



GENIALG

e-Learning course

SUSTAINABLE SEAWEED FARMING PRACTICES

Module 1 - Seaweed Cultivation and Monitoring Protocols

LESSON 1

Seaweed Cultivation

©Atlantic Sea Farms



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DEFINITION



- Relatively young and robust form of aquaculture
- Does not require fertilizers, hormones or antibiotics. Aids/contributes to water purification - **environmental impact is minimal**
- Potential to be used as a complimentary crop to traditional agricultural crops
- 34 seaweed species are cultivated around the world, percentage of reported farmed tonnage worldwide:
 - **red** (*Rhodophyta*) - 54.4% of reported farmed tonnage worldwide
 - **brown** (*Phaeophyceae*) - 33.6%
 - **green** (*Chlorophyta*) - 0.08%
- Provides a variety of valuable **ecosystems services**



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BENEFITS



Environmentally friendly



Water footprint is very limited



Growing seaweed in the open sea does not require agricultural land



Seaweed is defined as “autotrophic chlorophyllian thallophytes” it does not depend on other organisms to feed or to grow and elaborate its own matter



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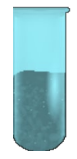
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BENEFITS



Relies on natural energy (solar light) captured and its “chemistry factory” which works via assimilator pigments

$O_2 \rightarrow CO_2$ O_2 production vs CO_2



Dissolved nitrogen and phosphorus uptake in the water column



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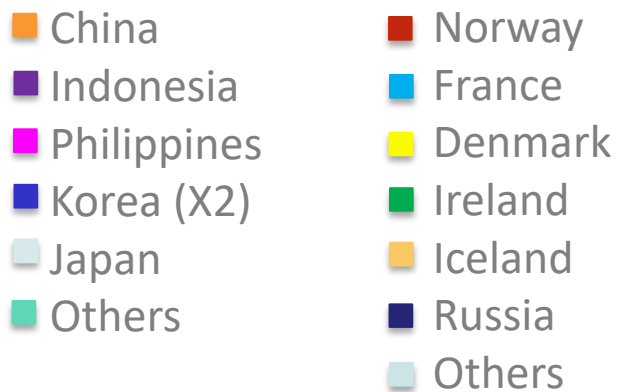
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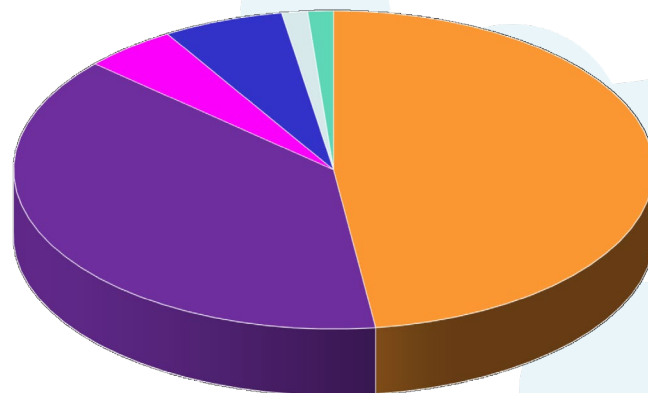


Did you know?

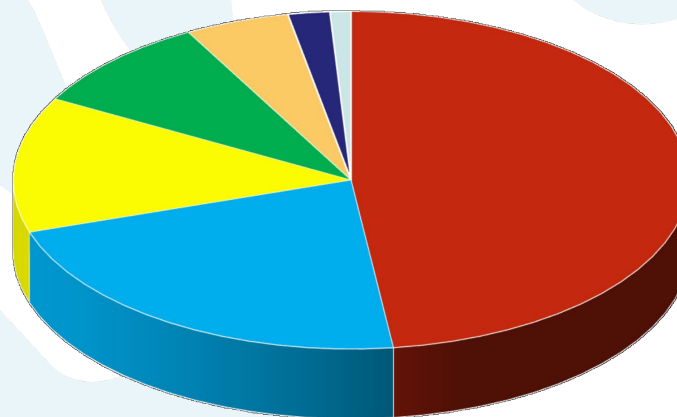
Seaweed cultivation is common practice in almost ~150 countries



MAJOR FARMED SEAWEED PRODUCERS (FAO 2016)



E.U. SEAWEED PRODUCTION (FAO 2015)

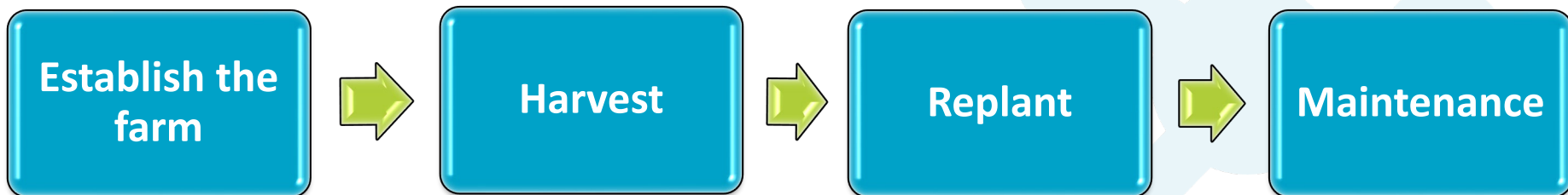


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CULTIVATION PROCESS



To be productive, the farm sites should be regularly visited and checked by the farmer

