IO3.1 Seaweeds in Aquaculture & IMTA

ERASMUS+ programme

Macroalgae Initium project

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INDEX:

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- Principles of IMTA and Seaweed Cultivation
- Description of the life cycles of the main cultivated species
- Cultivation process
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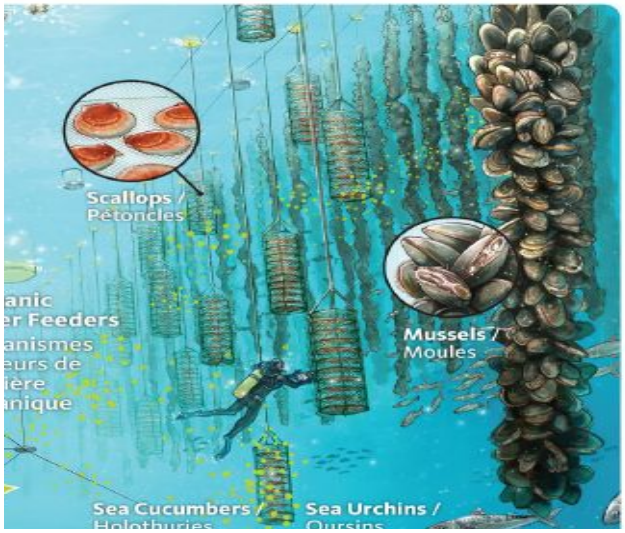
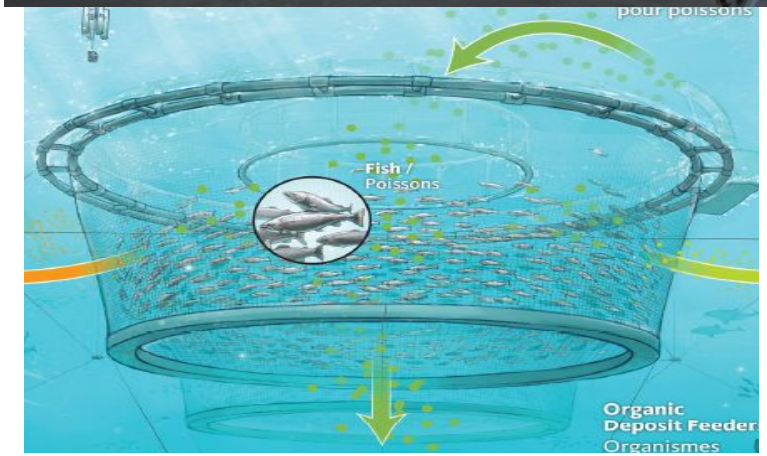
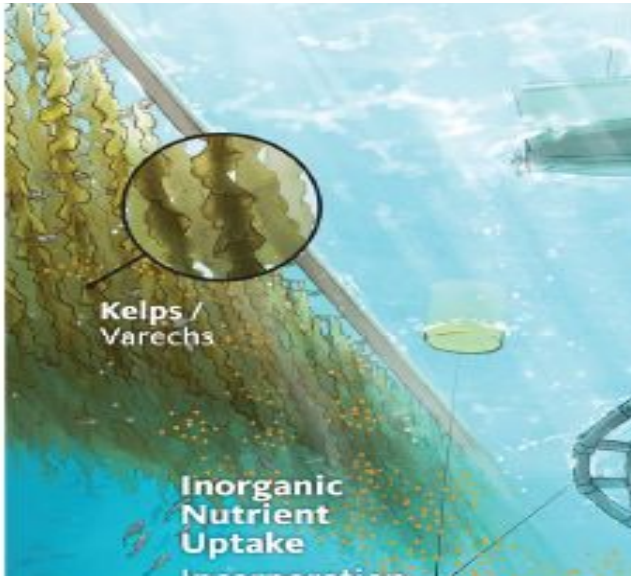
AQUACULTURE



Scallops and Mussels (Organic filter feeders)



FISH (Salmon)



Seaweeds (Inorganic Nutrient Uptake)

WHAT DO YOU SEE IN THIS IMAGE?

