

Blue Growth from a Danish Perspective

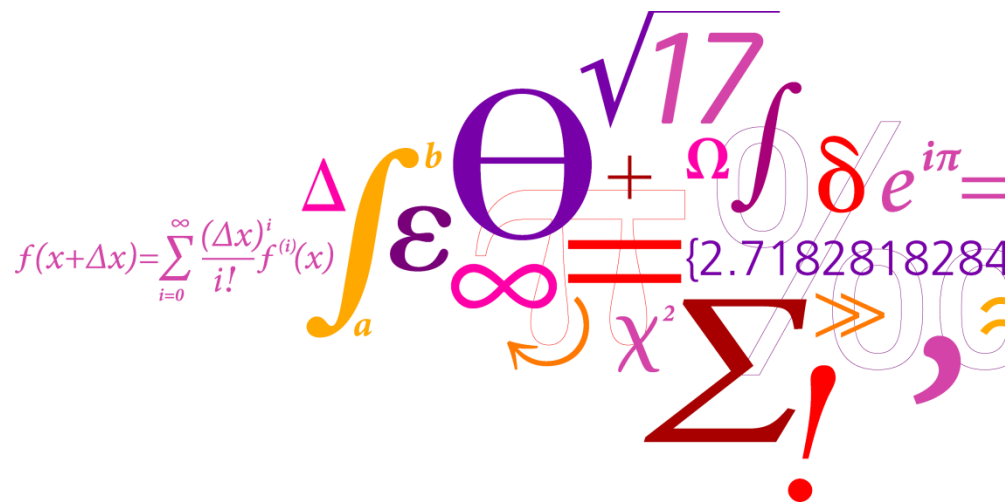
- Focus on Rest Raw Materials

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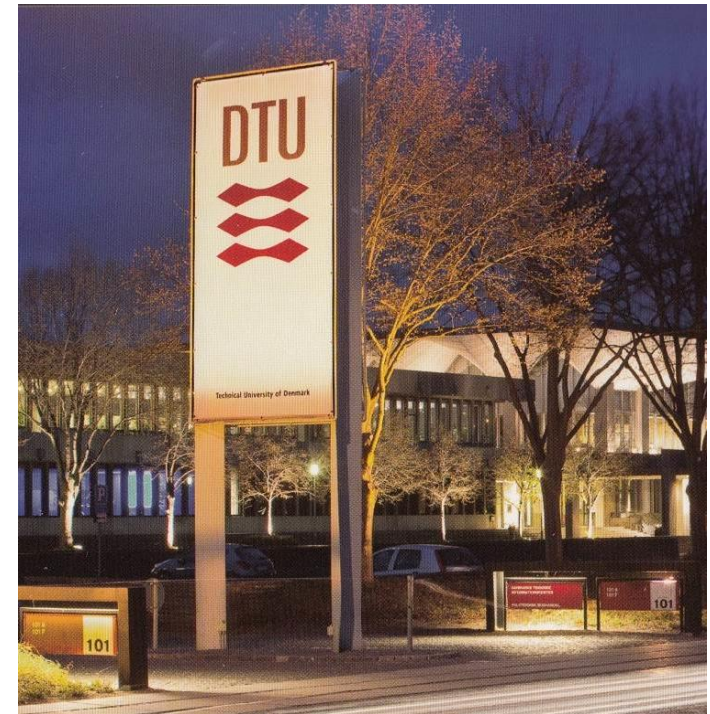
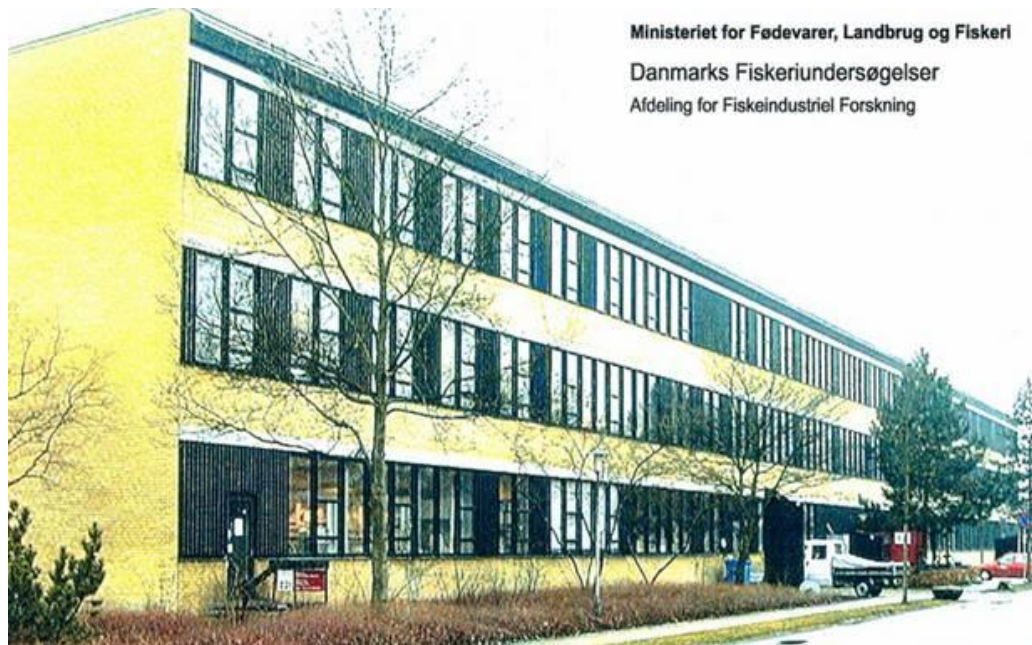
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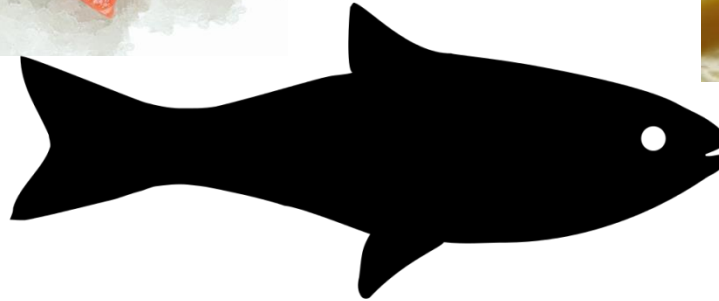
Technical University of Denmark



Research Groups

Fish, Feed, & Processing

Fish oil, Antioxidants & Emulsions



Outline

- Part I: Denmark & Rest Raw Material
- Part II: Example 1 Waste to Value (Solid)
- Part III: Example 2 Waste to Value (Liquid)
- Part IV: Conclusions & Perspectives

Part I: Denmark & Rest Raw Material

2020

8 Billion People

126 Mt Food waste

60% Fish supply farmed

50 Mt Shortage seafood



Part I: Denmark



Part I: Danish Priorities

2010, The Ocean an unexploited resource,

Henrik Jarlbæk and Torger Børresen

- Increased exploitation of marine biomass - algae
- Discovery of new compounds, materials and biological activities
- Extraction of valuable biochemical components



