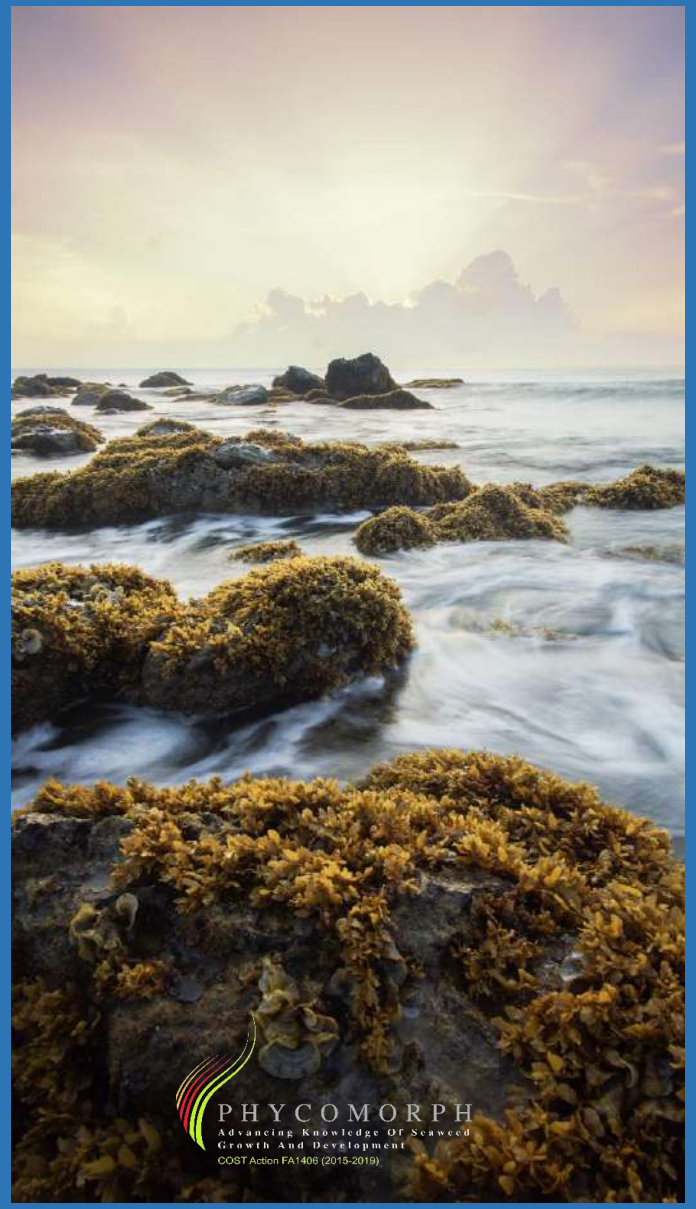


cost
EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

PHYCOMORPH EUROPEAN GUIDELINES FOR A SUSTAINABLE AQUACULTURE OF SEAWEEDS

Michèle Barbier[1], Bénédicte Charrier[2], Rita Araujo[3], Susan L. Holdt[4], Bertrand Jacquemin[5], Céline Rebours[6]

(1) Institute for Science & Ethics, Nice, France; (2) CNRS, Station Biologique de Roscoff, CNRS, France; (3) European Commission – DG JRC – Ispra; (4) Technical University of Denmark, Copenhaguen; (5) CEVA, Centre d'Etude et de Valorisation des Algues, France; (6) Møreforsking Ålsund AS, Norway;

COST is supported by the EU Framework Programme Horizon 2020

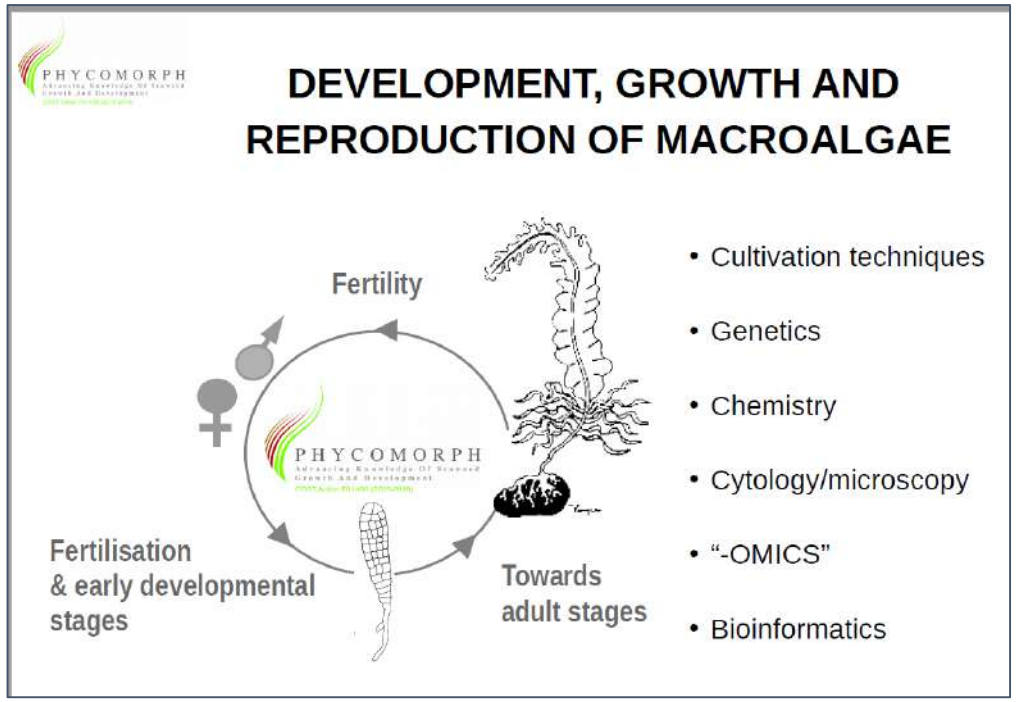
European Cooperation in Science and Technology is a **funding organisation for research and innovation networks.**

COST Actions: help connect research initiatives across Europe; **bottom-up networks** to boost research, innovation and careers