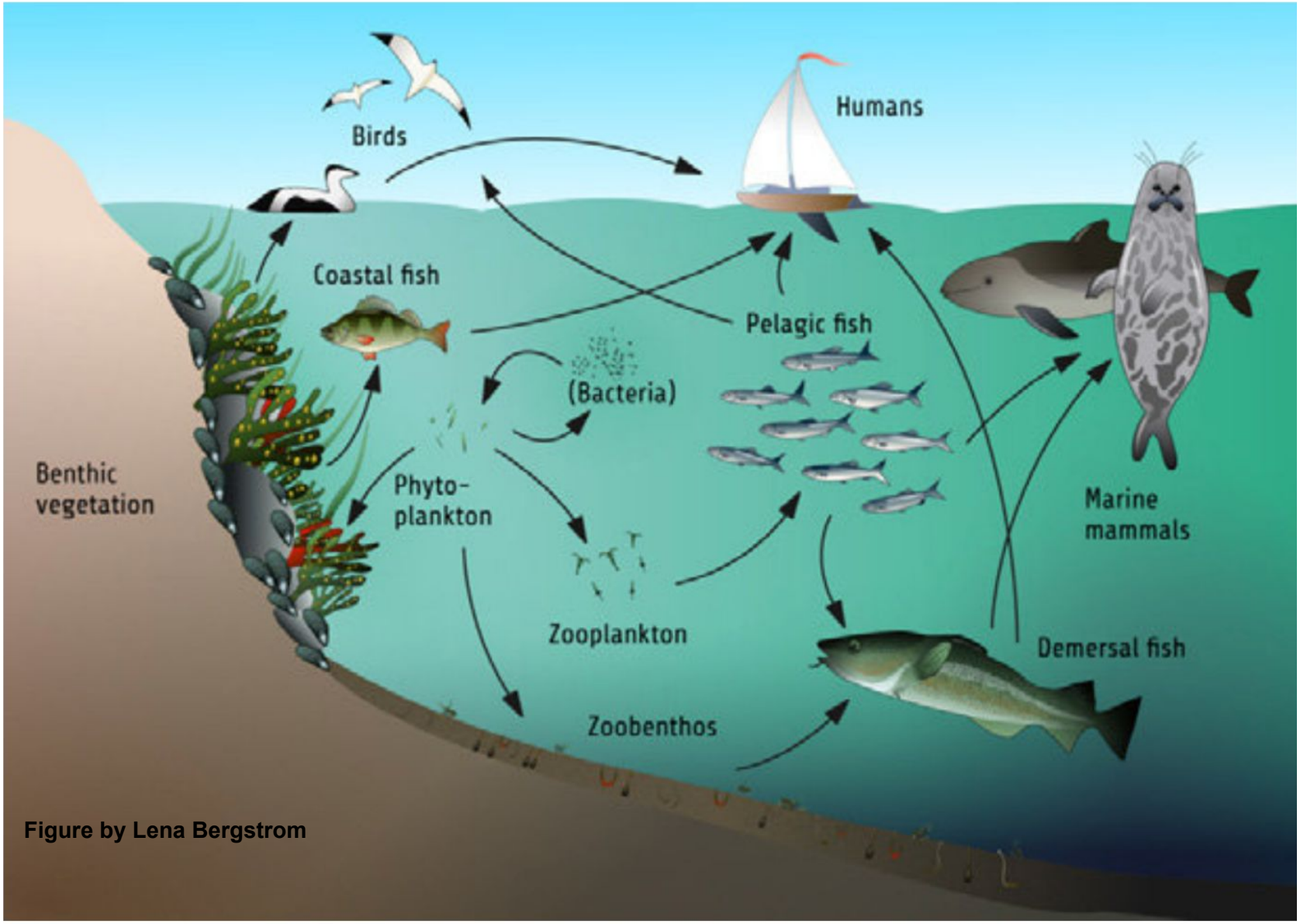
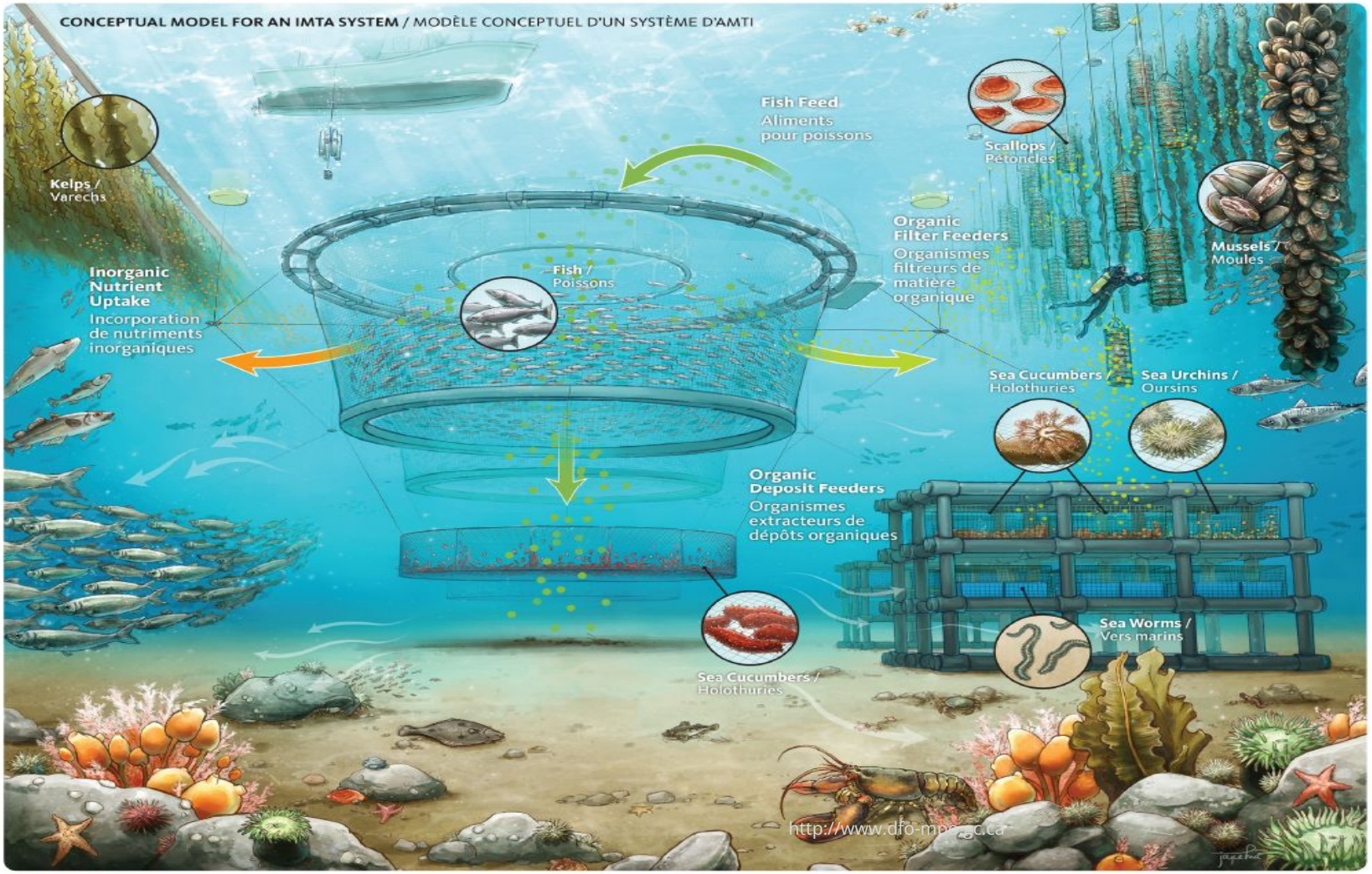
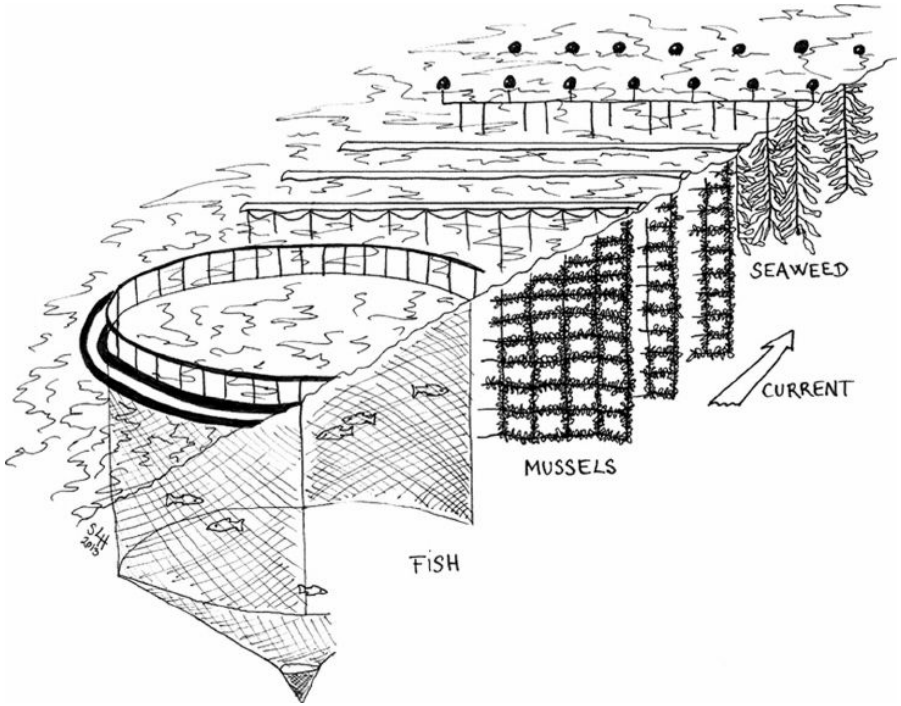


