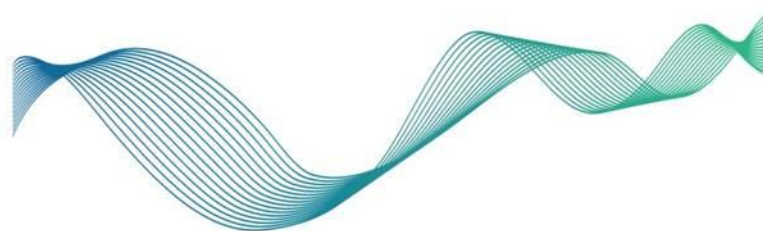


# MarineBiotech



## SeaRefinery

**The Seaweed Biorefinery – for high value added products**

Anne-Belinda Bjerre, Wolfgang Stelte  
Randi Neerup, Bert Groenedaal, Benny Pycke,  
Rósa Jónsdóttir, David de Smet

ERA-MBT 1st Transnational Joint Call: Biorefinery processes

21st November 2017



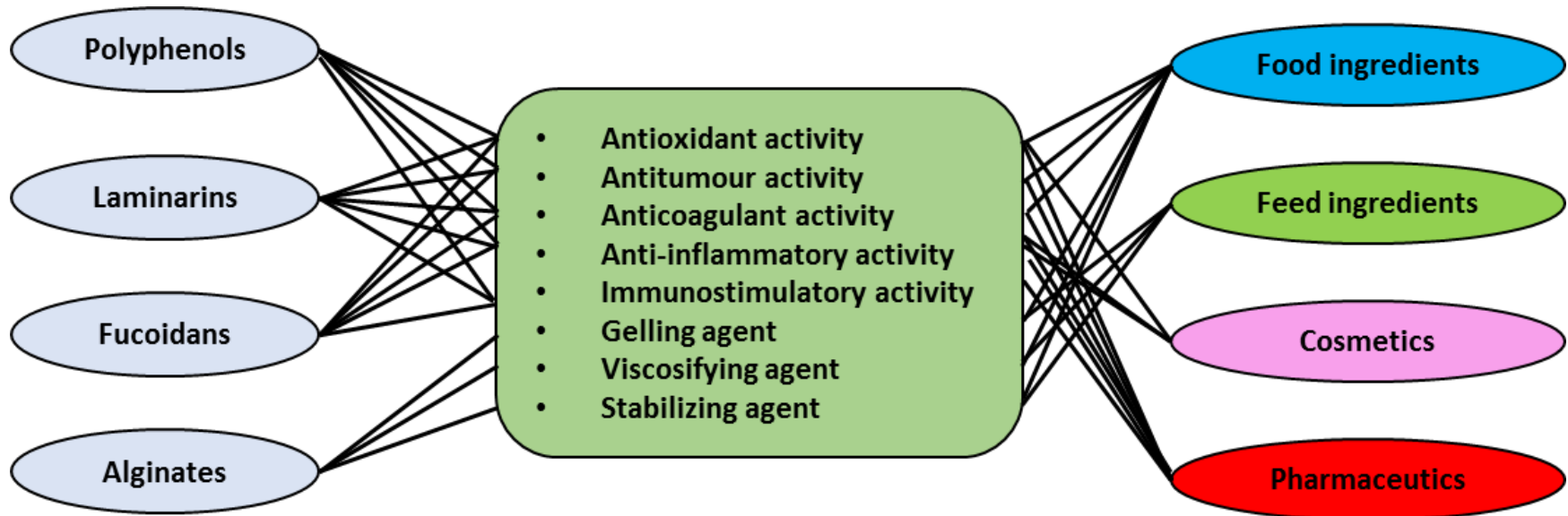
# THE CONSORTIUM

PRINCIPAL INVESTIGATOR	INSTITUTION	COUNTRY
<b>Consortium Coordinator Name</b>	Danish Technological Institute	DK
Partner 1	Danish Technological Institute	DK
Partner 2	Marinox ehf.	IS
Partner 3	CyberColloids Ltd	IRL
Partner 4	SIOEN Industries NV	BE
Partner 5	Centexbel	BE
Partner 6	Hortimare	NO
Partner 7	ViVox	DK
Partner 8	Cork Institute of Technology	IRL

**Project period: November 2015 – October 2018**

# Seaweed Biorefinery

**Brown seaweed** contains a portfolio of **commercially interesting substances** which implies high values for market sectors such as:



