



## Transposing circular economy principles to aquaculture

Killian Chary, Anne-Jo van Riel, Ramon Filgueira, Aurélie Wilfart, Souhil Harchaoui, Abigail Muscat, Marc Verdegem, Imke de Boer, Geert Wiegertjes

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# Transposing circular economy principles to aquaculture

Review in prep.

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Session Environmental Impact and Interactions



# Introduction and context

- Food production is the main drive causing environmental change
- Circular economy (CE) as a tool for more sustainability
- Concepts originating from industrial ecology
- Recently adapted for systems that rely on biomass (food, energy, etc.)

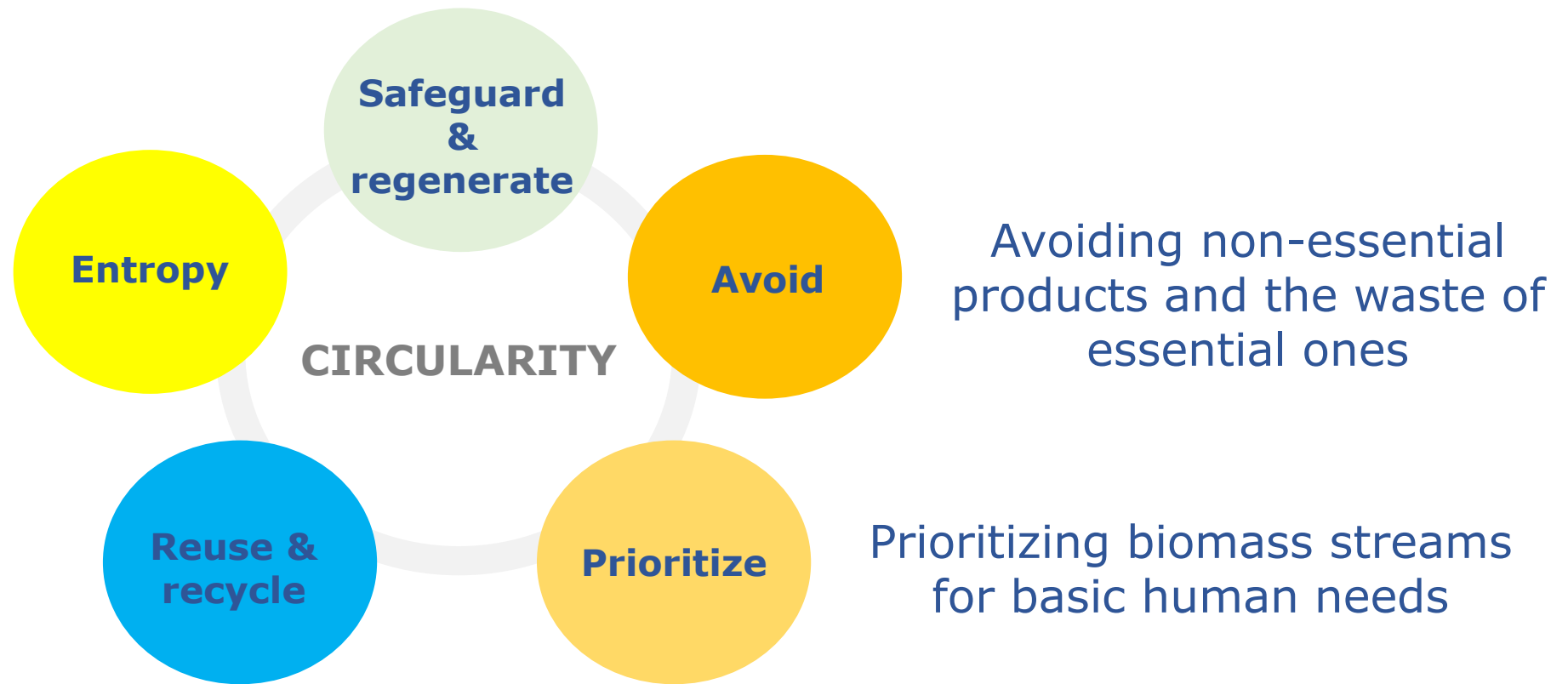


## Principles, drivers and opportunities of a circular bioeconomy

Abigail Muscat<sup>1</sup>, Evelien M. de Olde<sup>1</sup>, Raimon Ripoll-Bosch<sup>1</sup>, Hannah H. E. Van Zanten<sup>2</sup>, Tamara A. P. Metze<sup>3</sup>, Catrien J. A. M. Termeer<sup>3</sup>, Martin K. van Ittersum<sup>4</sup> and Imke J. M. de Boer<sup>1</sup>

