Marine biotechnology for aquaculture, fish health and ocean health

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Biotechnology in Bergen

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Marineholmen Science Park is a cluster in Life Science with focus on marine, environmental and aquaculture-related research (Dept. of Molecular Biology, Dept. of Biology, the Sars Centre, CBU, Uni Research)

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- Bergen Marine Research Cluster

Marine biotechnology workflow

Products

- Drugs
- Elicitors
- Biofuels
- Food/feed
- Enzymes
- Biopolymers
- Organic compounds
- etc.

- Processes
- Basic research
- Ecosystem management
- Bioremedition
- etc.

Biotechnology toolbox:

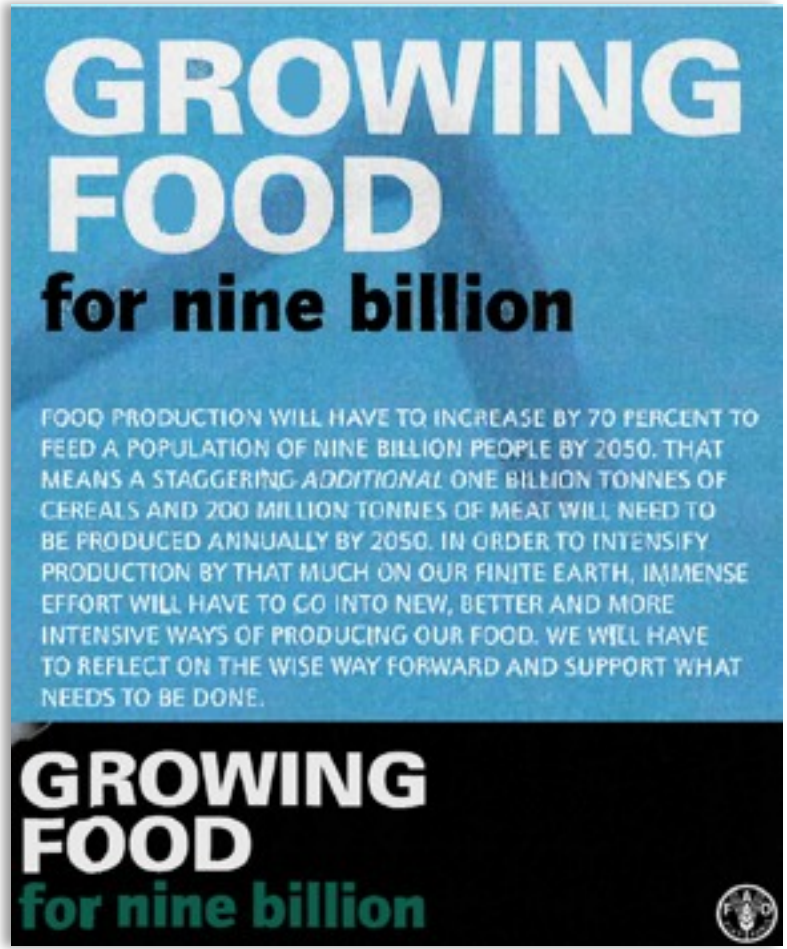
- biodiscovery
- molecular biology
- microbiology
- 'omics'
- etc.

Value chain

Major challenges for the aquaculture industry

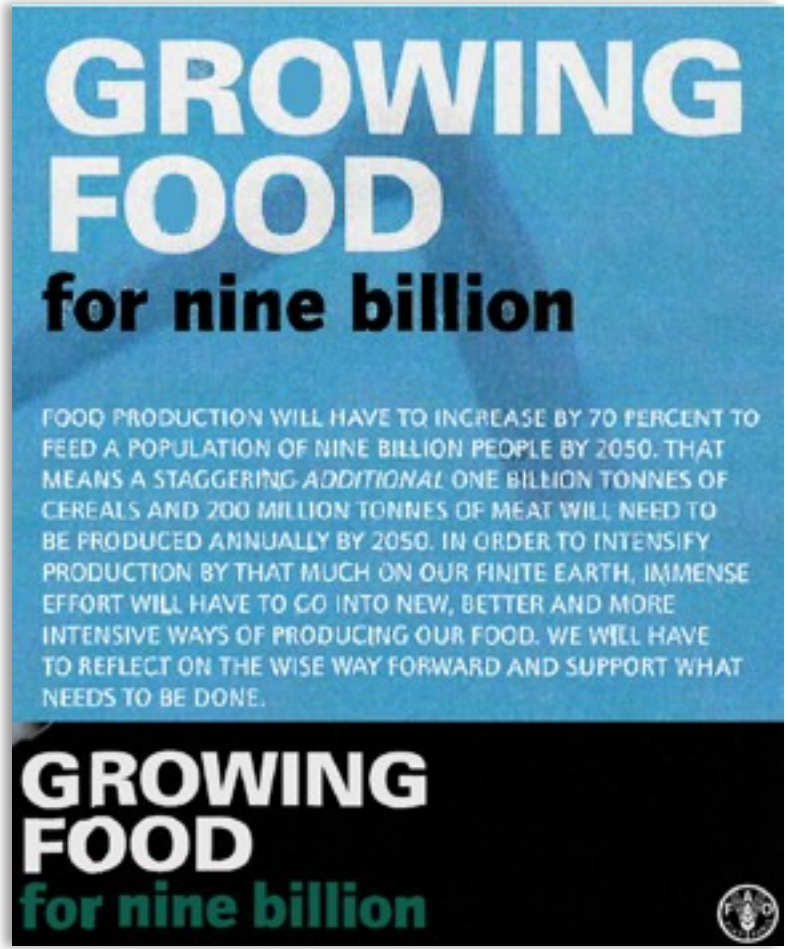
- Escape
- Salmon lice
- Fish health
- Feed availability and functionality
- Exploitation of byproducts

