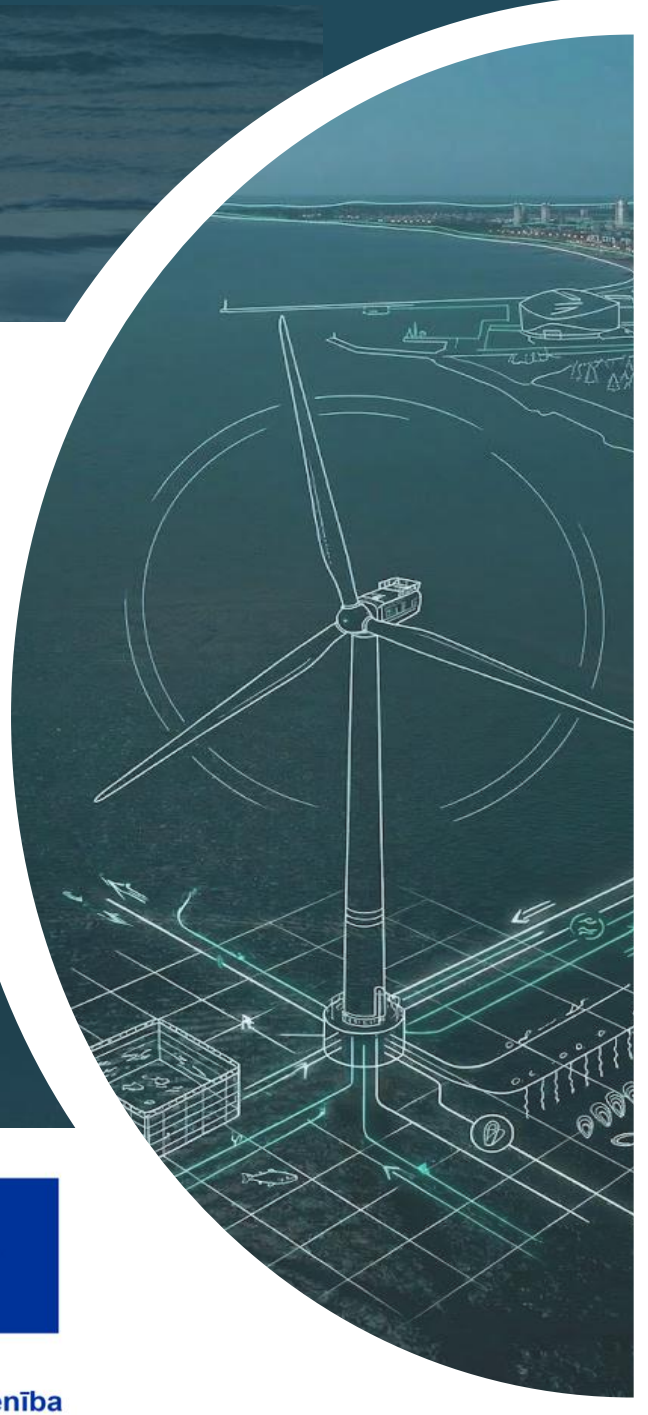
# JŪRAS SINERĢIJAS FORUMS



## BALTIJAS GLIEMEŅU BIOMASAS PIEVIENOTĀS VĒRTĪBAS RADĪŠANA


**Indrek Adler**

Akvakultūras un biomasas valorizācijas pētnieks
Tartu Universitātes Igaunijas Jūras institūts