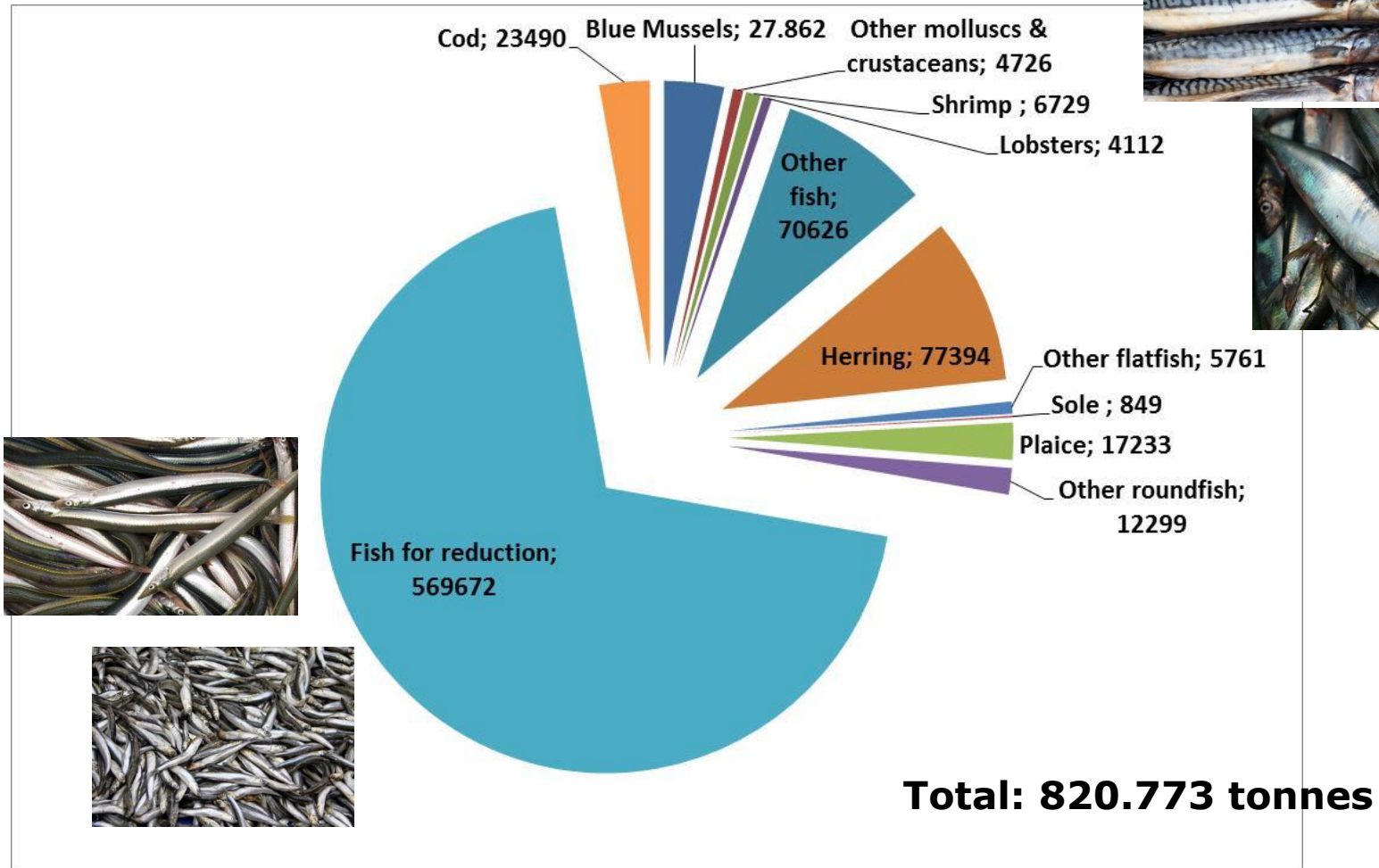
2014, Dansk Fiskeri og Akvakultur

Vækst Team Fisk

- 2020: 30% fisheries and 50% aquaculture revenues
- Couple research and innovation for growth
- Analyse the barrier for full utilisation of biomass
- Branding Danish fish e.g. story telling