# Seaweed Biorefinery

## Market potential

Product category	Global market in Million €	Global market in tonnes DW	Average price kg/DW in €
Alginate	500	50,000	10
Mannitol	1000	142,857	7
Fucoidan	3	15	200
Laminarin	300	100,000	3
Plant Nutrition	500	52,632	9.5
Sea vegetables	100	6,667	15
Total	2403	352,170	

Source: Olavur Gregersen, Ocean Rainforest

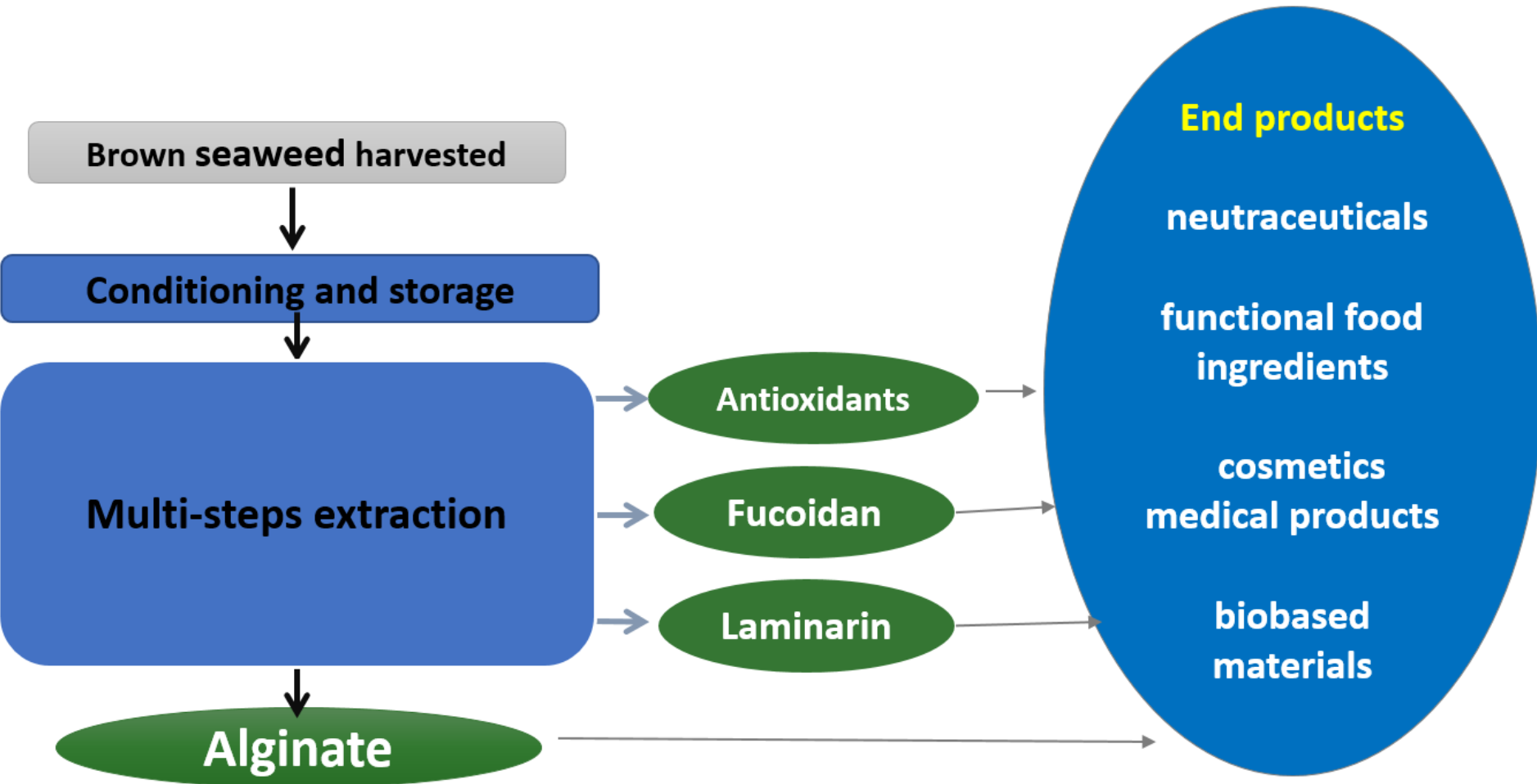
# Project Objectives

To **develop and test an innovative biorefinery approach for seaweed exploitation in Northern Europe**, led by **industrial key players** with the aim to produce Algal **bioactive molecules** for nutraceuticals, functional foods, cosmetics, pharmaceuticals and biobased materials.