FARMS ULT

KURZEMES PLĀNOŠANAS REĢIONS

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TARTU ÜLIKOOL

# CREATING ADDED VALUE FROM BALTIC MUSSEL

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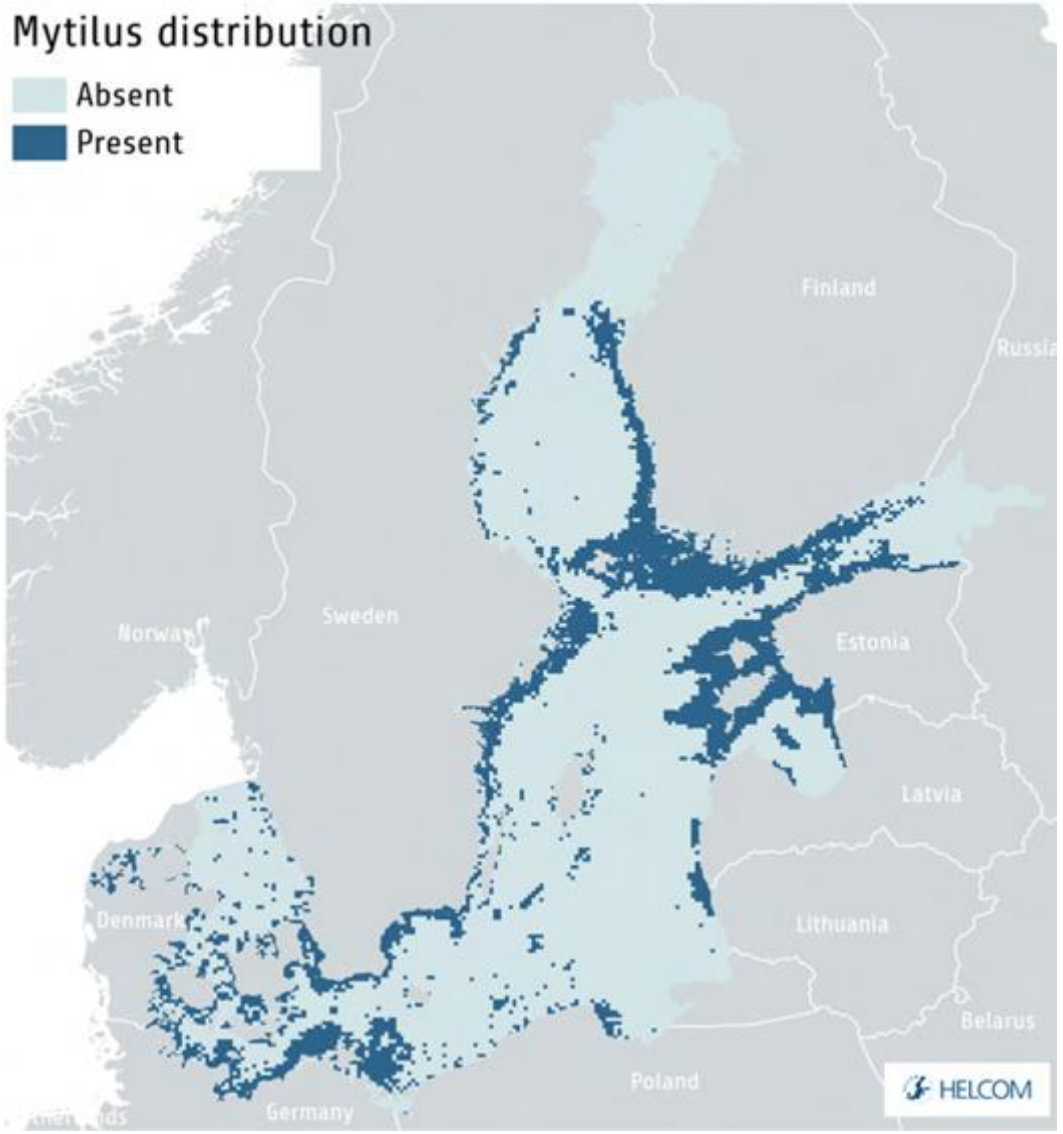
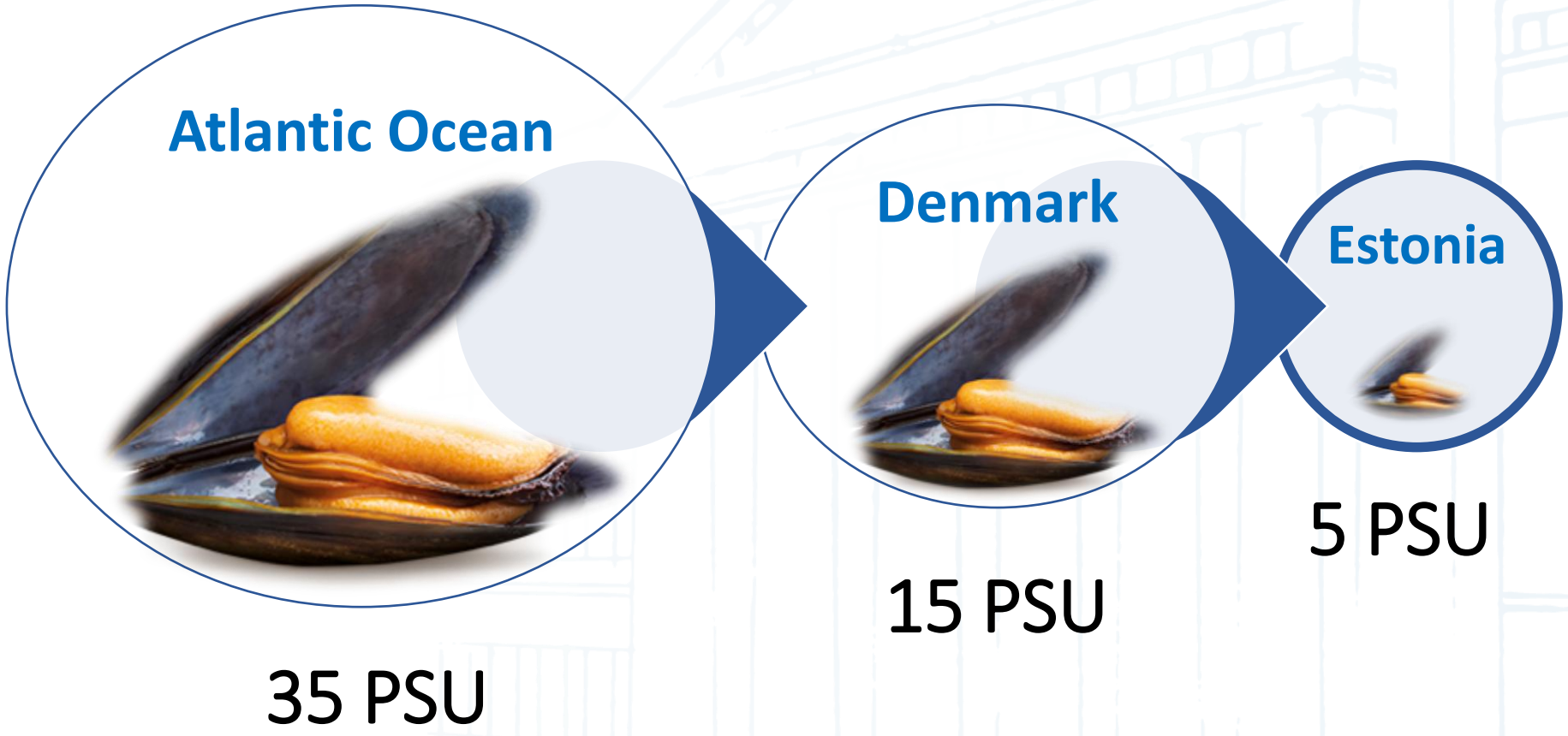
16.04.2026

# Ecological Importance of Blue Mussels in the Baltic Sea

- Widespread but environmentally constrained distribution
- Key ecosystem role
- Baltic-specific adaptation
- Hybrid species