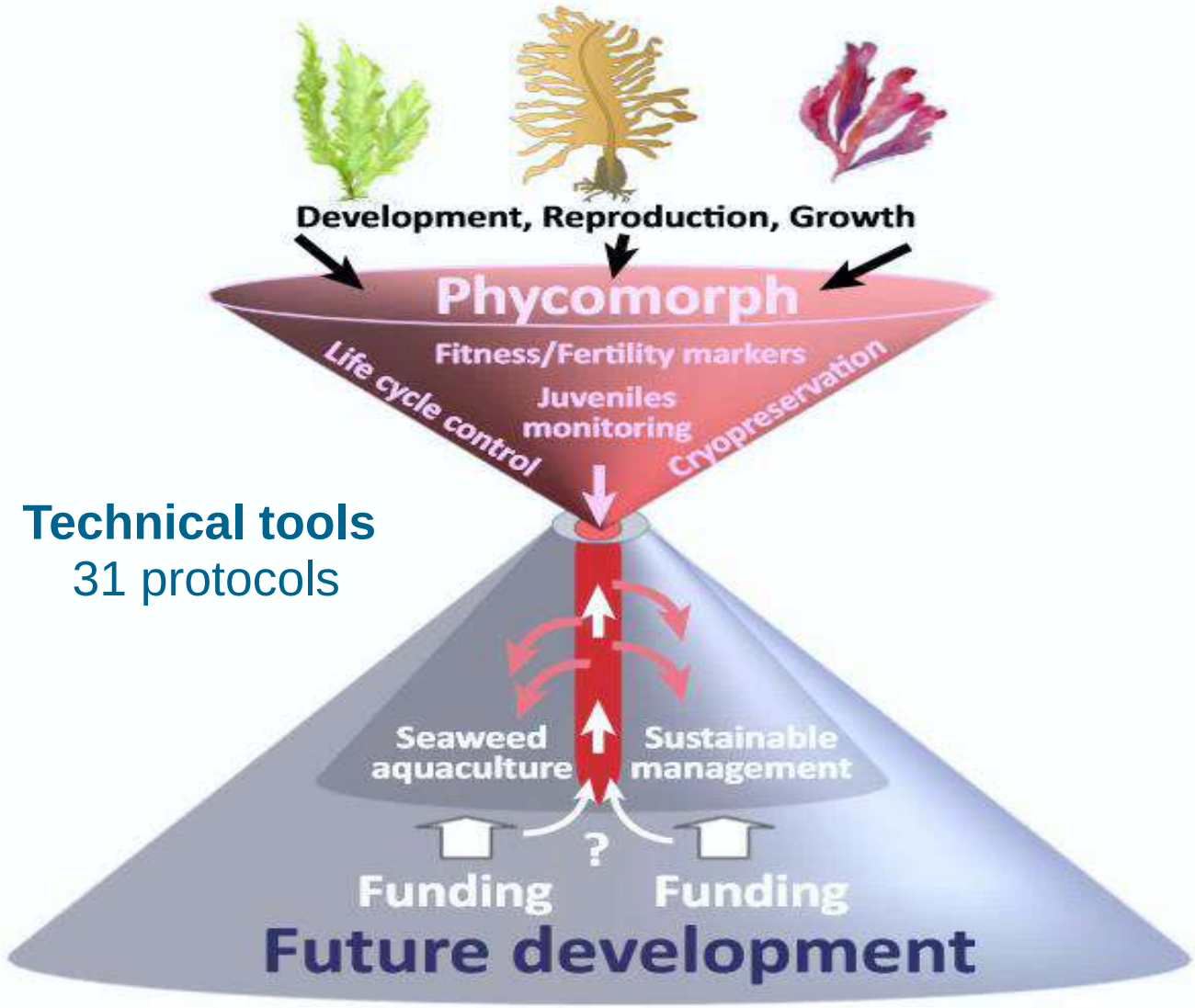
Bénédicte Charrier, Station Biologique Roscoff, France

http://phycomorph.org/

TRANSFER KNOWLEDGE TO THE SEAWEED AQUACULTURE SECTOR



Technical tools
31 protocols



Trends in Plant Science

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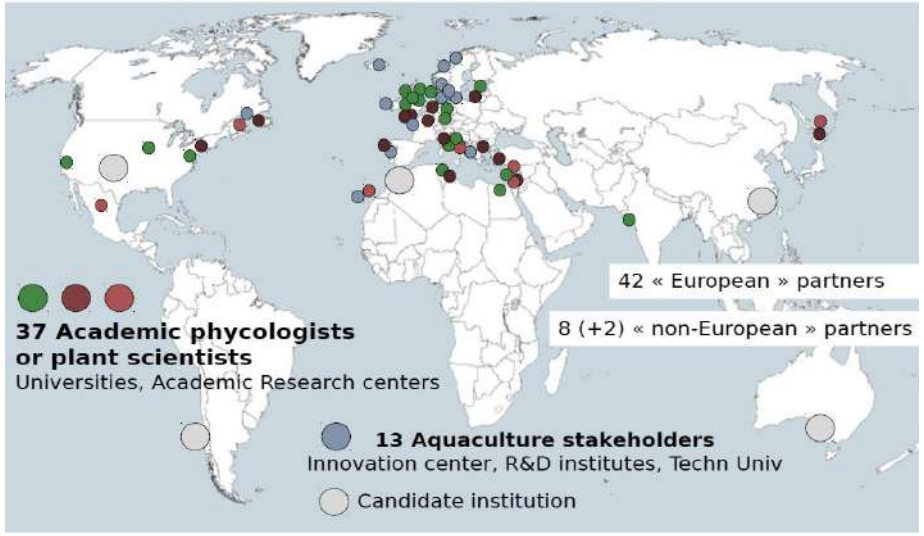
Advancing Knowledge Of Seaweed Growth And Development

COST Action FA1406 (2015-2019)

BEYOND EUROPE



37 Academic partners (among which 6 Technological Universities)
10 R&D centers
4 SMEs
+ JRC

SEAWEEDS, GLOBAL PRODUCTION

30 MT/year (+ 5,2 % /yr) 50 countries

1MT harvested 29 countries (2015)

Ariel Marinkovic/AFP/Getty Images

In **CHINA**, in 2015, 13 M tons of seaweed were produced through cultivation, 24,300 tons was harvested from the natural habitat

Indonesia 9M Tons and largest producer of red algae for carrageenan market

Philippines : 1,5 MT third largest producer of the red algae *Kappaphycus* and semi-refined carrageenan,

The republic of Korea produces 1,2 M tons . In 2016, export of *Pyropia* products was 353 million US$