Regulation and establishment of best practice guidelines for the harvesting, management and cultivation of seaweeds are needed



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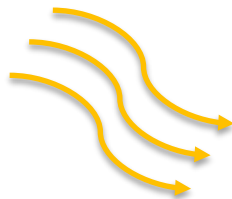


PRINCIPLES

Planting and growing of seaweed crops in optimal conditions



Ensure optimal sunlight



Ensure optimal water movement within the plants for the maximum/optimal uptake of nutrients and gases



Optimisation of photosynthesis



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PRINCIPLES



During the grow-out phase, cultivation is mostly about ensuring continued photosynthesis at the optimal rate until the desired yield



This involves making sure seaweeds stay in place to grow in the desired spatial arrangement while continuously monitoring for threats as much as possible

Most threats are difficult to control, and vulnerability to them must be minimised in the precultivation choices, e.g. **matching a seaweed species with its optimal cultivation technique for each site selected**



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PRINCIPLES



- Technical variations in cultivating seaweed depends on:
 - Species
 - Local conditions
 - Experience
- Seaweed Cultivation involves a series of steps, each of which has many variations. This provides great **flexibility** and **resilience** in the application of the concept to each cultivation situation



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PRINCIPLES



Steps to consider when planning, conducting or evaluating seaweed cultivation at sea:

- 1) Evaluating the characteristics of each coastal-marine environment (i.e. water and climate, environmental quality and biodiversity, other uses of the water, access and facilities, available workforce, socioeconomic, cultural, and legal characteristics);
- 2) Selecting the right seaweed species to farm in each environment for the purposes intended (i.e. food, feed, phycocolloids, specific biochemicals, bioenergy, and/or ecosystem services);
- 3) Selecting the right site(s) within each environment, focusing on the local conditions in relation to the seaweed species selected;
- 4) Selecting and implementing reproduction/propagation techniques to ensure sufficient quantity and quality of propagules with reliable timing;



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PRINCIPLES



Steps to consider when planning, conducting or evaluating seaweed cultivation at sea:

- 5) Selecting and implementing an optimal cultivation technique (planting), populating the farmed area in the optimal spatial arrangement and density of propagules;
- 6) Ensuring that the crop stays in place in the desired spatial arrangement during the entire cropping period for biosynthesis to occur, while aiding the growth process by maintaining biotic and abiotic stresses as low as possible;
- 7) Harvesting the product and bringing it to land or processing it at sea;
- 8) Post-harvest processing of the product to the point that it is a) ready to use; b) ready to market in bulk, or, c) ready to be processed further.





IMPORTANT PARAMETERS

1 LOCATION CHOICE

- ✓ Water, sunlight and gases availability
- ✓ Adequate supply of nutrients
- ✓ Water current should be below 1 m/s - 20 - 40 m/min considered optimal in the sense that water movement is desired to supply seaweeds with nutrients

On a successful farm, the capacity of seawater to provide nutrients through motion or upwelling is matched with or surpasses the uptake potential of the cultivated seaweed



IMPORTANT PARAMETERS



2 CONTROL ARCHITECTURE

- ✓ All measuring and rotating devices (control hardware) must be precisely controlled to optimise the efficiency of the farm
- ✓ Controlling hardware includes sensors, motors, pumps, electronics, computer and software

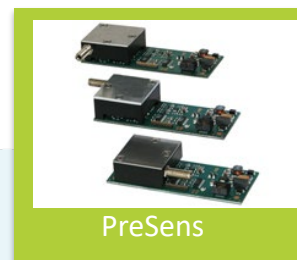


IMPORTANT PARAMETERS

3 DISSOLVED OXYGEN (DO)

- ❌ Low DO harms seaweed
 - ↑ water temperature
 - ↓ less capable of holding O₂

- ✅ Two ways to monitor DO:
 - ✅ Electronic and chemical test kit probes
 - ✅ Manual probes



Sensors used to measure DO



IMPORTANT PARAMETERS

4 TURBIDITY

- ✓ Measure of water clarity
- ✓ Filtration is carried out by two main processes:
 - ✓ Mechanical filtration
 - ✓ Biological filtration



IMPORTANT PARAMETERS



4 TURBIDITY

- ✓ Caused by microscopic algae (phytoplankton), bacteria, dissolved organic substances, clay particles and colloidal solids that suspend in the water, reducing the transparency
- ✗ Sediments enter the water from disturbed sites:
 - ↓ water quality
 - ↓ light penetration
 - ↓ limit growth