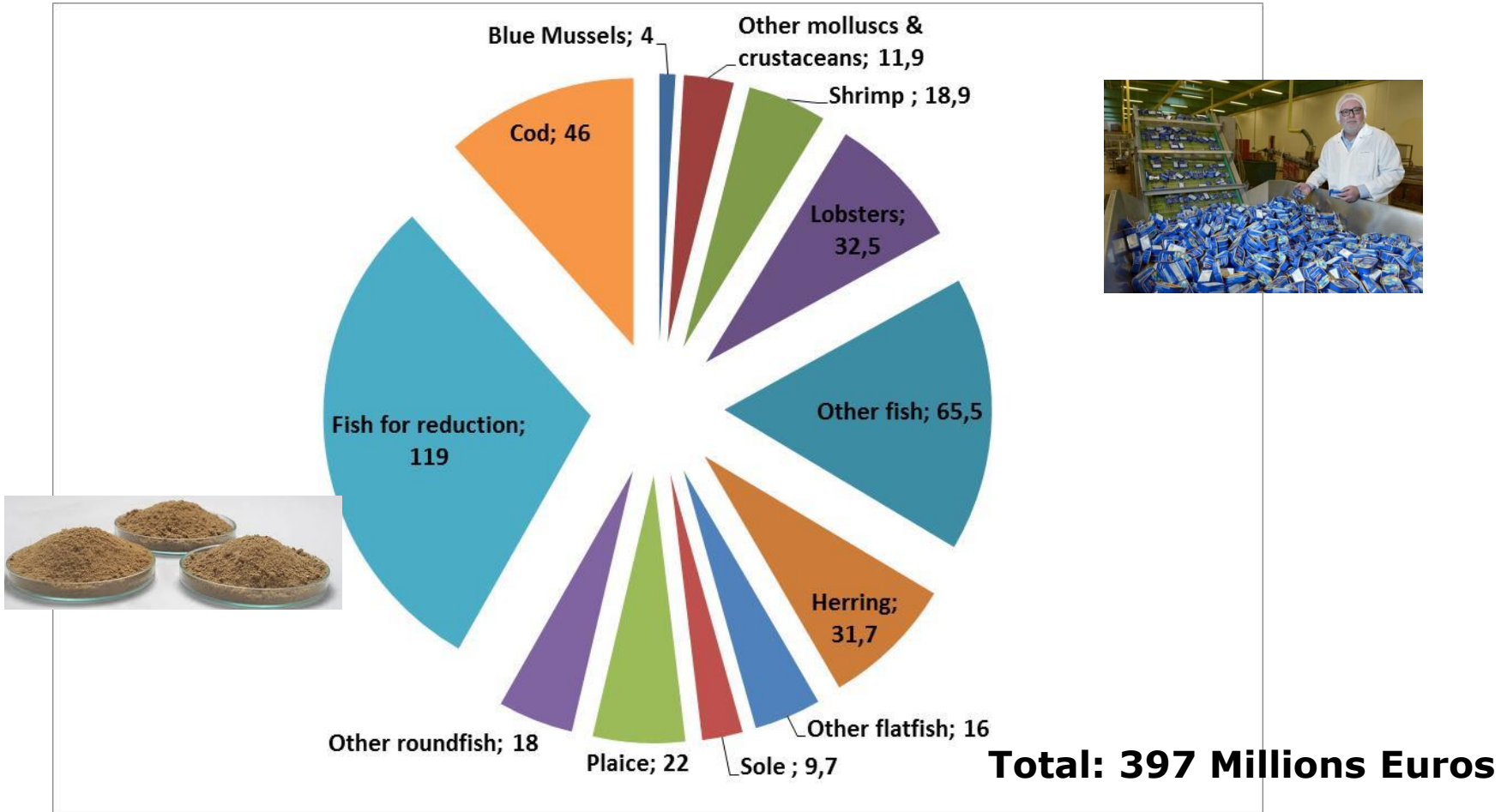


Part I: Landing in 2010



Danish Fishermen Association, The Directorate of Fisheries

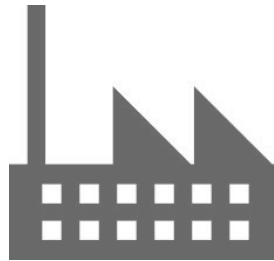
Part I: Values in Euros (2010)



Danish Fishermen Association, The Directorate of Fisheries

Rest Raw Material

Raw material



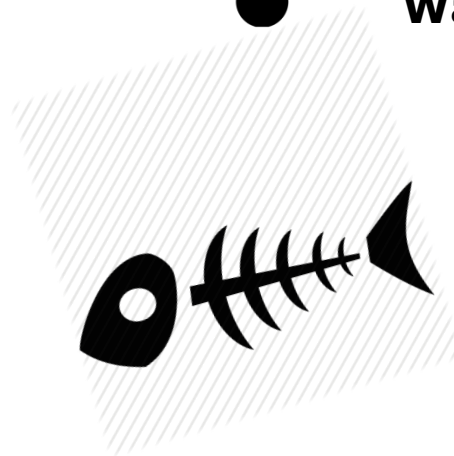
Processing



Products

- Fresh
- Frozen
- Canned
- Dried
- Marinated

Water



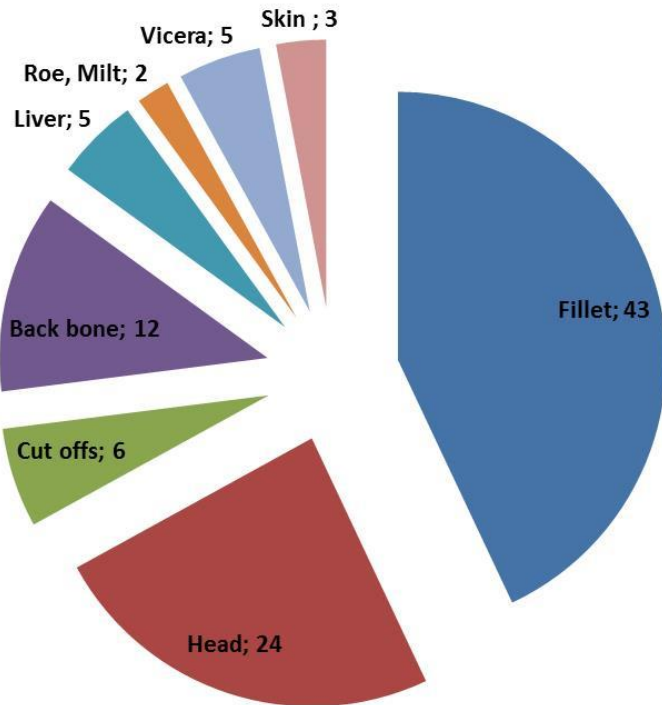
50% Rest Raw Materials

- Head
- Tongue
- Skin
- Bones
- Roe, Milt
- Liver, Viscera
- Shell



Part I: Rest Raw Material

Example Cod Norway



239 000 t cod by products (2004)

