

# PEGASUS

Phycomorph European Guidelines  
for a Sustainable Aquaculture of  
Seaweeds



## **PHYCOMORPH EUROPEAN GUIDELINES FOR A SUSTAINABLE AQUACULTURE OF SEAWEEDS**

Bénédicte Charrier  
CNRS researcher  
Station Biologique Roscoff  
France

# WHY ?

- Because **EU seaweed-based economy** is lagging behind
- Because of the **absence of homogenised governance through EU**

- Differences policies
- Different authorized species
- Different procedures for licence delivery
- Different socio-economic context



- Because there was **no EU document so far** summarizing the current state of seaweed aquaculture
- Because **EU (DG-Mare)** expressed its interest in knowing more about it



**Aquaculture Advisory Council May 2018**



# PEGASUS at the EU parliament

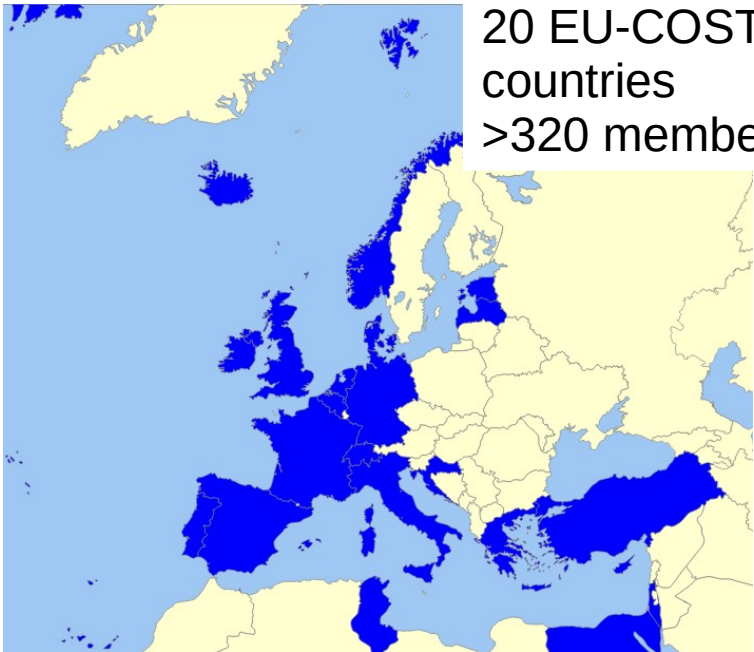
26 Feb 2019, invited by the SEARICA Intergroup



- MEPs
- DG-Mare, DG-Santé
- JRC,
- NGO « Sea-at-risk »
- Aquaculture Stewardship Council
- Dupont Nutrition & Health
- SES