Europe: 1%

Canada - Quebec: 250 T/yr harvested

Norway: 13,5% GSW harvesting

Asia: 97%

Northern African coast, Morocco: red alga

North & south America

Western african coast: Ghana, Senegal, Nigeria

8.1 B€ /yr (+ 6.7 % /yr)

www.farmafrica.org

Chile: 31,6% GSW harvesting

In **Tanzania**, *Kappaphycus* & *Euchema*

In **South Africa**, Harvest *Ecklonia Laminaria*

badins/Shutterstock

FAO, 2015

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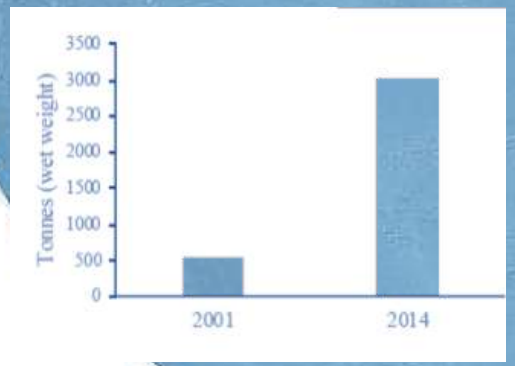
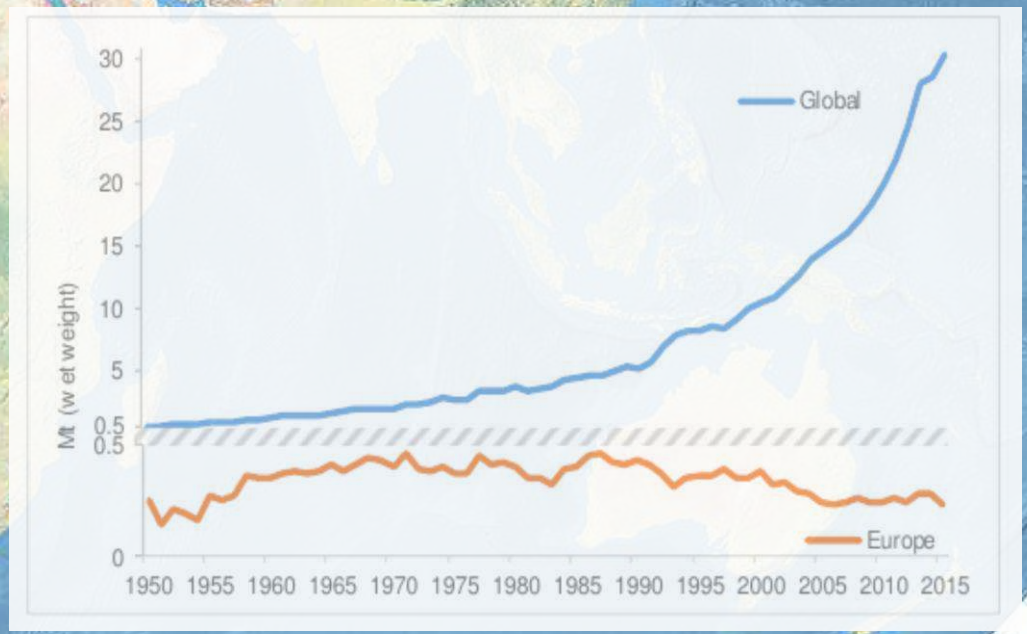
cost

SEAWEEDS PRODUCTION IN EUROPE
ONLY 1% OF GLOBAL PRODUCTION





Camia et al., Biomass production, supply, uses and flows in the European Union

FAO, 2015

SEAWEEDS, Important ecological role

- Support complex food web in coastal system
- Defence role
- Carbon sequestration
- Removal of dissolved nutrient (N & P uptake)
- Removal of ions (petrol, dyes)

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SEAWEEDS, a source for human needs

HEALTH & HUMAN WELL-BEING

FOOD & food processing/additive

AGRICULTURE

BIOFUEL

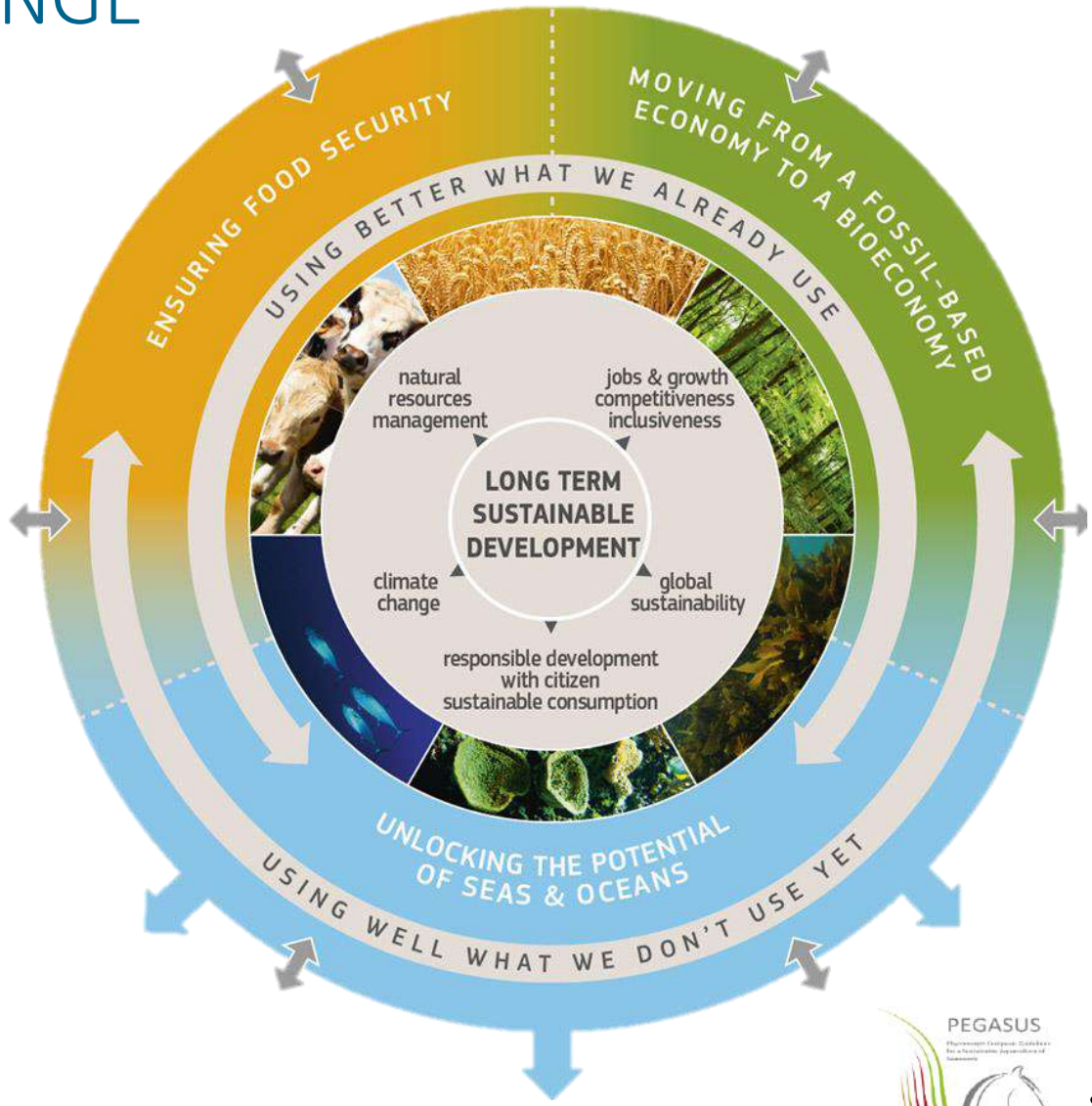
POLYMER (bioplastics)