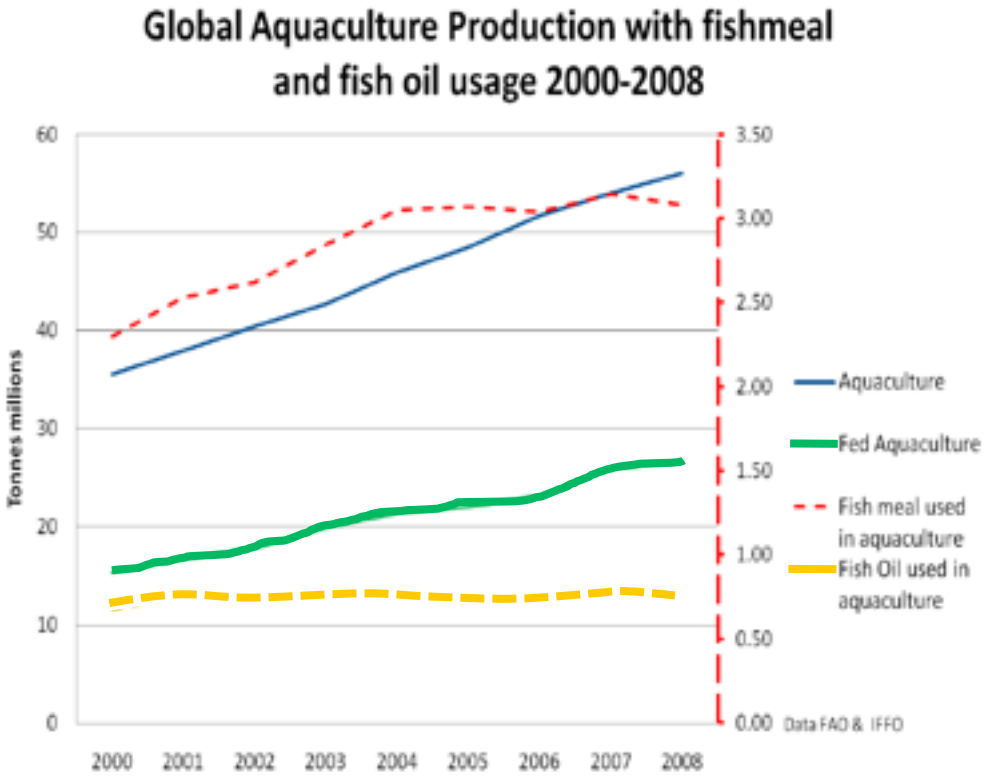
solutions to be found in biotechnology



Source: Jackson, IFFO

A sustainable growth is needed



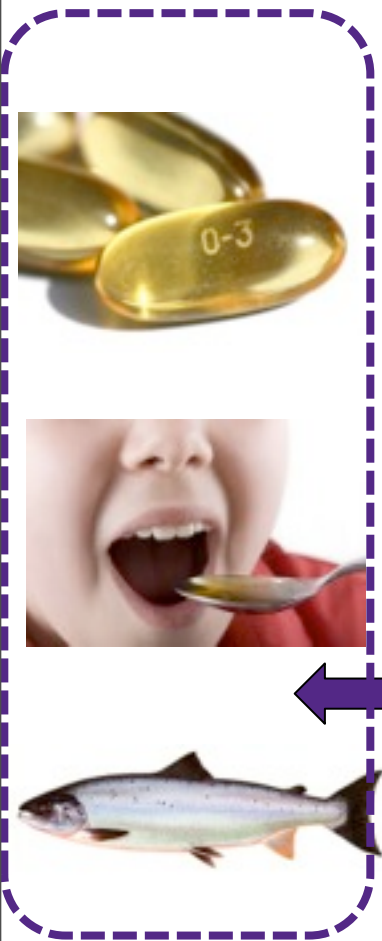


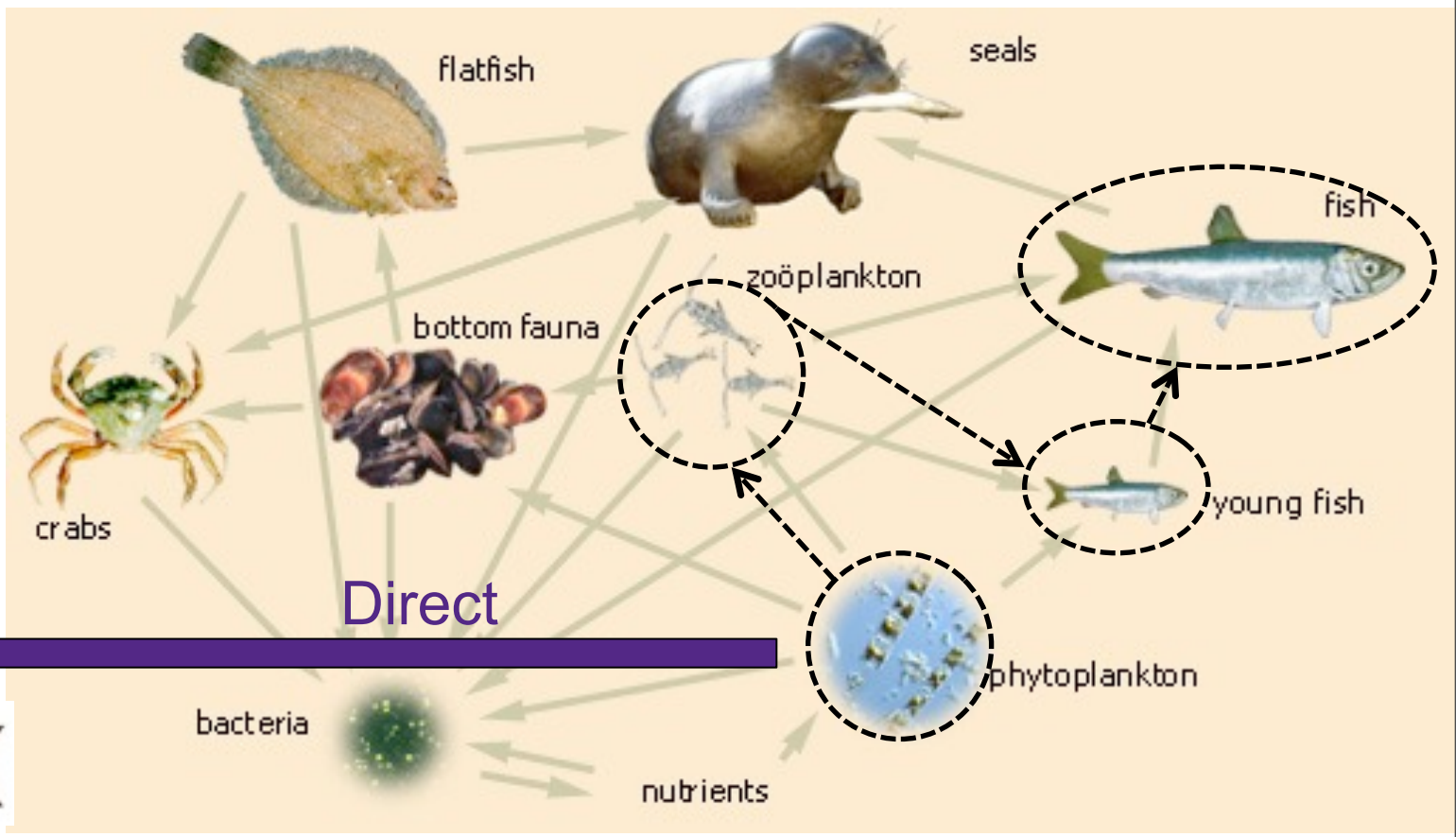
Source: Jackson, IFFO

Aquaculture face shortfall on fish oils

- Joint industry report
  - Limited pelagic resources
  - Increased –ceuticals use
  - Dramatic shift in 2-3 years
- Alternative feed resources
  - GM-rapeseed (EPA)
  - Krill
  - Microalgae
- Choice will depend on:
  - Costs and omega-3 price
  - Technical feasibility
  - Sustainability

Sustainable omega-3 FA source

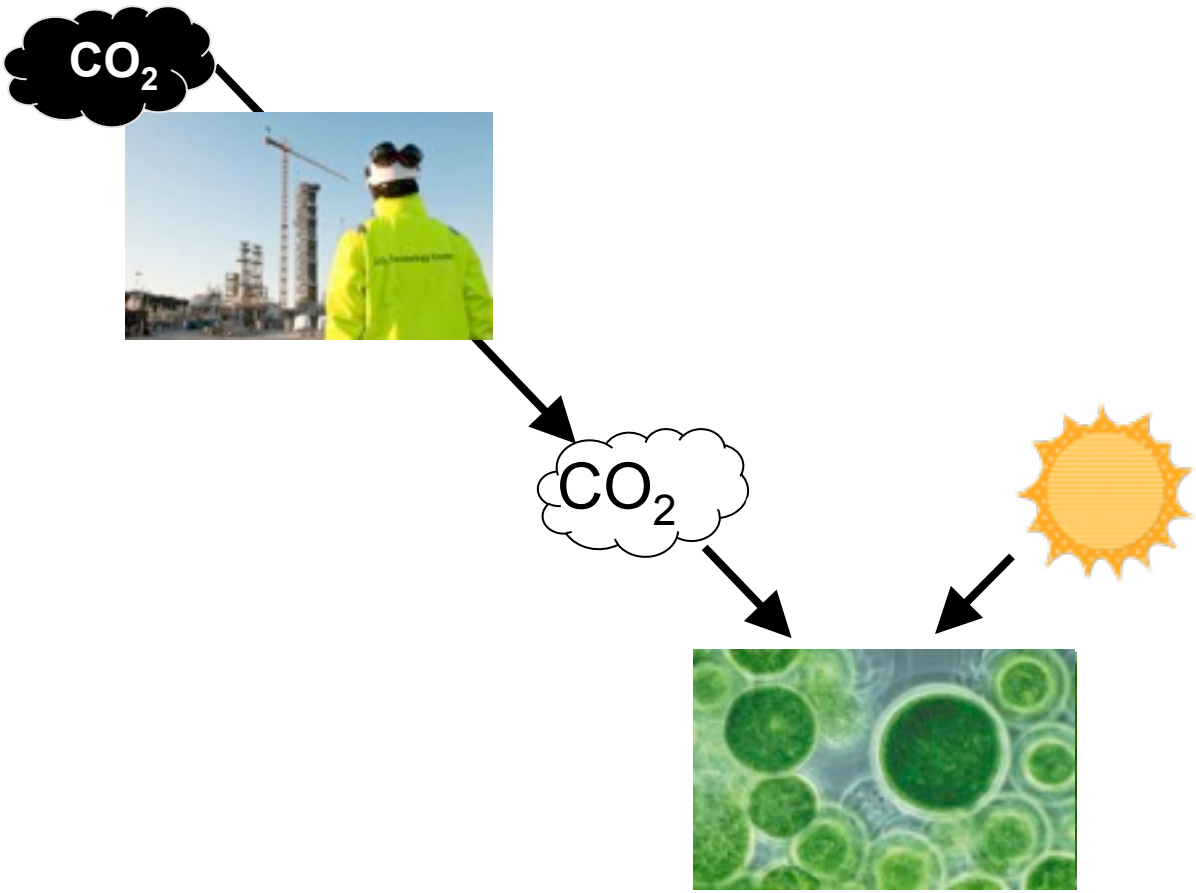




CO_2 Technology Centre Mongstad (TCM)

- Worlds largest pilot facility for CO_2 capture (opens 7th May 2012)
- Develop capture technologies
- Designed to capture 100 000 tons/y
- Form basis for upscale and subsurface storage

Technology ‘moon landing’