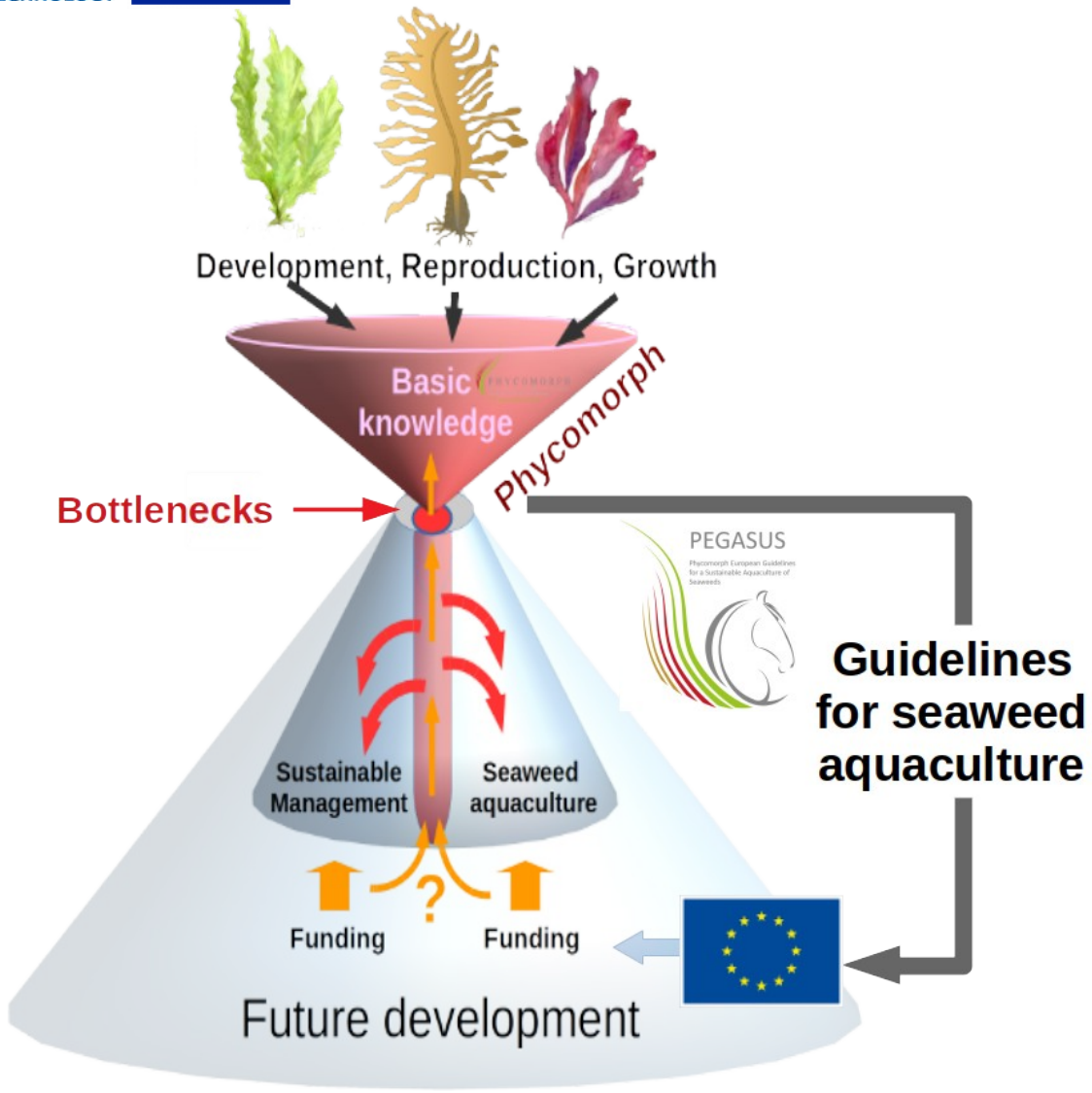


# PEGASUS ORIGIN



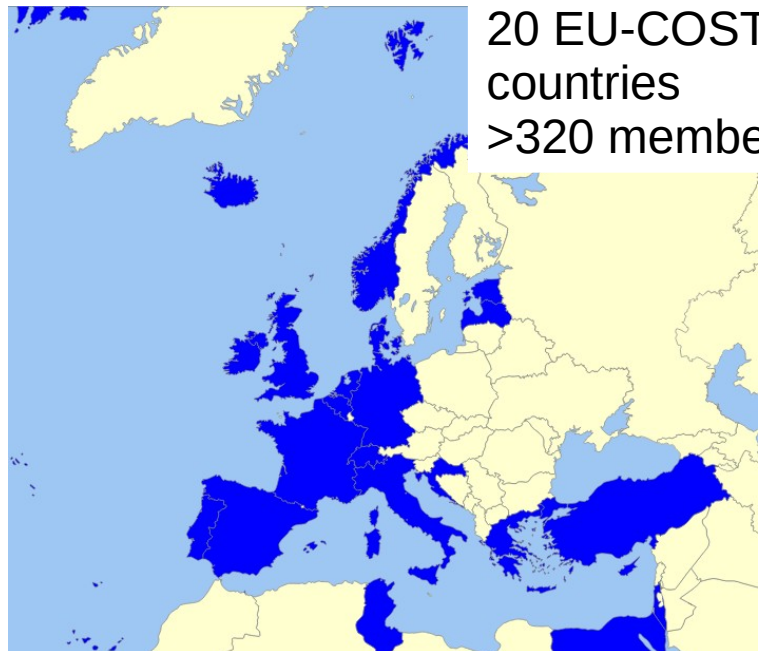
20 EU-COST  
countries  
>320 members

+ Merinov (CA), IOCAS (CH)





## PEGASUS ORIGIN



20 EU-COST  
countries  
>320 members

+ Merinov (CA), IOCAS (CH)

### Legislation

PhD  
JRC,  
Biomass  
monitoring,  
Seaweed ecology  
(EU)



R. Araujo

### Dissemination

PhD  
EU expert  
in Ethics,  
International Science  
Officer CIESM  
(FR)



M. Barbier

### Research

PhD  
COST Action  
Chair  
CNRS Researcher  
Editor book &  
special issues (FR)



B. Charrier

### Main coordination

### Food

PhD  
Secretary ISA  
Council,  
Chair Danish  
Standard Committee  
DTU Researcher (DK)



S. Holdt

### Genetics

PhD  
CEVA project  
leader  
Seaweed  
Population genetics  
(FR)



B. Jacquemin

### Production

PhD  
Pdt ISAP  
Project leader  
Moreforsk  
Seaweed production  
(NO)



C. Rebours

18-month project  
6 coordinators

50 contributors  
Several formats  
of dissemination

## 50 Contributors

- [Helena Abreu, ALGAplus, Portugal;](#)
- Isabel Azevedo, CIIMAR, Portugal;
- Sara Barrento, University of Porto, Portugal;
- Suzannah-Lynn Billing, Scottish Association for Marine Science, UK;
- Tjeerd Bouma, NIOZ, The Netherlands
- Annette Bruhn, Aarhus University, Denmark;
- Alejandro Buschmann, Universidad de Los Lagos, Chile;
- Iona Campbell, Scottish Association for Marine Science, UK;
- Olivier de Clerck, University of Gent, Belgium;
- Elizabeth Cottier-Cook, Scottish Association for Marine Science, UK;
- Alan Critchley, Ian Critchley, Cape Breton University, Canada
- [Maeve Edwards, Irish Seaweed consultancy, Ireland](#)
- Jan Emblemståg, Norwegian University of Science and Technology, Norway;
- Aschwin Engelen, Universidade do Algarve, Portugal
- [Jon Funderud, Seaweed Energy Solution, Norway;](#)
- Claire Gachon, Scottish Association for Marine Science, UK;
- Alexander Golberg, Tel Aviv University, Israel;
- [Aleksander Handå, SINTEF, Norway;](#)
- [Anicia Hurtado, Integrated Services for the Development of Aquaculture and Fisheries, Philippines;](#)
- Eun Kyoung Hwan, Incheon National University, Korea;
- Kapilkumar Ingle, Tel Aviv University, Israel;
- Leila Ktari, INSTM – National Institute of Marine Sciences et Technologies, Tunisia;
- Rafael Loureiro, Ave Maria University, USA
- Adrian Macleod, Scottish Association for Marine Science, UK;
- Nagwa G. Mohammady, Faculty of Science Muharem Bey, Alexandria University, Egypt;
- Michéal Mac Monagail, National University of Ireland;
- Valéria Montalescot, Scottish Association for Marine Science, UK;
- [Frank Neumann, Seaweed Energy Solution, Norway;](#)
- Amir Neori, Israel Oceanographic and Limnological Research institute, Israel
- [Sotiris Orfanidis, Fisheries Research Institute, National Agricultural Research Foundation, NAGREF, Greece;](#)
- [Shaojun Pang, Institute of Oceanology, Chinese Academy of Sciences, China;](#)
- César Peteiro, IEO - Instituto Español de Oceanografía, Spain;
- [Pierre Ronan, CEVA, Centre d'Etude et de Valorisation des Algues, France ;](#)
- [Pierrick Stévant, Møreforsking Ålesund AS, Norway;](#)
- [Eric Tamigneaux, CÉGEP-GÎM, École des pêches et de l'aquaculture du Québec, Canada;](#)
- Klaas Timmermans, NIOZ, Royal Netherlands Institute for Sea Research, Netherlands;
- Julio A. Vásquez, Universidad Católica del Norte, Chile;
- Florian Weinberger, GEOMAR, Germany;
- Thomas Wichard, IAAC, University Jena, Germany;
- Charles Yarish, University of Connecticut, USA
- [Jos Heldens, Hortimare](#)
- Global Seaweed-STAR Team
- Latin Seaweed network



## WHAT PEGASUS DOES :



**Summarises the current status of seaweed aquaculture**

**Identify the bottlenecks**

**List the related challenges**

**Propose recommendations**

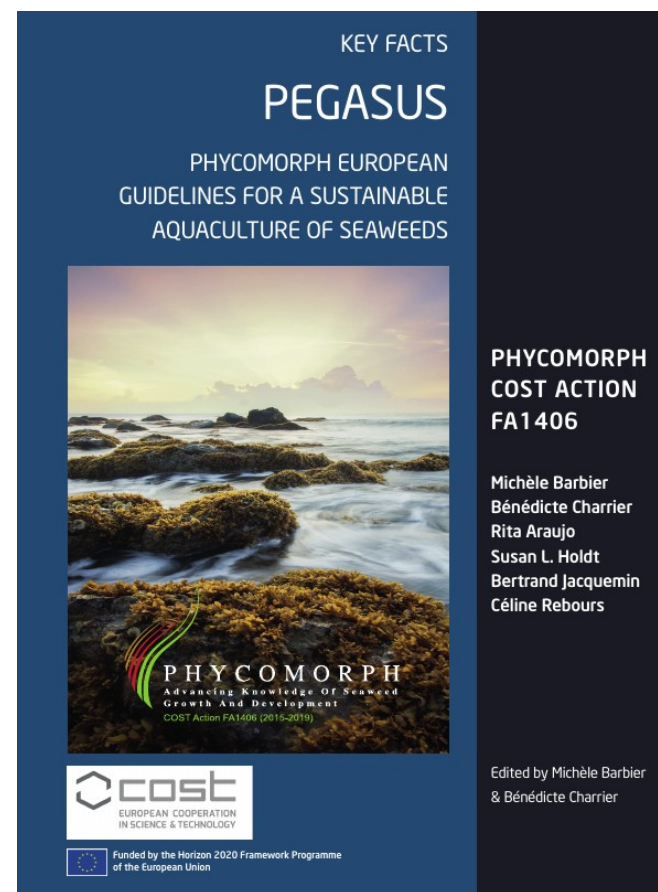
## & WHAT PEGASUS DOES NOT :

Provide « know-how » about seaweed aquaculture  
(i.e. no cultivation protocol,  
no legislation procedure to follow, etc...)