# The Salinity effect



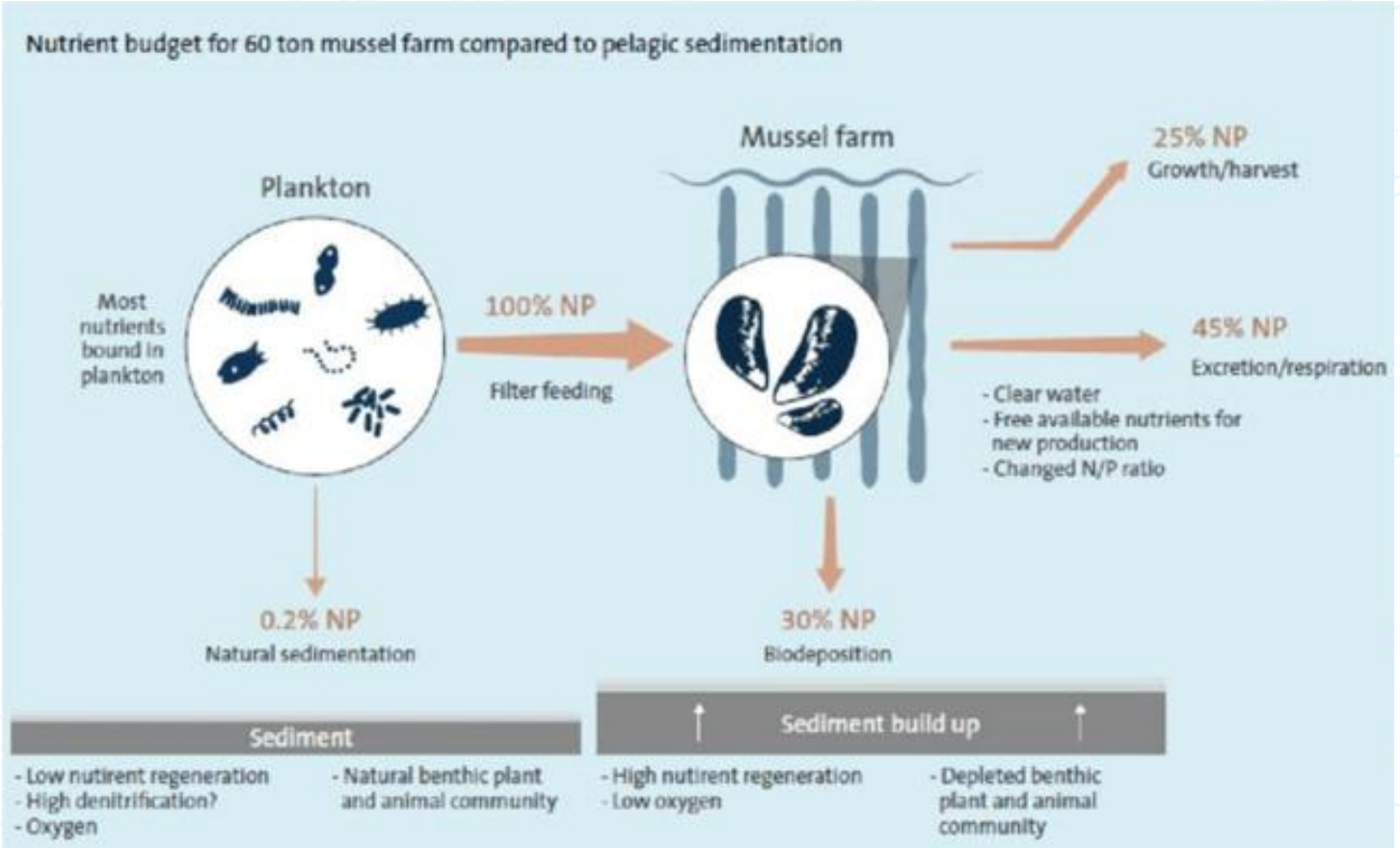
# Nature-positive impact of an individual farm

**Farm area is approximately 27 ha, therefore:**

**N removal:** ~14.4 kg/ha/year

**P removal:** ~1.6 kg/ha/year

**$CO_2$ capture:** ~0.85 t/ha/year

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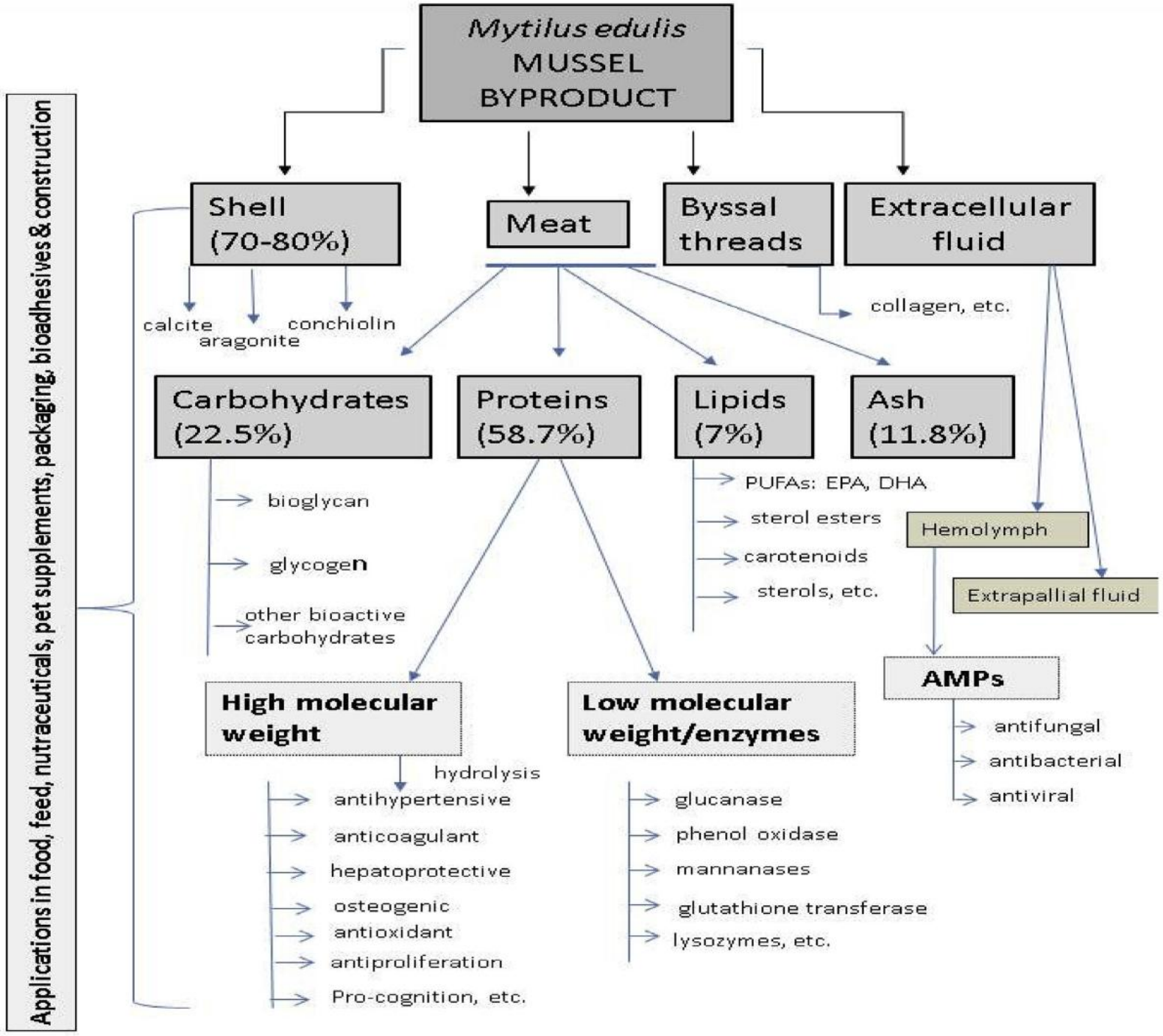
**These values are equivalent to the annual nutrient removal capacity of a small wastewater treatment plant (serving 700–875 inhabitants).**