HAZARDS



1 BIOTIC STRESSORS

- Pathogenic microorganisms
- Fouling organisms, ranging from other seaweeds and cyanobacteria (epiphytes) to a variety of invertebrates that use the cultivated seaweeds to attach to and grow on zoophytes

see the next slide as an example



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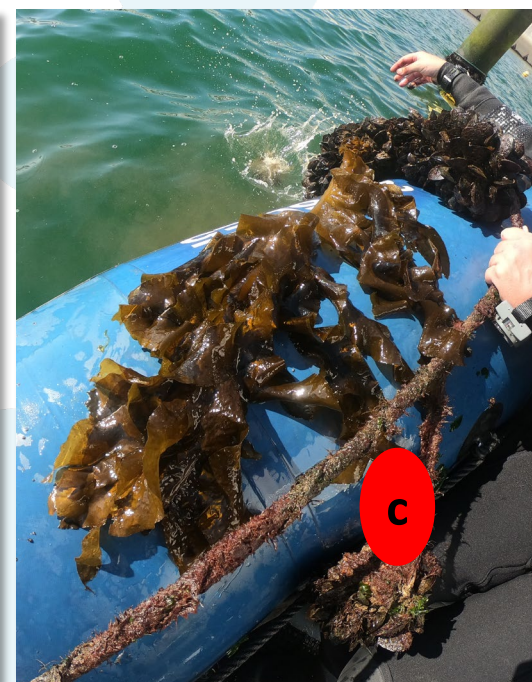
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HAZARDS

1 BIOTIC STRESSORS

Example of species that grew in *Saccharina latissima* (1) farm (ropes) – CIIMAR (Matosinhos, Portugal): **a** – *Mytilus*; **b** – *Undaria*; **c** - Filamentous seaweed



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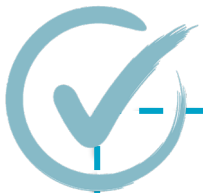
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HAZARDS



1 BIOTIC STRESSORS

- Invertebrates that feed on seaweed tissue, such as snails, sea urchins, crabs, and copepods
- Vertebrates that feed on seaweed tissue, such as herbivore fishes and sea turtles



Biotic stressors may also have **positive effects**:

- 1) The cyanobacteria fouling seaweeds may also fix atmospheric nitrogen
- 2) Herbivory can also be beneficial when it enhances fisheries and nutrient recycling



HAZARDS



2 ABIOTIC STRESSORS

- Usually the result of adverse or nonoptimal environmental conditions, often happening in a short time:
 - Very low or too high irradiance
 - Water temperature and salinity



HAZARDS



2 ABIOTIC STRESSORS

- Effects:
 - Direct: promoting a variety of undesirable responses, including complete disintegration of the crop
 - Indirect: triggering or favouring pathogenicity

To deal with such stressors - prevention in the form of selecting the optimal site, seaweed species, cultivar and propagules, and cultivation method for each environment are the best approaches.



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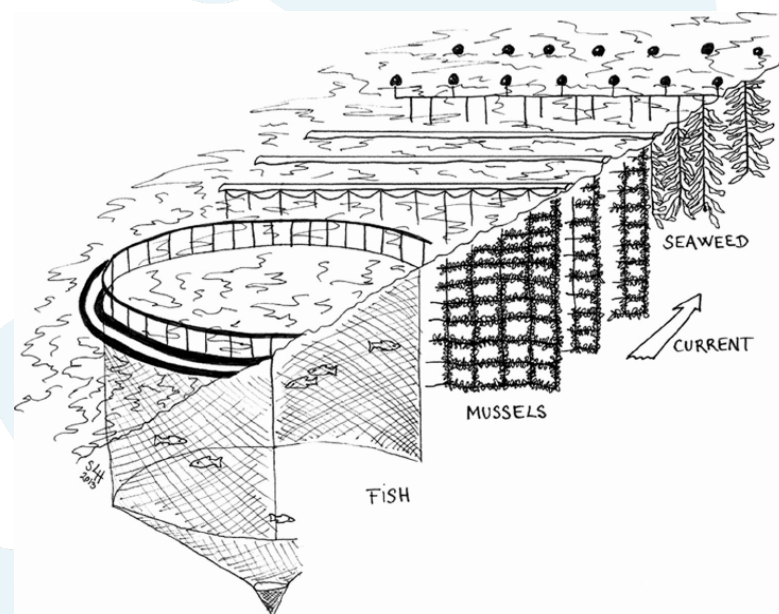
IMTA



Monoculture or in polyculture
with other seaweeds or with fish
aquaculture



There is growing interest in combining seaweed cultivation with fish cultivation to improve water quality, which is called **Integrated Multitrophic Aquaculture (IMTA)**



Tank and pond seaweed culture, often considered small scale though intensive, can have large-scale applications



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Successful seaweed cultivation must be “climate- and water-smart.” For this, proper selection of site, seaweed species and propagation, and cultivation techniques are essential specific elements that determine control for each situation





**LESSON 1 OF
MODULE 1
FINISHED**

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