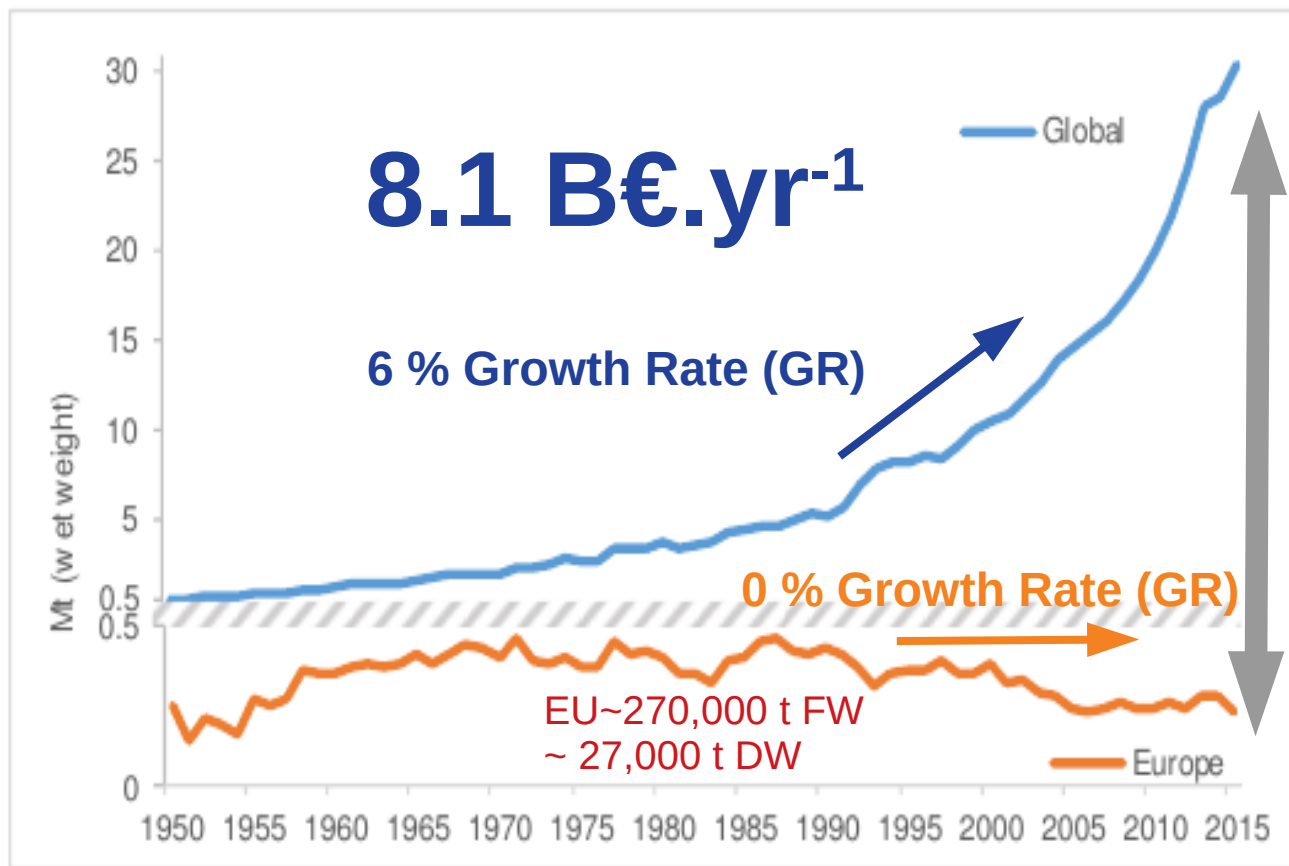
## Where can I download PEGASUS from ?

[www.phycomorph.org](http://www.phycomorph.org)



- Reference document (190 pages) : DOI :10.21411/2c3w-yc73
- 20 page document for Ministries, policy makers in EU : Policy oriented document
- Brochure (8 p) : “Phycomorph Statement”

## EU : an UNUSED POTENTIAL



**30 Mt.yr<sup>-1</sup>**



**EU (incl NO) < 1 % of the worldwide production**

## EU : a HIGH potential



### Trends in food consumption

- Nutritional quality
- EU Vegan/vegetarian diet + 350% in last decade (young people)
- Rich in proteins (~ leguminous), fibers, minerals, low in fat
- Organic food increase

### Coastline

- EU Maritime area > EU Land area (largest EEZ in the world = 22 M km<sup>2</sup>)
- EU coastline 68 000 km (185 000 with NO, IS and TK) = x3 USA ; >9 times more coast per inhab / China.
- 1/7 EU citizen lives < 500m from the sea (labour availability)

### Importation

SW importation ~  
SW EU production

### Cosmetics

> 2000€ / kg

### Technical innovation

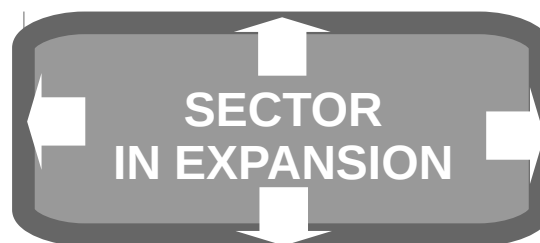


### Research

Leadership in Seaweed Genomics, Population genetics, Cell biology, Metabolomics, Transgenics and GE

### Biodiversity

> 3000 different species of seaweeds







**SIG Seaweed**  
INDUSTRIAL BIOTECH NETWORK NORWAY

## **SIG Seaweed 5 Conference**

27-28 November 2019, Trondheim

**FOCUS : How do we create a  
market for seaweed products  
and biomass ?**

## CREATE A MARKET ATTRACT CONSUMMERS



### Seaweed nutritional quality

**Seaweed** are rich in fibers, pigments, polyphenols, minerals (Na, K, P, Ca, Mg, I, Fe) and vitamins (A, B1, B2, B6, B12, C, D, E). They produce texturising agents: carrageenan, agar-agar, alginates and some species (e.g. *Porphyra*) contain 40% proteins. Seaweed have low Na/K ratio and low lipid (50% PUFA).