ECOSYSTEM MANAGEMENT

FOOD SECURITY
PRESSING GLOBAL CHALLENGE

SUSTAINABLE DEVELOPMENT GOAL 14

Conserve and sustainably use the oceans, seas and marine resources for sustainable development



How to obtain economic and environmental sustainability and competitiveness of primary production and processing industries?

A sustainable management of resources essential for establishing the balance between **economic growth** and **healthy ecosystem** and incentivised by **policymakers**

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Cultivated strains & cultivation techniques must be adapted to the local environment of the farm

Obtain the best cultivar

Storage of strains

Improvement of strains

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Environmental factors

Cultivation, abiotic and biotic factors

Genetics

Cryopreservation
Breeding

Controlled fertility

Disease

Risk in the lab, in greenhouse cultivation, in mariculture

Sourcing

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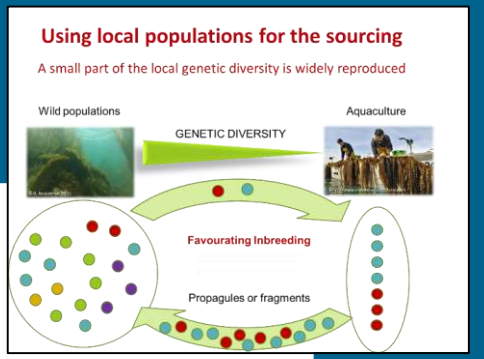
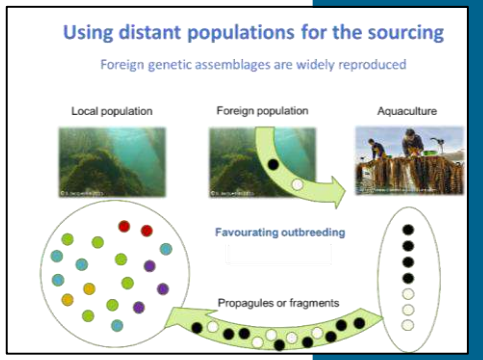




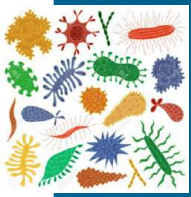
Environmental impact

Genetic dispersion

C. fragile

G. vermiculophylla

U. pinnatifida



Invasive species

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PRODUCTION TECHNIQUES

Controlled conditions

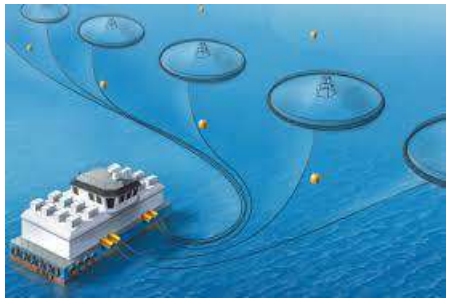
Mechanization and automation,

Reduction in transportation times and volumes

At sea

Open water

Seaweed carrier



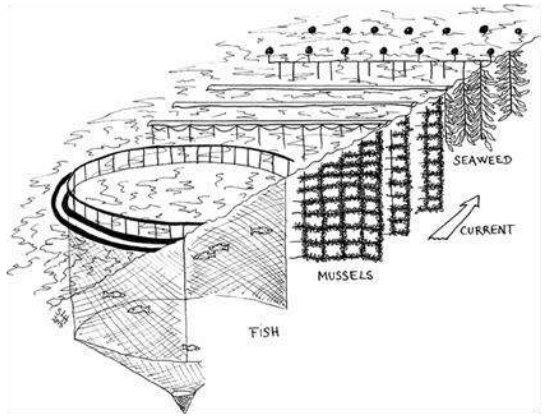
EU project At-sea, 2015

Benthic production

2D textile substrate

EU project SEABIOPLAS

Land-based



IMTA

Combination of different aquaculture productions (trophic relationship, reduce environmental impact, diverse markets.

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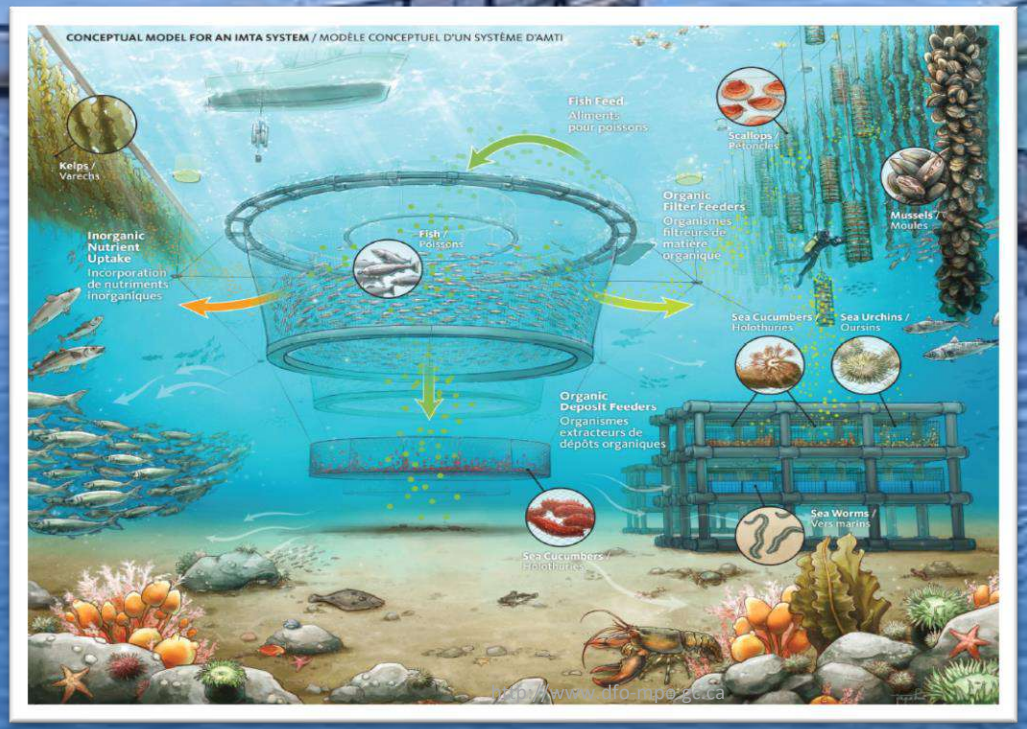
MARITIME SPACE USAGE