# Chemical composition of Blue mussel

**Naik A.S, Hayes M.** (2019). Bioprocessing of mussel by-products for value added ingredients.

*Trends in Food Science & Technology*, Vol 92 pp 111-121

# High-Value Components in Baltic Mussels

### Bioactive molecules

- **Glycogen**

✓ Fast-access energy polymer; potential cosmetic active and functional ingredient

- **Marine peptides / protein hydrolysates**

✓ Cosmetic, nutraceutical and functional formulation potential

- **Mytilin**

✓ Antimicrobial peptide with biomedical interest

### Lipid and nutrient fractions

- **EPA**

✓ Anti-inflammatory omega-3 with nutritional and cosmetic relevance

- **DHA**

✓ Premium omega-3 associated with brain and eye development

- **Pigment-rich fraction**

✓ Minor but potentially valuable antioxidant/cosmetic side-stream

### Shell-derived value streams

- **Nacre-derived fraction**

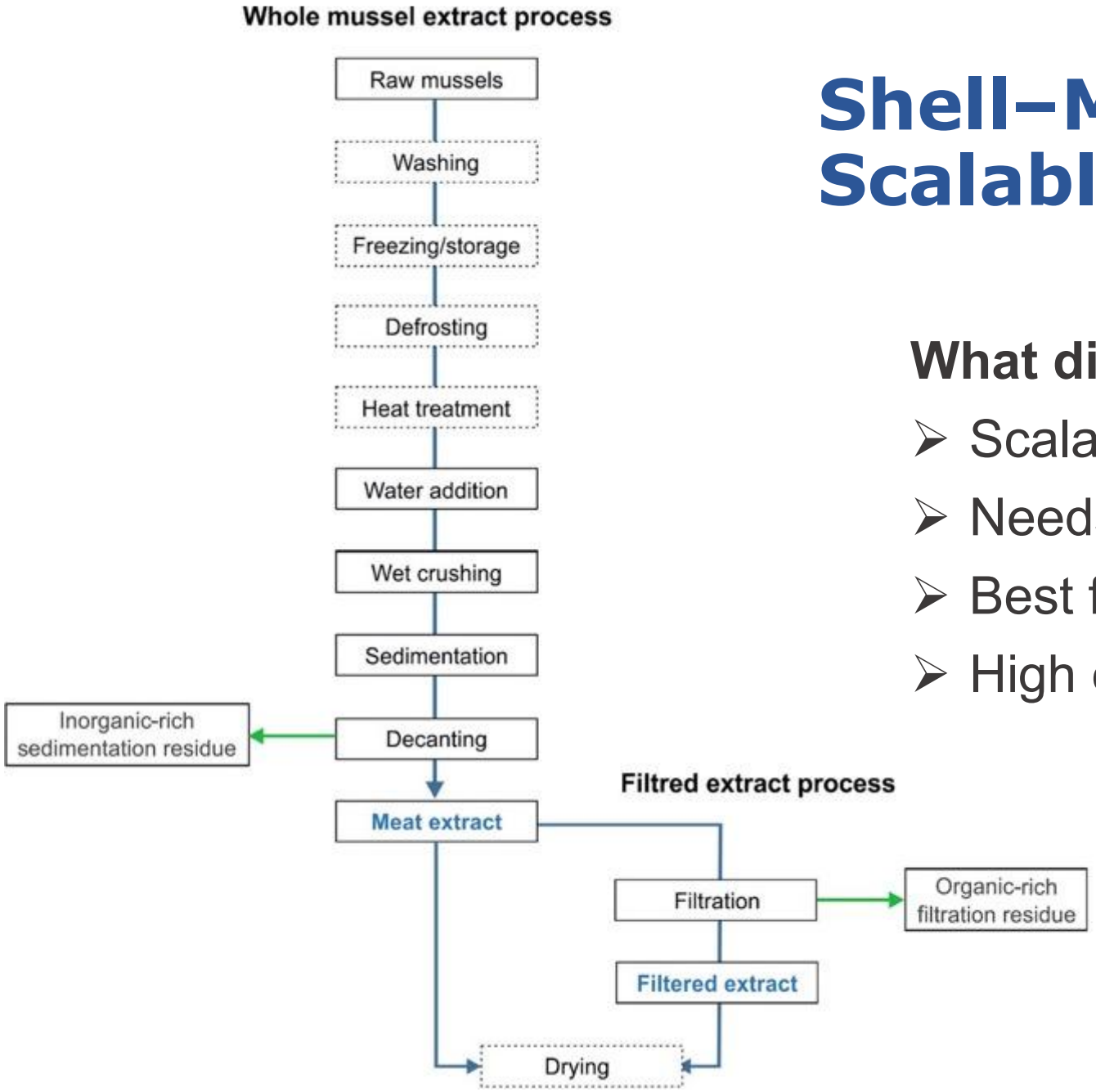
✓ Pearlescent mineral ingredient for cosmetics and decorative applications