Figure by Lena Bergstrom

OPEN system


CONCEPTUAL MODEL FOR AN IMTA SYSTEM / MODÈLE CONCEPTUEL D'UN SYSTÈME D'AMTI
Kelps / Varechs
Fish Feed
Aliments pour poissons
Scallops / Pétoncles
Organic Filter Feeders
Organismes filtreurs de matière organique
Mussels / Moules
Inorganic Nutrient Uptake
Incorporation de nutriments inorganiques
Fish / Poissons
Sea Cucumbers / Holothuries
Sea Urchins / Oursins
Organic Deposit Feeders
Organismes extracteurs de dépôts organiques
Sea Worms / Vers marins
Sea Cucumbers / Holothuries
http://www.dfo-mpo.gc.ca



CHAPTER 1: Principles of IMTA and seaweeds cultivation

Adapted from the INTEGRATE teaching materials made by
Lars BRUNNER and **Bertrand JACQUEMIN**

Part 1 – What is IMTA ?

The concept of IMTA and the different systems of interests

Part 2 – Seaweed Aquaculture

The different groups of seaweeds, their role in the marine ecosystem, the cultivation of seaweeds

Part 3 – Why use seaweeds in IMTA ?

The different roles for seaweeds in an IMTA system

Part 4 – What to remember ?

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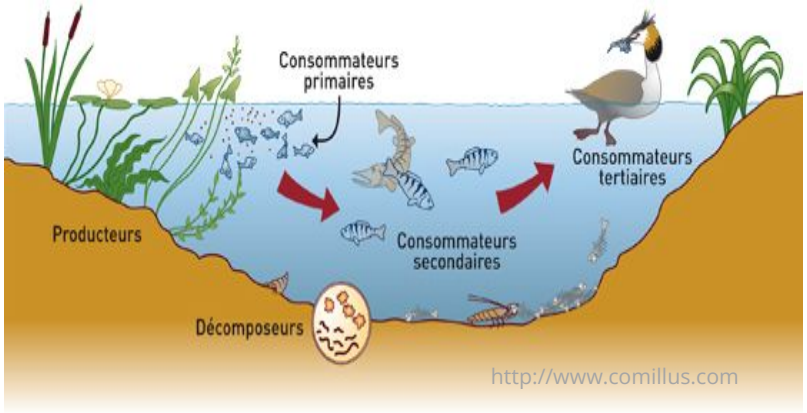
WHAT IS IMTA?
Integrated Multi-trophic Aquaculture



To integrate

To place something in a set so that it is in harmony with the other elements.

Multi-Trophic

Several feeding strategies/behaviours

- Herbivorous
- Carnivorous
- Detritivorous
- Filtering

Aquaculture

Production of aquatic organisms

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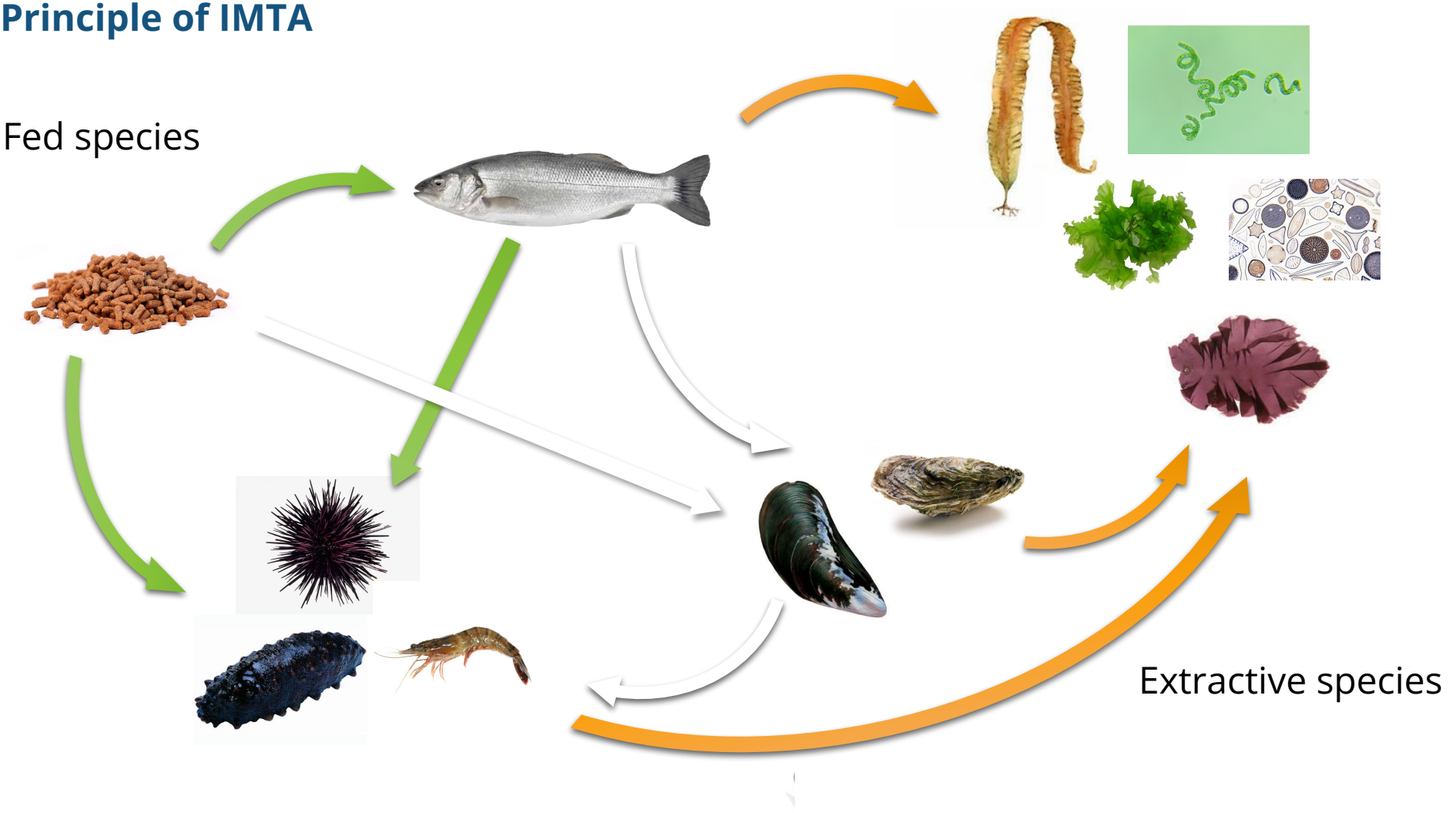
CLOSED system

