



# GENIALG

**e-Learning course**

**Sustainable seaweed farming practices**

**Module 1 – Seaweed Cultivation and Monitoring  
Protocols**

**LESSON 2**

*Techniques and Protocols*

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# Module 1 – Seaweed Cultivation Protocols

## LESSON 2 – Techniques and Protocols

### 1 Propagule (seedling) production



- Sexual or asexual reproduction of seaweed is complex and requires expertise to be implemented
- The capacity to **produce propagules** is particularly important to ensure abundant material for vegetative propagation
- Morphological aspects, including similar or dissimilar gametophyte and sporophyte phases, make it necessary to determine or select the proper morphology to farm



# Module 1 – Seaweed Cultivation Protocols

## LESSON 2 – Techniques and Protocols

### 1 Propagule (seedling) production



- Due to behavioural adaptations, many seaweed species naturally tend to disintegrate after reproduction or in response to seasonal or other drastic or rapid changes



For example, *Saccharina latissima* propagation is through spore formation



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### 1 Propagule (seedling) production



- Laboratory-produced spore propagules attach themselves directly to ropes, nets or to strings that are then attached to ropes and nets and planted for the growing season
  - ☑ Advantage: high quality and uniform propagules from selected vigorous and healthy parental lines can be used



# Module 1 – Seaweed Cultivation Protocols

## LESSON 2 – Techniques and Protocols

### 2 Cultivation



- After obtaining or producing propagules, planting is done using the main cultivation techniques, mostly based on the use of ropes and nets



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### 2 Cultivation



- Attaching the right number or density of propagules with the desired characteristics to ropes or nets – **seeding**
- **Planting** consists of placing these at sea at a given depth in a predetermined spatial arrangement based on an optimised **density** of plants per area
  - Density - determined based on the expected size at harvest by establishing the number of plants within and between rows for ropes or the equivalent parameters for nets



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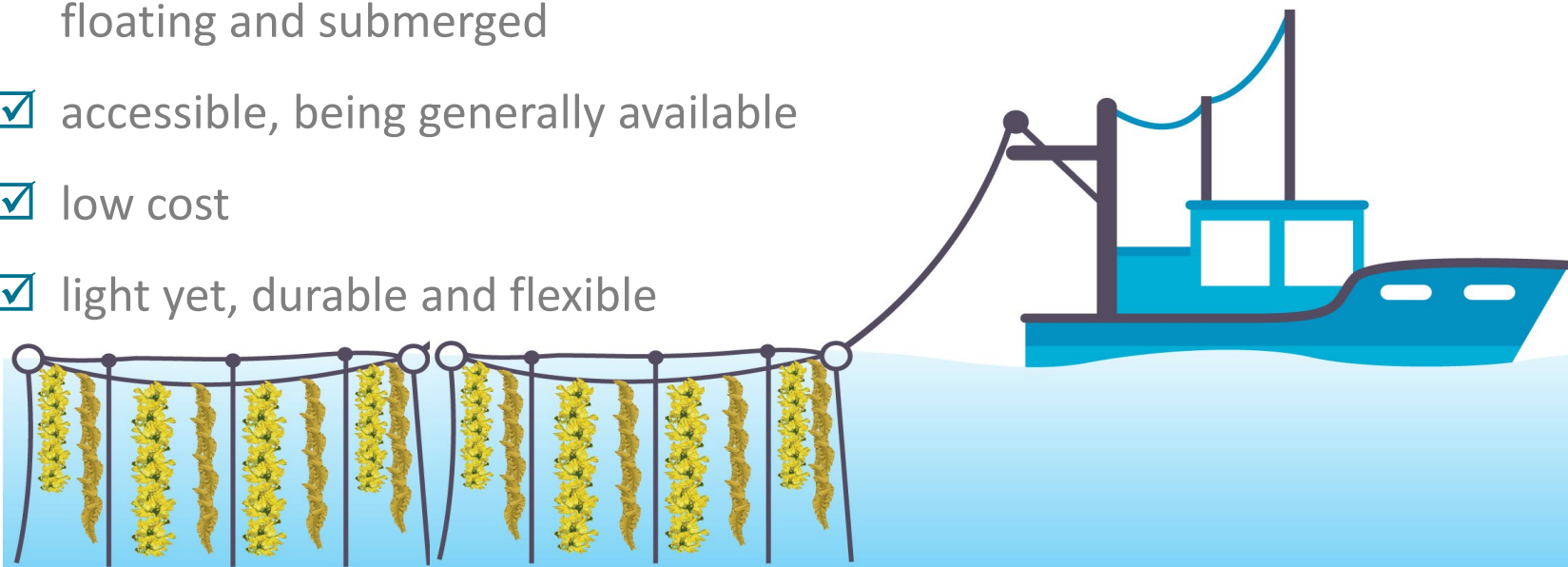
## LESSON 2 – Techniques and Protocols