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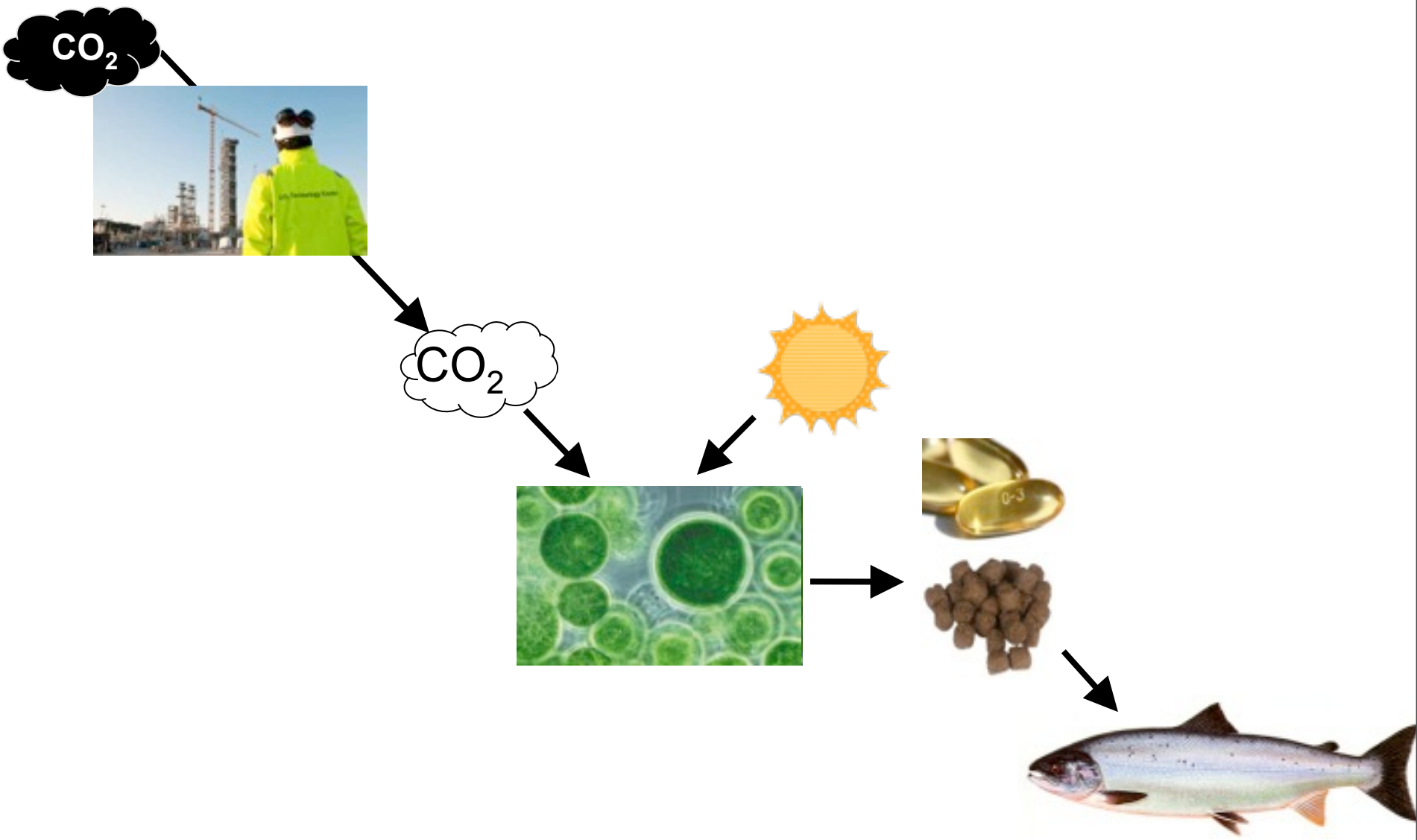
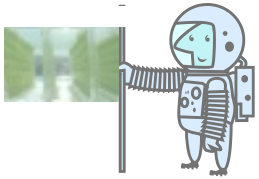
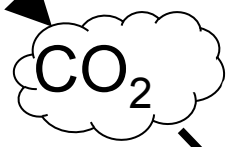
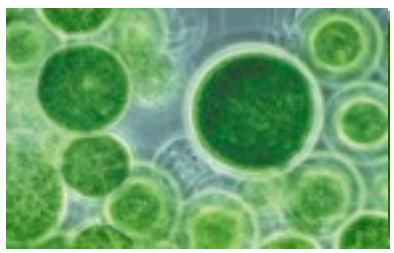


The opportunity;
A bioTechnology ‘moon landing’







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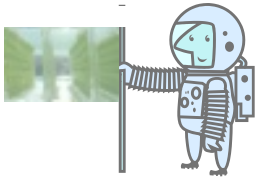
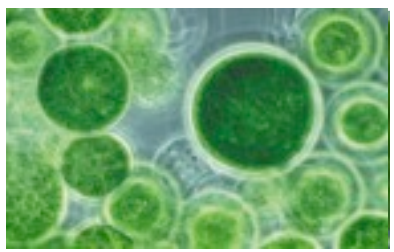


CO_2

CO_2



DET KONGELIGE
OLJE- OG ENERGIDEPARTEMENT

Meld. St. 9

(2010–2011)

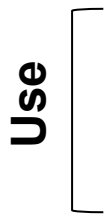
Melding til Stortinget

Fullskala CO_2-håndtering

ressurs som kan anvendes som et supplement til deponering. Intensjonen er at det skal etableres forskjellige typer prosjekter, i første omgang knyttet til algeproduksjon for produksjon av biodiesel og fiskefôr, og kjemisk produksjon basert på CO_2 som råvare. Arbeidsgruppen planlegger også å etablere et selskap hvor forskningsinstitusjoner og industrielle aktører deltar i det videre arbeidet på Mongstad.

Algae suitable for aquafeed

Algae suitable for aquafeed



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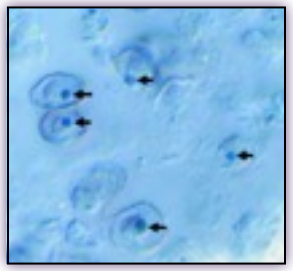
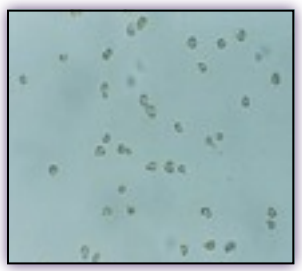
Use

Production



I. galbana
DHA



P. lutheri
EPA & DHA

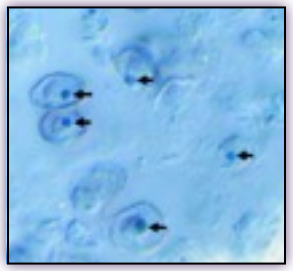
P. tricornutum
EPA & DHA

Algae suitable for aquafeed

- Choosing the algae

Use
- High EPA and DHA
- High digestibility and nutritional value
- High protein – similar aa composition to fishmeal

Production
- Local strain
- Fast & stable growth
- Mixotrophic growth
- Suitable for breeding/selection



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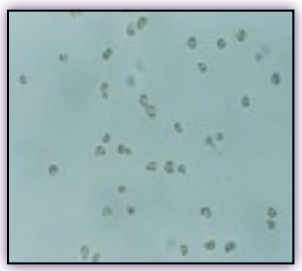

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- Choosing the algae
  - Use
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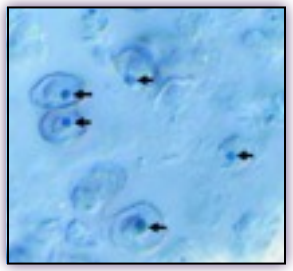
    - High protein – similar aa composition to fishmeal
  - Production
    - Local strain
    - Fast & stable growth
    - Mixotrophic growth
    - Suitable for breeding/selection
- Bergen Marine Biobank
  - Collection of microalgae and diatoms
  - Screening for suitable strains



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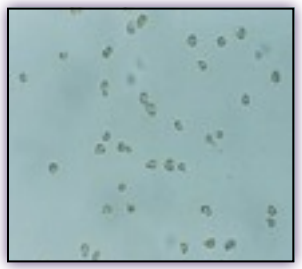


P. lutheri
EPA & DHA

P. tricornutum
EPA & DHA

Growth of salmon and cod

Microalgae (*P. tricornutum*) content:
0. 3%, 6% and 12% (DW)


Foto: Elin Kjørsvik, NTNU

Atlantic salmon:

- Feeding period: 82 days
- 31 ind. pr. tank

- Similar feed uptake
- No difference in feed digestion
- No difference in growth up to 6% microalgae content
- No difference in gut morphology

Atlantic cod:

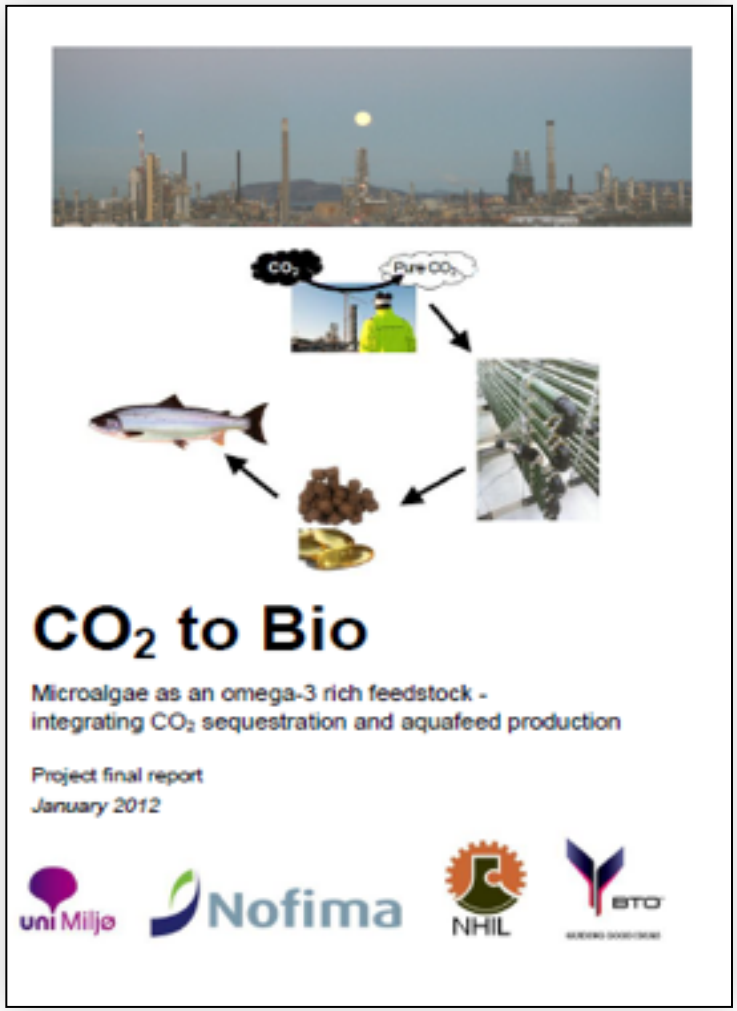
- Feeding period: 95 days
- 20 ind. pr. tank