### 7 Reasons To Eat Seaweed Regularly & Best Recipes

by Jayne Leonard June 9, 2016



### Seaweed-derived food-packaging films



Bio-plastic has 2 years of shelf life without using preservatives, biodegradable, dissolve in warm water and 100% nutritious.

Can also be customized for different taste, color, and brand logo.

### Indonesian startup **Evoware**



# CREATE A MARKET

## ATTRACT CONSUMMERS



### Seaweed nutritional quality

**Seaweed** are rich in fibers, pigments, polyphenols, minerals (Na, K, P, Ca, Mg, I, Fe) and vitamins (A, B1, B2, B6, B12, C, D, E). They produce texturising agents: carrageenan, agar-agar, alginates and some species (e.g. *Porphyra*) contain 40% proteins. Seaweed have low Na/K ratio and low lipid (50% PUFA).

7 Reasons To Eat Seaweed Regularly & Best Recipes  
by Jayne Leonard June 9, 2016



### Seaweed-derived food-packaging films



Bio  
life  
bio  
wa  
  
Ca  
diff  
logo.



OhOO

### Indonesian startup Evoware





# CREATE A MARKET

## KNOW WHAT WE EAT

Standardisation of the product  
and the production line

(DW / FW, methods?)



Final Report – year 1

CEN/BT/WG 218 'Algae'

Approved by CEN/BT – February 2017



Maintenance of the quality :  
post-harvesting storage, shelf-life

(drying, freezing, fermentation?)



(ProSeaFood)

# CREATE A MARKET

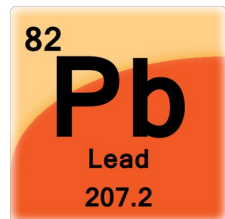
SECURE WHAT WE EAT



## EU LEGISLATION

Quantification of the toxic compounds

Heavy metals

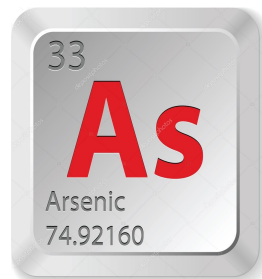


Iodine



Arsenic

Allergens



- No distinction between organic and inorganic heavy metals (**UE 2018/464**)
- Contaminant quantification : based on DW, different quantification methods
- Heavy metals considered only in seaweed extracts
- Post-harvesting/storage contamination
- Different Organic certifications
- Imported seaweeds not subject to legislation

# CREATE A MARKET

## SIMPLIFY LEGISLATION

« What can we grow ? What can we eat ? »





# CREATE A MARKET

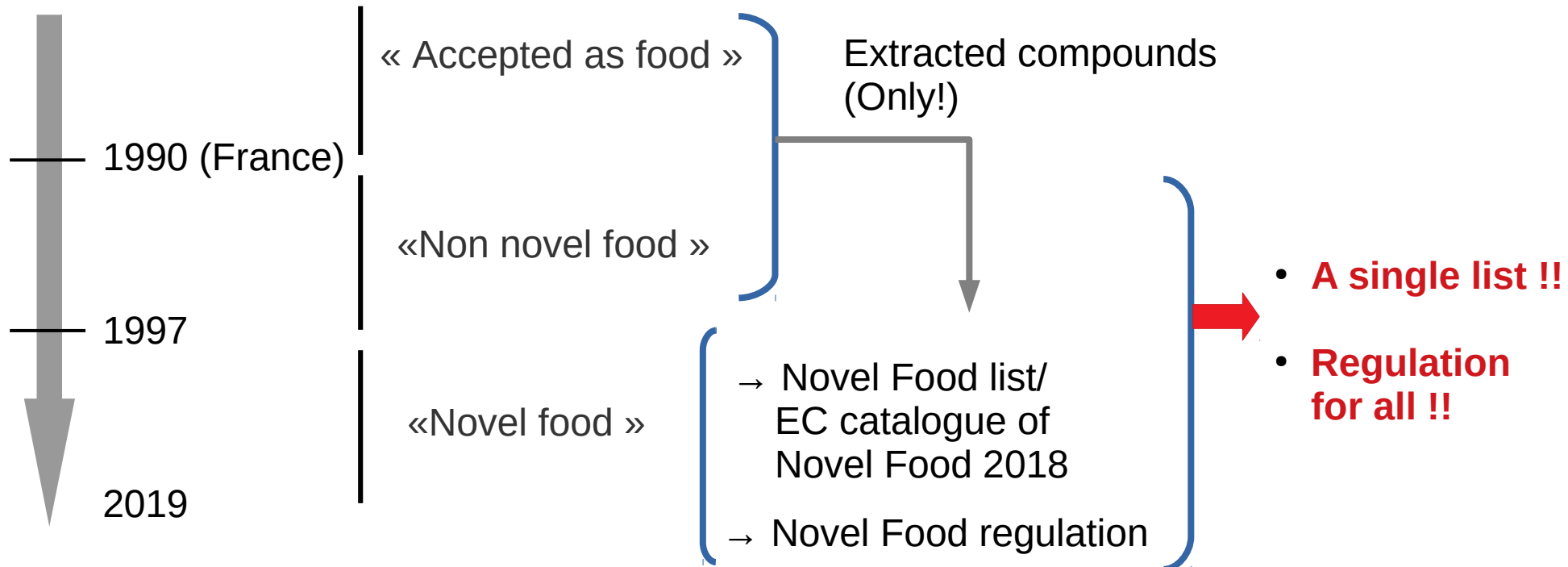
## SIMPLIFY LEGISLATION

« What can we grow ? What can we eat ? »