# Project Objectives

- To demonstrate **sustainable cultivation** of the brown seaweed *Saccharina latissima*
- To cultivate with focus on **seasonal variations** for algal **production of natural chemical biomolecules of industrial interest.**
- To develop **chemical and enzymatic processes for the extraction of bioactive molecules, hydrocolloids, and proteins** for industrial utilization
- To evaluate algal compounds for **nutraceuticals, functional foods, cosmetics, pharmaceuticals and biobased materials** (e.g. textiles and textile coatings)
- To **disseminate relevant results to investors and policy makers** to inform about Blue Growth perspectives for seaweed.

# Project overview



# Project structure

WP5 Management (DTI)

**WP1** Seaweeds cultivation, harvesting, conditioning, storage and pre-conversion (SIOEN)



**WP2** Biorefinery of the harvested seaweed (DTI)



**WP3** Test and formulation of final products (Marinox)



**WP4** Dissemination, exploitation & IPR (SIOEN)

# Progress & Results

**Seaweeds cultivation, harvesting, conditioning, storage and pre-conversion**

Direct seeding with apparatus (IHC) at Osland, Norway (8000 m in 2 days)



Hortimare

# Progress & Results

## Seaweeds cultivation, harvesting, conditioning, storage and pre-conversion

Harvesting at Hortimare's cultivation site in Solund, Norway



Hortimare



Hortimare

# Progress & Results

## Seaweeds cultivation, harvesting, conditioning, storage and pre-conversion

Results from Cultivation trials with *Saccharina latissima* and *Alaria esculenta*. The obtained yield for *Saccharina* and *Alaria* were similar, but depending on cultivation system

Cultivation Technique	Yield
Rope	3 kg/m (fresh weight)
Ribbon	5 kg/m (fresh weight)
Nets	19 kg/m
Sheets	14 kg/m <sup>2</sup> (increase to 25 kg/m <sup>2</sup> )