Principle of IMTA



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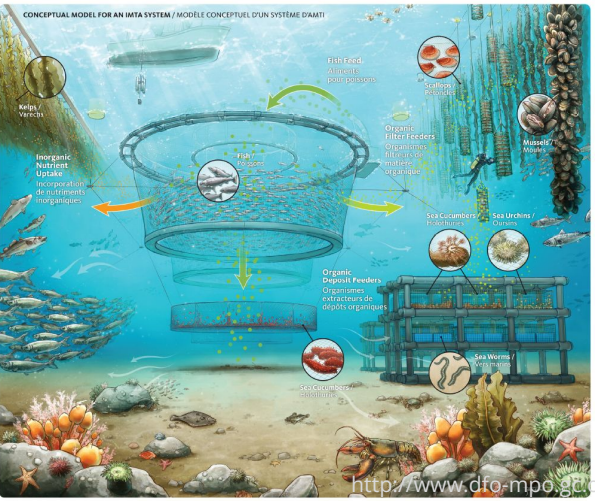
From: www.dfo-mpo.gc.ca

Different systems of IMTA

OPEN



CLOSED

\- +

Control of the parameters and the flows of matter

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PART 2- SEAWEEDS AQUACULTURE

Different groups of seaweeds

Seaweeds are Macroalgae

The thallus (= vegetative part of the individual) of seaweeds can be:

- Filamentous
- Blade
- More or less branched/ramified

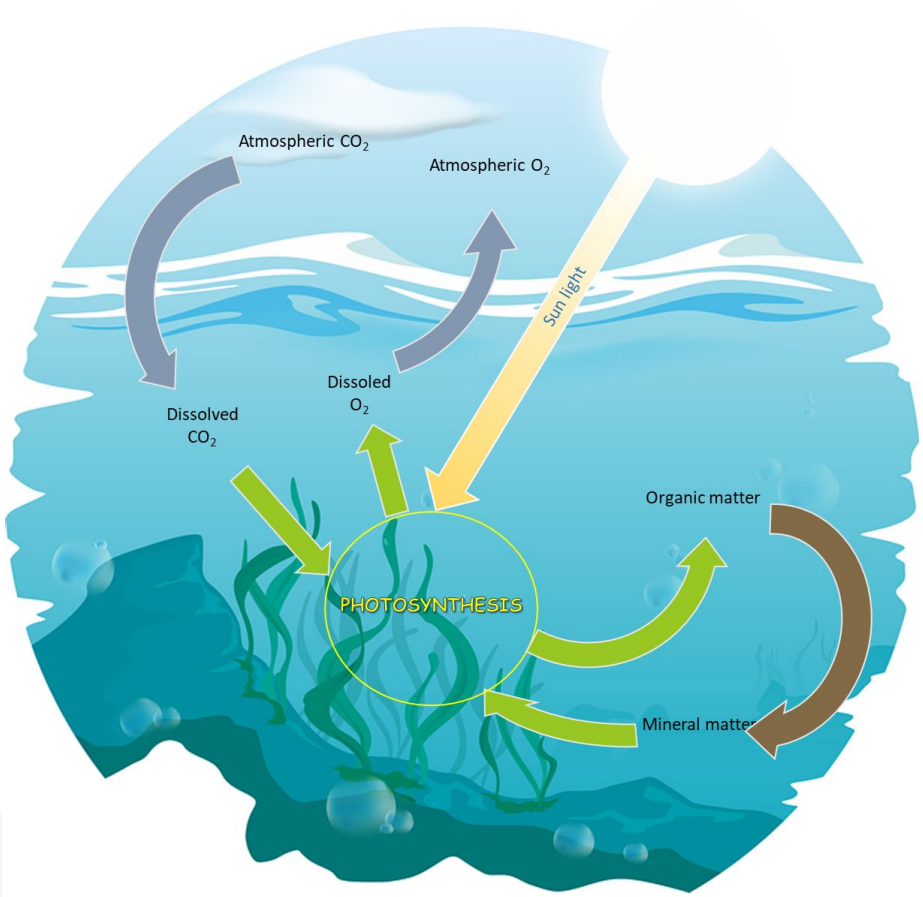
The role of Seaweeds in the marine ecosystem

Recycle the matter

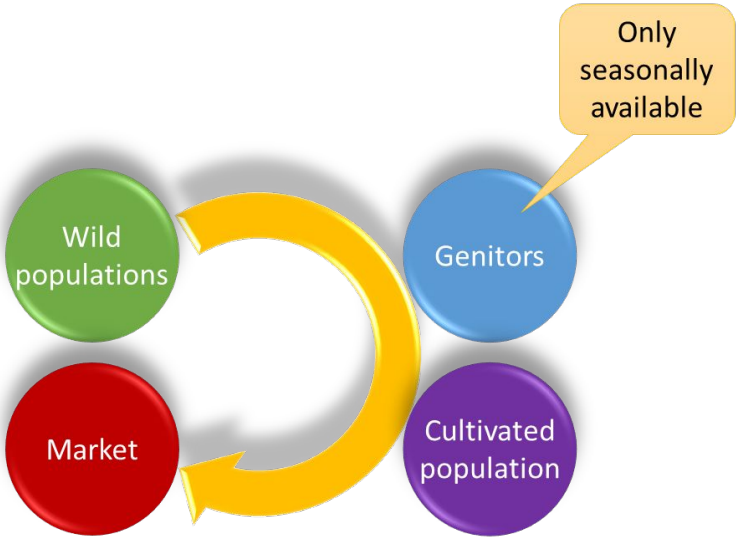
- Use CO_2 and mineral matter to produce organic matter = PHOTOSYNTHESIS
- Food for other organisms