- **Calcium carbonate ($CaCO_3$)**

✓ Bulk mineral stream for fillers and biomineral products

- **Byssus-derived proteins**

✓ Wet-adhesion proteins of interest for biomaterials research



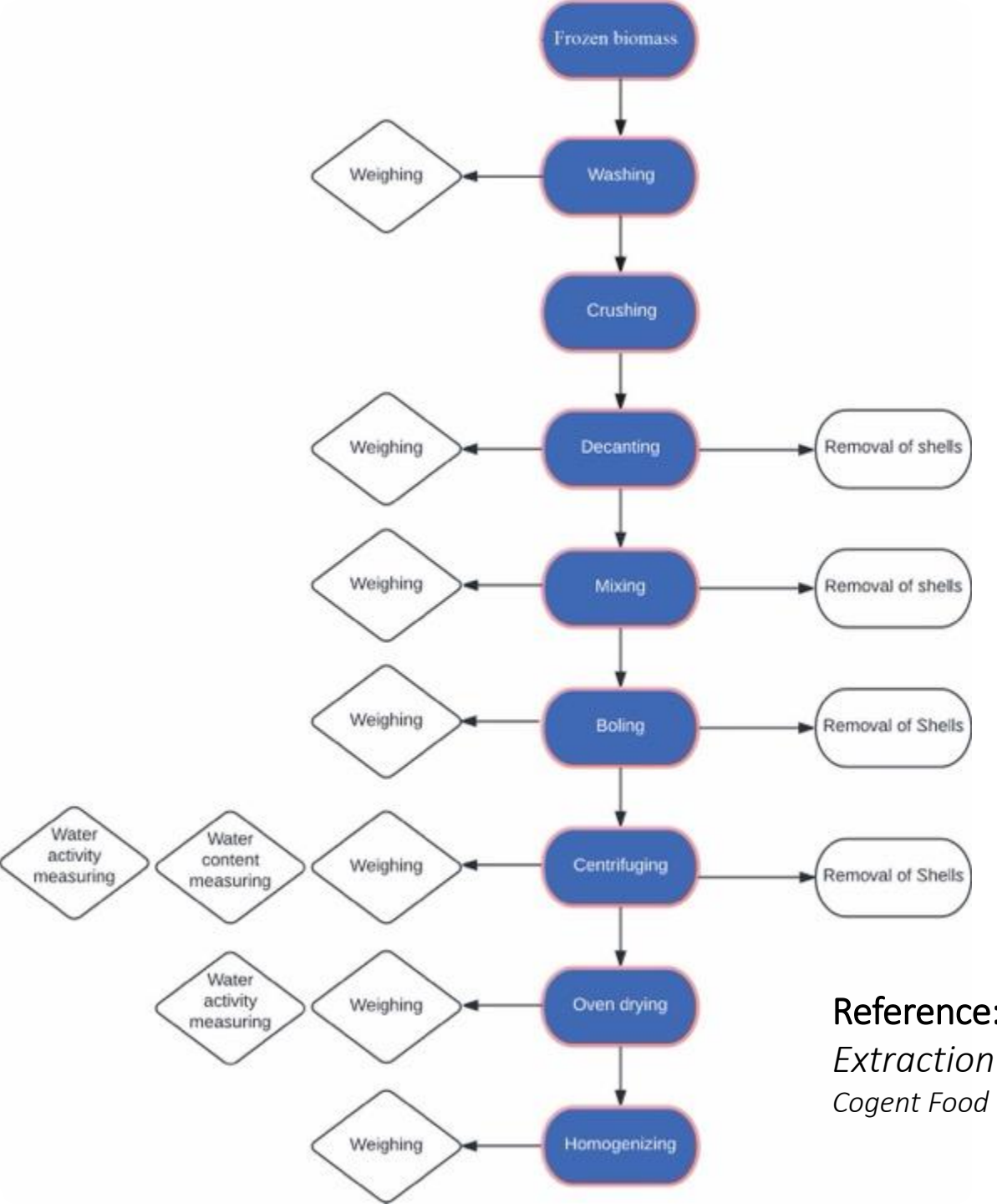

# Shell–Meat Separation as a Scalable Processing Route

## What did we learn?

- Scalable
- Needs refining
- Best for protein-focused recovery
- High energy and excess water

Reference: *Optimizing the processing of shellfish (Mytilus edulis and M. trossulus hybrid) biomass cultivated in the low salinity region of the Baltic Sea for the extraction of meat and proteins*

*Avaldatud: 20.05.2022, Applied Sciences (https://www.mdpi.com/2076-3417/12/10/5163)*