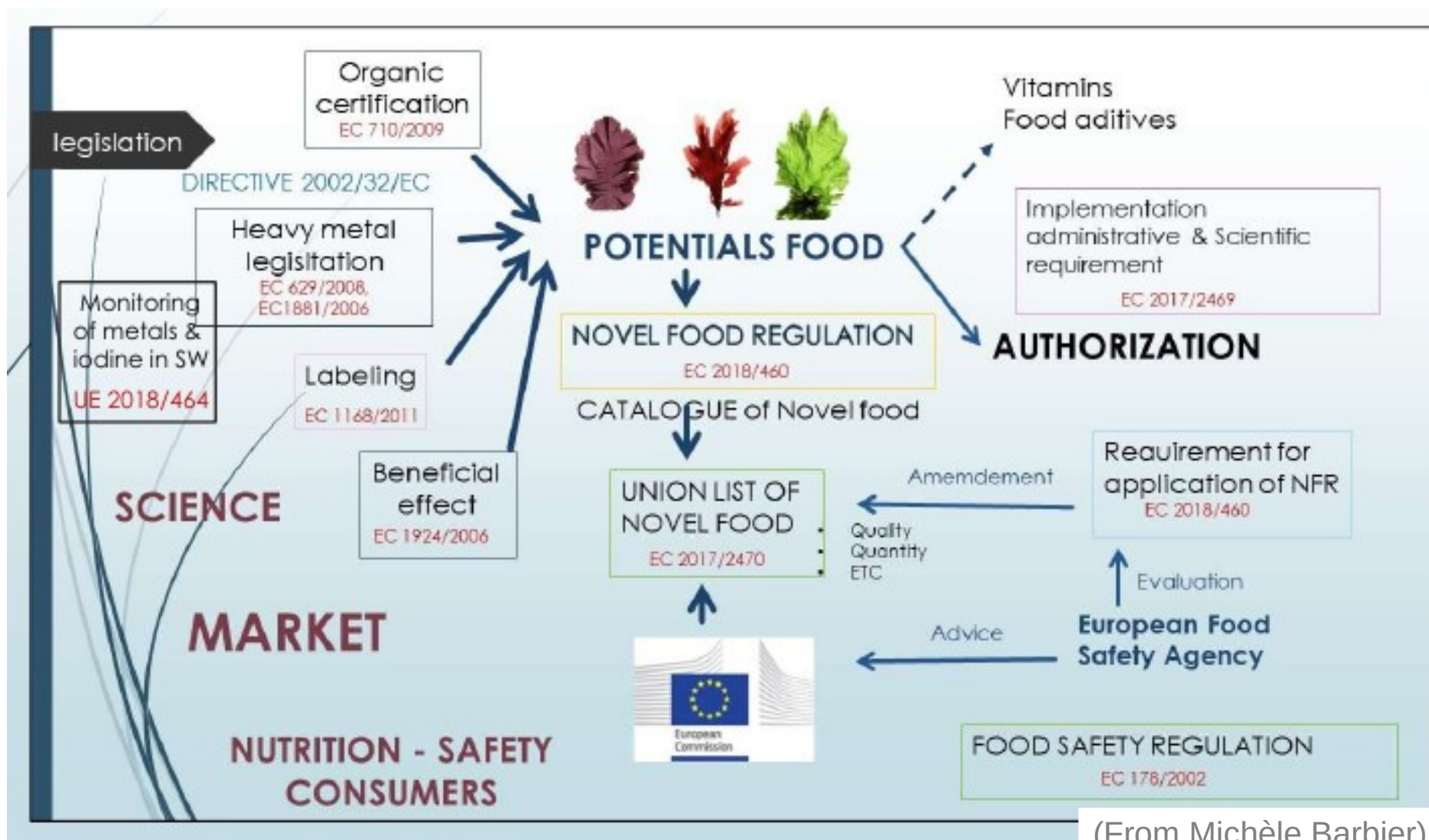
« **Not accepted** » :

because no request for authorization,  
or assessment not ended,  
or rejected



# CREATE A MARKET

## SIMPLIFY THE LEGISLATION



# CREATE A MARKET

## MAKE THE PRODUCTION COST-EFFECTIVE

### Cultivation

#### Scaling up

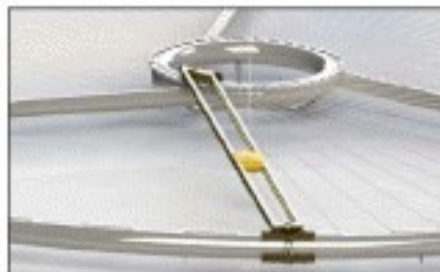
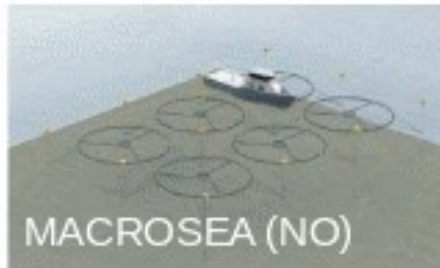
- Mechanisation/automation
- Offshore cultivation ?

#### Currently



#### Lower the production costs

#### Future ?



### Biorefinery



- Availability of the raw material ?
- Registered enzymes
- Wild stock under licences

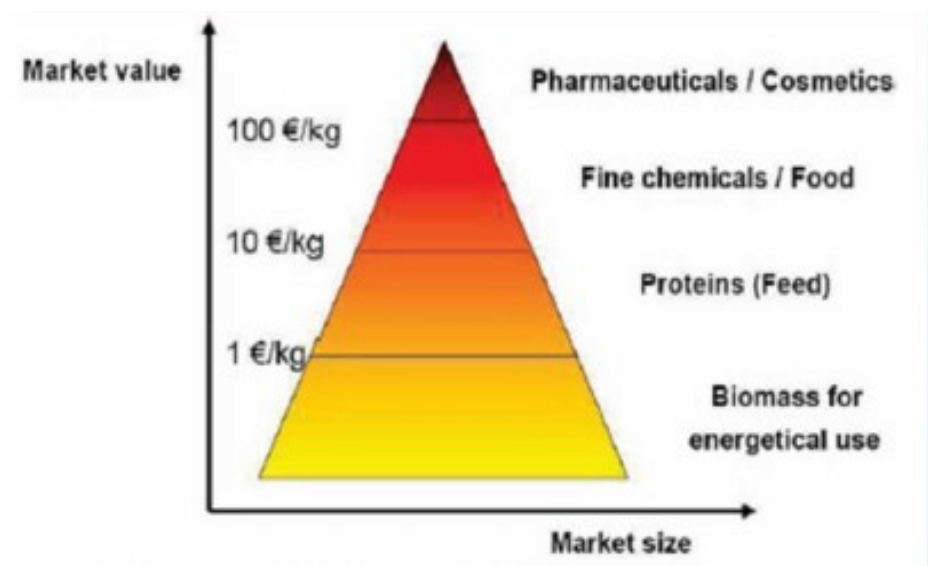
# CREATE A MARKET

## PROPOSE NEW PRODUCTS

### BIOPROSPECTING

#### Find new bioactivity

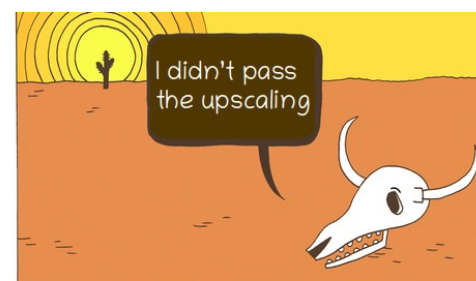
- High-end markets like cosmetics & pharmaceuticals
- Identify the seaweed tissue in which the activity resides (dilution due to extraction from the whole alga)
- Be able to explore new seaweed candidates (new molecules will come from unknown species)



#### Analyse Risk / Benefit

- Clinical tests, duration, amount ?
- Combinatory effect with other products?
- Cost