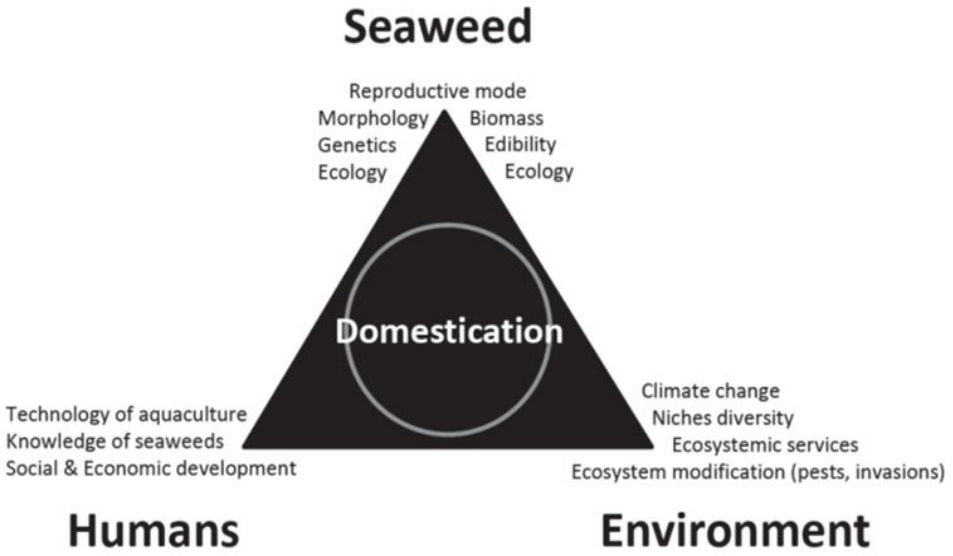
Structure the ecosystem

- Substrate for fixed organisms
- Shelter / Nursery for mobile organisms



The domestication of seaweeds





From: Valero *et al.*, 2017

Seaweed aquaculture depends on wild collected genitors to produce the cultivated population.

But seaweed domestication is one complex process which results from the interaction of seaweed, human and environmental factors.

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Different ways to cultivate seaweeds

Land-based farms

Marsh farms

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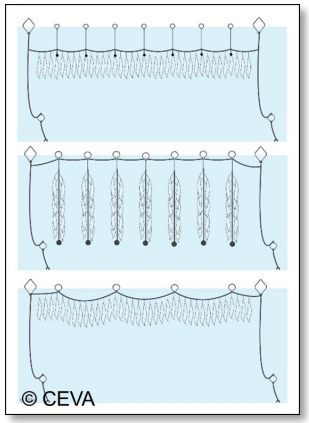
Different ways to cultivate seaweeds

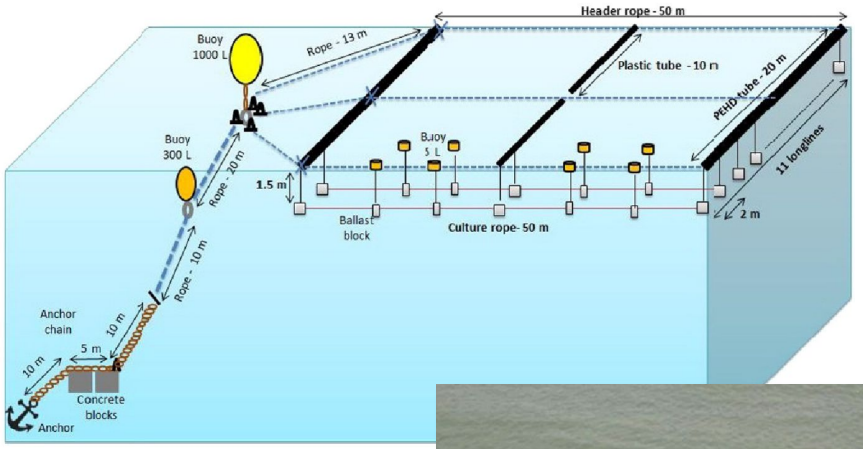
At-sea farms

Floating structures

Long lines



Rafts



2D textile

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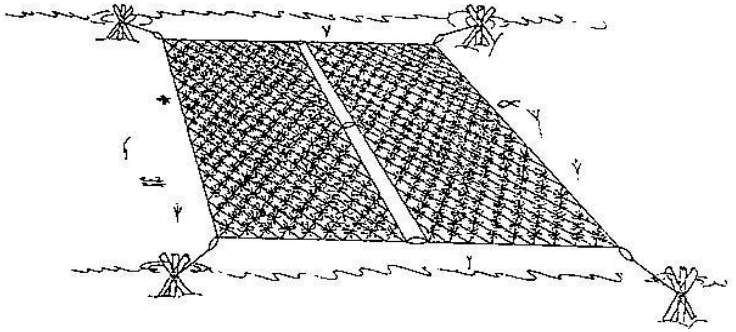
Different ways to cultivate seaweeds

At-sea farms

Benthic structures

Long lines

Nets



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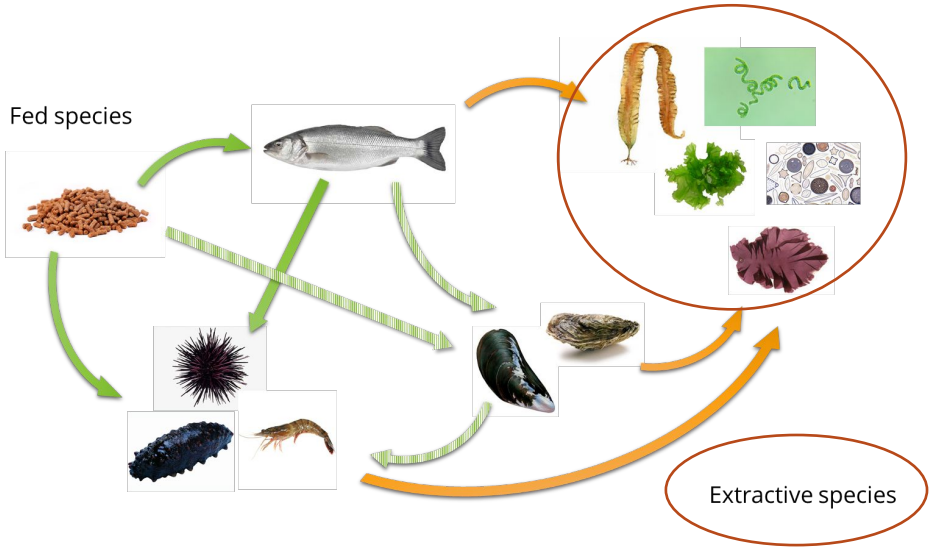
PART 3- WHY USE SEAWEEDS IN IMTA SYSTEMS ?