- 13% Human consumption
- 22% Fish meal, silage, fertilizer
- 64% Dumped

6.600 t lipids → 280.000 people/year

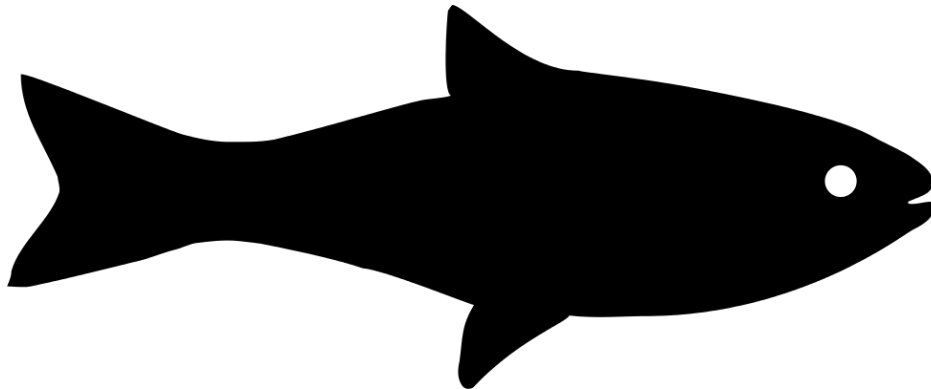
2.330 t omega-3 → 6.4 million/year

22.150 t protein → 1.2 million/year

Data from Rustad et al. Norway

Part I: Rest Raw Material

NOT JUST : Lipids, Protein, Omega-3



Organic acids: taurine

Enzymes

Peptides

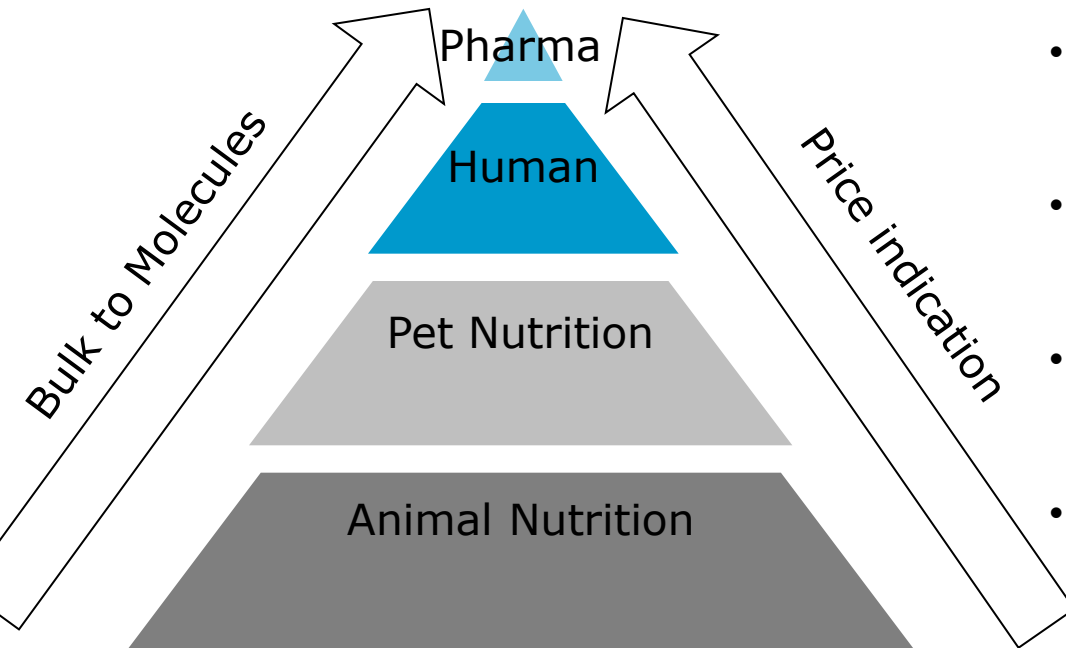
Protein: Collagen, histone,
protamines

Micronutrient: Calcium, iron

Chitin, chitosan

Secondary metabolites

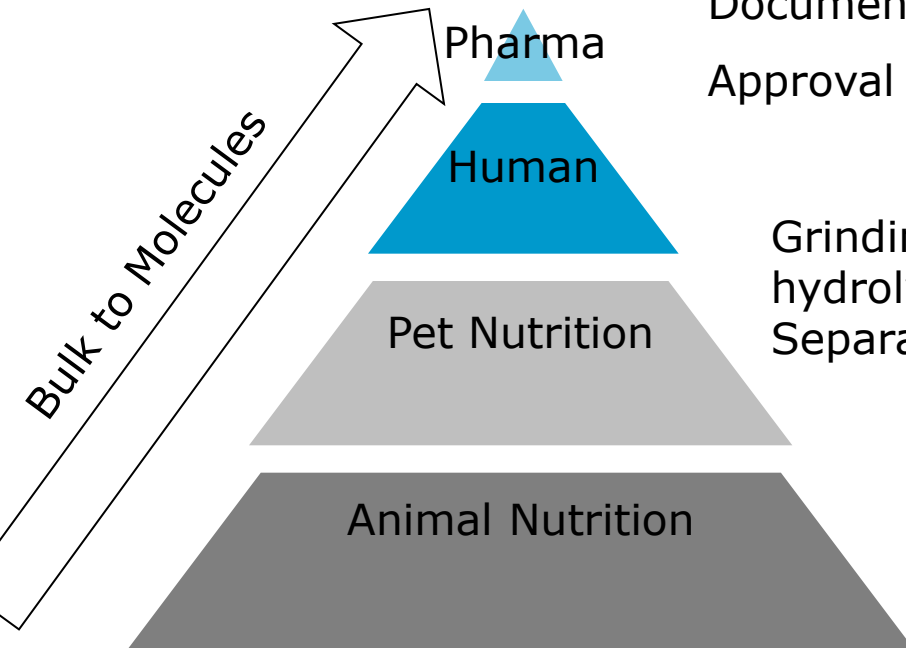
Part I: Rest Raw Material



- 70- 700 Euro/kg
- 4-70 Euro/kg
- 1-8 Euro/kg
- 0.2- 1 Euro/kg



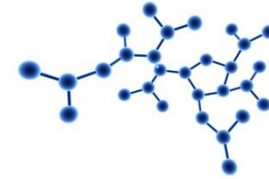
Part I: Rest Raw Material



Documentation of effect
Approval by regulating body

Grinding, Processing (e.g. hydrolysis, enzymes, extraction), Separation & Purification

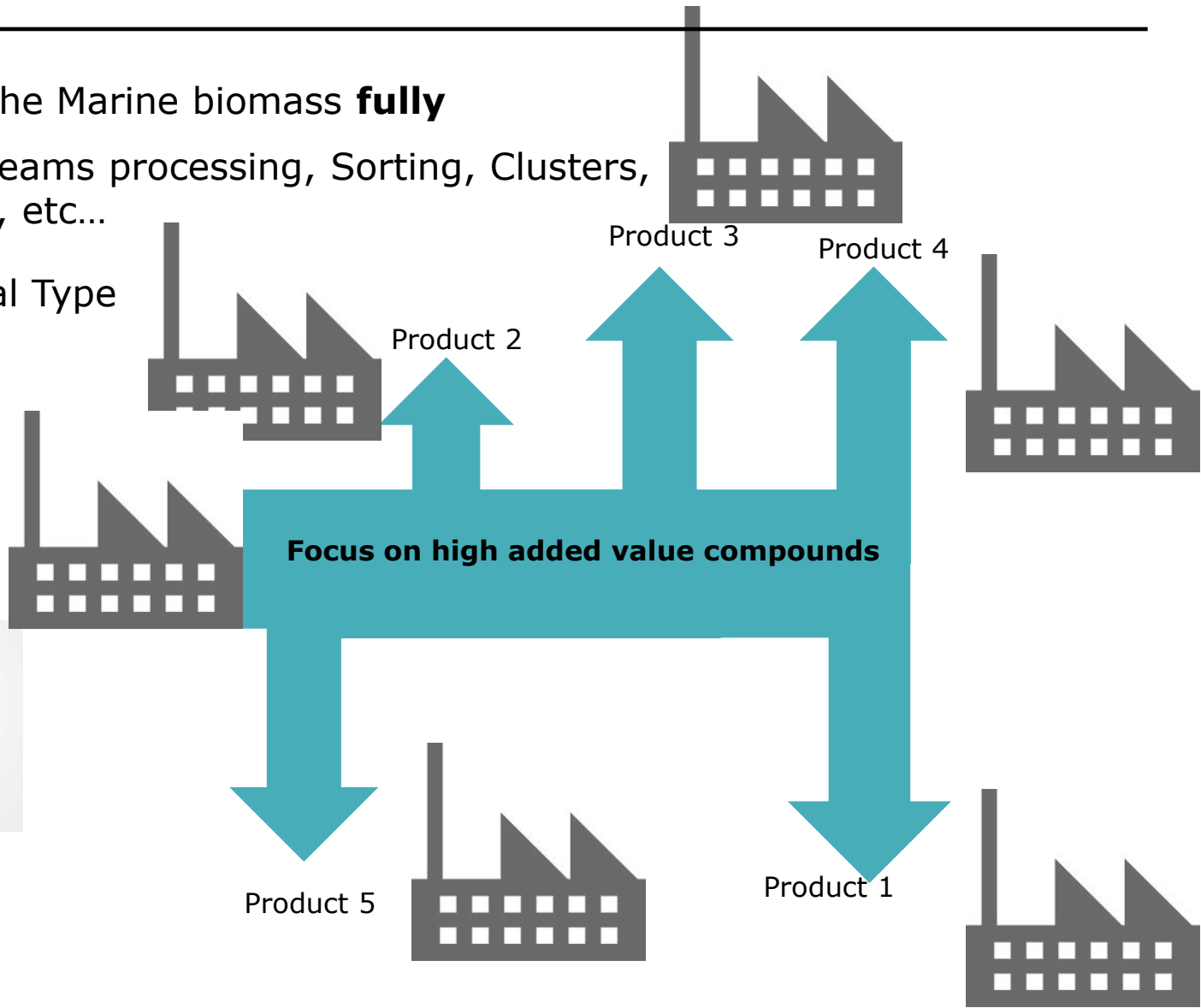
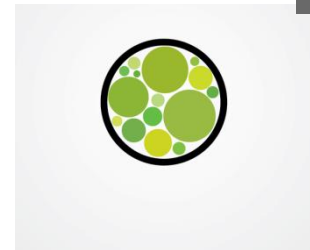
Heating, Grinding, Centrifugation, Drying, Milling