Need regulatory framework

Acceptability by the society



Sourcing from indigenous species

Consider seaweed reproduction

More research on breeding & selection programmes under controlled conditions

More research on pests & diseases

More research on impact on the environment

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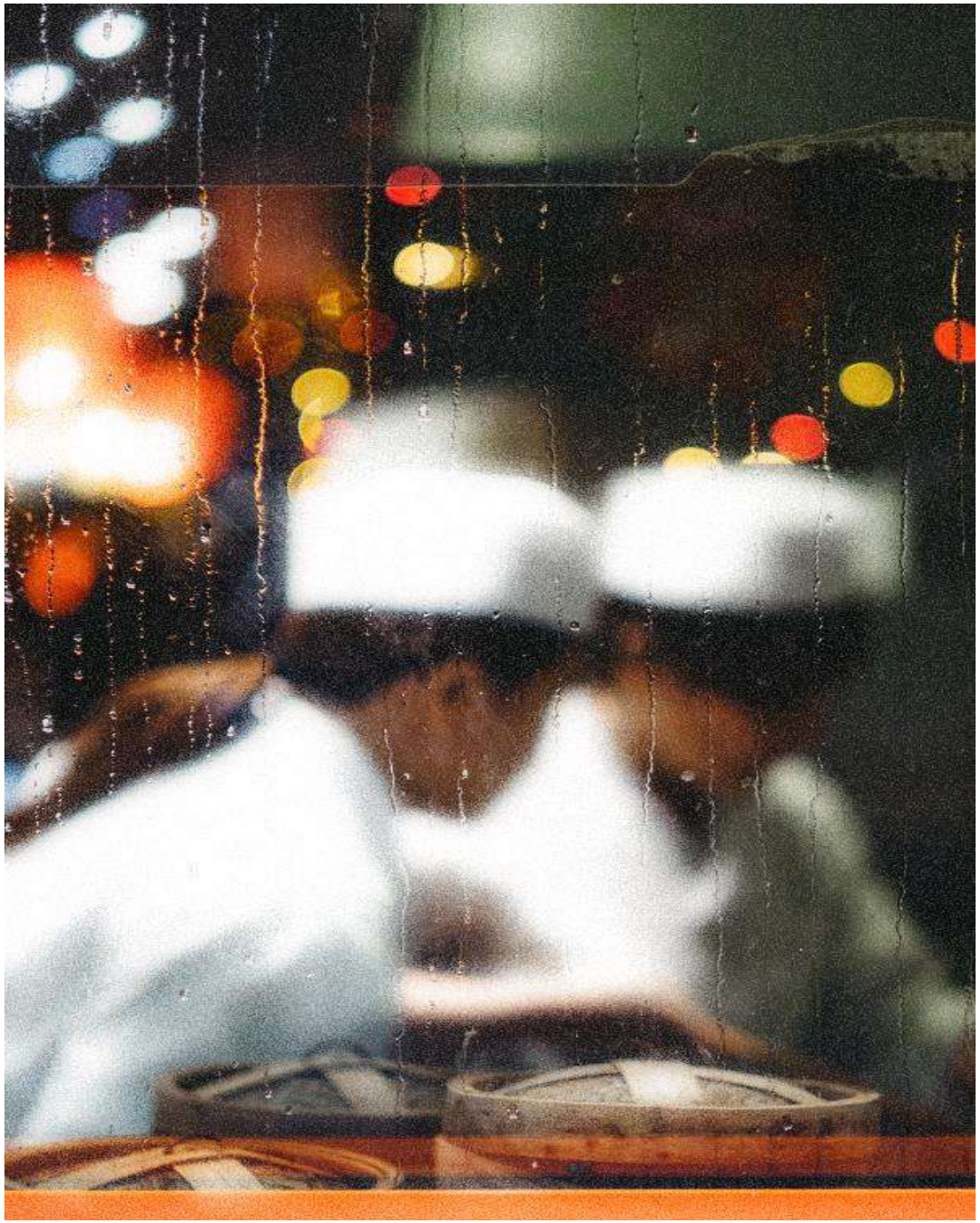
Choose best location for cultivation

More research on the biology of seaweeds and gene flow, connection with the environment

Assess impact of introduced species on the environment

Reconsider some regulations on alien species and some European regulations/ directives

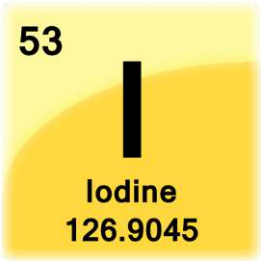


SEA VEGETABLES: EXPENDING MARKET

- EU Vegan/vegetarian diet, Organic food increase (+ 350% in last 3 yrs)
- Rich in fibers, proteins, low in fat, pigments
- Low Na/K ratio
- Minerals: Na, K, P, Ca, Mg, I, Fe
- Vit A, B1, B2, B6, B12, C, D, E
- Polyphenols

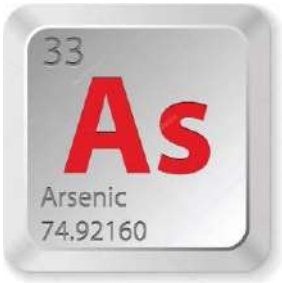
CHALLENGES FOR THE INDUSTRY

Update Novel food list with species already on the market.
An official list of all seaweed species (accepted as food before May 15, 1997) to facilitate its use by stakeholders



