Processing Marine Biomass at Norway's National Bioprocessing Facility

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Nofima – Norway's National Food Research Institute

- National food research institute, established on January 1, 2008.
- Comprises the former Akvaforsk, Fiskeriforskning, Matforsk and Norconserv

Target markets

- Food industry and aquaculture and fisheries industry

Owners:

- State (Ministry of Trade, Industry and Fisheries): 56.8%
- The Agricultural Food Research Foundation: 33.2%
- Akvainvest Møre and Romsdal: 10 %

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We do Research on:

Aquaculture

- Breeding and Genetics
- Nutrition and Feed Technology
- Fish Health
- Production Biology

Fisheries, Industry and Market

- Consumer and Marketing Research
- Industrial Economics and Strategic Management
- Seafood Industry
- Processing Technology
- Marine Biotechnology

Food Science

- Food and Health
- Raw Materials and Process Optimization
- Customer and Sensory Science
- Food Safety and Quality

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Marine Biotechnology

Find, clean and process biomolecules from marine organisms and by-products for industrial exploitation

Bioprocessing and bioprospecting

- Exploitation of marine by-products
- Refining of biotechnological products
- Analytical and preparative scale (lab ➔ pilot)
- Bioactive molecules, protein and lipid fractions

Expertise

- Extraction and isolation of biomolecules
- Enzymes and enzyme inhibitors
- Enzymatic hydrolysis
- Lipid stability
- Bioprocessing technology (fine chemicals and hydrolysates)

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We Need Sustainable Use of Marine Resources

- Future; increased need for:
  - Food and feed
  - Ingredients and materials
- Use all biomass
  - A large amount wasted
  - Available biomass is not used
- Biotech solutions, processes,
- incentives, regulation

- Can also utilize unused biomass for:
  - Proteins, fats, minerals, chemicals
  - Bioprospecting
  - Health food and Cosmetics
  - Pharma
  - Bioplastics

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Quality of Biomass
– Classification dictates use

Food / human consumption

main product

the rest

Receiving
Handling
treating

marine ingredients for consumption
meal, oil, hydrolyzed protein, etc

Category 3

Category 2

Category 1

INCREASED RISK

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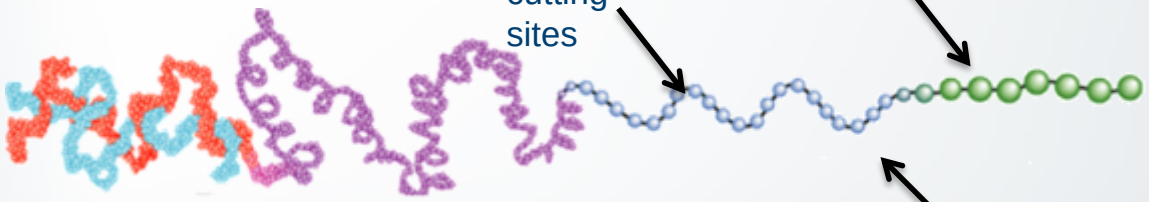
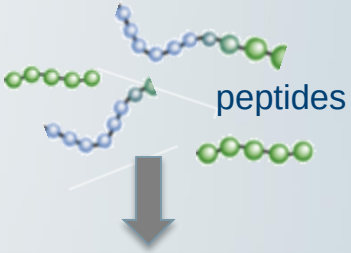
Hydrolysis and Fermentation

add enzymes

Phase separation

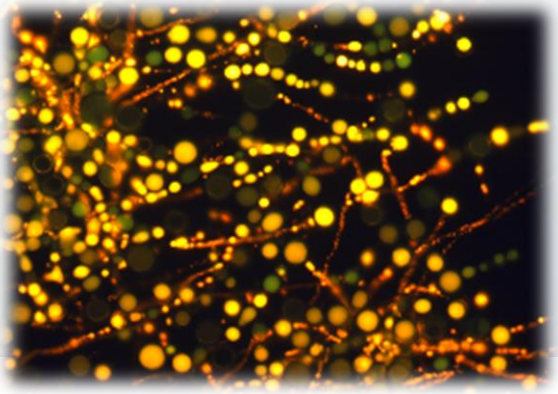
Enzymes cutting sites





peptides

Lipid production



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National Facility for Marine Bioprocessing

- Located outside Tromsø in Northern Norway
  - Close to Nofima's headquarters
- Built to improve research and innovation infrastructure
- Indented to increase commercialization of products and processes based on research from academia and industry
- Partly publicly financed
- Owned and operated by Nofima

National Facility for Marine Bioprocessing

In our flexible mini-factory we work with businesses to test and optimize processes for extracting high value components from marine biomass

- Processes can be developed in collaboration with Nofima
- Small businesses can test their processes
  - No large infrastructure investments
  - Prototype can be tested in marked
  - Cost estimates for production
- Also use in research and development
- Also use in education