### 2 Cultivation



#### ■ Ropes and nets:

- ✓ provide adequate substrate for cultivation of seaweed
- ✓ allow for varying lengths and widths of plots for a variety of situations - floating and submerged
- ✓ accessible, being generally available
- ✓ low cost
- ✓ light yet, durable and flexible



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### 2 Cultivation



- The desired spatial arrangement of seeded ropes – or lines – and nets is obtained by holding them in place and depth through two main methods:
  1. For shallow waters wooden pegs or poles buried in the sea floor are used
  2. For deeper waters, **anchors** and **buoys** are used

- Burlap sacks filled with sand
- Concrete blocks weighing a ton or more



- Reused plastic bottles, jugs, and barrels
- Factory-sourced buoys





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### 2 Cultivation



- Yield mapping is important to differentiate the quality of the seaweed at the seeding and growing stage
- Optimal harvesting time is critical to production. Seaweed should be harvested as soon as it reaches its optimal size
- Overgrown plants break and drift away on the seabed



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### 2 Cultivation



#### Main Seaweed Cultivation Techniques

1. **Line cultivation** - Seaweed are attached to ropes of varying lengths (e.g. from 10m to 50m or longer) that are placed in a parallel arrangement with varying spacing between them, depending on size of the seaweed species at harvest (from 0.5m to 1.0m or more), at depths that vary according to the following:
  - a) Off-bottom – planting close to the bottom near shore, preferably with a minimum of 0.3m of water on top at lowest tide. This method is widely used with small and/or frequently harvested species
  - b) Submerged hanging line – planting is midwater near shore, submerged several metres at high tides and at the surface or even exposed during low tides
  - c) Floating line (long-line) – planting at or close to the surface with seaweeds slightly submerged. Excepting the need for anchoring, this method allows cultivation regardless of the depth to bottom



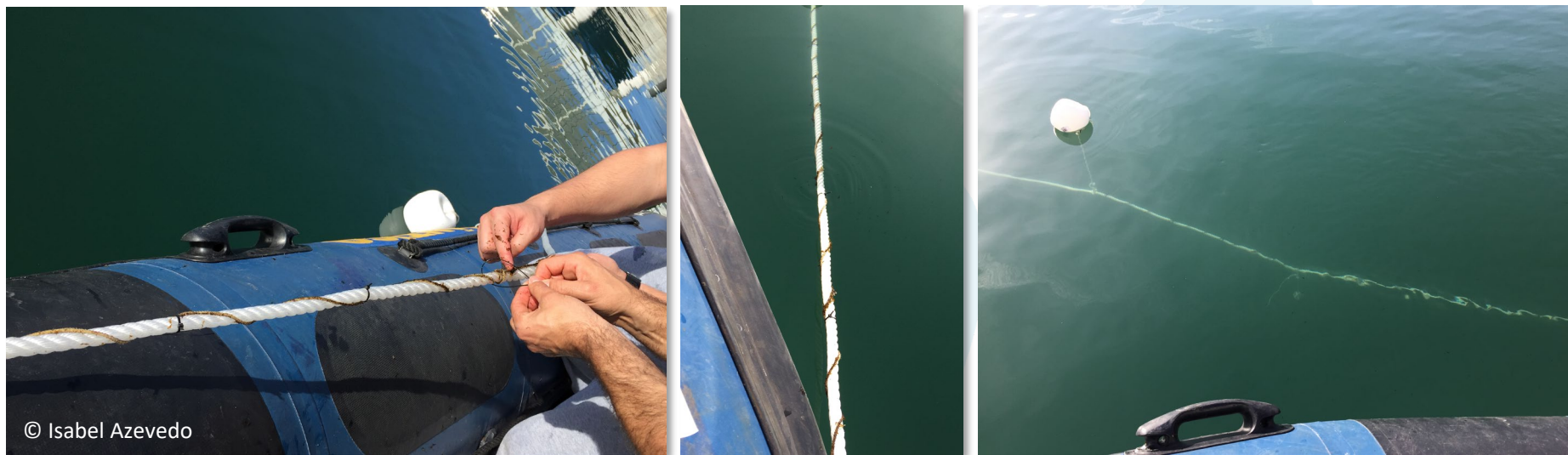
# Module 1 – Seaweed Cultivation Protocols