# 5 principles to guide biomass use towards a circular bioeconomy

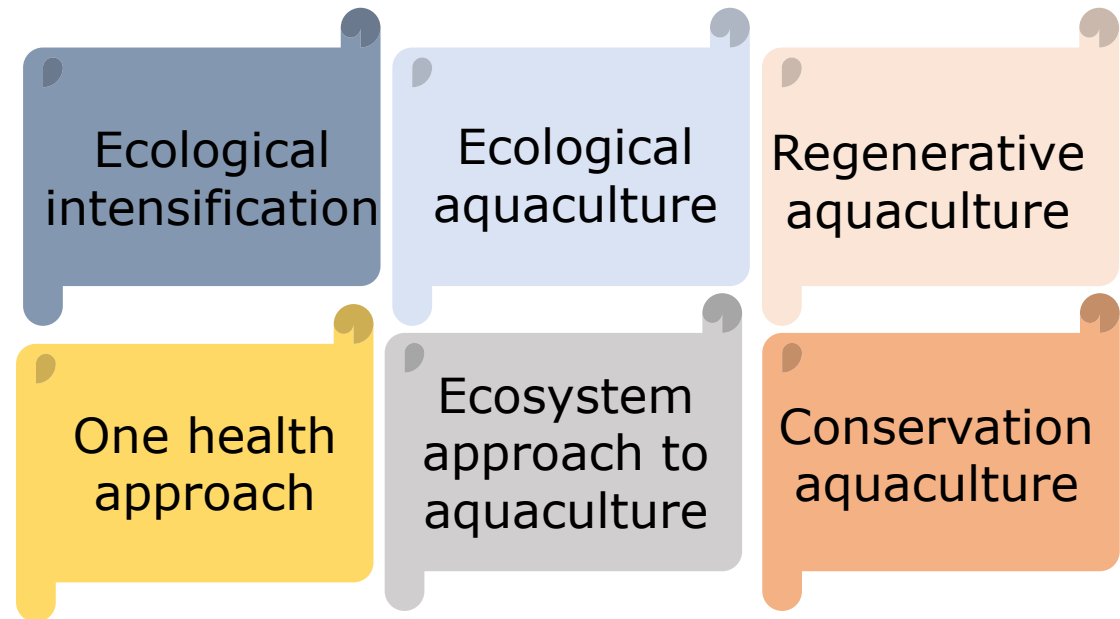
## What does it mean for Global aquaculture?



Adapted from Muscat et al. 2021

# What will be new?

- Changes in the way society legislates, produces and **consumes**
- From farm or value-chain optimization to **food system** approach.



# Principle 2: Avoiding non-essential products and the waste of essential ones

**What makes aquaculture products essential (compared to other foods)?**

Here, essential =



Nutrition & health benefits

Fill nutrient gaps and ensure well-being



Contribution to food security

Provides affordable & accessible food for all

# Nutritional and health benefits

Avoid

## Advantages over other animal source foods:

- Alternative source of protein
- Source of essential fatty acids (PUFA)
- Iron, zinc, Iodine, calcium, Vit. A, B12, D

Reduction of non-communicable disease (compared to red meat)

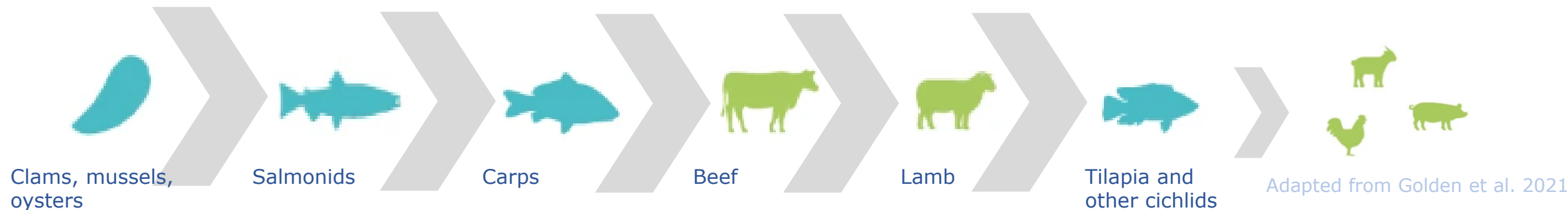


Healthy pregnancy

Growth, brain and eye development



## Mean nutrient richness of various animal source food (based on composition and daily recommended intake)



# Contribution of aquaculture to food security

**Avoid**

A topic still largely debated

Positive	Negative

Need for a finer resolution. Species level?