Part I: Blue Growth

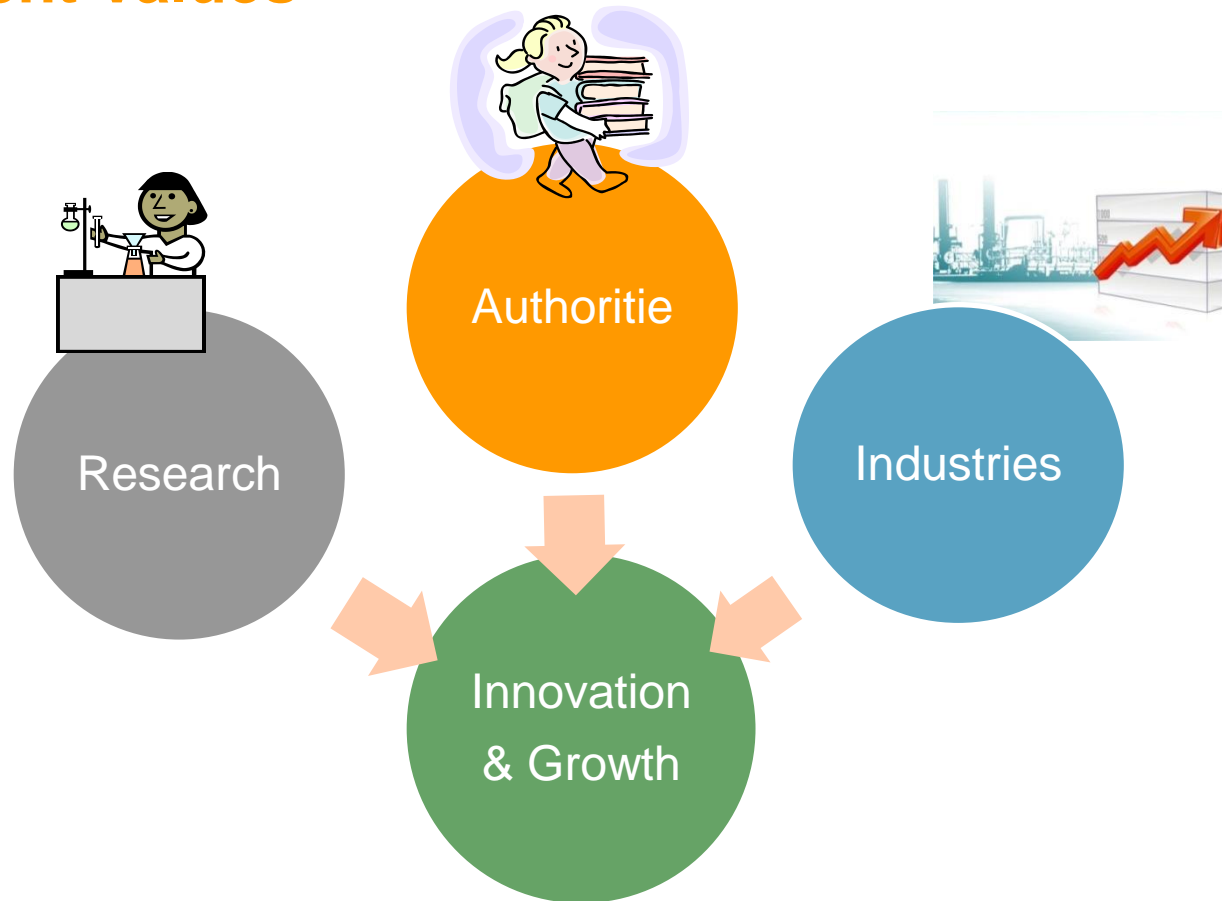
- Exploit the Marine biomass **fully**
- Multi streams processing, Sorting, Clusters, Symbiose, etc...