Unclear signals/regulation on the threshold values of different contaminants in seaweeds as food: **Update the Arsenic threshold level in legislation (harmful inorganic)**

Need for standards and definitions of chemical compound classes, activities, traceability, standards of methods and claim



Definition of Best storage procedures

Industrial classification codes defined by the seaweed experts & industry and put forward to the authorities for food control

CHALLENGES FOR THE INDUSTRY

Disperse certification bodies in diff. countries for organic certification (cultivation/ harvest/ products)

Impact of post-harvest handling on quality and quality of the stability of seaweed

- nutrient content
- organoleptic properties
- Microbiology

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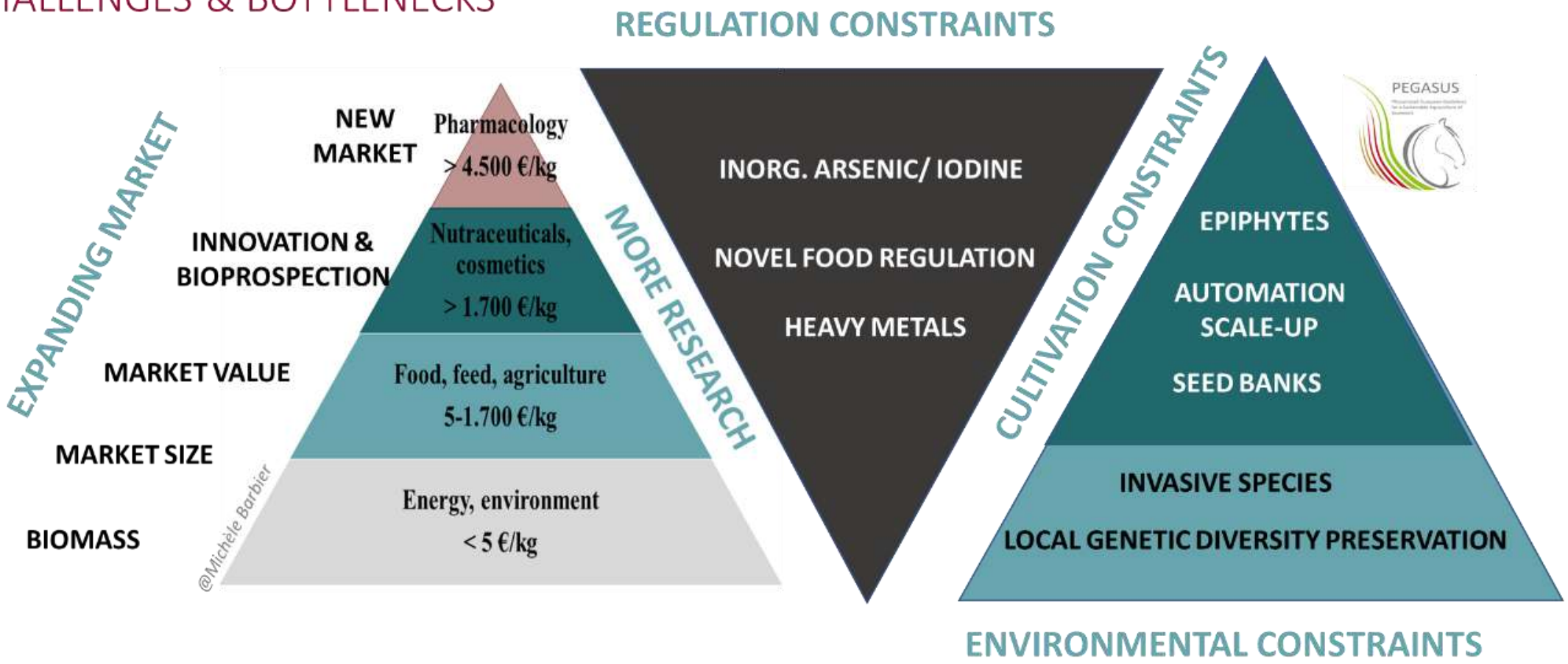
CHALLENGES AND NEEDS FOR THE INDUSTRY	RECOMMENDATIONS	
	RESEARCH	GOVERNANCE
Secure food security: inorganic arsenic, iodine, heavy metals	Risk-benefit analyses and more knowledge on speciation of iodine/chemical form, bioavailability	Update the threshold value of contaminants and define this for seaweed as food, as well as a common standard on dry weight or wet weight basis
Elevated concentrations of iodine in some large brown seaweeds Monitoring of potentially undesirable compounds in edible seaweeds	Standardization & definitions of chemical compound classes, activities, traceability, methods and species identification	
Food preservation to maintain consistent contents and improve organoleptic properties	More knowledge of effect of preservation methods & treatments on biomass	Set up certification centres
Unknown impacts of post-harvest handling (preservation treatments) on the quality and quality stability of seaweed (nutrient content, organoleptic properties); Stabilization of seaweed biomass	Definition of best storage procedures & best practices to evaluate product shelf-life	Implement best practice/industrial classification codes developed in collaboration with companies and national / European authorities
Various certification processes for organic certification in different EU countries		Harmonize organic certification across EU
Know more on seaweed behaviour in the human body and effect on health	Risk- benefit analyses of seaweeds	
Cultivate additional seaweeds	More knowledge on domestication process	
Attract consumers	Implement sensory evaluation panels	Increase public awareness, create vocabulary to describe the flavour of seaweed

CHALLENGES & BOTTLENECKS




Scale-up production and lower its costs
More technological development
Support Investment
Reliable production
More research on the biology of seaweeds and on pests & diseases
Standardization of the product & production line
Post-harvest treatment & storage
ENSURE QUALITY : Quality control, traceability for food, & high level product
Secure food safety
Update legislation
More research on:
- heavy metals, iodine, arsenic uptake
- post-harvest treatment, storage
- risk-benefit analysis
Diversify the offer
Update the list of novel foods
Cultivate additional seaweeds
More research on domestication
Bioprospection
Educate consumers
Implement public consumer panels
Create seaweed flavour words
Improve the market
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PRESERVE THE LOCAL GENETIC DIVERSITY