# Contribution of different species to food security

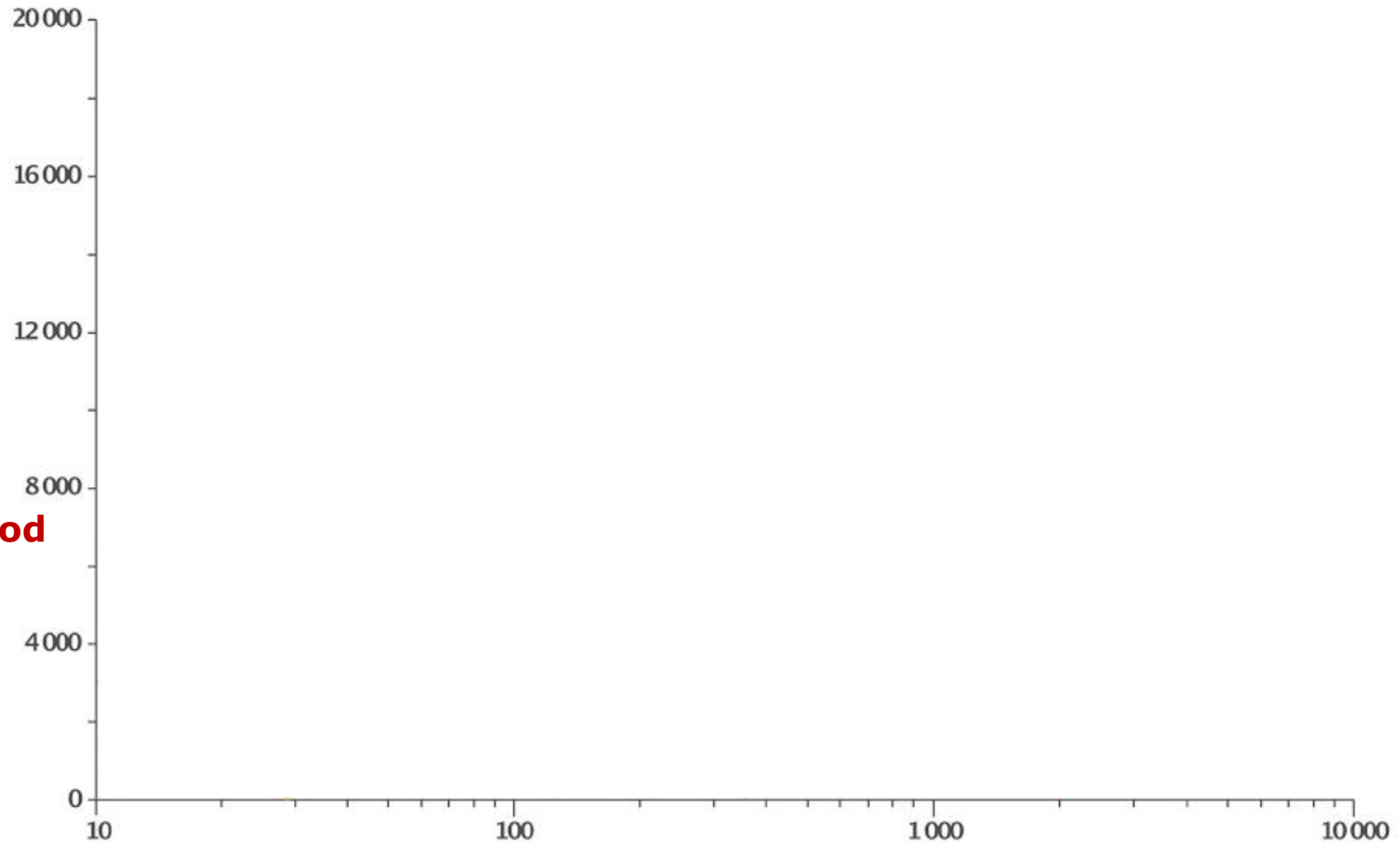
Avoid

Price (USD/ tonne) = access

## Trends:

- Cash and export crops
- Resource intensive species (feed, oxygen)
- Large environmental footprint