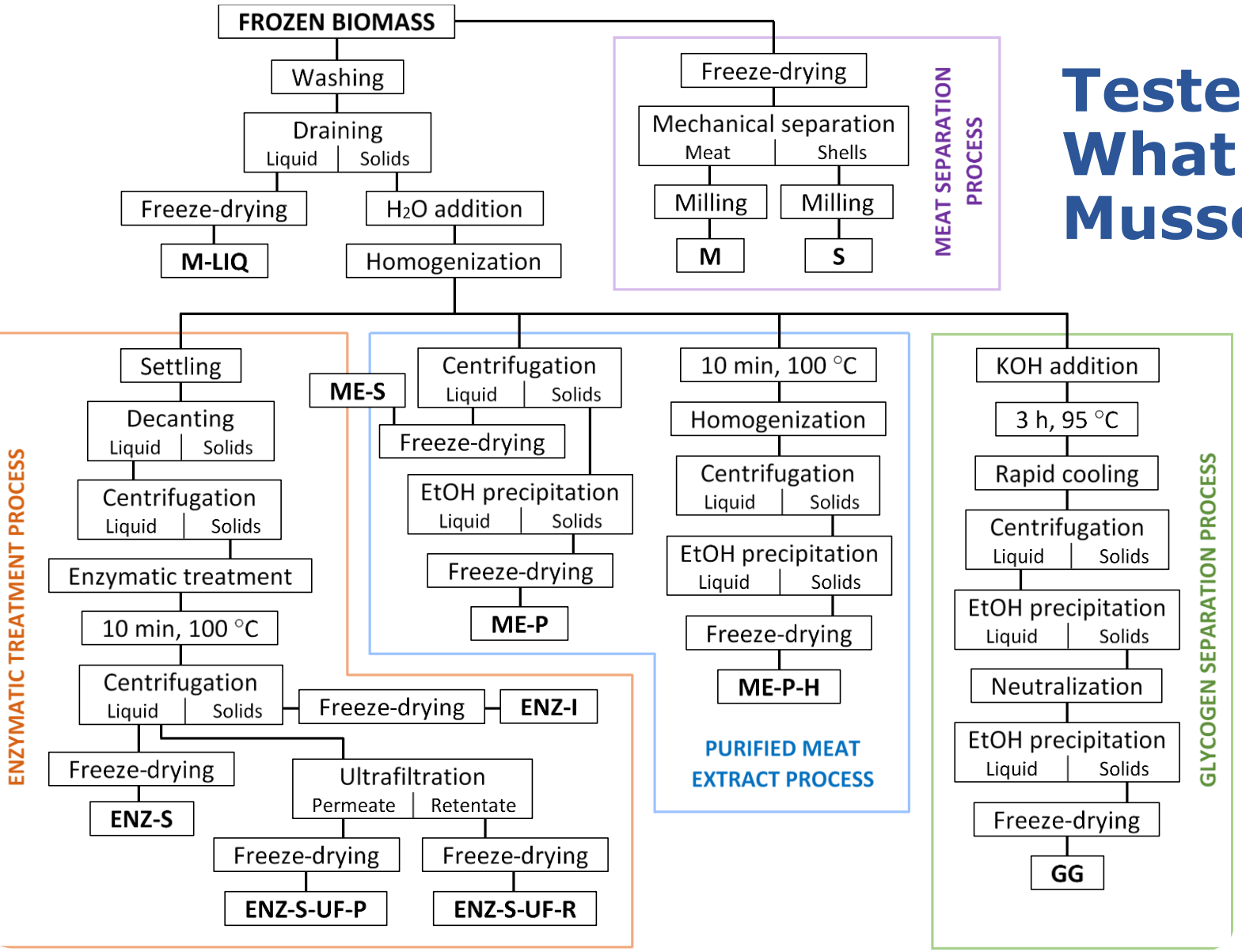



# Optimising Shell–Meat Separation

## What did we learn?

- Mussel texture is season-dependent
- Yield can be improved through process tuning
- More processing is not always better
- Taste and odor issues are manageable

Reference: *Unlocking the Potential of Shellfish Biomass: Refining Protein Extraction from Baltic Blue Mussels for Sustainable Food Applications*
*Cogent Food & Agriculture https://doi.org/10.1080/23311932.2024.2405880*



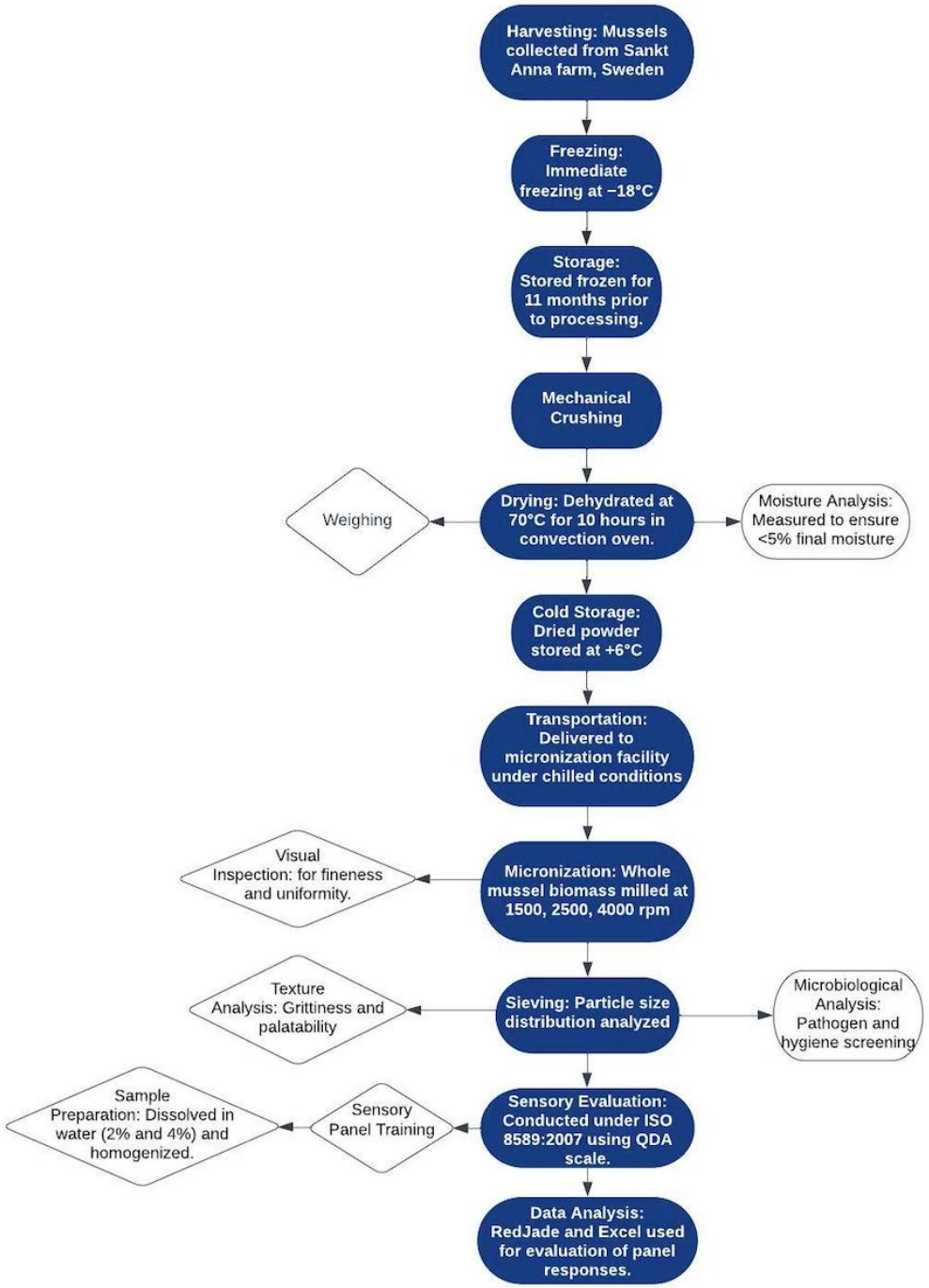

# Tested Processing Routes: What Did They Reveal About Mussel Biomass Value?

## What did we learn?

- Season strongly affects composition
- Mussels are rich in omega-3s and essential amino acids
- Enzymatic treatment improves prebiotic potential
- Biomass has value for both nutrition and sustainability

**Teadusartikkel :** *Valorization of Baltic Sea farmed blue mussels: Chemical profiling and prebiotic potential for nutraceutical and functional food development*