- Raw Material Type



Part I: (Blue) Growth

Different Values



Part I: Danish industries



Fødevarer

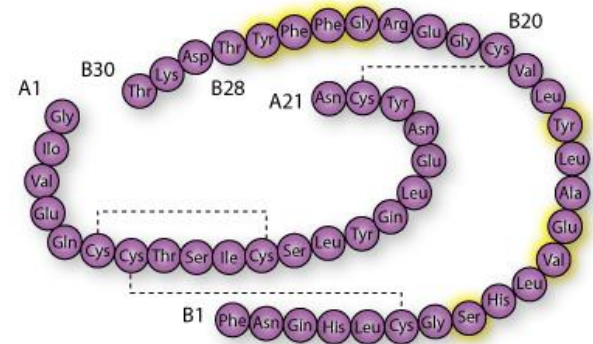


Part II: Fish Peptides

- From rest raw material

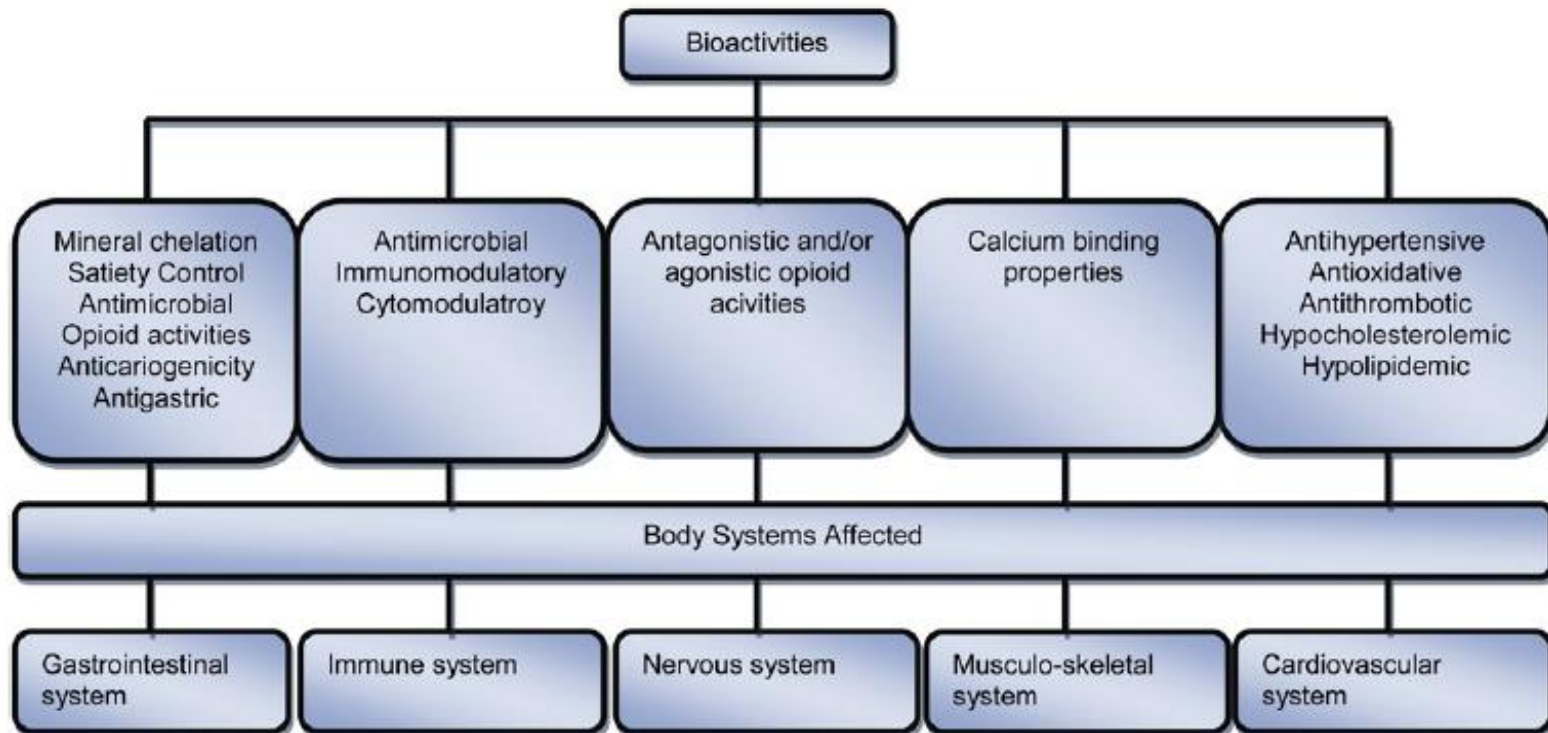
Part II: Peptides

- Peptides are amino acid sequences (max 100) that are the building blocks of proteins
- Oligopeptide: from 2 to 10 amino acids
- Polypeptide: from 10 to 100 amino acids
- Many peptides have bioactivities/function in vivo
e.g. peptides hormones, neurotransmitters, enzyme inhibitors
- Beside the medical aspect of "bioactive peptide" it is also emerging as an interesting additive in different products such as nutraceuticals, cosmetics, feed etc.



Part II: Bioactive Peptides

Bioactive peptides display various physiological functions in the body



Part II: Fish Peptides

PEPFISH: Utilisation of Bioactive Peptides from Fish Processing – Upgrading the Value of Secondary Products

April 2008- Dec 2012

Financed by the Danish Strategic Research Council

Partners: DTU, KU, Lund University, University of Tromsø
Marinova, Biofac A/S, Novozymes

Budget: 1,1 Million Euro

Aim:

- Purification and characterisation of bioactive peptides present in fish or produced by hydrolysis of fish proteins
- Characterise activity and mechanisms
- Generate scientific documentations

Part II: Fish Peptides

Discovery and characterisation of novel bioactive peptides from marine secondary raw material

- PhD project (2010 – 2013)
- Financed Research council from the Faroe Islands and Danish Centre for Advanced Food Research (LMC)

Partners:

- University of Aarhus
- University of Faroe Islands

Budget: 0,3 Million

Aims:

Discover and characterize bioactive peptides from salmon rest raw material (gill, belly flap & skin) naturally present or obtained using gastrointestinal protease.

Part II: Projects concepts

- Hydrolyze of protein from rest raw material (bellyflap, skin, intestine etc..) with commercial enzymes and gastrointestinal enzyme
- Characterization of commercial hydrolysates (Marinova A/S, Biofac A/S)
- Extraction of peptide from rest raw material
- Fractionation of the peptides
- Testing of biological activity *in vitro*
- Characterization of peptide
- Characterization of bioactivity and of mechanisms
- Evaluate the possibilities to be used in food

Part II: *In Vitro* Test Results

Test performed	Activity
• Antibacterial activity (<i>Helicobacter pylori</i>)	-
Direct killing bacteria	+++
Prevention of adhesion to epithelial cells (AGS)	+++
• Anticancer activity (pancreas cancer cells)	+++
• Blood pressure reduction (Inhibition of ACE)	+++ (?)
• Antioxidative activity in food	++
• Retain activity under simulated of gastric digestion	+++/-

Part II: Documentation of health effect?

In vitro Assays



Difficult to translate to *in Vivo*

- Important in early phase
- Can be used to develop strategies
- Cheap: many tests in a short time

Clinical Trial



Highest level of documentation

- Strict control over the diet, length, subject/people
- **Very Expensive**
- Impossible to perform to demonstrate disease
- Several Phases (15 to 1000 people)

Animal Testing



Translation to human is limited

- Possible to have control over the experiment
- Give insight into how human study can be designed

Epidemiology



Observation of a segment of the population

- Intake associated with disease
- Indication of interactions
- Many factors interact

Part II: Peptides in a Global Perspective



Part III: Fish Processing Water

- The pelagic industry from boat to barrel



Part III: PIPE Project

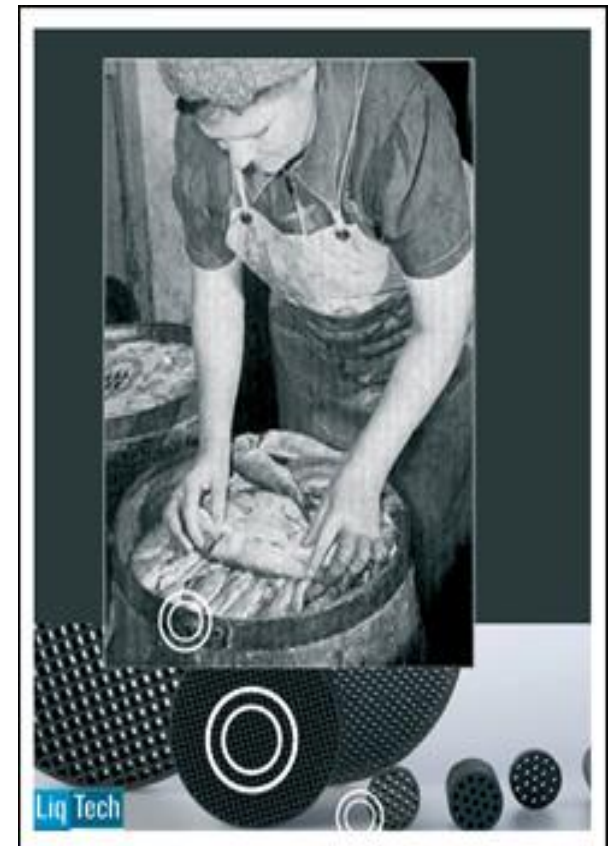
PIPE – Pelagic industry processing effluents, innovation and sustainable solutions