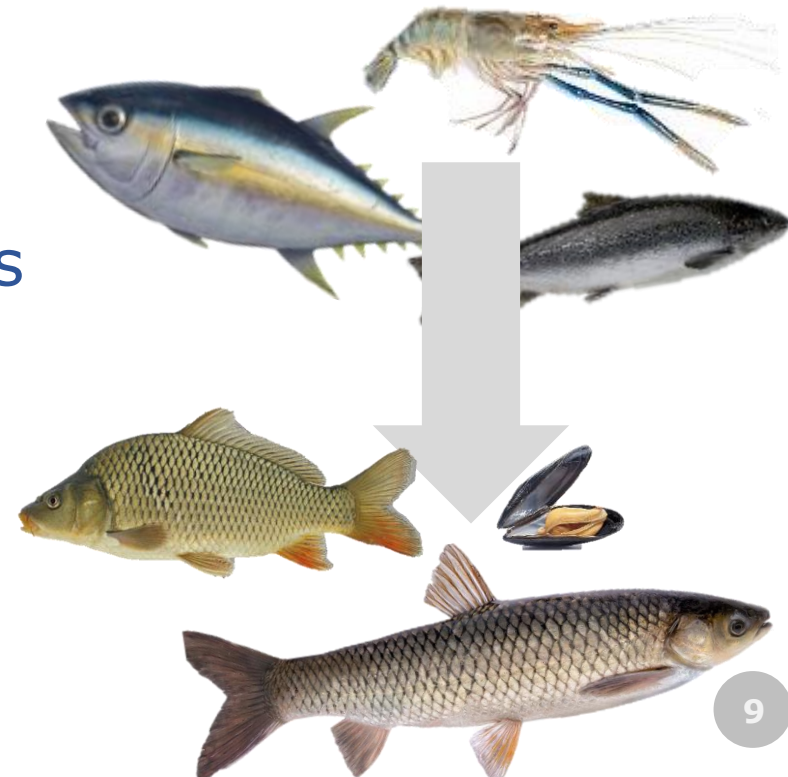
**Low contribution to food security**



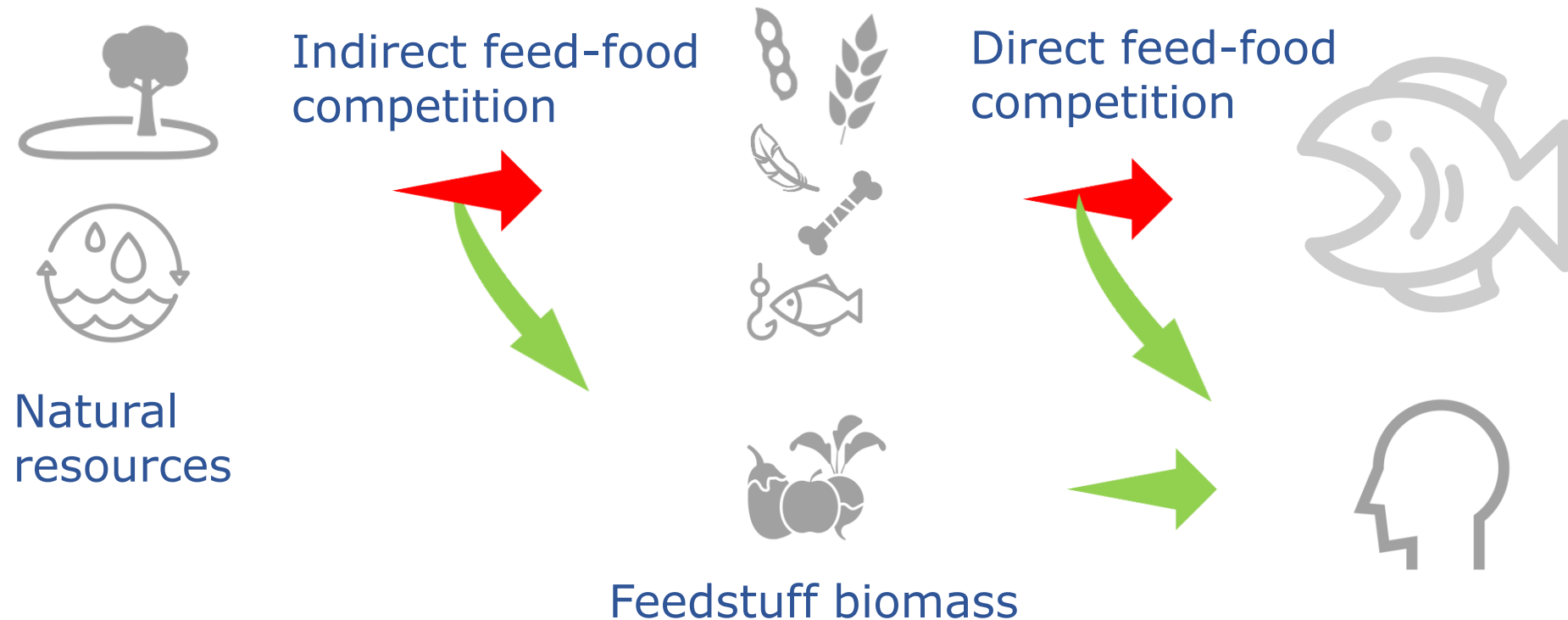
Adapted from  
Henriksson et al. 2021

# Avoiding non/less essential aquaculture products imply

- Policy-maker:
  - Prioritize nutrition-sensitive aquaculture
  - Regulate production of luxury species
- Consumer (Global North):
  - Substitute red meat by blue foods
  - Reduce consumption of luxury species
  - Shift towards less-resource intensive species



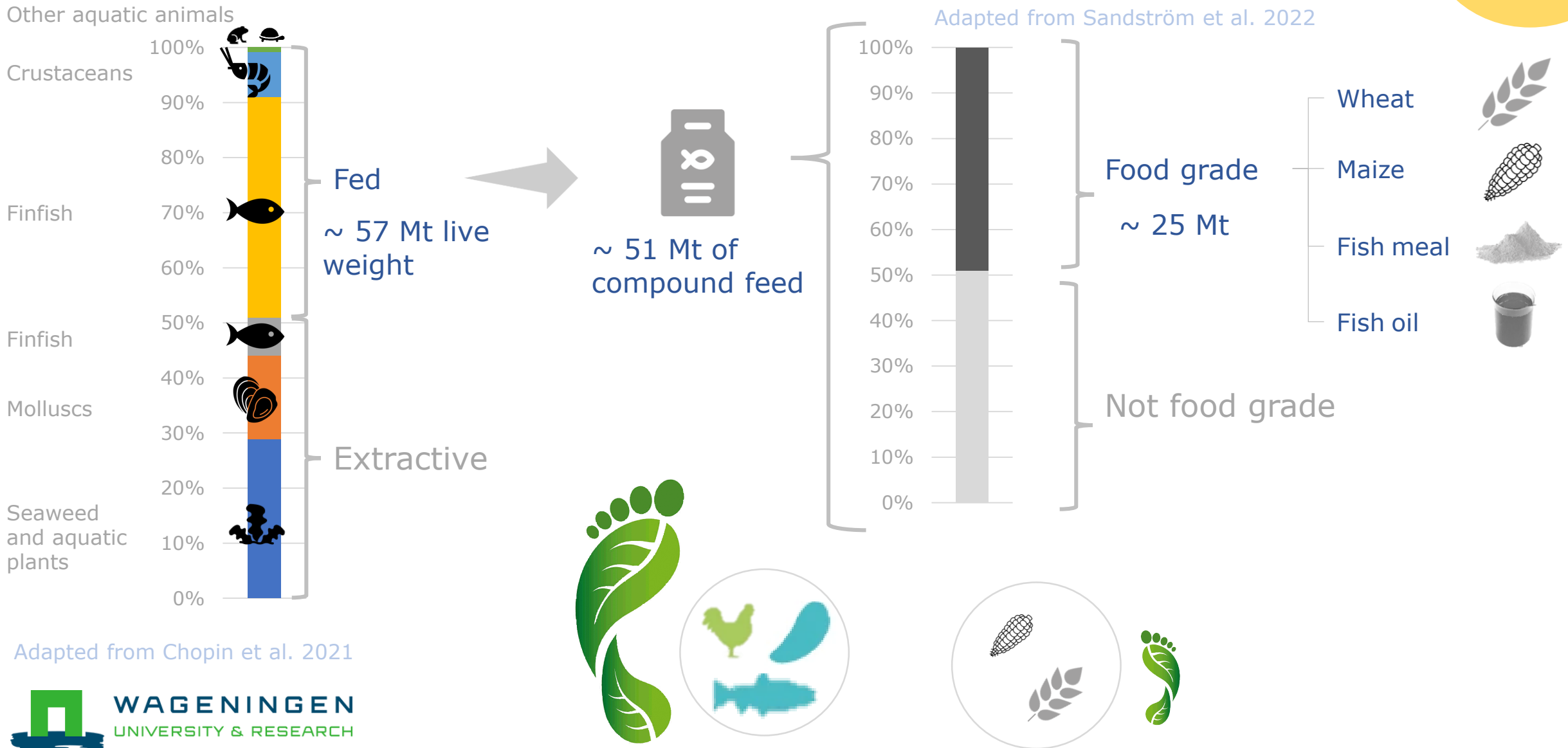
# Principle 3: Prioritizing biomass streams for basic human needs