*Avaldamisele: Oktoober 2024, Food Chemistry X (https://www.sciencedirect.com/science/article/pii/S2590157524006242?via%3Dihub)*




# Whole-Biomass Micronisation: Turning a Raw Material into a Functional Platform

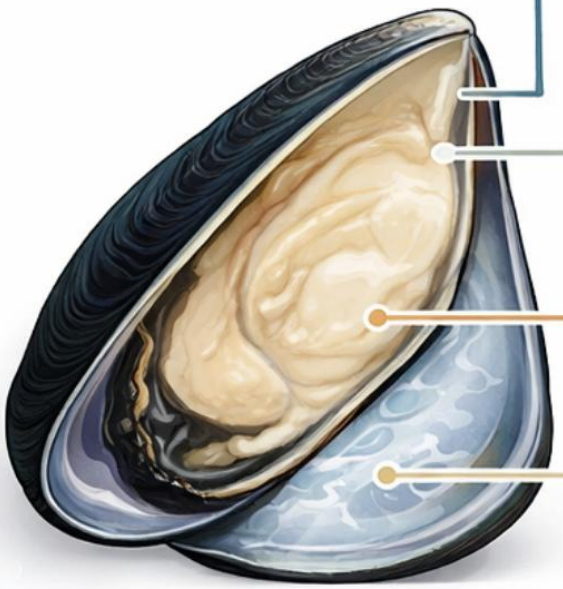
## What did we learn?

- Fine milling improves palatability
- Creates a strong platform for downstream extraction
- Supports full-biomass utilisation
- Near-term fit: feed; longer-term potential: food

Reference : *Micronization of Low-Salinity Baltic Sea Blue Mussels: Enhancing Whole-Biomass Utilization and Nutritional Viability*
*Fishes 2025, 10(5), 199; https://doi.org/10.3390/fishes10050199*

# Why Whole-Biomass Fractionation?

## Baltic mussels are not one product — they are a multi-fraction raw material



**Glycogen**
- Fast-access energy polymer

**Proteins / peptides**
- Marine bioactives

**Lipids / omega-3**
- Omega-rich fraction

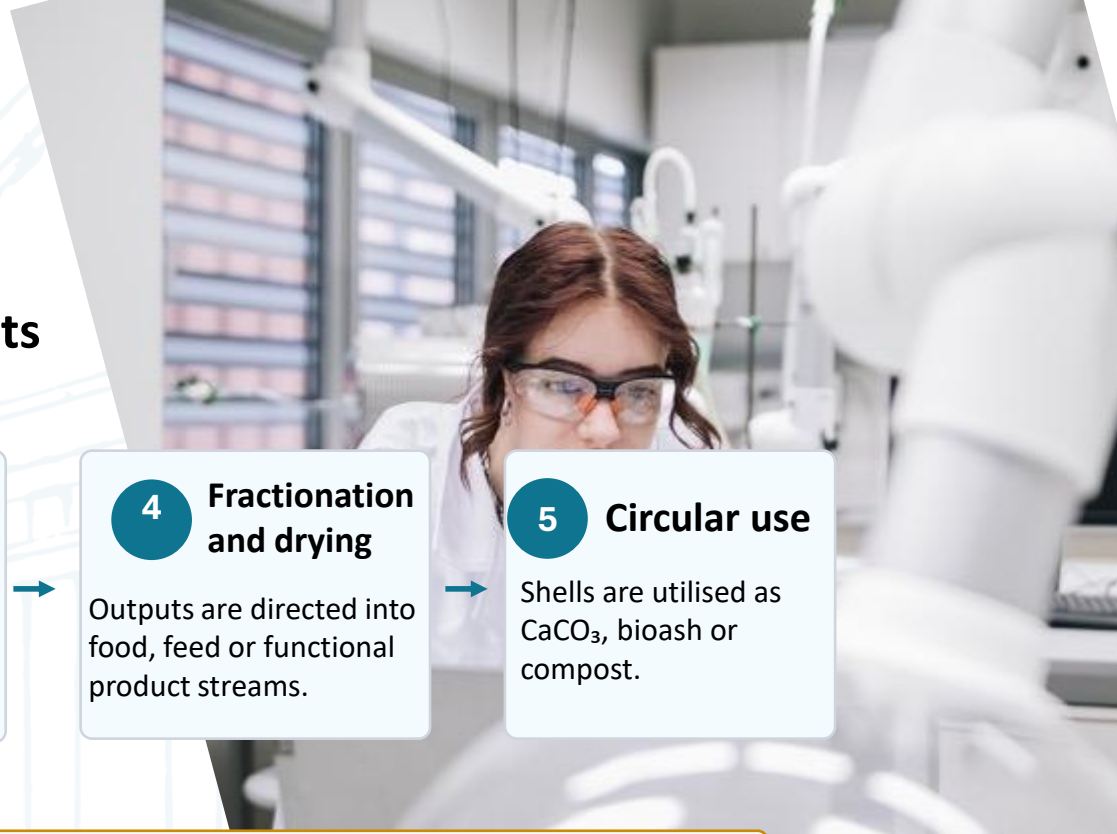
**Shell minerals / nacre**
- Pearlescent calcium carbonate

- ✓ High-value fractions are dispersed across the whole biomass
- ✓ Meat-only processing leaves significant value in the shell and minor fractions
- ✓ Micronisation creates a uniform feedtock for selective extraction
- ✓ This enables a cascade from one biomass into multiple product streams

**The objective is not separation for its own sake**— it is to unlock several value layers from the same tonne of mussels.

# Pilot Plant Process Logic

## Focus on full biomass valorisation and circular use of by-products



**1 Raw material and pre-treatment**

Mussels from sustainable aquaculture are cleaned and homogenised.

→

**2 Wet micronisation and separation**

A water-cooled process produces a homogeneous mass (<63 µm).

→

**3 Extraction and hydrolysis**

Lipids, pigments and protein fractions are separated.

→

**4 Fractionation and drying**

Outputs are directed into food, feed or functional product streams.

→

**5 Circular use**

Shells are utilised as $CaCO_3$, bioash or compost.