#### Up-scaling

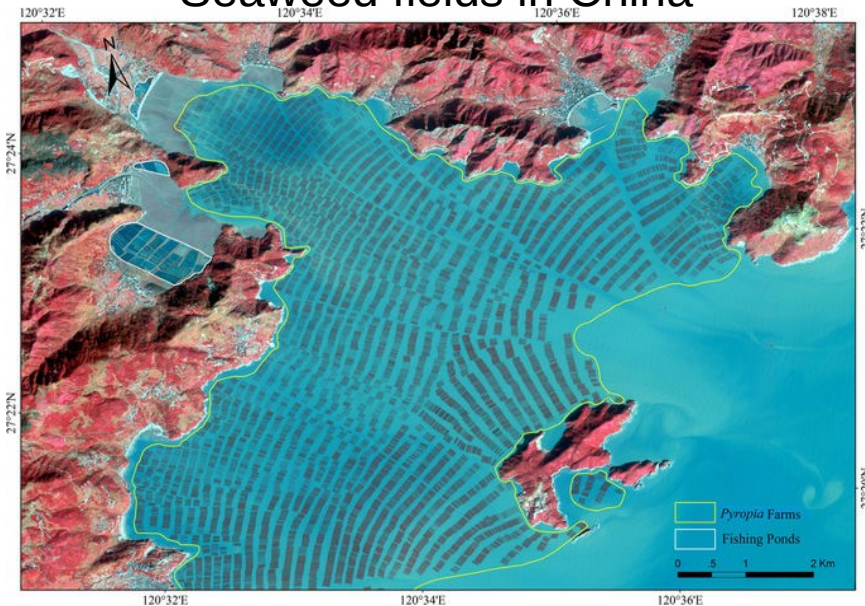




# BUT AT WHICH COST ?

## AND HOW LONG FOR ?

Seaweed fields in China



Low production cost  
Disease  
High Environmental impact

- Impact on the environment
- Sustainability
- Anticipation

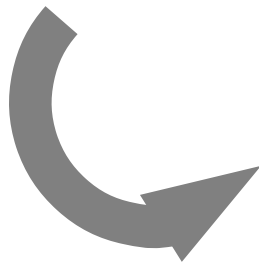
# ENVIRONMENTAL IMPACT

## Biodiversity

Seaweed cultivation



Impact?

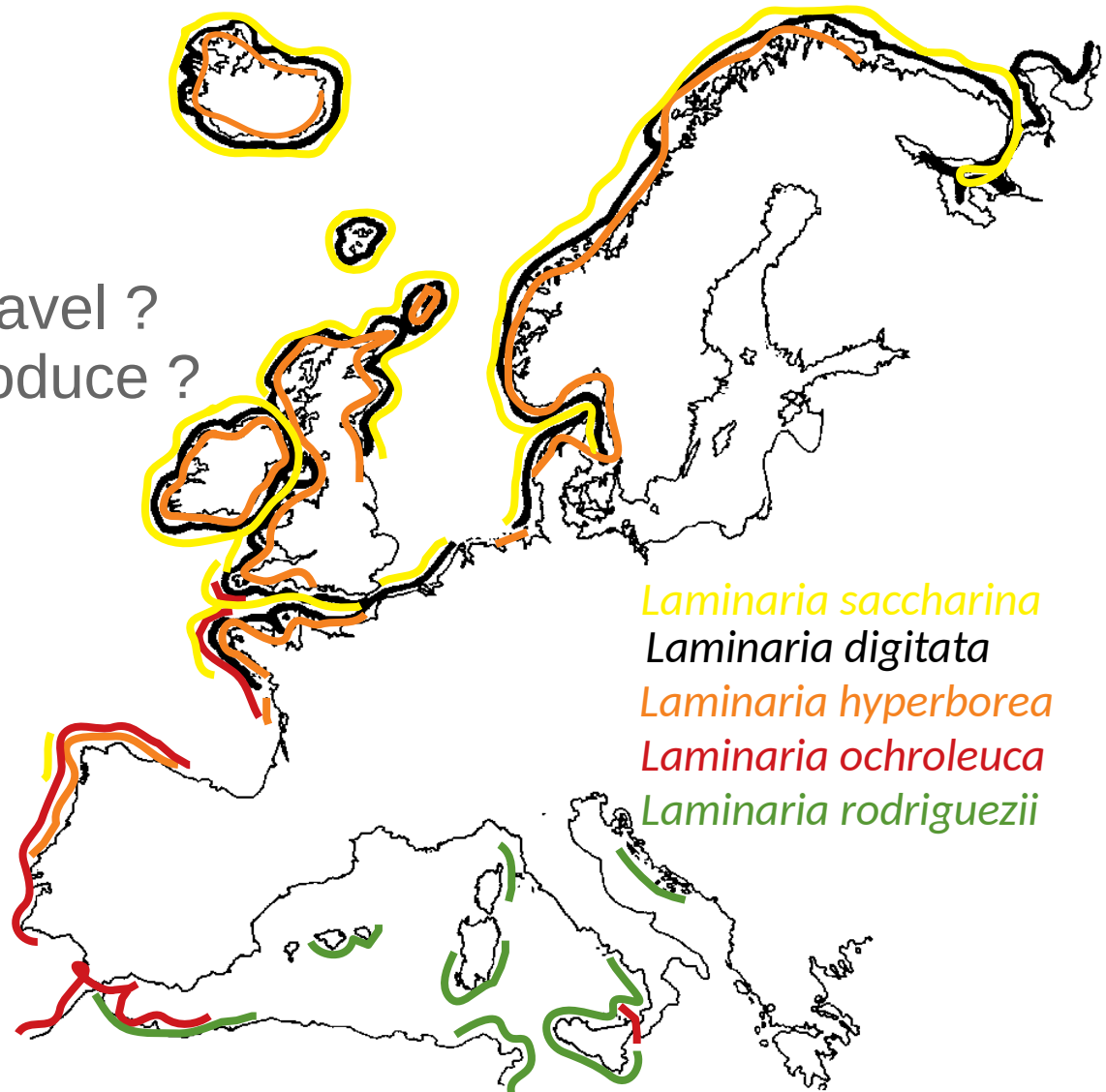




# ENVIRONMENTAL IMPACT

## Biodiversity

How far do they propagate/travel ?  
How **efficiently** do they reproduce ?  
How much do they settle ?  
Do they **mix** together ?



# SUSTAINABILITY

## Conservation of the genetic diversity

**Sourcing**

**Domestication / breeding**

Explore the **breadth of the local diversity** and avoid in-breeding and out-breeding depressions



~ 10.000 ya



Dissemination  
control ?

## PEGASUS recommendations

**In land-based systems, non-native species/non-local populations can be cultivated but within a cell-defined framework.**

Cultivation systems must ensure optimal treatment of discharged water in order to avoid any dispersion in the wild marine ecosystem.

**In at-sea systems, only local populations from native species or cultivars/strains selected from crosses between local genetic variants should be cultivated** until the population dynamics and population genetics are better understood for each cultivated species. However, the definition of a local population is a relative concept based on genetic diversity [...]. Data are still missing to be able to assess it for most seaweeds.



# SUSTAINABILITY

## Conservation of the genetic diversity

**Sourcing**

**Domestication / breeding**

Explore the **breadth of the local diversity** and avoid in-breeding and out-breeding depressions



~ 10.000 ya



Dissemination  
control ?