**Is aquaculture making an efficient use of biomass and natural resources?**

# Direct feed-food competition

Prioritize

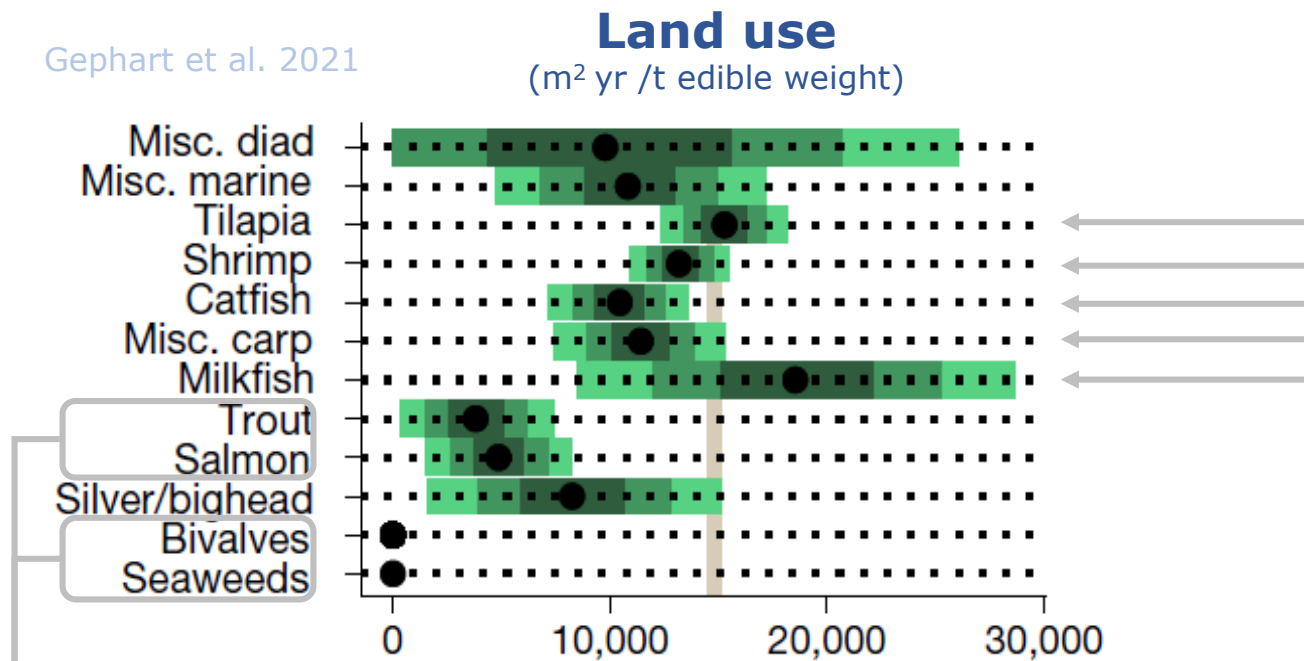


Adapted from Chopin et al. 2021

# Indirect feed-food competition

How much food could be produced from these lands?

Gephart et al. 2021



Low FCR or no feed =  
Low indirect-feed food competition

*Off-farm*



High % of plant-based ingredients

Omnivorous and/or  
pond-farmed species



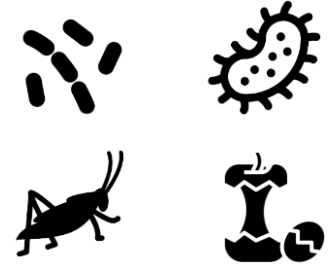
*On-farm*

Potentially large areas

# Prioritizing biomass stream for basic human needs imply

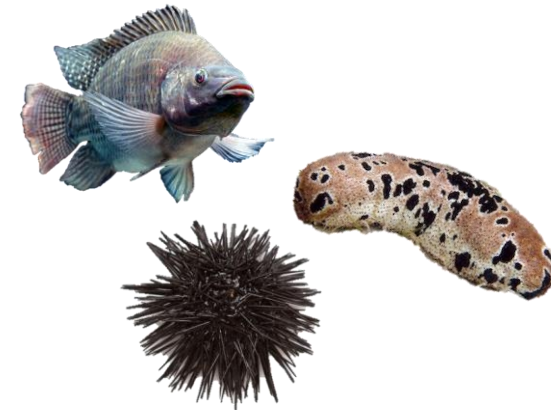
## Aquafeed manufacturer:

- Increased use of by-products and residues and other human inedible ingredients



## Farmer:

- Selection of species naturally capable of using a broad range of by-products and detritus



## Land/Marine-planner:

- Incorporate feed-food competition issues in planning

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# More to come in the full paper

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- 5 principles
- Implications for main types of species and production systems
- Recommendations for multiple actors

# Thank you !

## Contact information



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# References

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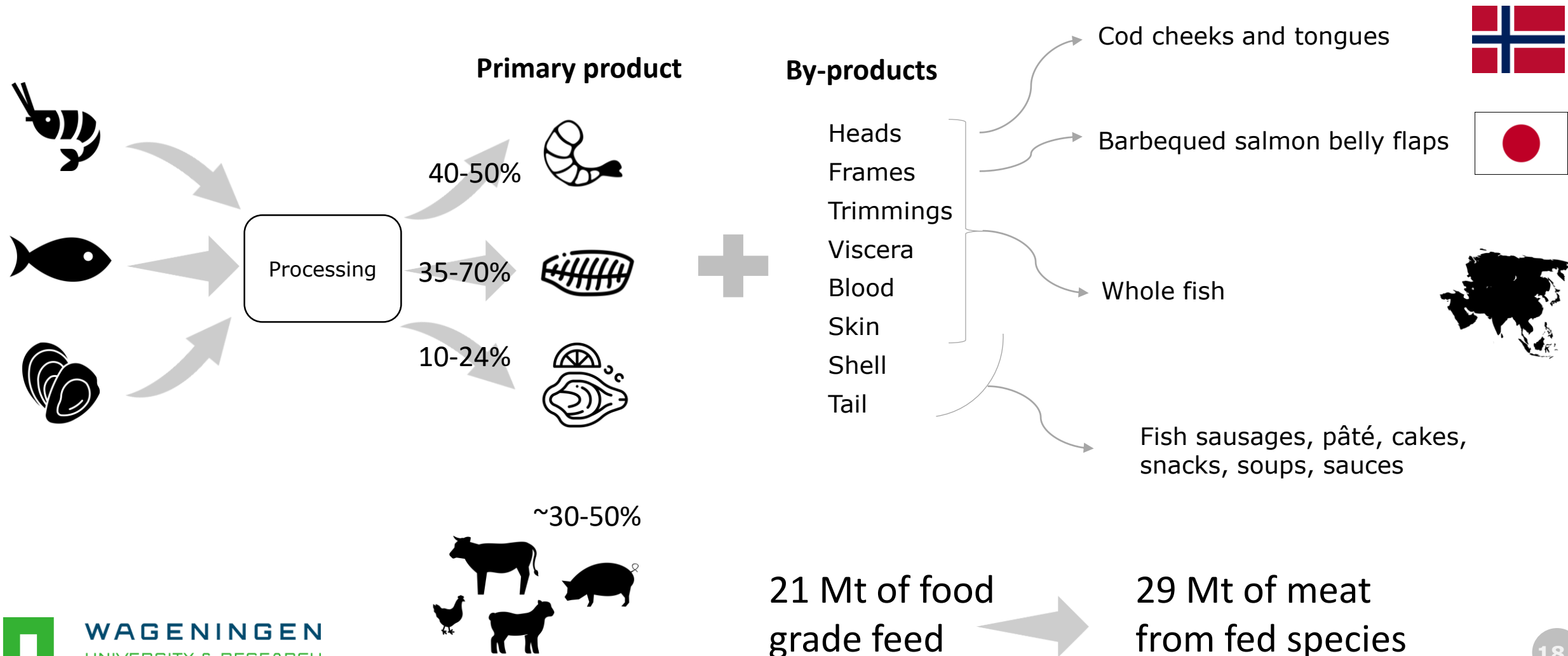
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# **Supplementary material**