- Universities:
 - Technical University of Denmark, DK
 - Chalmers University of Technology, SE
 - University of Iceland, IS
- Producers
 - Paul Mattsson AB, SE
 - Lykkeberg A/S, DK
- Technology
 - LiqTech A/S, DK
 - A-Factory ApS, DK
 - Fisk & Fødevarer support, DK
- Budget
 - 1 Million Euros



Part III: PIPE Aims

- Aim: solve the problem of high organic load effluents in the marinated herring industries
- Characterizing the composition of the different types of effluents produced during the process.
- Recovering/concentrating the high value organic matter from the effluents.
- Investigating the potential market for the recovered/concentrated organic matter.



Part III: Herring Processing



Part III: Water Types

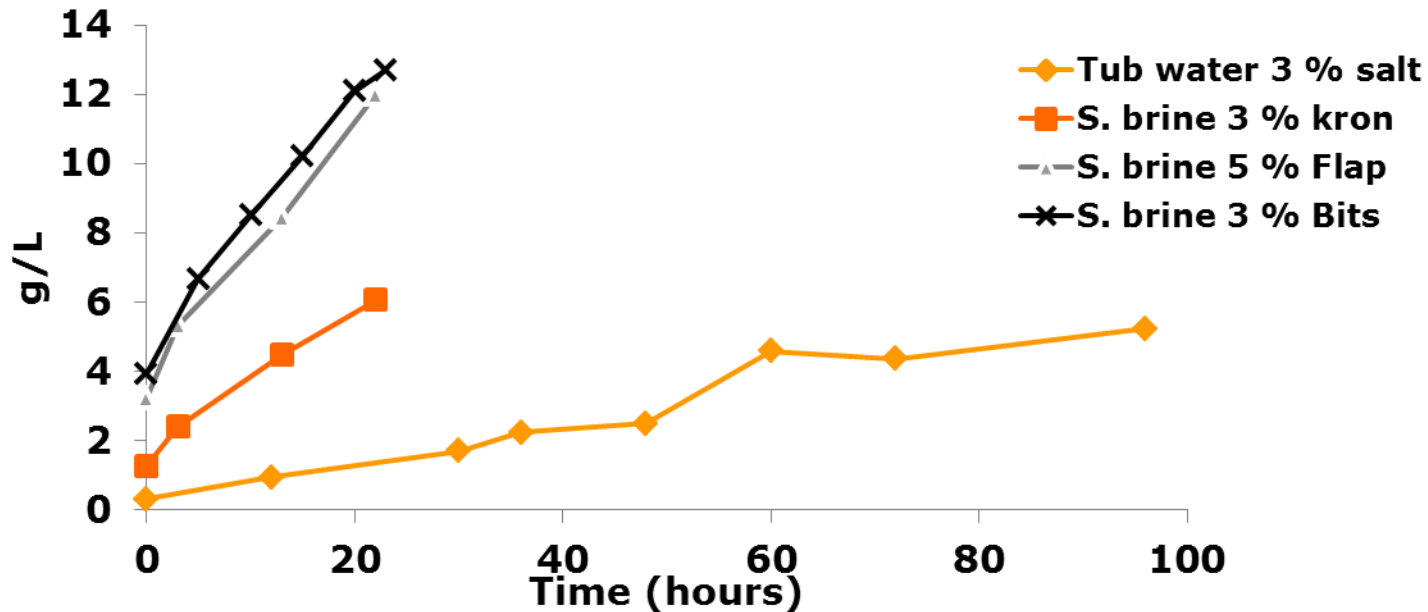
From boat to barrels:

- **Refrigerated sea water (RSW):** On board (not investigated)
- **Tub storage water:** intact herring kept in 3 % salt brine before processing.
- **Salt brine Kron:** headless, gutted herring with backbone and tail (no head and gut) kept in salt brine.
- **Salt brine Flaps:** double fillet with skin (no head, tail, bone and gut) kept in salt brine.
- **Salt brine Bits:** pieces of skinless single fillet (no head, skin, bone and gut) kept in salt brine.

From barrels to Jars:

- **VC:** vinegar cured herring (herring marinated in salt + acetic acid+ water).
- **SC:** spice cured herring (herring marinated in spices + sugar+ salt brine).
- **TSa:** Traditional barrel-salted herring (herring marinated in salt brine).
- **TSp:** Traditional barrel-salted spice cured (herring marinated in salt + sugar + spices).

Part III: Protein Content



Traditional barrel-salted herring (TSa)

Traditional barrel-salted spice-cured herring (TSp)

Vinegar-cured herring (VC)

Spice-cured herring (SC)

Protein content (g/L)

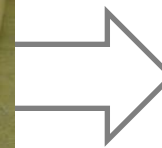
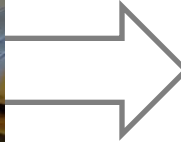
48.4 ± 0.02

56.7 ± 0.02

9.3 ± 0.01

41.7 ± 0.1

Part III: Water Volumes & Biomass

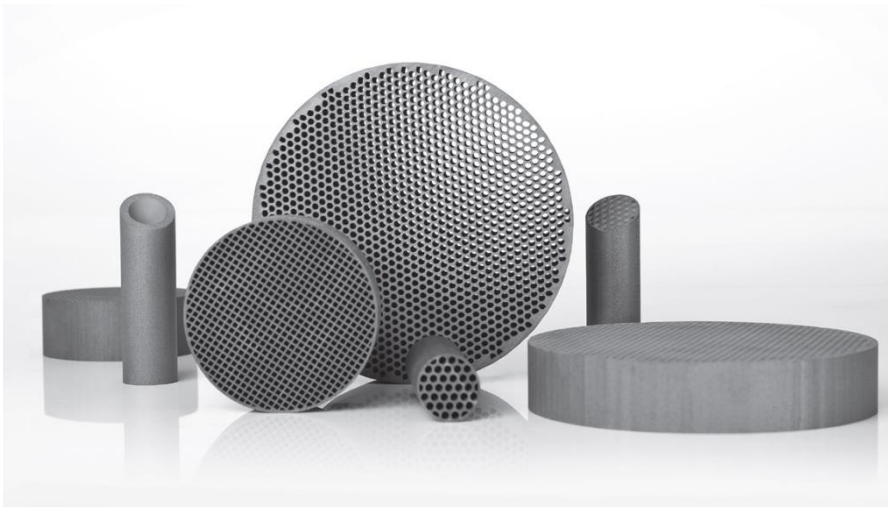


To Jars

From boat

**100 kg herring produce up to:
500 L processing water
5-10 kg protein
1-2 kg lipids**

Part III: Filtration Technologies



- Pre-treatment using electrochemistry
- Pre-treatment using dead-end 50 μm polypropylene filters
- Ultra-filtration using ceramic membranes