Seaweeds as a filter

Seaweeds are at the end of the process

Seaweeds will consume mineral dissolved nutrients

- Clean the water from animal production
- Produce dissolved O2
- But: absorb and accumulate the chemical inputs as heavy metals and veterinary treatments (hormones, antibiotics…)



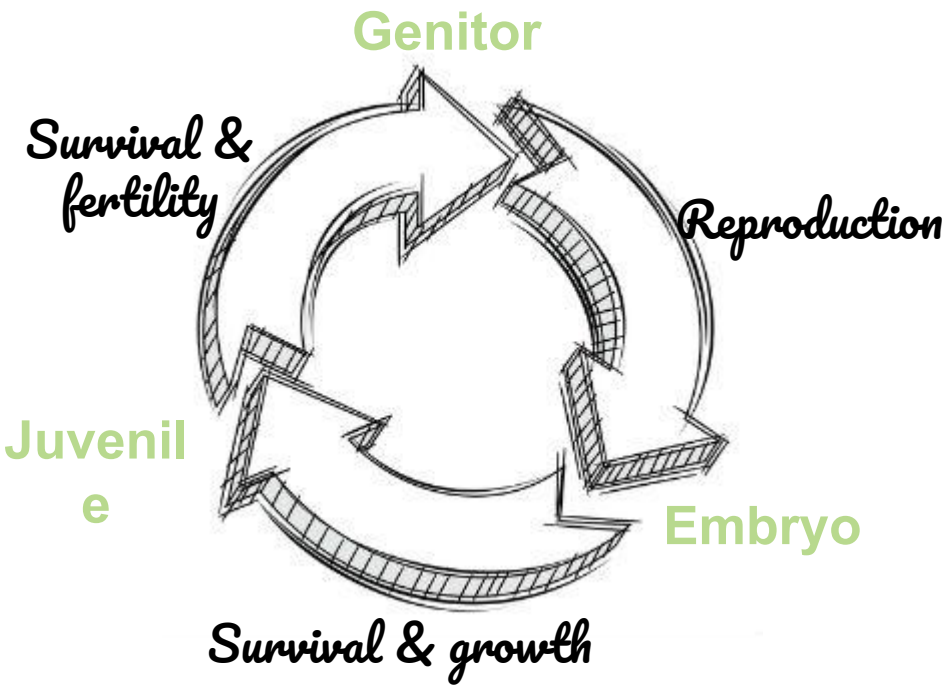
The quality of seaweed could decrease for the concerned market

WHAT TO REMEMBER ?

- IMTA is a simplified ecosystem where different cultivated organisms interact
- Seaweeds provide food for animals (fish, shellfish, sea urchins…)
- Seaweeds provide extraction of inorganic nutrients

Cultivating seaweeds in an IMTA system should induce:

- New resources for the producers
- Reduced environmental impact of aquaculture



CHAPTER 2

Description of the life cycles of the main cultivated seaweed species

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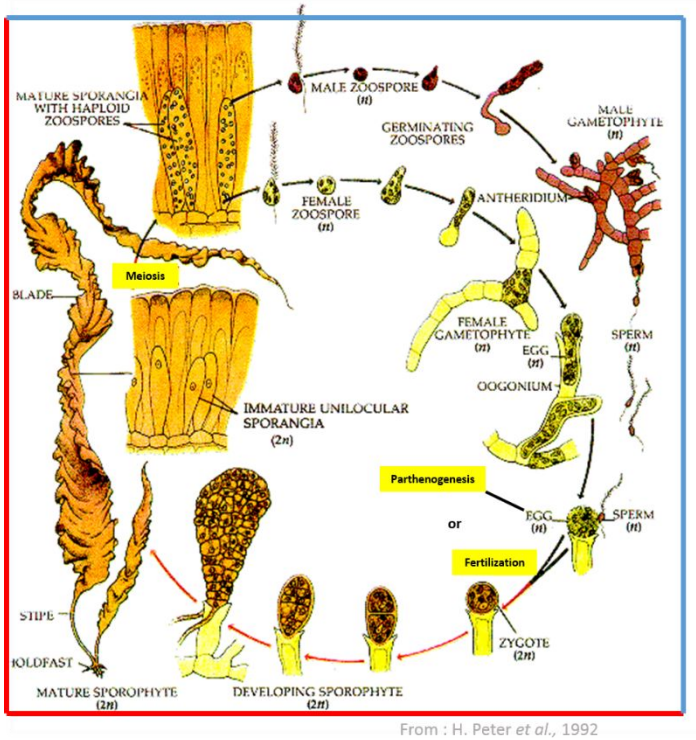
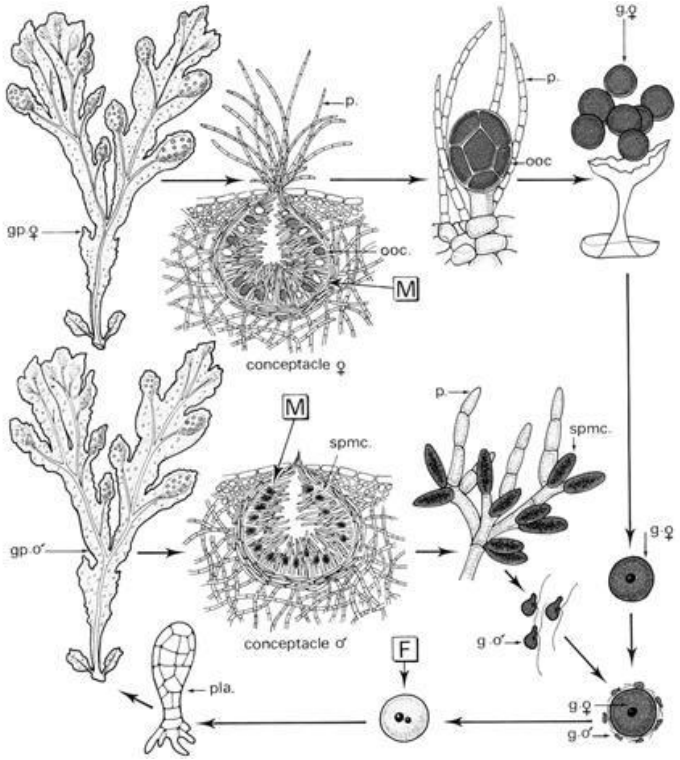
PART 1 - THE BROWN SEAWEEDS

Saccharina latissima (Sugar kelp)



From : H. Peter *et al.*, 1992

Fucus serratus (Rockweed / Bladder-wrack)