# Edible yields of aquatic animals

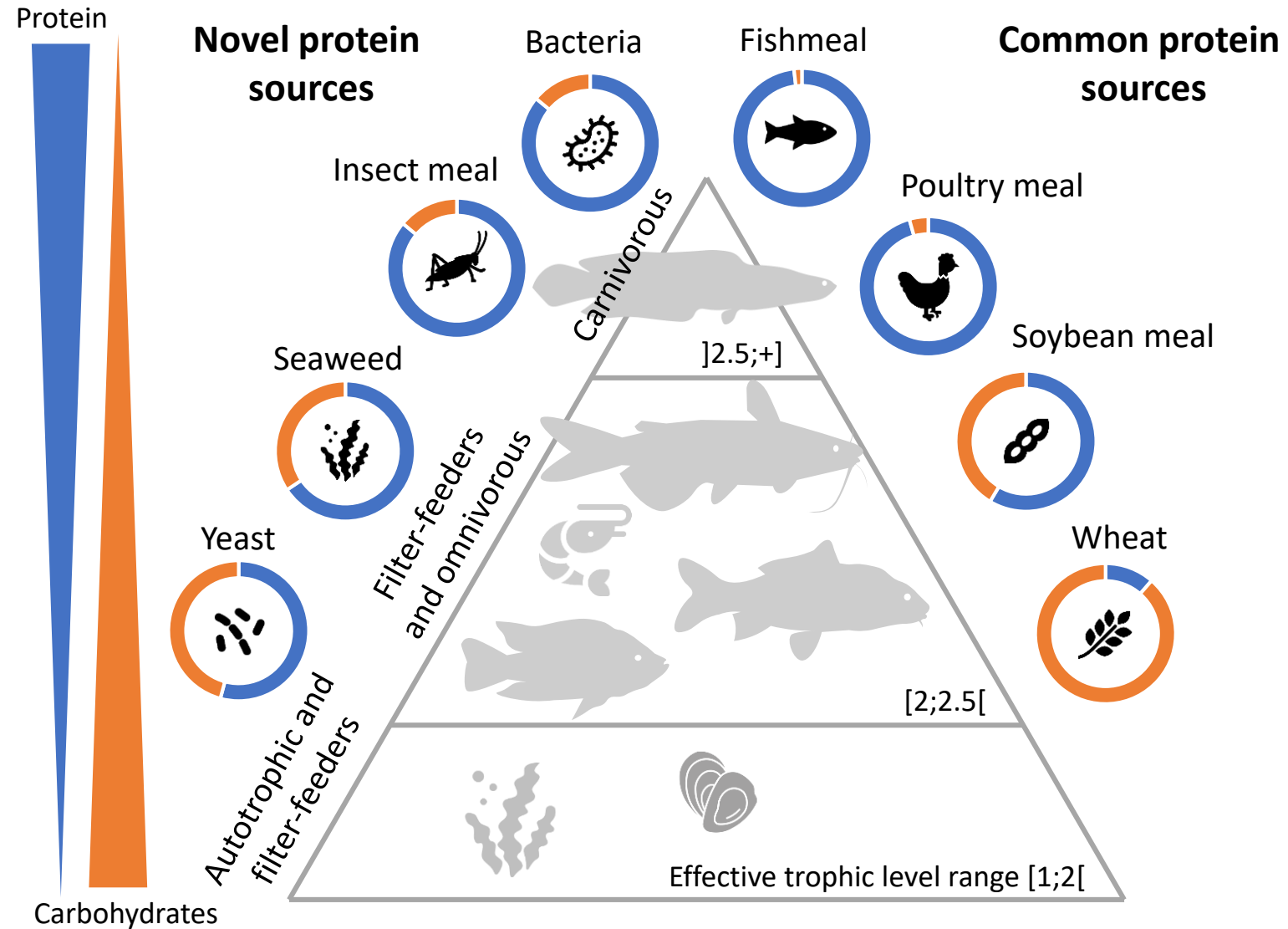
Prioritize

Can we valorize the “fifth quarter”?