- Similar feed uptake
- No difference in feed digestion
- Tendency to increased growth with algae inclusion
- Significant difference in skin pigmentation
- No difference in gut morphology

Thank to the Research council of Norway and Colleagues at NOFIMA Marine, UMB, NTNU and EWOS

Courtesy: Kjell Inge Reitan, SINTEF

Company start-up October 2011



CO2Bio AS:

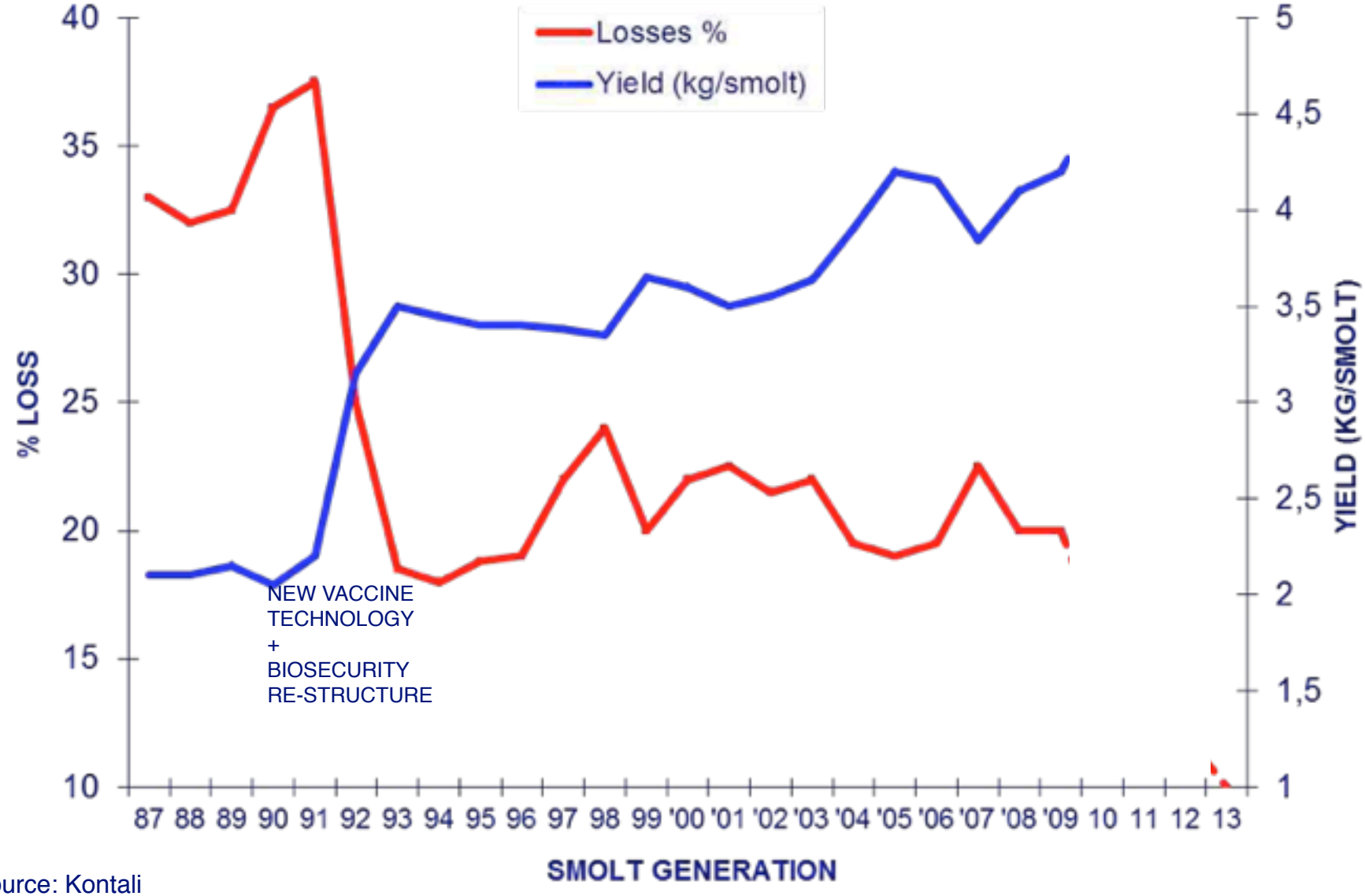
- NHIL industry consortium
- Bergen Technology Office
- EWOS AS
- Grieg Seafood ASA
- Salmon Group AS

Aim:

- Establish pilot plant
- R&D projects together with research institutions
- Assess up-scale production

Productivity in Norwegian Salmon Farming

% loss vs yield



Source: Kontali

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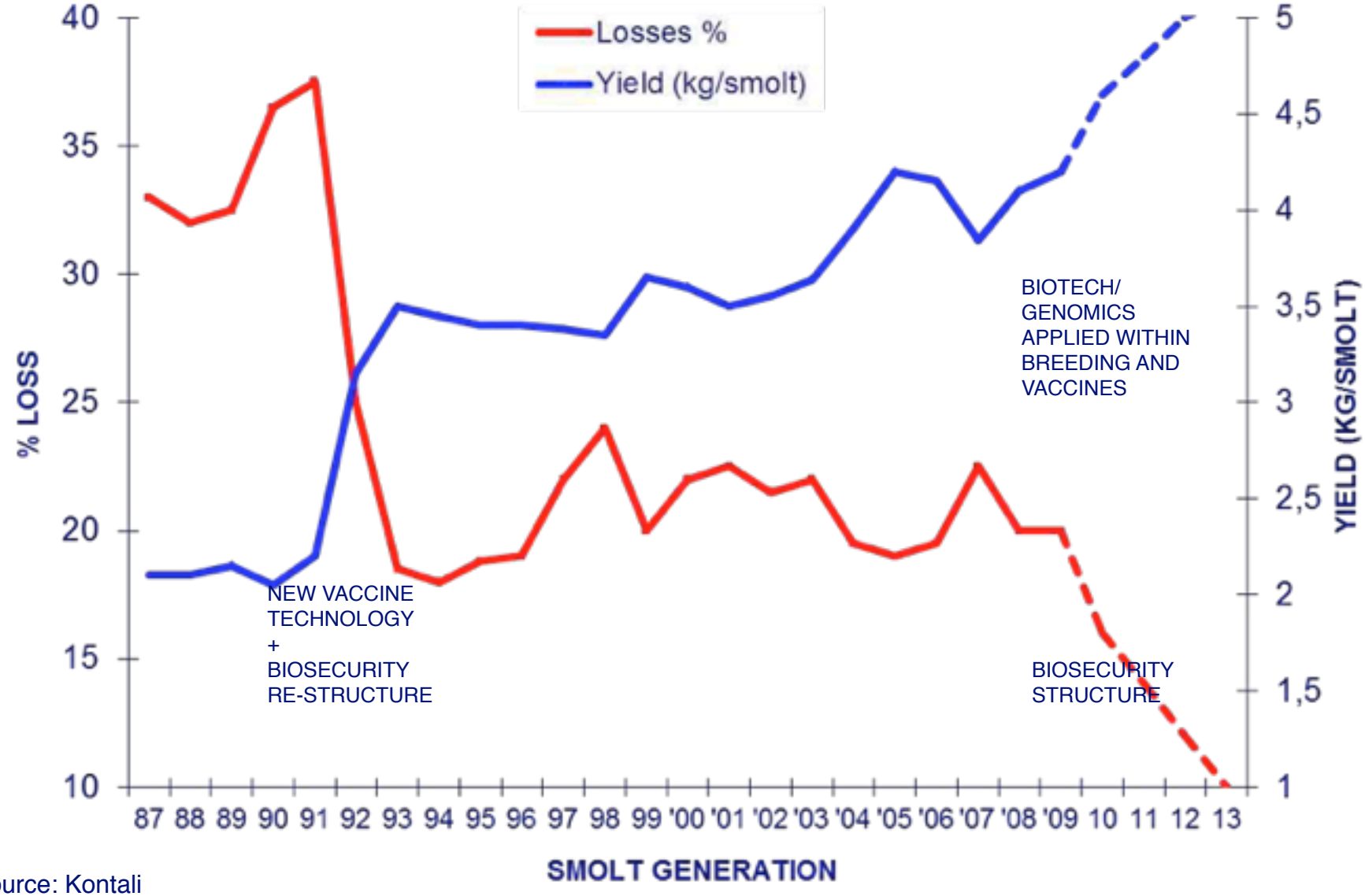


Source: Kontali

Sea Lice Research Centre

Centre for Research-based Innovation (RCN) - 2011-2019

Aim:

The Sea Lice Research Centre aims at becoming world leading on research on salmon louse and similar parasites. The nature of the centre will facilitate development of new methods for lice control and shorten the time from basic research to new products and tools for parasite control in the aquaculture sector to achieve a true integrated pest management in the future.