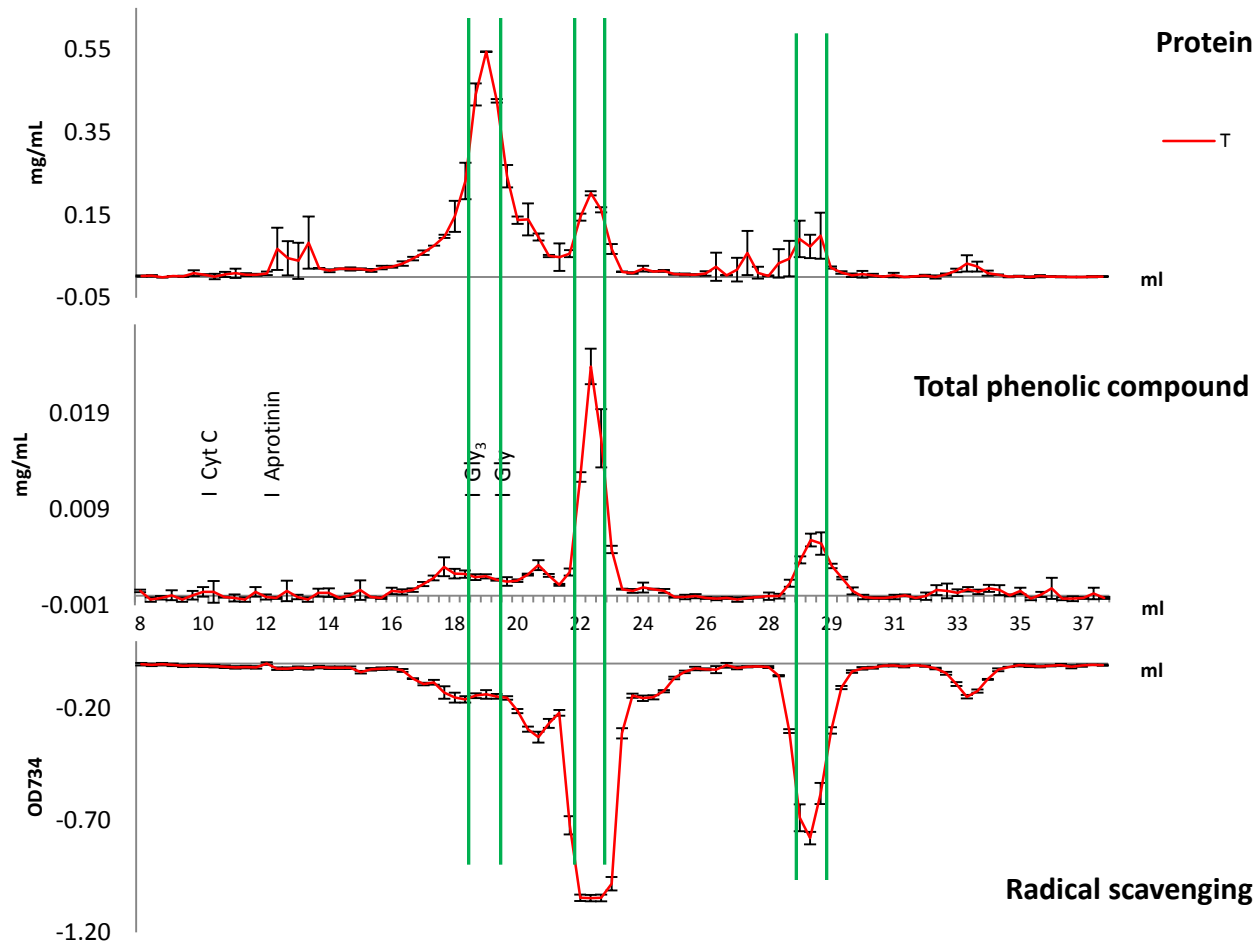


Part III: Mass Balance & COD

Samples	Proteins
Initial feed	747.3 g
Floated fat	6.9 g
Feed after floatation	719.7 g
Foam electrochemistry (EC)	123 g
Inlet to ultra-filtration	514.9 g
Permeate	47.2 g
retentate	442.3 g

Part III: Fractionation & Activity

Bioactivity in the 94 fractions



Part III: Results on Bioactives

Amino Acid	Brine Fractions		
	P1	P2	P3
<i>Essential</i>			
Histidine	-	-	-
Isoleucine	205	-	-
Leucine	366	-	-
Lysine	1295	60	-
Methionine	n.a.	n.a.	n.a.
Phenylalanine	13	31	-
Threonine	-	-	-
Tryptophan	n.a.	n.a.	n.a.
Valine	302	-	-
Total (a)	2181	91	0
<i>Nonessential</i>			
Alanine	473	-	-
Arginine	-	-	-
Aspartic acid & Asparagine	157	-	-
Cysteine	n.a.	n.a.	n.a.
Glutamic acid & Glutamine	818	-	-
Glycine	-	-	-
Proline	130	-	-
Serine	48	-	-
Tyrosine	-	37	-
Total (b)	1626	37	0
Grand total (a + b)	3807	128	0

Phenolic acids	Brine Fraction		
	P1	P2	P3
Gallic	-	8.96 ±2.54	-
2,5-Dihydroxybenzoic	-	-	0.27 ±0.007
Caffeic	-	1.60 ±0.127	1.35 ±0.457
Vanilic	-	35.32 ±1.90	35.04 ±0.557
Ferulic	-	65.33 ±2.36	-
Total	0	11.21	36.66

Part III: Fish Processing Water Perspective

- Process waters from marinated herring industry contain substantial amounts of proteins and lipids and potential bioactive.
- Technologies tested are potential techniques for the recovery of proteins (75 – 85 %) and lipids (95 – 99 %).
- The application of such technologies significantly decreased the need for treatment (BOD, COD) associated with herring process waters.
- Sustainability of marinated herring industry can be improved and should be an area of great interest (> 300 tons proteins and > 100 tons fatty acids are wasted yearly).

Part IV: Conclusions & Perspectives

- Great potential to harvest residual value in rest raw material from fisheries/aquaculture/fish processing industry (from solid to liquid)
- Investment, collaboration with university, industry, government in a triple helix concept
- Market push, Market pull
- Innovation: New product/New market Old product/New Market
- Thinking global and branding

Part IV: Conclusions & Perspectives

➤ Growth in a world of scarcity

Perseverance, Excellence, and Authenticity

Brick by brick by David Robertson



Thanks to...



Flemming Jessen



Ingrid Undeland



Torger Børresen



Henrik Hauch Nielsen



Henrik Jarlbæk



Nina Gringer



Vali Hossein



Ali Osman



Susan Falkenberg