Data and Images from SIOEN



Rope



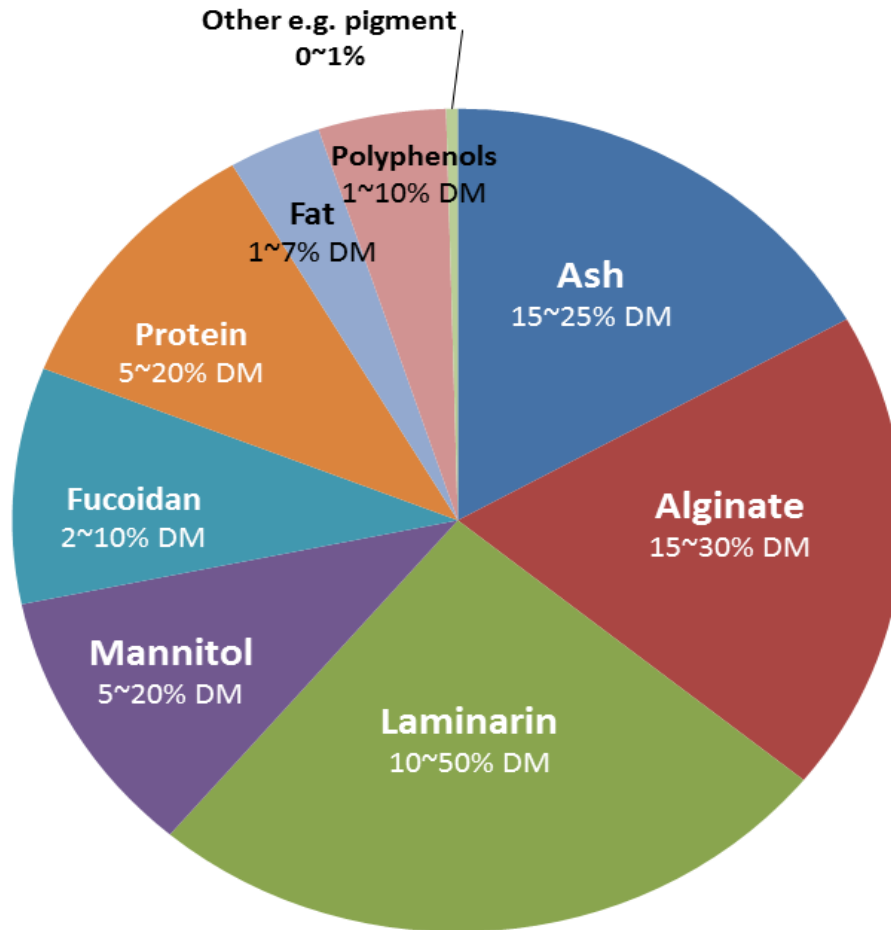
Ribbon



Nets

# Progress & Results

## Biorefinery



Laminarin: 10-50%

Alginate: 15-30%

Manitol: 5-20%

Fucoidan: 2-10%

Protein: 5-20%

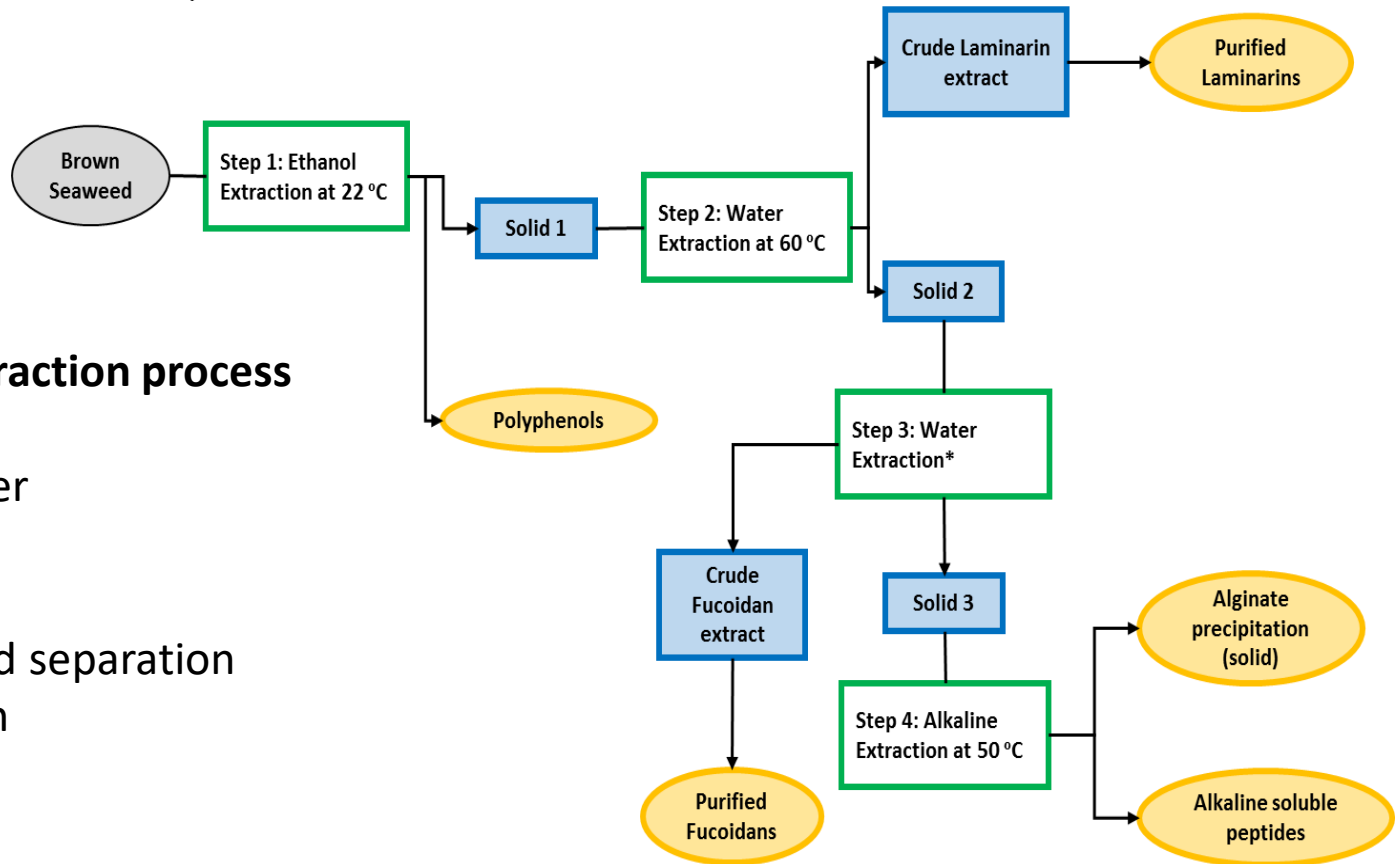
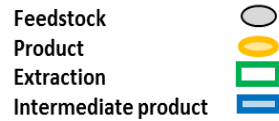
Fat: 1-7%