# Capacity to unlock inedible material

Prioritize



# Food recovery hierarchy

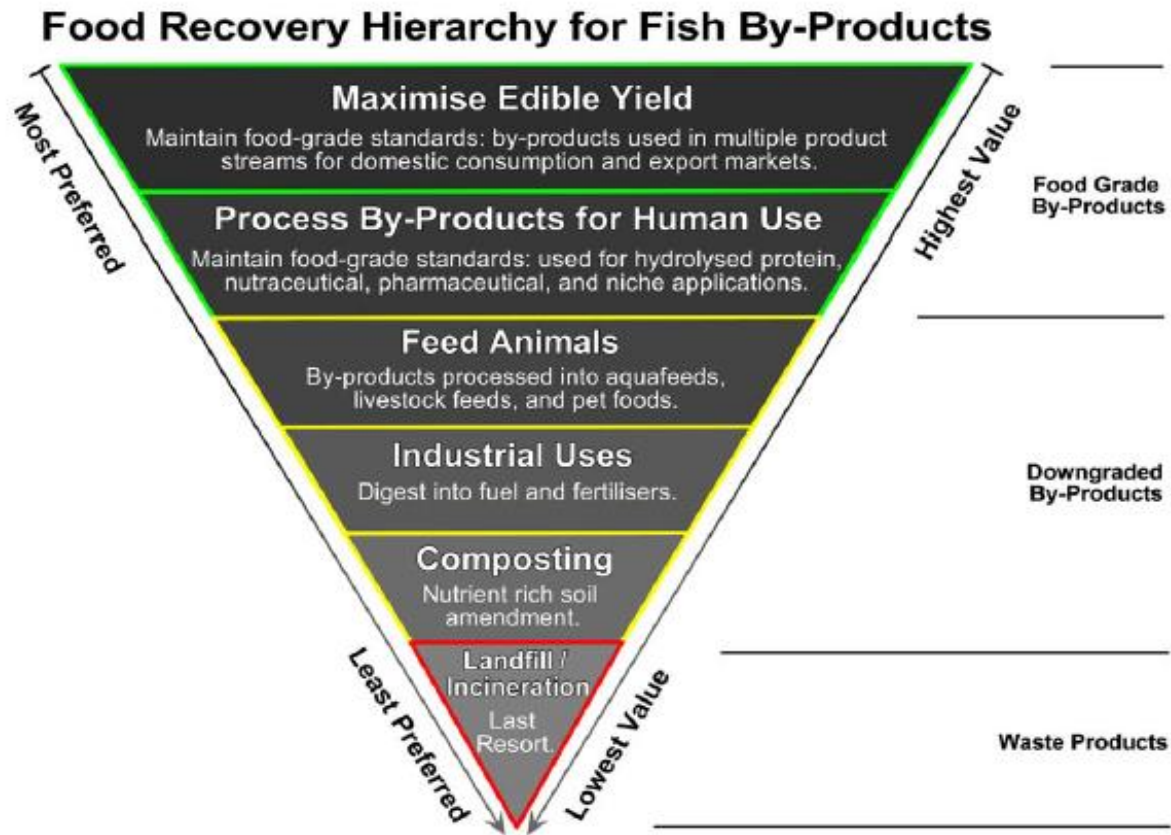
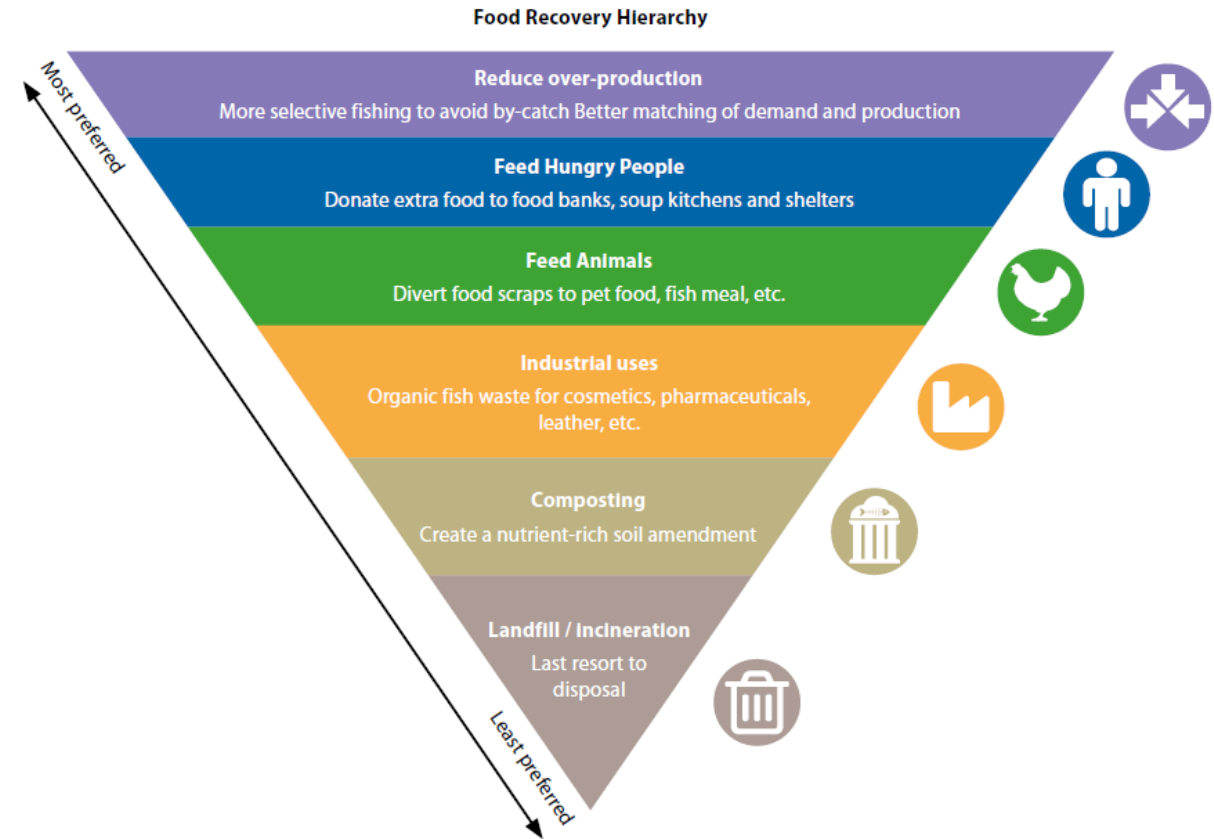


Fig. 8. Food recovery hierarchy for fish by-products. 1.5 column.  
Adapted from US EPA [65].



Source: Adapted from the [Food Recovery Hierarchy of the US Environmental Protection Agency](#)

# Hypothesis from Sandström et al.

Food-competing feedstuff	Non-food competing feedstuff
Cereals, pulses, sugar crops, whole fish used for fish meal and fish oil	Livestock by-product (e.g., blood meal, poultry oil)
Terrestrial feedstuffs that meet quality criteria for food use (e.g., fodder maize)	Roughages (e.g. grass and leaves), Crop residues Food processing by-products (e.g. wheat bran)
Oil from oilseeds	Meals/cake from oilseeds

# Five environmental reasons to avoid feed-food competition

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- Emissions from feed production > emissions from vegetable farming
  - Feed to edible protein conversion ratio greater than 2
  - Use of by products decrease growth and digestibility
  - Additional transport to take feed to animals
- Deforestation for agriculture is dominated by feed -> losses of carbon
- Additional emission as metabolic waste
- Additional emissions from processing
- Wastage is high for fresh animal products