**Alien and non-indigenous species**

Establish the list of Seaweed alien species & update regulations (last : Aug 2019 : still no SW !)

**Genetically modified species**

Court of Justice of the EU (July 2018) :  
Genome-edited (CRISPR-Cas9) = GMOs

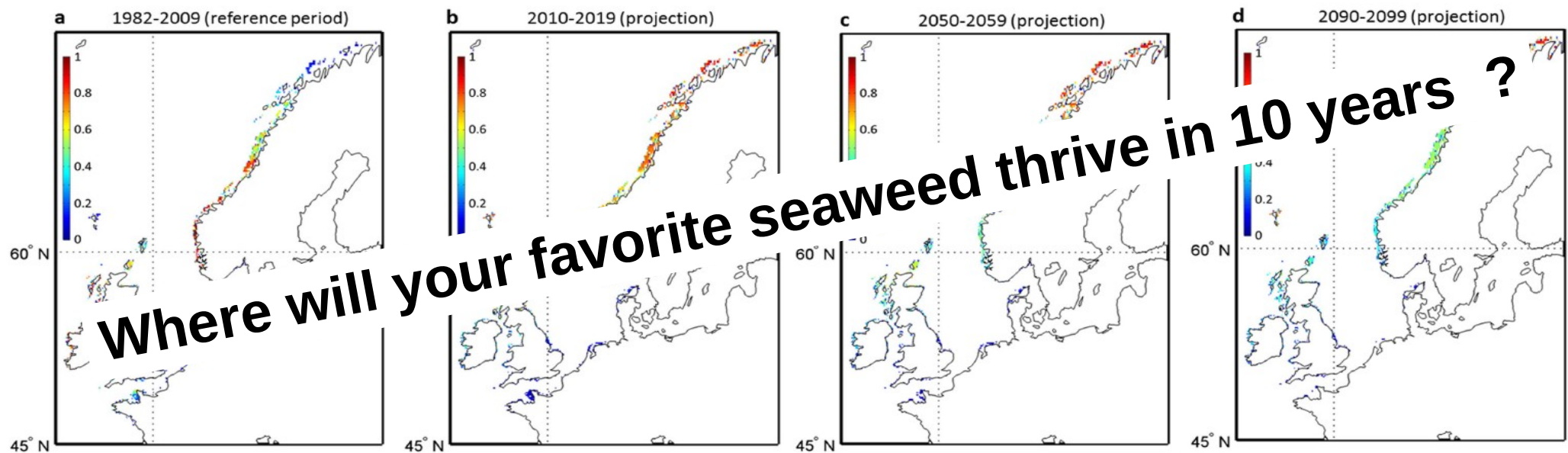
**Pests and diseases**

More research

# SUSTAINABILITY

## Impact of climate change

Prediction of *Laminaria digitata* occurrence



# SUSTAINABILITY

## Management of the biodiversity from the local to the EU levels

Especially now, that major changes in the species structure will happen at the short term



Reliable storage  
of local strains  
(Seed banks, local  
and EU-level)

**Regional Technical and  
Certification Centres to**  
1) control the origin of  
the cultivated strains  
and 2) train and supply  
the farmers