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Facilities

- Handling of many biomasses
- Reactors 2,2 m^3
- Two- and three phase decanter
- Separator
- Purification of oil
- Membrane filtration of aqueous phase
- (ultra/micro/nano/reverse osmosis)
- Concentration/ evaporation
- Mill drying
- Spray drying
- Powder handling
- Packaging

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Different biomasses requires different processes

The plant can receive and process a variety of biomasses

- Fresh, frozen, fish, plant, shellfish, processed, etc

Designed to be able to run a variety of processes

- Compared to a large scale production facility that will be specially designed to run one process
- We has miles of pipes enabling us to shunt between processes and infrastructure
- Mainly marine biomass
- Want to include a large number of innovations within processing and development
- Continually improving and expanding infrastructure

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Most common process – batch hydrolysis

- Biomass is received and ground/pumped into reactor which is mass and temperature controlled.
- Enzyme added and hydrolysis is allowed to proceed for defines amount of time/pH/temperature
  - Enzyme will modify proteins (most common), carbohydrates or fats
- Biomass is pumped into clean zone (pasteurized) where water phase, lipid phase and solid phase are separated
- Solid phase is commonly dried and ground into powder
- Oil phase is filtered and clarified
- Water phase is filtered using micro/ultra/nano or reverse osmose filter
- Concentrated and (spray) dried

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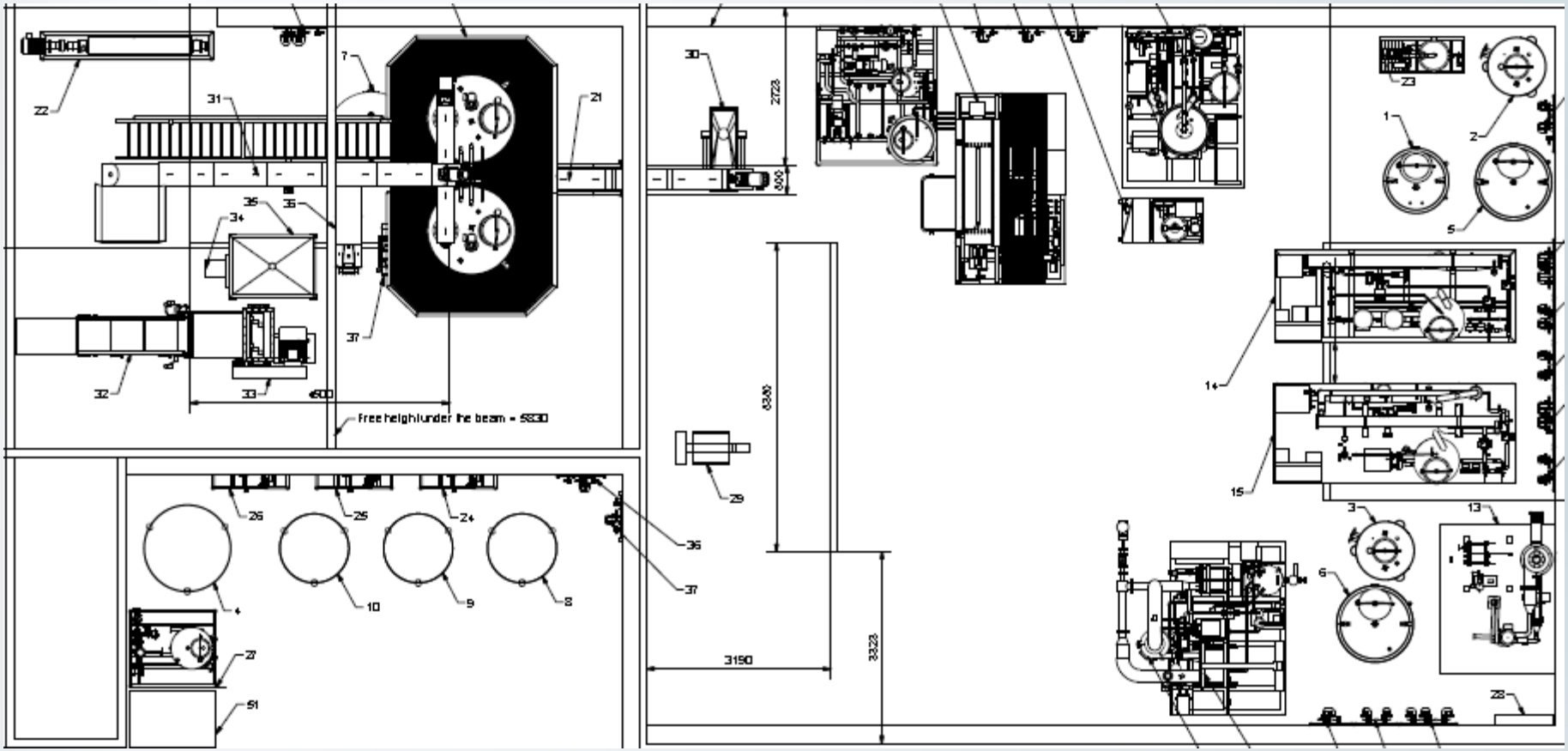
Processing plant