Partners

Host institution: University of Bergen, Department of Biology,
+ Departments of Molecular Biology and Informatics

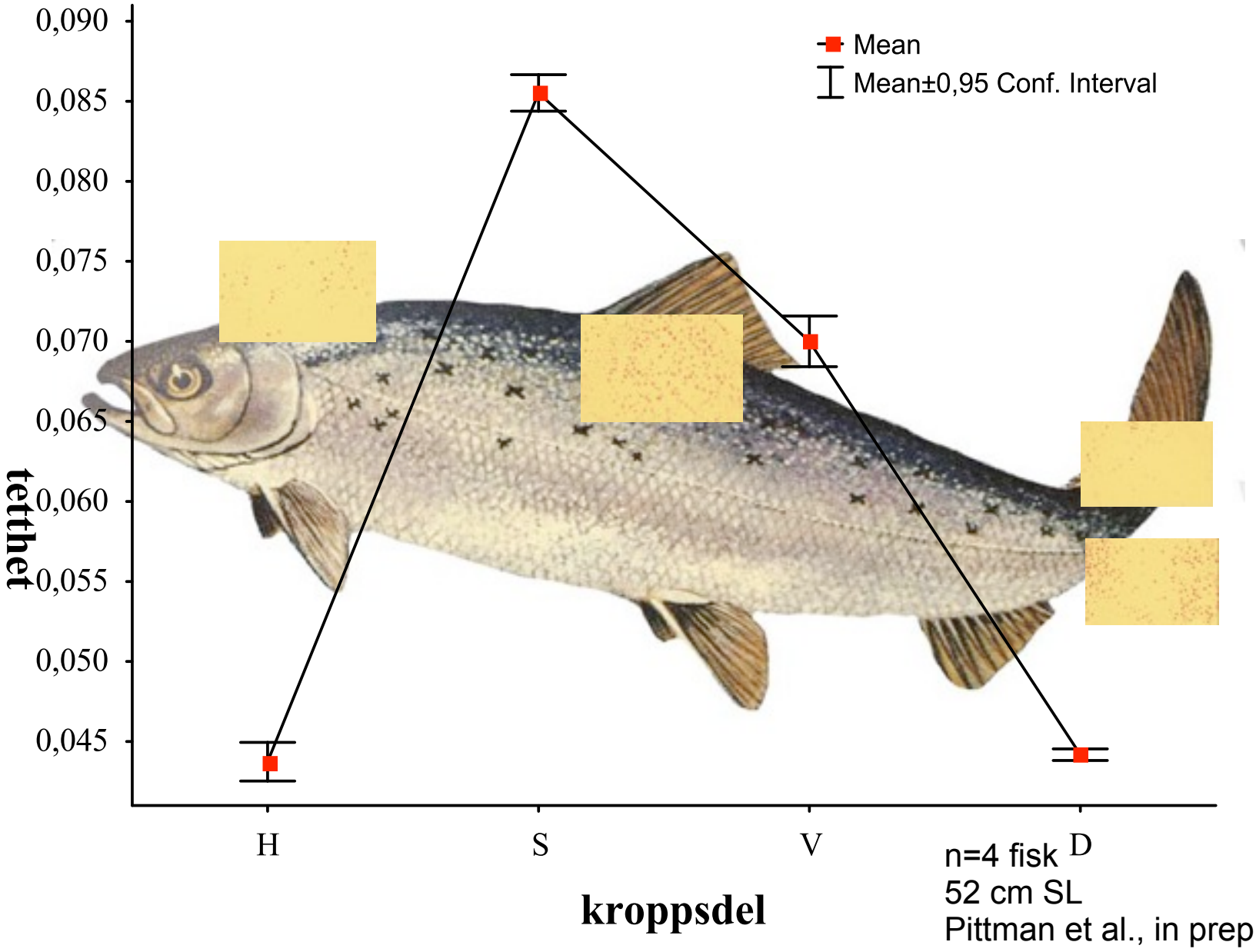
Academic partners:
Institute of Marine Research
Norwegian College of Veterinary Medicine
Uni Computing

Industry partners:
Novartis Animal Health
EWOS Innovation
Patogen Analyse
Marine Harvest
Lerøy Seafood

Centre director: Prof Frank Nilsen UiB

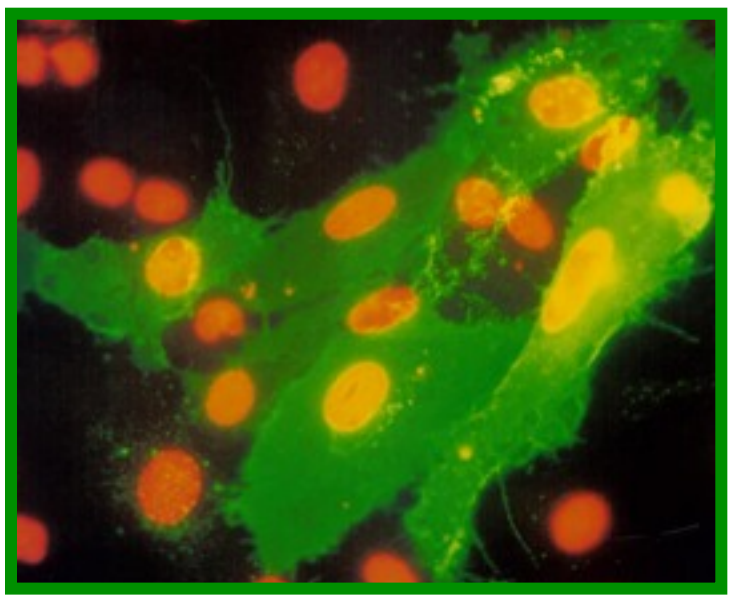
Budget: ca. 25 mill. NOK/year, (8 years = 200 mill. NOK = 25 mill. €)

More mucus cells on the dorsal side



Fish health: Cell line TO (salmon)

- Best production system for virus to vaccines against two of the most damaging diseases in salmon farming: ISA og PD.
  - ISA vaccine approved in Chile 2010
  - Vaccination against ISA allowed in Norway 18.10. 2010



ISA virus (green) multiplying in TO cells.

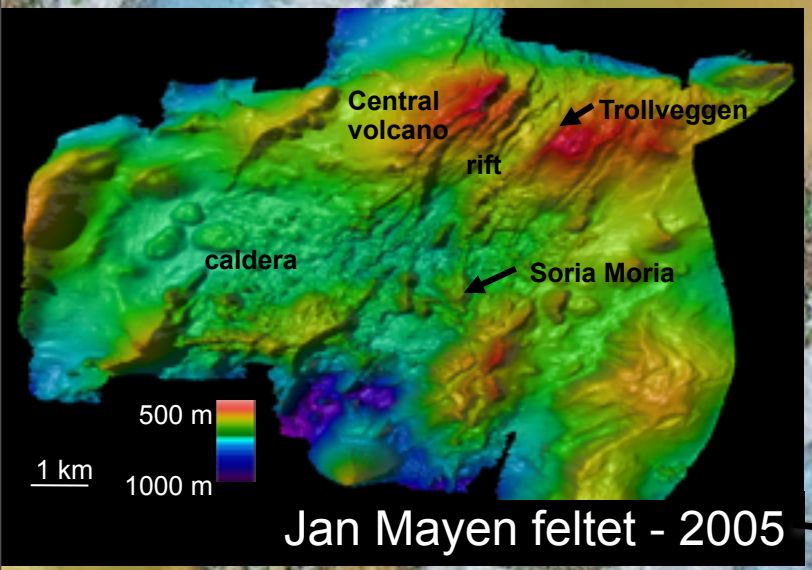
Red cell nuclei showing surrounding cells not yet infected.

Hydrothermal vents along the Arctic Mid-Ocean Ridge

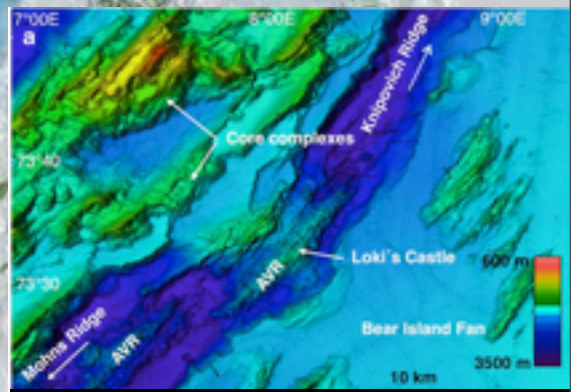
Centre for Geobiology

Norwegian Centre of Excellence

Deep Seafloor • Deep Biosphere • Deep Time • Roots of life



Jan Mayen feltet - 2005



Lokeslottet - 2008

Håkon Mosby Mud Volcano

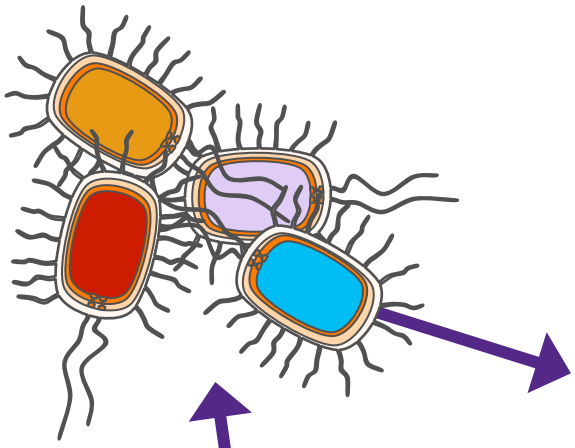
Nyegga

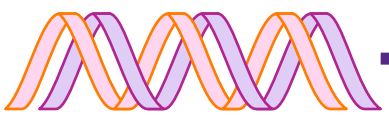
Pedersen, RB. *et al.* *Nature Communications*, 1:126 (2010).