**MAPPING “local  
sourcing”**

**Wild, local species**

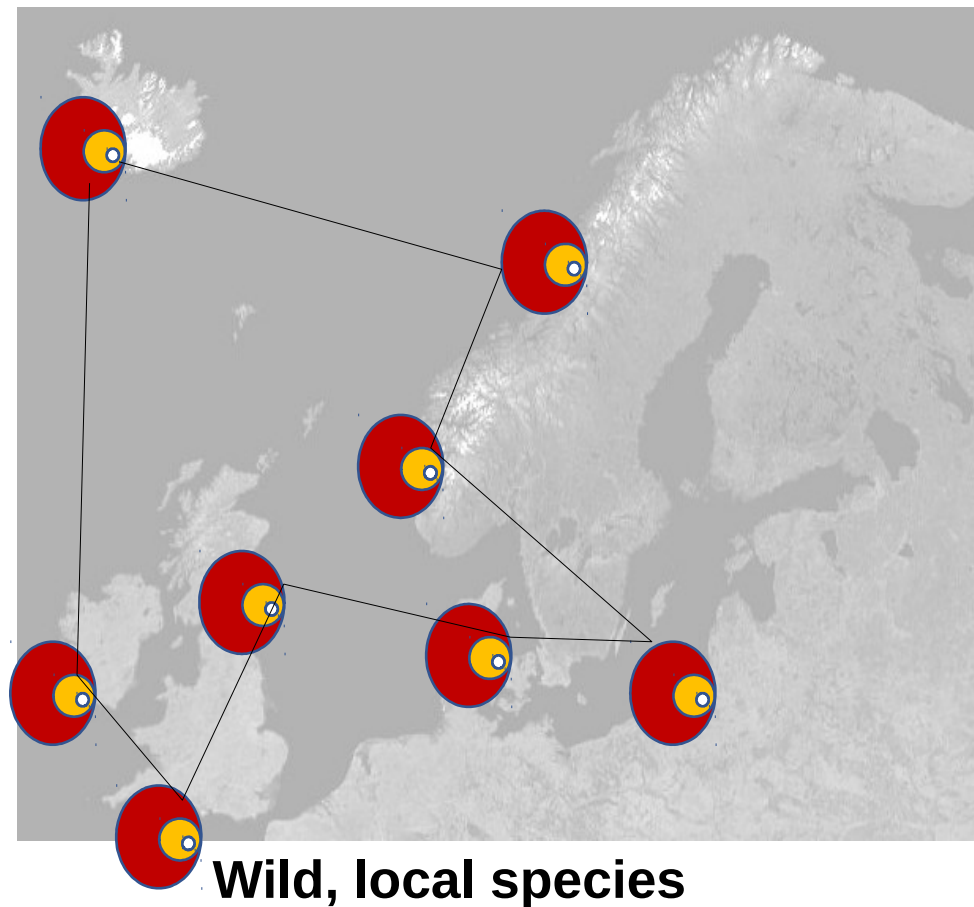
**CERTIFY**

**EDUCATE**

**STORE**

# SUSTAINABILITY

## Sharing Management of the biodiversity from the local to the EU levels



CERTIFY  
EDUCATE  
STORE  
SHARE



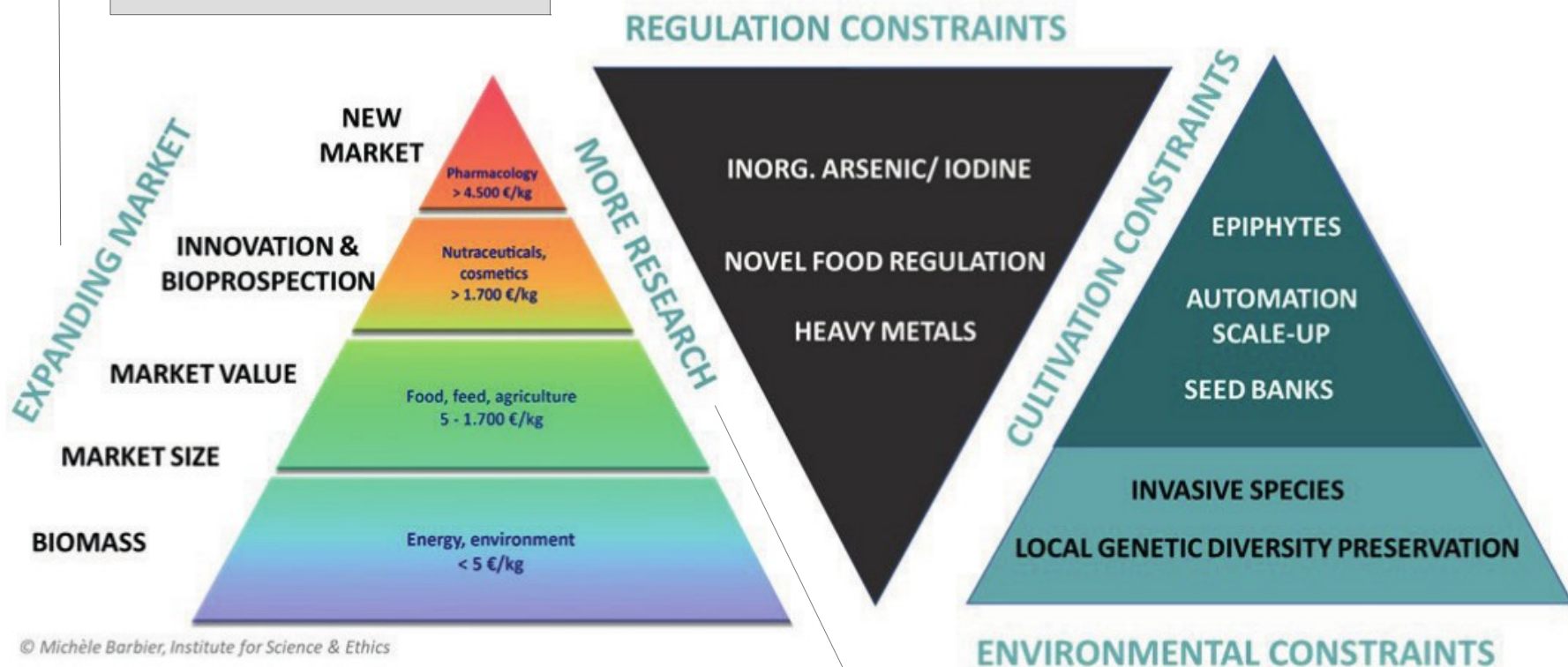
## SUMMARY

### Middle-term

**Data reporting**  
**Standardisation**  
**Know-how sharing**

### Short-term

**Legislation**  
Food safety, Novel food, Alien



### Long-term


**Economic models**  
**Up-scaling**  
**Ecological hazard**  
**Genetics control**

# EUROPEAN GUIDELINES FOR A SUSTAINABLE AQUACULTURE OF SEAWEEDS

## Coordinators



+ Academics,  
NGO,  
Private sector

 : function and task at the EU level

Aquaculture guidelines  
Reference document

PEGASUS

Phycomorph European Guidelines  
for a Sustainable Aquaculture of  
Seaweeds

>1000 reads

Botanica Marina (Open access) : in press  
ISAP Newsletter (in progress)

HOMOGENISE

Directives & Regulations

### 1) Revision and development of the aquaculture guidelines :

- list of seaweed species used as food in Europe
- national and EU level regulation on aquaculture

### 2) **Brief** on algae biomass production by the Knowledge Centre for Bioeconomy


**Brief** on fisheries and aquaculture contribution to food security by the Knowledge Centre for Global Food and Nutrition Security

# EUROPEAN GUIDELINES FOR A SUSTAINABLE AQUACULTURE OF SEAWEEDS

## Coordinators



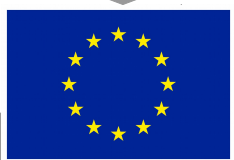
**+ Academics,  
NGO,  
Private sector**

 : function and task at the EU level

**Aquaculture guidelines  
Reference document**




>1000 reads  
Botanica Marina (Open access) : in press  
ISAP Newsletter (in progress)



**HOMOGENISE**  
Directives & Regulations

**HELPS SOLVE BOTTLENECKS**  
Inventory



**CENTRAL PORTAL**  
Your gateway to marine data in Europe


JRC: Algae portal in EMODnet inventorying algae production in Europe.  
**Please answer the survey to update the portal with new data !!**  
 EU needs the companies to reply !!!

# EUROPEAN GUIDELINES FOR A SUSTAINABLE AQUACULTURE OF SEAWEEEDS

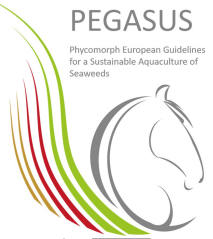
## Coordinators



**+ Academics,  
NGO,  
Private sector**

 : function and task at the EU level

**Aquaculture guidelines  
Reference document**



**>1000 reads**  
Botanica Marina (Open access) : in press  
ISAP Newsletter (in progress)



**HOMOGENISE**  
Directives & Regulations

**HELPS SOLVE BOTTLENECKS**  
Inventory  
**Call (research, innovation)**





## EU FUNDING FOR RESEARCH AND INNOVATION 2021-2027

Investing in research and innovation is investing in Europe's future. It helps us to compete globally and preserve our unique social model. It improves the daily lives of millions of people here in Europe and around the world, helping to solve some of our biggest societal challenges.

Building on the achievements and success of the EU's past flagship research and innovation programmes, the Commission proposes a budget of €100 billion for 2021-2027 for Horizon Europe and the Euratom Research and Training Programme.

### Mission areas

5 mission areas have been identified, each with a dedicated mission board and help specify, design and implement specific missions in Horizon Europe.

[Mission area: Adaptation to climate change including societal transformation](#)

[Mission area: Cancer](#)

[Mission area: Climate-neutral and smart cities](#)

[Mission area: Healthy oceans, seas, coastal and inland waters](#)

[Mission area: Soil health and food](#)

## Aims of missions in this area

A mission in the area of healthy oceans, seas, coastal and inland waters will be a powerful tool to raise awareness of their importance among citizens and help develop solutions on a range of issues.

These include

- systemic solutions for the prevention, reduction, mitigation and removal of marine pollution including plastics
- transition to a circular and blue economy
- adaption to and mitigation of pollution and climate change in the ocean
- sustainable use and management of ocean resources
- development of new materials including biodegradable plastic substitutes, new feed and food
- urban, coastal and maritime spatial planning
- ocean governance
- ocean economics applied to maritime activities

# PEGASUS

Phycomorph European Guidelines  
for a Sustainable Aquaculture of  
Seaweeds



*On its way to the further  
development of Seaweed  
Aquaculture in Europe .....*

# THANK YOU