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From lab scale to pilot scale

- Processes are optimized in lab and small scale
  - Multi-hydrolysis – 100 mL
    - IR, HPLC, pH, brix
    - Enzymes, time, temperature, fraction
    - Multivariate analyses
  - Scale-up to 30 L
  - To processing plant

Skala

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Example productions

- Calanus
  - Total exploitation of the *Calanus finmarchicus*
  - Oil, hydrolysate, powder, freeze dried, salmon lice net
- Marealis
  - Shrimp peel from *Pandalus borealis*
  - hydrolysate peptide nutraceutical
- Kvalvik Bait
  - Sustainable baits for angling and commercial fisheries

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Calanus

- Private Norwegian company developing new bio-industry on the marine copepod Calanus finmarchicus, the largest renewable and harvestable resource in the North-Atlantic Ocean.
- Covering the whole value-chain, focus on human health and nutrition products including a novel marine oil with unique properties.
- The company has documented that Calanus finmarchicus may be harvested and utilized for valuable products in an ecologically and economically sustainable manner.

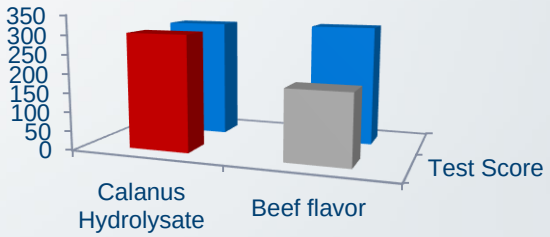
Calanus

- Calanus® Oil: Main product, launched in Norway and the USA (Arctic Ruby® Oil) in late 2012, with good response. Market believed to be in the range of 500 million US$ (GOED, 2014).
  - Food supplement, possible use within clinical nutrition is investigated. Secondary uses long term (lower price): starter feed, pet food.
- Calanus ® Hydrolysate: Soluble peptide fraction from the extraction of oil (meal or concentrate). Currently sold as ingredient to marine starter feed. Investigates possible use as a functional food ingredient (flavor).
- Calanus ® Powder: Whole meal of Calanus (including shell fraction) after extraction of oil. Used in starter feed, pet food and ornamental fish feed.
- Frozen and freeze dried Calanus: Applications within starter feeds (marine fish fry, shrimp fry and ornamental fish feed).

Calanus

Studies show:

- Calanus® Oil counteracts obesity-related metabolic disorders (e.g. Br J Nutr 2013, 110(12): 2186-2193)
- Clinical studies at the University Hospital North-Norway (UNN) has confirmed human safety
- Documented increased growth rate in marine fish with use of Calanus Hydrolysate in fish feed and additional studies at Norwegian universities in progress
- Study at University of Utrecht confirms that Calanus Hydrolysate is a superior palatant in pet food



Marealis

- Marealis AS
  - Norwegian marine biotechnology company focusing on the development of novel bioactive peptides derived from sustainable sources of the Arctic Ocean.
- Subsidiary of peeled shrimp producer (Stella Polaris)
- First product derived from hydrolyzed shrimp peel

Marealis

- Peel from shrimp production
  - Hydrolysis of shrimp peel
  - Isolation of water phase
  - Filtration performed to isolate specific molecular weight hydrolysate
    - Combination of peptides and low molecular weight components
    - Dried and tableted

Marealis

- Developed through bioprospecting of fractions of hydrolyzed shrimp peel
  - Analyze specific size fractions of hydrolysate
  - Bio-activity assays can be performed to detect and demonstrate specific effects
    - enzyme inhibitor
    - antioxidant
    - others
  - Bioprospecting at Nofima had demonstrated bioactive peptide in hydrolyzed shrimp peel that can lower blood pressure
  - Inhibits an enzyme; ACE (angiotensin converting enzyme)

- Animal studies followed by clinical trials to demonstrate effect

Kvalvik Bait

- Sustainable bait for anglers and commercial fisheries
- Fisheries by-product used to create attractants for various fish types
- Hydrolyzed by-products in specially designed swellable polymer

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Kvalvik Bait

- Combination of polymer science with hydrolyzed fisheries by-products to specifically attract
  - Cod
  - Halibut
  - Salmon/Trout
- Sustainable use of by-product
- Decrease use of food grade fish for bait
  - Reduced price compared to fish
- Decrease weight of commercial fishing boat
  - Reduce cost of transport and CO_2 emissions

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Kvalvik Bait

- Developed through attractant testing of hydrolyzed by-products
- Specific polymer with swelling properties
  - Biodegradable
  - Low weight in transport
    - Swells in water to release attractant

https://www.youtube.com/watch?v=4juxTbomfTg

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