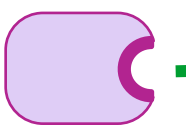
Mining for robust enzymes

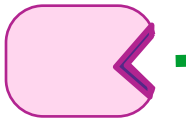
Mining for robust enzymes

Fish waste





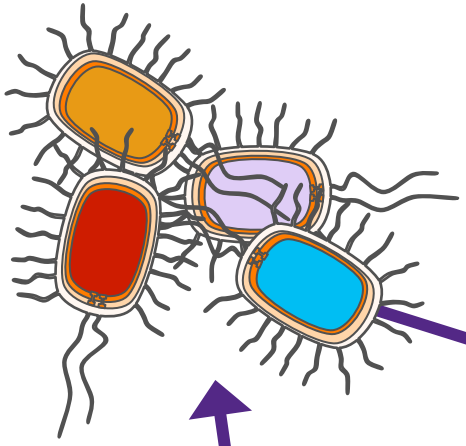


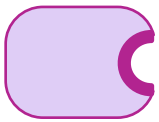


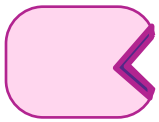
Biological process

Product

Mining for robust enzymes



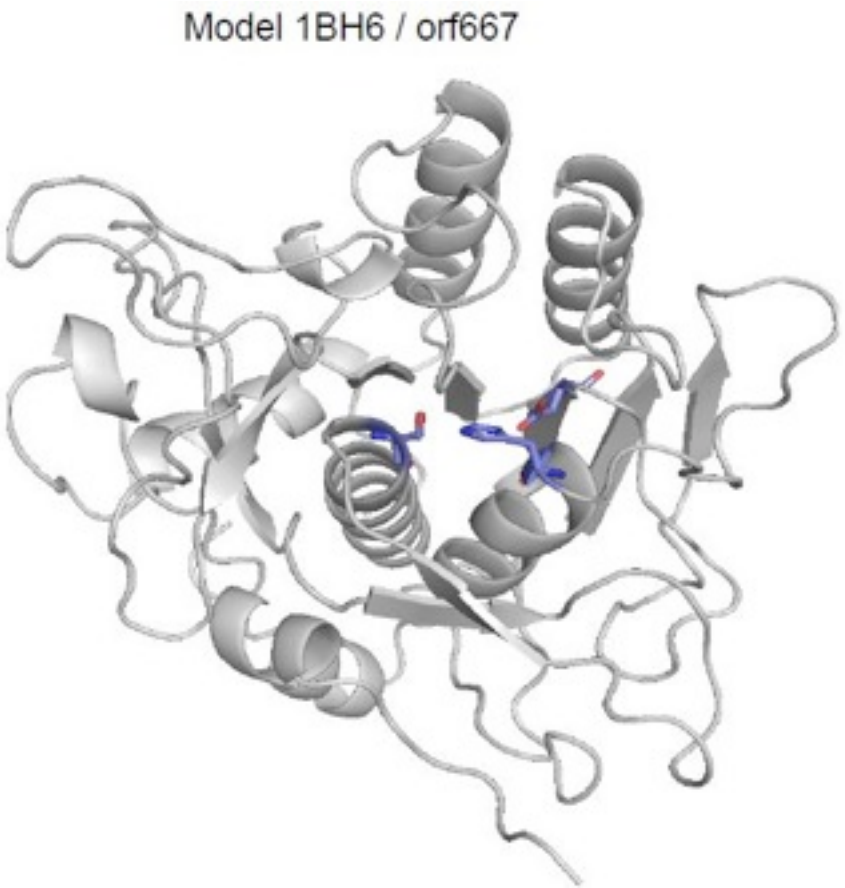




Biological process

Product

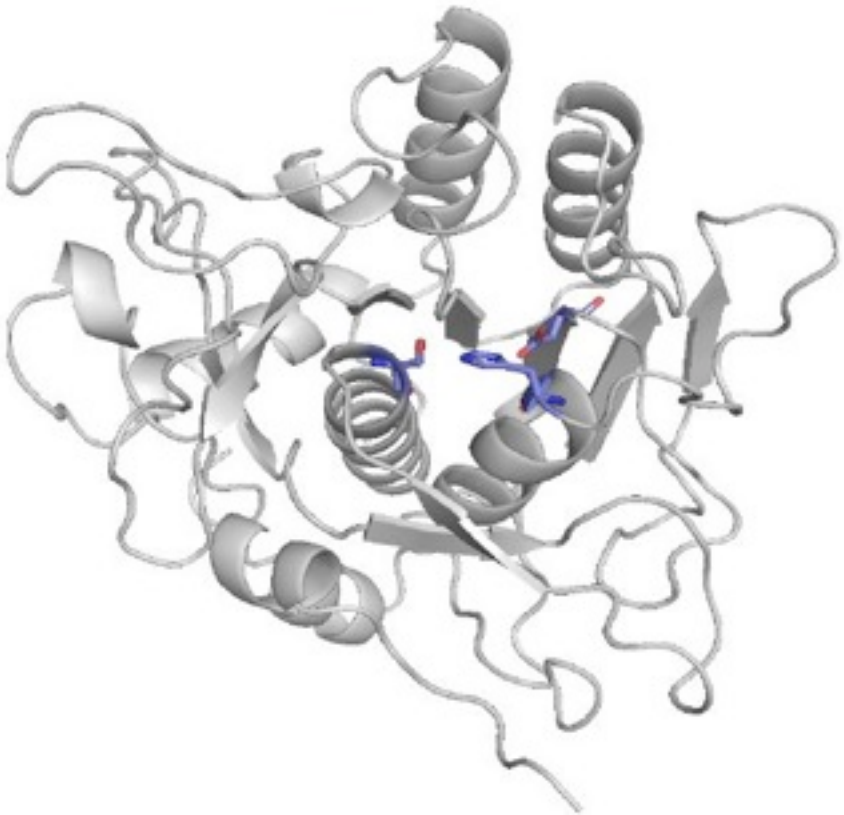
New enzymes for biorefinery of marine byproducts



uni Research
Senter for anvendt bioteknologi

New enzymes for biorefinery of marine byproducts

Model 1BH6 / orf667



Forsiden • Oppdrett • Åpnet ny fabrikk for marin bioraffinering

Åpnet ny fabrikk for marin bioraffinering

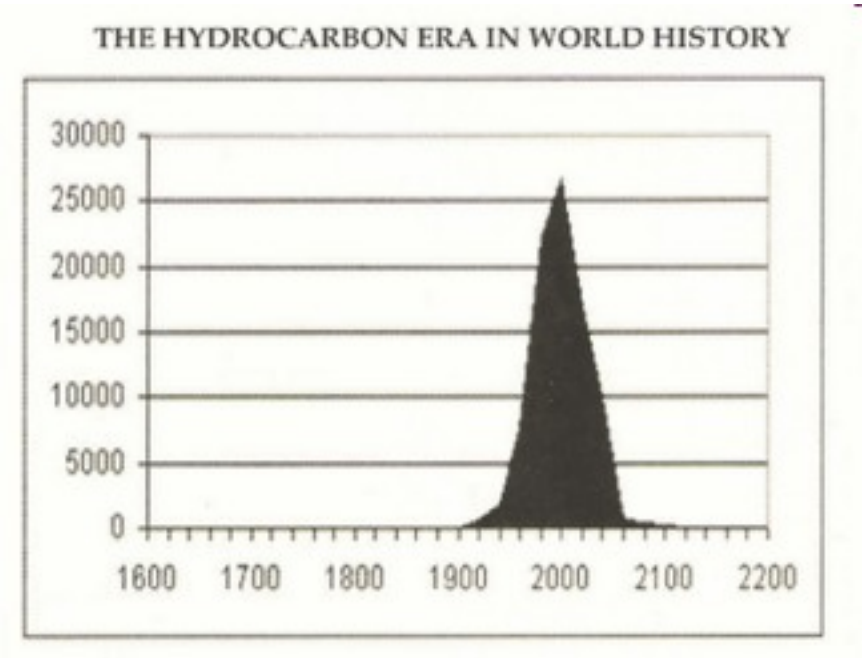
on 16. mars 2012 02:43.

Biomega AS sin nye fabrikk for marin bioraffinering på Skaganeset i Sund kommune på Sotra. (Foto: Åsta Viksøy).