### Expected product portfolio

- Omega-3 enriched lipid fractions
- Astaxanthin and other pigments
- Protein hydrolysates for functional ingredients
- $CaCO_3$-based mineral products for fertilisers or fillers

### Core innovation

- Technology adapted to small Baltic mussels, not imported standard solutions
- Whole biomass utilisation – not only meat extraction
- Scalable model extendable to other low-trophic species

# Target Product Streams and End Uses

One biomass cascade → multiple value-added ingredients


## Glycogen-rich active

Lead fraction for premium cosmetic positioning

- Skin hydration and vitality concepts
- Functional marine active
- High-value, low-volume ingredient

## Marine protein / peptide fraction

Bioactive and functional ingredient stream

- Cosmetic formulations
- Hydrolysates / peptide-rich extracts
- Potential nutrition and feed crossover

## Nacre-derived pearlescent mineral

Shell-based premium mineral fraction

- Pearlescent cosmetic powders
- Decorative fillers
- High-value shell valorisation

## Residual $CaCO_3$ mineral stream

Bulk circularity outlet

- Fillers
- Biomineral products
- Fertiliser / technical applications

**The pilot plant is designed not to make one product**, but to unlock a portfolio of premium actives, functional ingredients, and circular mineral streams.

# Why Circularity Matters

Turning low-value residue into multiple usable output streams improves economics and sustainability.

## Meat-focused processing

- High-value fraction removed
- Shell and residual biomass become waste or low-value residue
- Disposal, odor, logistics, and lost-value problem

Waste

## Whole-biomass biorefinery

- Glycogen-rich active
- Protein / peptide fraction
- Nacre / pearlescent shell fraction
- Residual $CaCO_3$ mineral stream


✓ Multiple value layers

**Circularity is not only an environmental principle—it is the economic logic that makes low-value biomass worth processing.**

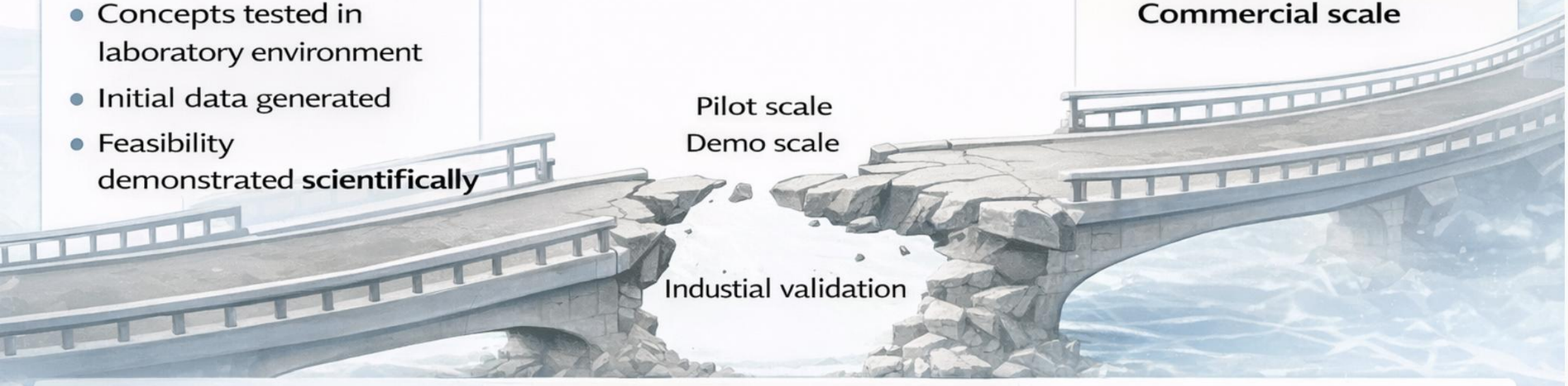
# **The Missing Link:** From Laboratory Proof to Industrial Validation

## Research / Lab

- Concepts tested in laboratory environment
- Initial data generated
- Feasibility demonstrated **scientifically**

## Industry / Market

**Commercial scale**




✓ **Lab scale**
Concepts tested in laboratory environment

✓ Initial data generated

✕ Public sector: too experimental

✕ Private sector: too risky

✕ SMEs: too small to carry R&D risk alone

Without support for pilot and demonstration scale, innovation remains scientifically promising but commercially stranded.

# Regulatory Bottlenecks

Excessive permit fees and complex procedures are blocking the path from pilot projects to real-world impact.


### PERMIT FEE FORMULA

Area ($m^2$) × land value × **3%**

### EXAMPLE: TAGALAHT PERMIT AREA

276,000 $m^2$ × €4.51 × 3%

= **€37,342.80** per year

### THE REALITY

Significant annual cost **BEFORE** any revenue exists

- Creates a major barrier for pilot and demo projects
- Disproportionately impacts SMEs and innovators
- Discourages investment in sustainable solutions
- Delays the transition to a circular blue economy

Even environmentally restorative aquaculture **cannot sustain** annual permit fees of more than **€37,000 — not** at pilot stage, and **not even with a proven business model.**

# “Misaligned Incentives in Environmental Policy”

**Oil shale mining**

100 t of oil shale

Extraction fee ≈ €100

Area affected ≈ 0.1 ha

Restoration cost: €2,000–8,000

Environmental impact: irreversible / long-term

$CO_2$ emissions, groundwater and landscape damage

**Blue mussel farming**

100 t of blue mussels

Construction (use-of-water) fee ≈ €38,000

Area used: 27 ha of sea

Restoration cost: €0

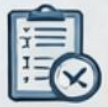
Environmental impact: positive

Removes N and P, filters water, sequesters $CO_2$, restores habitat

**Fun Fact : In Estonia, it is 380 times more expensive to clean the environment than to destroy it**

# Unlocking the Blue Bioeconomy's Potential

Strategic Directions for Advancement



## Streamline and Differentiate Regulations

- Optimise permitting & classification logic
- Reduce bureaucratic planning and licensing barriers
- Align incentives to reflect different impacts

## Support Applied Research & Innovation

- Create funding pathways for pilot and demo-scale validation
- Enable interdisciplinary scientific collaboration
- De-risk breakthrough ventures in sustainable blue growth

## Facilitate Industrial Scale-Up Pathways

- Target strategic funding to pilot and industrial at-scale demonstration
- Build public-private co-investment levers
- Coordinate regionally for best practice sharing

## Join Efforts Towards a Regenerative Model

- Position low-trophic blue biomass as a public-good opportunity

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