USE LOCAL – THINK GLOBAL

NO INTENSIVE CULTIVATION

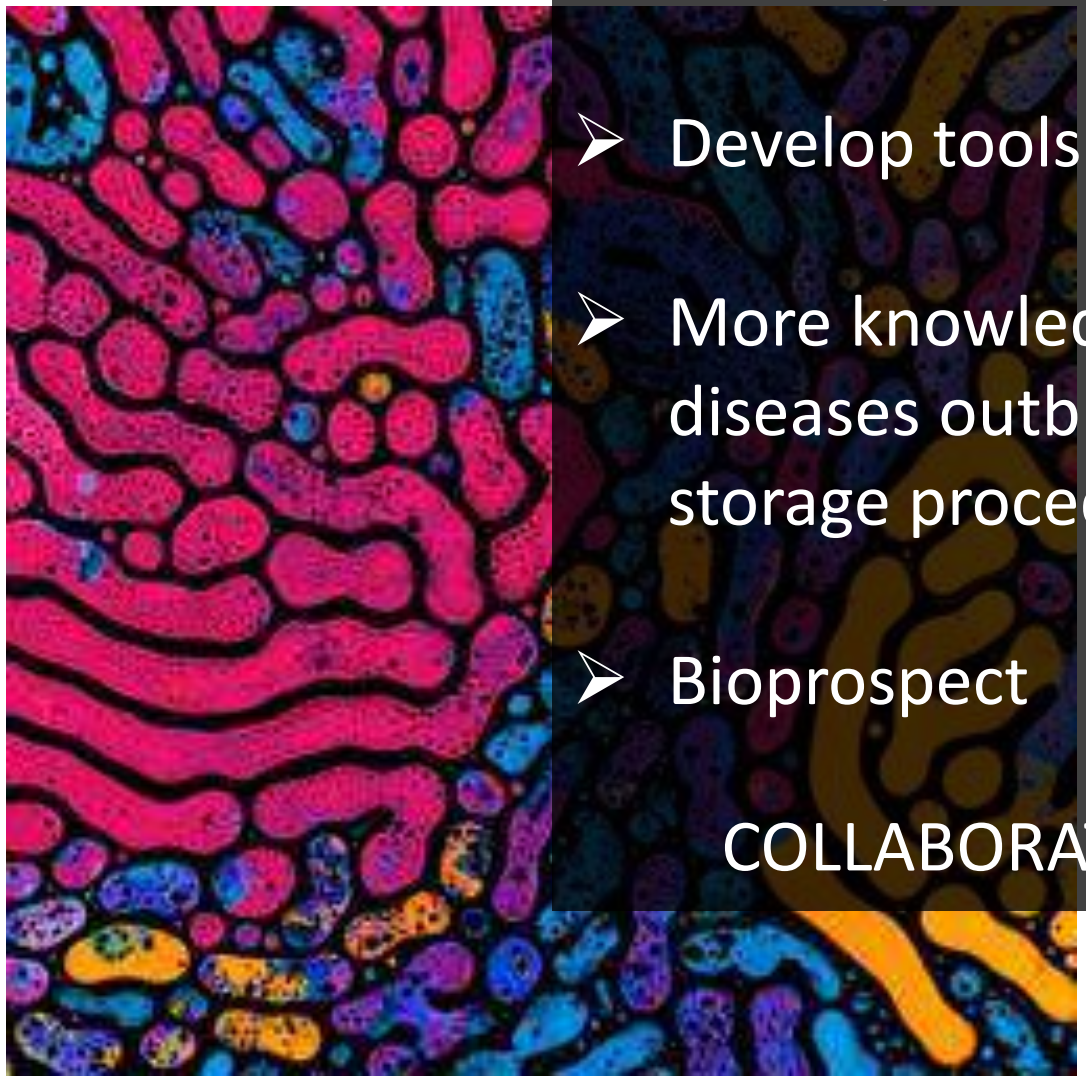
SHARE EXPERTISE

HOMOGENIZE REGULATIONS & UPGRADE LEGISLATIONS

ASSESS BENEFITS- RISKS

EDUCATE PEOPLE

PROVIDE THE BEST SCIENCE



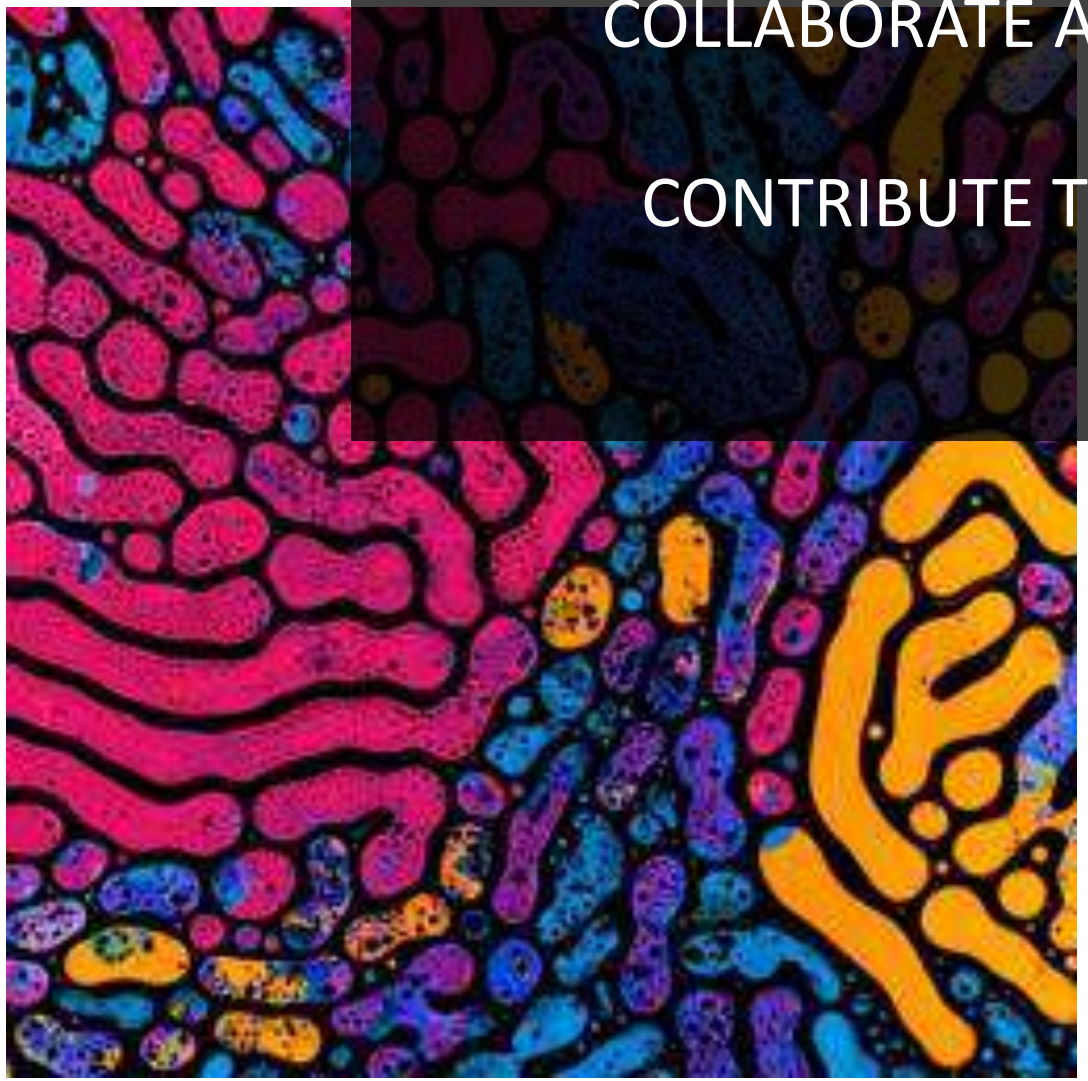
- Develop Breeding programs under controlled conditions
- Develop tools to ensure traceability of the strains/traits
- More knowledge on biology of seaweeds, pest and diseases outbreaks, uptake of seaweed iodine, best storage procedures, etc.
- Bioprospect