Polyphenols: 1-10%

Ash: 15-25%

# Progress & Results

## Biorefinery



## Multistep extraction process

- Ethanol
- Warm water
- Cold water
- Alkaline
- Solid/Liquid separation
- Purification

# Progress & Results

## Biorefinery

	Content of the compound in the <i>S. latissima</i> biomass (% DM)	Extracted in total of raw material (% DM)	Recovery efficiency (%)*
<b>Polyphenols</b>	1 ~ 5**	0.9	90
<b>Laminarin</b>	6.5	4	70
<b>Fucoidan</b>	10 ~ 12*	8	80
<b>Alginate</b>	44	12	27
<b>Remaining solids (protein and minerals)</b>	33-35	~ 38**	**

\* (g extracted per g in raw material) X 100 %

\*\* still under development

- A conceptual biorefinery was established for subsequently extracting polyphenols, laminarin, fucoidan and alginate
- Recovery efficiencies of polyphenols, laminarin and alginate were 90,70,80 and 27 % respectively
- Further optimization of extraction processes of alginate, protein and mineral are under development

# Progress & Results

## Test and formulation of final products

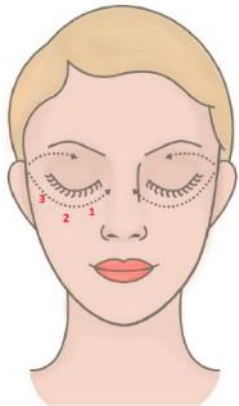
- **Nutraceuticals and functional food**
  - Immunomodulatory effects of *Saccharina latissima* extracts → anti-inflammatory
  - Anti-bacterial properties of extracts on selected bacterial strains → growth inhibition
- **Pharmaceuticals, cosmetics and medical products**
  - Skin cream → high antioxidant content → stability and skin test ongoing
- **Biobased materials**
  - Incorporation of algae based polymers into cultivation substrates → biobased cultivation substrate

# Progress & Results

## Test and formulation of final products







### EXAMPLE: Eye Cream

Color and stability test for cream (ongoing)



Skin test trials (ongoing)

### Eye cream

Colour for eye cream			
Photographic images	0.1%	0.5%	1.0%
Initial			
1 month			

# Progress & Results

## Test and formulation of final products

### EXAMPLE: Alginate based cultivation substrate

Developed by Centexbel and SIOEN

→ Successful production of alginate based cultivation substrates



# Progress & Results

## Dissemination and Exploitation

- Website <https://searefinery.eu/>
- Newsletter
- Flyers
- Poster presentation and oral presentations
- Workshops organized by SeaRefinery project for its stakeholders and public
  - Seaweed and ensilage workshop, 11<sup>th</sup> of April 2017, Taastrup, Denmark
  - Seaweed Industry Workshop, 27<sup>th</sup> of June 2017, Cork, Ireland
  - Workshop during World Seafood Congress, 10-13<sup>th</sup> of September 2017 in Reykjavik, Iceland
- Conferences
  - 6<sup>th</sup> Nordic Seaweed conference, Grenå, Denmark, 12th - 13th of October 2016
  - 7<sup>th</sup> Nordic Seaweed conference, Grenå, Denmark, 11th - 12th of October 2017

# Impact

- SeaRefinery is an **industrially driven project**, with the aim to **enhance the competitiveness of the marine high-value bio-industry**.
  - **Improving Breeding and cultivation techniques** for seaweed culture
  - **Improving Harvesting and storage technologies**
  - **Development of new processes and products**
  - **Raise awareness in the public and industrial sector as well as policy makers**
  
- Ultimately this is expected to **create jobs and generate income** especially in coastal areas of Europe
  
- **Contribute to mitigate eutrophication and improve the ecological status of the marine environment** in accordance with the EU Marine Strategy Framework Directive (Directive 2008/56/EC).

# Future directions and needs

- **Lacking Regulatory framework for seaweed cultivation** is an obstacle and barrier for the development of the industry
- **Standardization of seaweed based products** is a requirement for the development of this business area
  - Specifications for food/feed and non-food sector applications
  - Develop standards determination methods for algae and algae-based products
  - Technical committee has been established in Oct 2017 (CEN TC 454)
- Improving awareness for Seaweed based products in public

# Thank you for your attention!

The SeaRefinery Project  
Biotechnology ERA-NET 055  
Is financially supported by