Sund: Biomega AS har investert 130 millioner kroner i en ny fabrikk for marin bioraffinering som dobler produksjonskapasiteten.

uni Research
Senter for anvendt bioteknologi

Fossil-fuel to bio-fuel



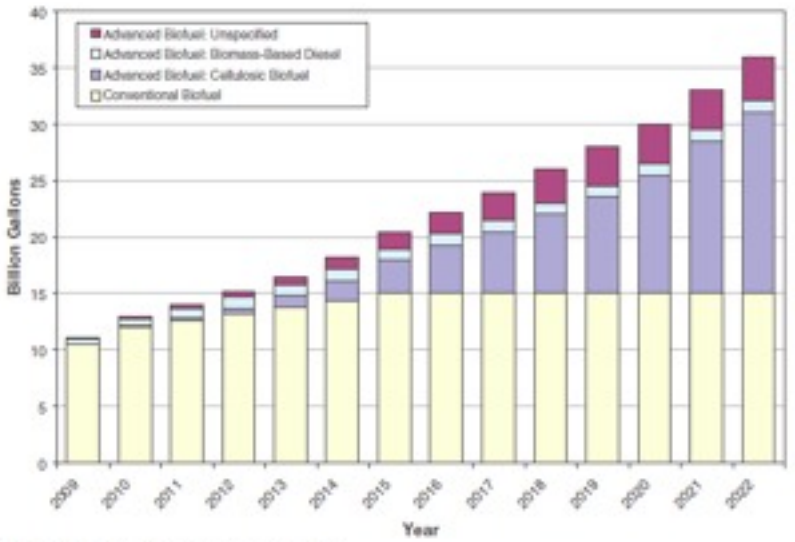


FIGURE 1 Volume changes over time.
Source: U.S. Environmental Protection Agency, Office of Transportation and Air Quality, Workshop Presentation by Bruce Rodan, June 23, 2009.

”..... most countries will be in a potential supply deficit for ethanol by 2020. On a global basis, supply could be short by at least 19 billion liters. The only country that will be in a position to supply the global ethanol market will be Brazil, which will be able to supply a minimum of 13.2 billion liters to the global market by 2020. No other country comes anywhere close to being able to supply these kinds of volumes.”

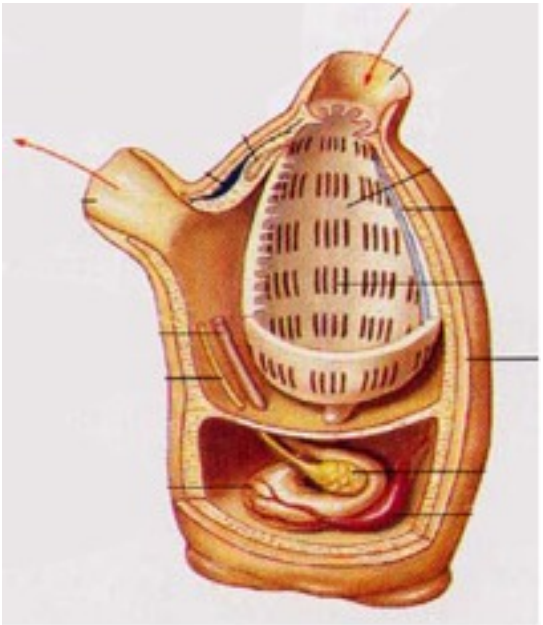
Hart’s Global Biofuels Outlook to 2015 (2010)

Novel source:
Ascidians/Tunicates

Tunicin

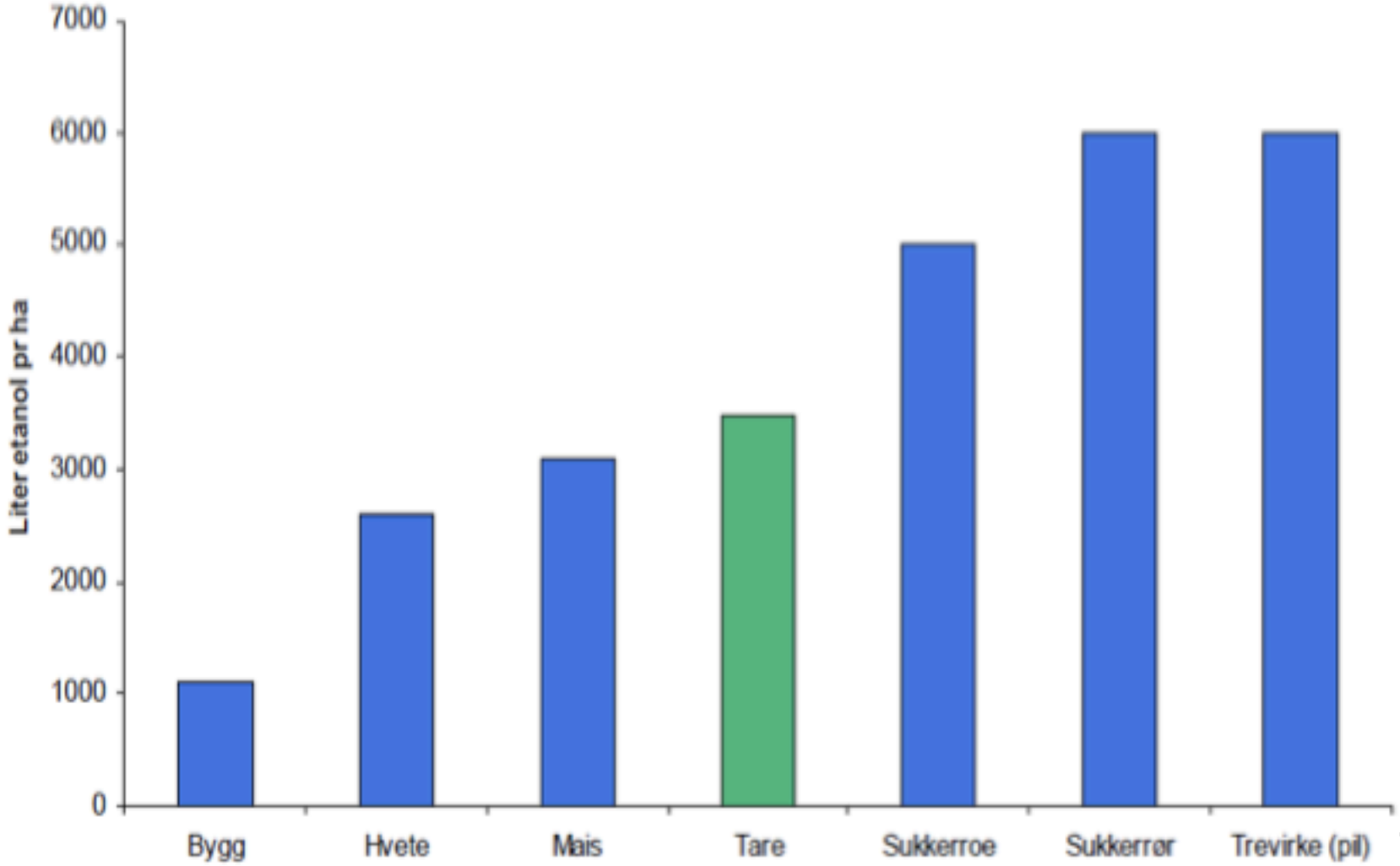
Tunicin - Animal cellulose; a substance present in the mantle, or tunic, of the Tunicates, which resembles, or is identical with, the cellulose of the vegetable kingdom.

Webster's revised unabridged dictionary



Most of the mantle is cellulose without lignin

Biofuel from the sea?



Tunicol

Figur 1. Produksjonsutbytte av etanol pr hektar for utvalgte avlinger. Utbytte fra tare er estimert av SINTEF Fiskeri og havbruk, trevirke (Pil) av Zero (http://www.zero.no).

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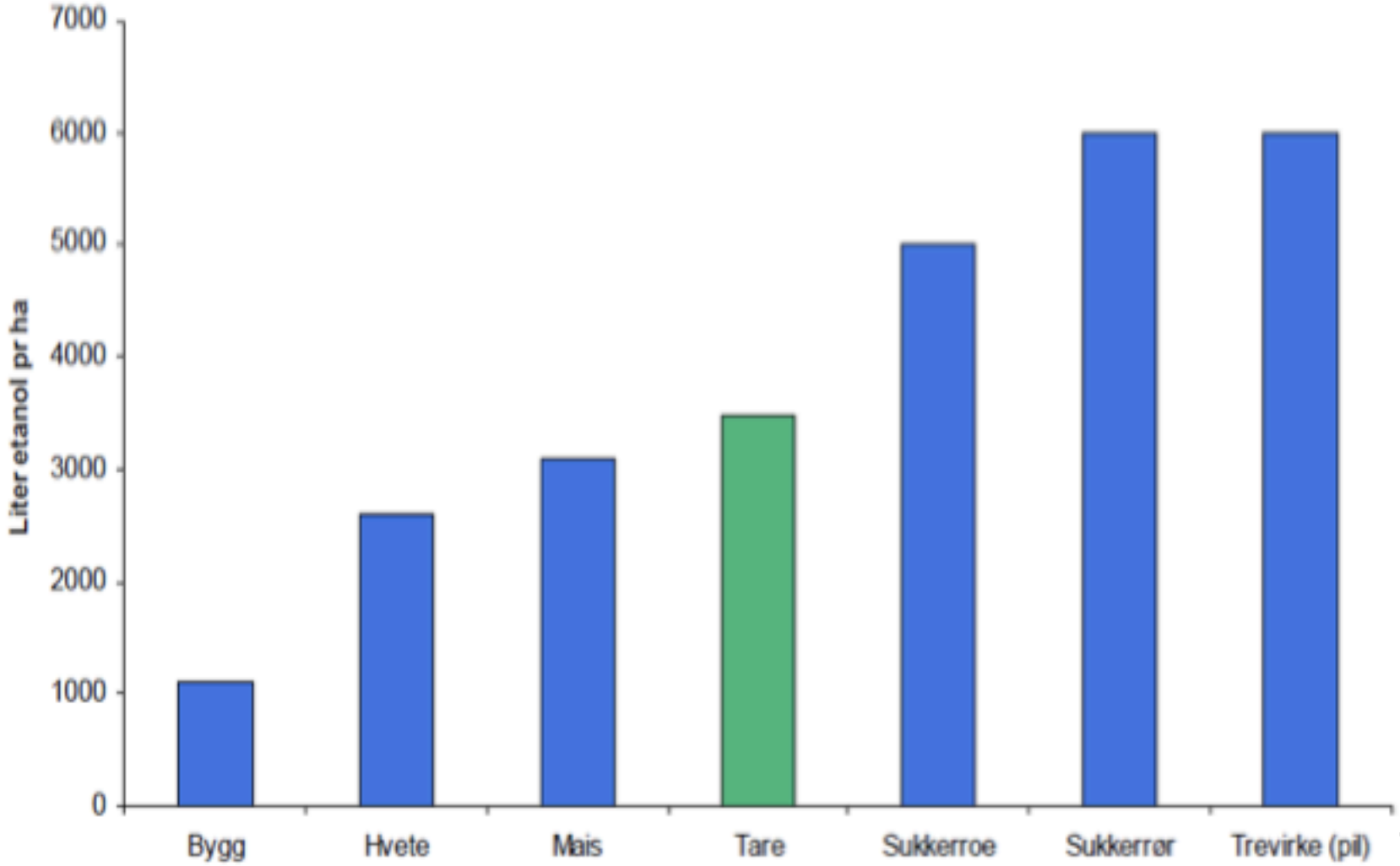

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Biofuel from the sea?