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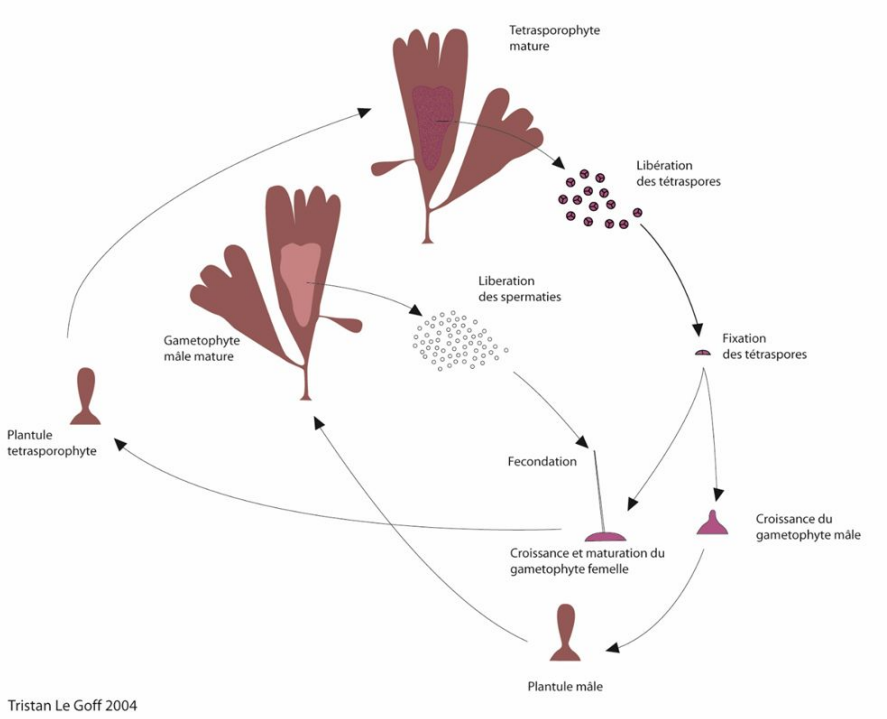
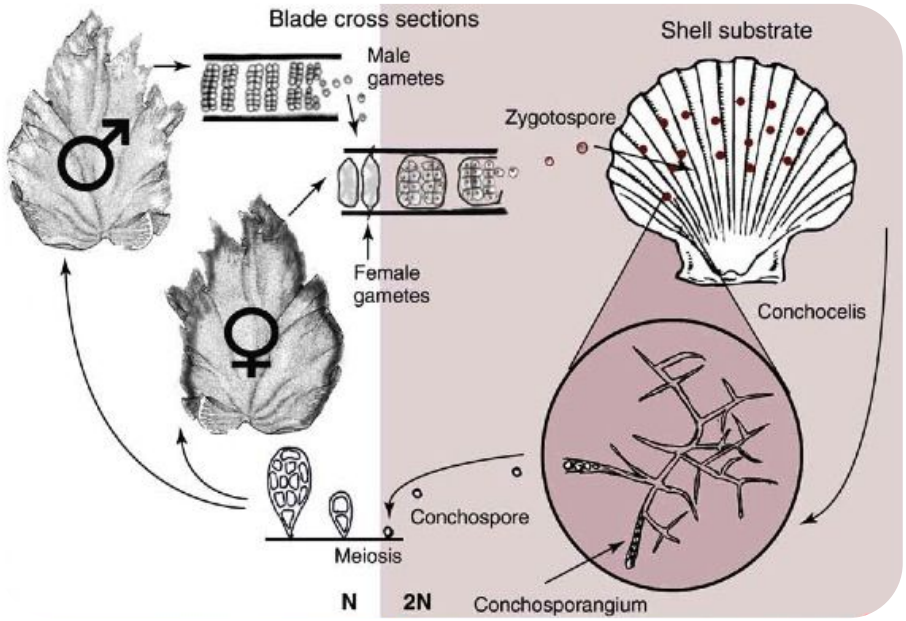
PART 2 - THE RED SEAWEEDS

Palmaria palmata (Dulce)



Porphyra sp. (Nori)



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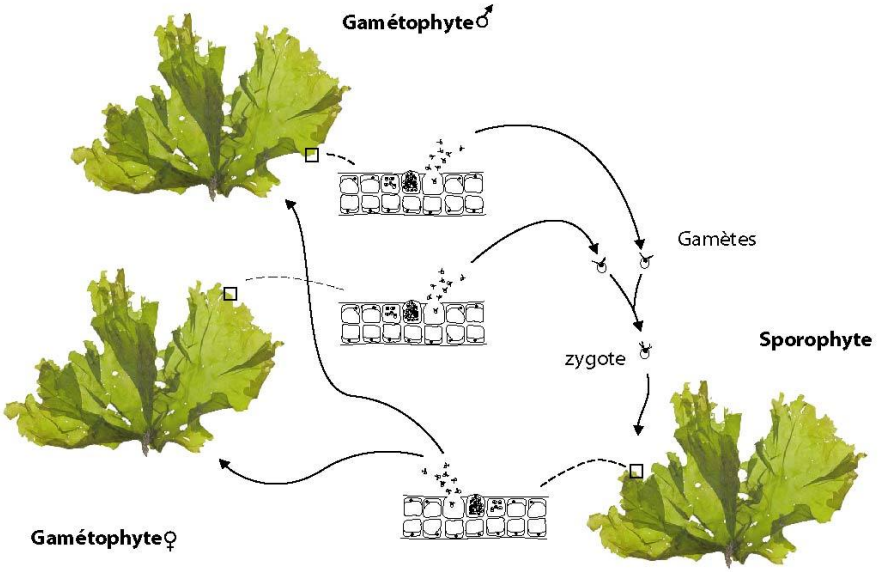
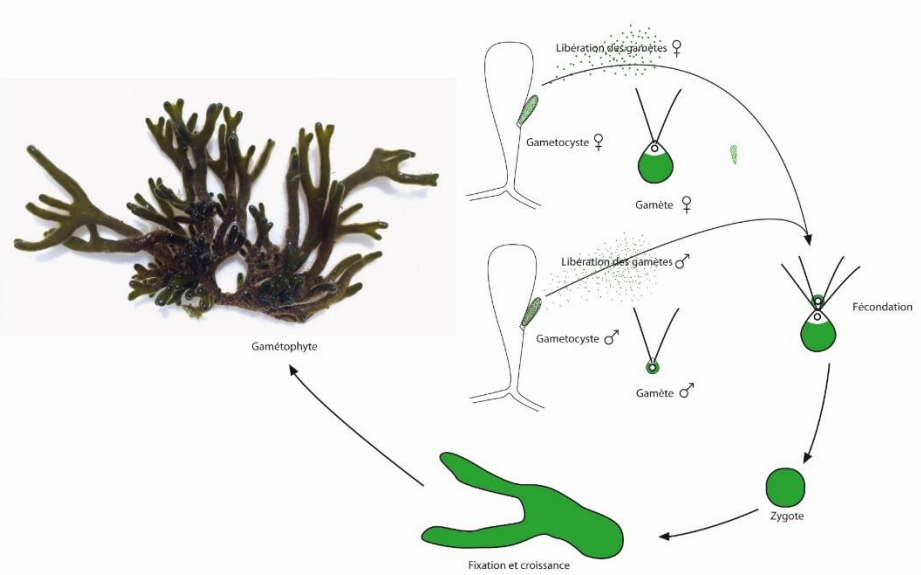
PART 3 - THE GREEN SEAWEEDS

Ulva sp. (Sea lettuce)



Codium tomentosum (Velvet horn)



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PART 4- THE MAIN INFLUENCING PARAMETERS

Life cycles are mainly driven by environmental parameters (dealing with seasons)

- Temperature : Growth and reproduction will step in different temperature scales
- Light : Intensity, colour and photoperiod (day/night length)
- Desiccation : for some intertidal species, emersion time induces reproduction

Some other parameters contributing (but not yet well known):

- Chemical communication between individuals

ex: pheromons for sexual reproduction or Warning signals agains predators and diseases

- Interactions with microorganisms

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PART 5– WHAT TO REMEMBER ?