COLLABORATE ACROSS SECTORS – SHARE EXPERTISE

PROVIDE THE BEST SCIENCE TO ANSWER SOCIETAL REQUIREMENTS

COLLABORATE ACROSS SECTORS – SHARE EXPERTISE

CONTRIBUTE TO IMPROVE SOCIAL ACCEPTABILITY



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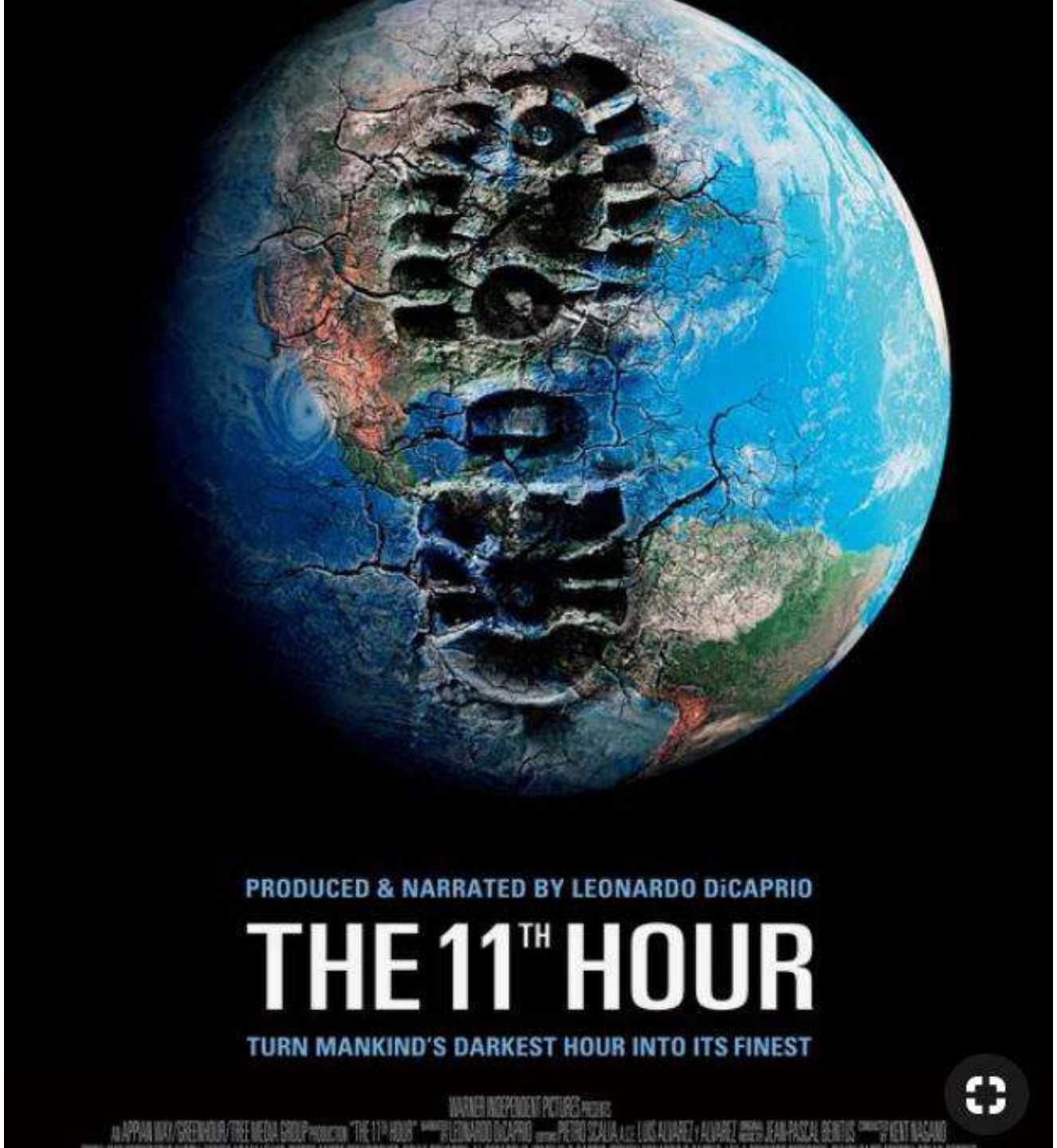
Phycomorph European Guidelines for a Sustainable Aquaculture of Seaweeds

Responsibility
Resources
Environment
Actions
Stewardship



Sustainability
Stability
Resilience

Michèle Barbier, Bénédicte Charrier, Rita Araujo, Susan L. Holdt, Bertrand Jacquemin, Céline Rebours

With the contribution of ***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, Verschuren Centre for Sustainability in Energy and Environment, Cape Breton University, Canada; Maeve Edwards, Irish Seaweed consultancy, Ireland; Jan Emblemsvåg, 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; Jos Heldens, Hortimare, Netherlands; 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 Oceanografia, Spain; Pierre Ronan, CEVA, Centre d'Etude et de Valorisation des Algues, France ; Pierrick Stévant, Møreforsking Ålesund AS, Norway; Dagmar Stengel, National University of Ireland, 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 and Global Seaweed-STAR Team and the Latin Seaweed network***

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