- Ethanol output pr. hectar from Tunicol
- Patented product from UiB/Uni/BTO

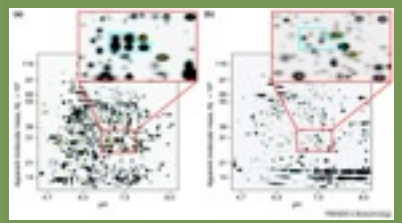
Tunicol

Developing a biological monitoring system for ocean health

"TOXIN"/STATUS

- Contaminants
- algal toxins
- endocrine disruptors
- allergens
- pathogens
- GMO
- growth
- health
- etc.

Differentially expressed genes, proteins, metabolites = biomarkers

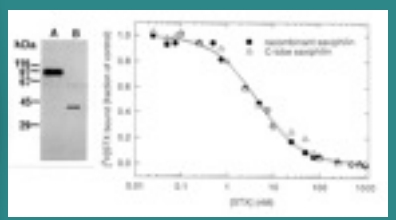


Binding candidates

OMICS PLATFORMS

GENOMICS INFORMATION

Develop antibody-based assay w/protein standard



Develop binding assay w/recombinant protein

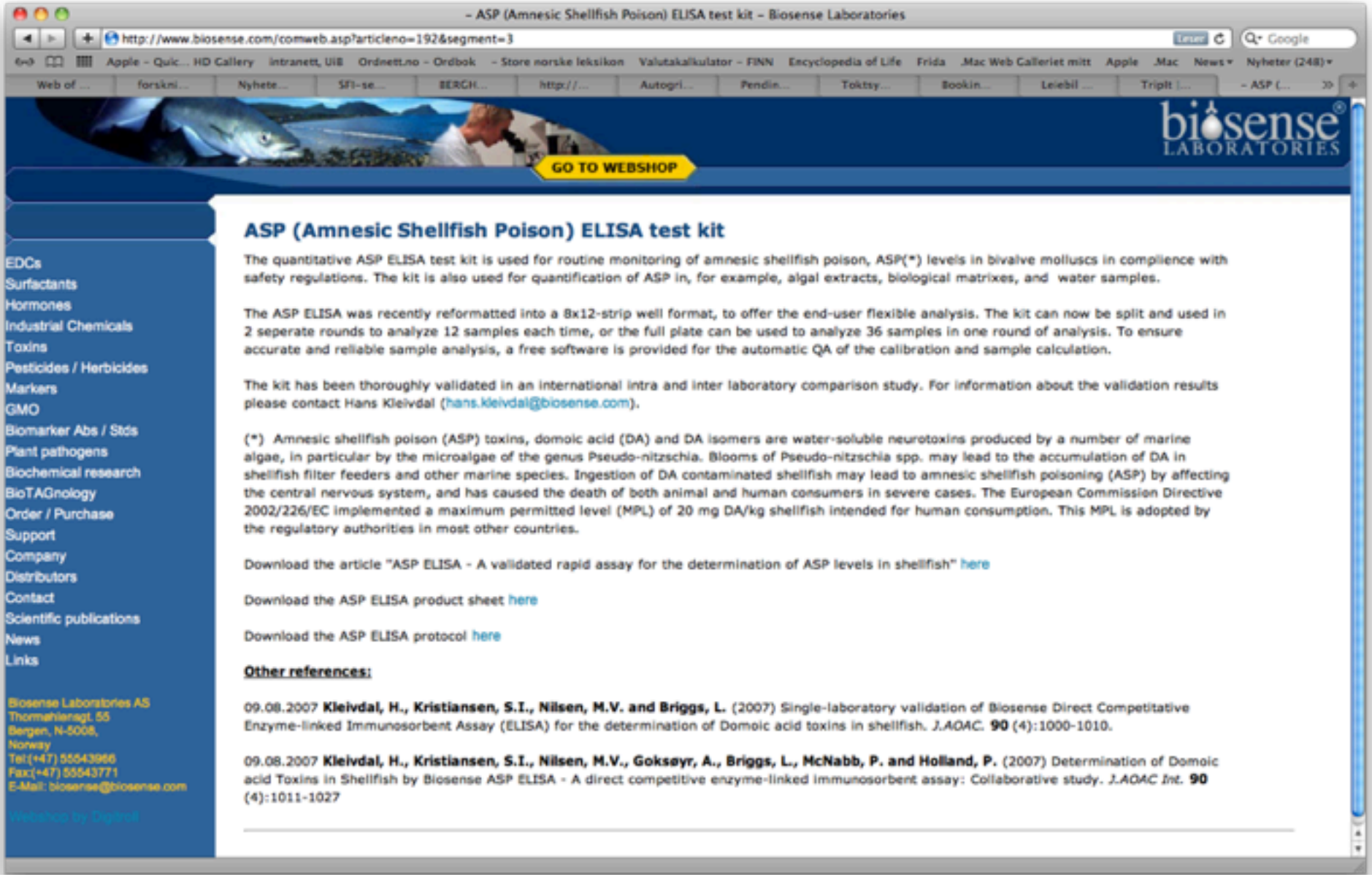
PROTEIN PRODUCTION

BIOINFORMATICS PLATFORM

Assay/kit

Protein array-based/ multiplex /chip

ANALYTICAL TECHNOLOGY PLATFORMS


– ASP (Amnesic Shellfish Poison) ELISA test kit – Biosense Laboratories
http://www.biosense.com/comweb.asp?articleno=192&segment=3
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ASP (Amnesic Shellfish Poison) ELISA test kit
The quantitative ASP ELISA test kit is used for routine monitoring of amnesic shellfish poison, ASP(*) levels in bivalve molluscs in compliance with safety regulations. The kit is also used for quantification of ASP in, for example, algal extracts, biological matrixes, and water samples.
The ASP ELISA was recently reformatted into a 8x12-strip well format, to offer the end-user flexible analysis. The kit can now be split and used in 2 seperate rounds to analyze 12 samples each time, or the full plate can be used to analyze 36 samples in one round of analysis. To ensure accurate and reliable sample analysis, a free software is provided for the automatic QA of the calibration and sample calculation.
The kit has been thoroughly validated in an international intra and inter laboratory comparison study. For information about the validation results please contact Hans Kleivdal (hans.kleivdal@biosense.com).
(*) Amnesic shellfish poison (ASP) toxins, domoic acid (DA) and DA isomers are water-soluble neurotoxins produced by a number of marine algae, in particular by the microalgae of the genus Pseudo-nitzschia. Blooms of Pseudo-nitzschia spp. may lead to the accumulation of DA in shellfish filter feeders and other marine species. Ingestion of DA contaminated shellfish may lead to amnesic shellfish poisoning (ASP) by affecting the central nervous system, and has caused the death of both animal and human consumers in severe cases. The European Commission Directive 2002/226/EC implemented a maximum permitted level (MPL) of 20 mg DA/kg shellfish intended for human consumption. This MPL is adopted by the regulatory authorities in most other countries.
Download the article "ASP ELISA - A validated rapid assay for the determination of ASP levels in shellfish" here
Download the ASP ELISA product sheet here
Download the ASP ELISA protocol here
Other references:
09.08.2007 Kleivdal, H., Kristiansen, S.I., Nilsen, M.V. and Briggs, L. (2007) Single-laboratory validation of Biosense Direct Competitative Enzyme-linked Immunosorbent Assay (ELISA) for the determination of Domoic acid toxins in shellfish. J.AOAC. 90 (4):1000-1010.
09.08.2007 Kleivdal, H., Kristiansen, S.I., Nilsen, M.V., Goksøyr, A., Briggs, L., McNabb, P. and Holland, P. (2007) Determination of Domoic acid Toxins in Shellfish by Biosense ASP ELISA - A direct competitive enzyme-linked immunosorbent assay: Collaborative study. J.AOAC Int. 90 (4):1011-1027

Competence and capacity

Foto: Paul Erik Rosenbaum, UiB

Competence and capacity

- Increased use of biotechnology in society will put a demand on increased absorbing ability, i.e. competence and capacity in end user groups: industry, health care, management etc. etc.

Foto: Paul Erik Rosenbaum, UiB

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Thank you for your attention!

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