Complex life cycles with a lack of knowledge for many species of interest

- **Which parameters to control the different phases?**

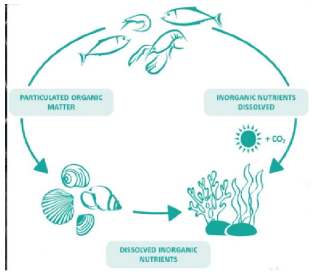
  Mainly temperature and light (intensity, colour and Day-length)

- **How to artificially ensure the optimal conditions?**

  Develop technical solutions and adapted devices

- **How to artificially cover all the life cycle to cultivate seaweeds ?**

  Define the best technical itineraries



CHAPTER 3:
The cultivation process

Part 1 – Vegetative cultivation

How to use fragmentation to produce seaweeds

Part 2 – Breeding cultivation

How to use sexual reproduction to produce seaweeds

Part 3 – What to remember ?

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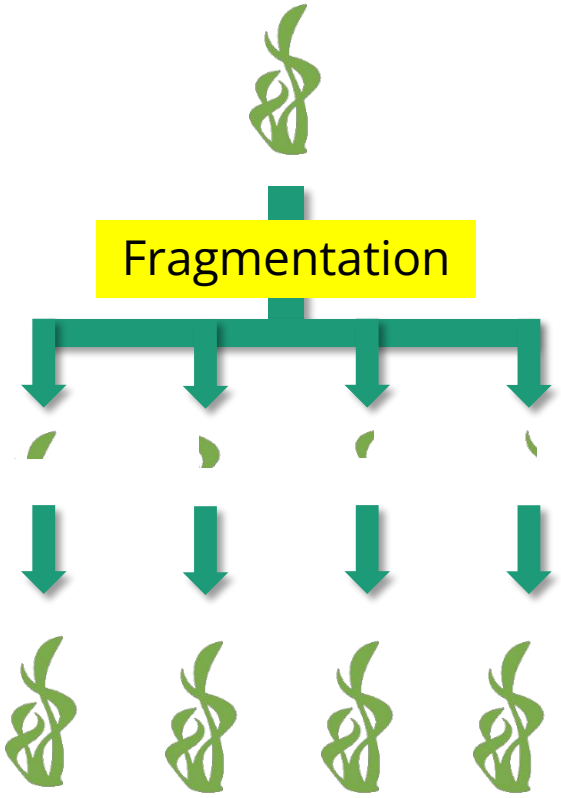
PART 1– THE VEGETATIVE CULTIVATION

- Can occur by simple fragmentation of the thallus. The fragment then has the ability to regenerate a whole plant (ex: *Caulerpa taxifolia*).
- Some species cause the fragmentation of their thallus (eg *Griffithsia*). Fragments then have the ability to attach onto a new medium.
- Other species generate specific organs, propagules, which are released to colonize new environments.



Vegetative cultivation :

- Needs to control the parameters influencing growth.
- Production quality depends on a single genome
- Allows the cultivation of a single traits of interests

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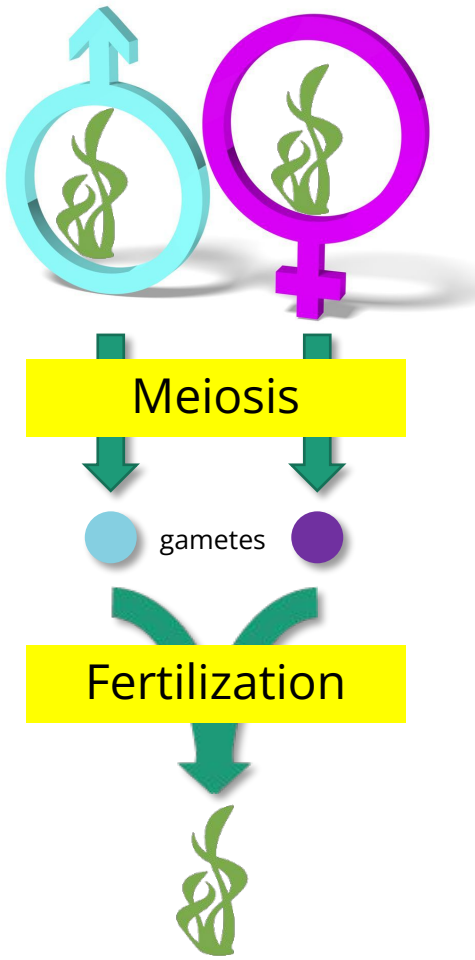
PART 2– THE BREEDING CULTIVATION

- Sexual reproduction involves a male gametophyte and a female gametophyte that can be morphologically very different.
- Fertilization can be done in the medium after release of the gametes or on the female foot depending on the species.
- The gametes can be mobile and carry one or more flagella.



Breeding cultivation :

- Needs to control the parameters influencing gametes production, gametes release and fertilization (= fusion between ♂ and ♀ gametes).
- Needs to control the parameters influencing growth
- Needs to have hatchery facilities
- Is more time consuming
- Allows the combination of traits of interests between different strains

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PART 3– WHAT TO REMEMBER ?

Two ways to produce seaweeds:

- Cultivation of fractionned individuals
- Sexual reproduction is induced in order to cultivate the offspring

What's the most adapted to IMTA systems?

- Depending on extractive or feed use of the seaweed
- Depending on the technical ability to control the reproduction
- Depending on the IMTA system (land-based or at-sea)

Practical:
IMTA small *demo*

INTRODUCTION:

- To introduce the main concepts (theory) and components in a IMTA system.
- To build with the students/participants the different components in a IMTA system. Provide different materials, allowing creativity (age dependent)
- The position of each of the farmed species and also the current (generated by the pump) in the tank can create great discussion.
- Pour the dye/ink slowly in the “fish tank” and observe what happens. You can do different trials by changing the position of the components.

IRISH SEAWEED CONSULTANCY

MATERIALS*:

- Mesh bowl/basket
- Bio-beads
- Weights (handmade with cement)
- Plastic packaging foam
- Cotton string
- Pipe cleaners
- Thin plastic sheeting
- Large box or small tank
- Pump

**List of materials included on a separate document*

EXPERIMENT:

- Place all the IMTA components in the tank
- Turn on the pump
- Use the syringe to add a squirt of dye into the fish cage and watch where it is dispersed by the water pump.

Reference list

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- http://integrate-imta.eu/category/training-materials/