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### 2 Cultivation

#### Main Seaweed Cultivation Techniques

##### 1. Line cultivation



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*Saccharina latissima* farm (CIIMAR – Matosinhos, Porto)



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### 2 Cultivation

#### Main Seaweed Cultivation Techniques

##### 1. Line cultivation



*Saccharina latissima* farm (CIIMAR – Matosinhos, Porto)



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### 2 Cultivation



#### Main Seaweed Cultivation Techniques

- 2. Net cultivation** - seaweed propagules are attached to nets placed at a given water depth, usually floating at the surface or slightly submerged, similar to line cultivation in relation to depth
- 3. Floating raft cultivation** - planting occurs at the surface, attaching seaweeds to lines or nets with the shape given by a floating rigid frame made of bamboo or other material



# Module 1 – Seaweed Cultivation Protocols

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### 2 Cultivation

#### Main Seaweed Cultivation Techniques

4. **Tank or pond culture** - culture in tanks under controlled conditions is important for delicate species for fresh market and/or for intensive production. Seaweeds can be tied or free-floating with suspension provided by tumbling. Culture for wastewater biofiltration in tanks, ponds, or canals used for fish and shrimp aquaculture is practiced to remove excess nutrients from the water, known as seaweed aquaponics



# Module 1 – Seaweed Cultivation Protocols

## LESSON 2 – Techniques and Protocols

### 2 Cultivation

#### Main Seaweed Cultivation Techniques

##### 5. Minor or experimental techniques, including:

a) direct planting on the ocean bottom or placing seaweeds attached to artificial substrate on the sea floor, resembling natural benthic growth like kelp forests and seaweed prairies;

b) free-floating rafts – equivalent to line or net cultivation but in spatial arrangements with or without rigid frames that hold shape and do not need anchoring but are left freely floating



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### 2 Cultivation



#### Main Seaweed Cultivation Techniques

- 6. Other cultivation techniques** - planting directly on the sea bottom in a manner similar to planting on land, such that farms resemble natural kelp forests and seaweed prairies. Planting seaweed propagules directly on the seabed or using artificial substrates placed on the floor with or without rigid frames that hold shape and do not need anchoring but are left freely floating.





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### 3 Harvesting

- Harvesting cultivated seaweeds is a key aspect
- Depending on the scale of the operation, the methods employed vary substantially:
  - manually bringing in an armful load on foot from intertidal off bottom plantings
  - mechanised harvesting of floating line plantings from large barges in deeper waters



### 3 Harvesting



#### 1. Total harvests:

- include ropes or nets together with the seaweed material, as is done with *Saccharina latissima*
- may be required at the end of the growing season, when maximum growth has been achieved and/or to avoid the crop suffering negative effects from seasonal changes
- harvested lines holding these seaweeds are passed through a hole (line stripper) where all material is removed from the rope



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### 3 Harvesting



#### 1. Total harvests:



*Saccharina latissima* farm (CIIMAR – Matosinhos, Porto)



### 3 Harvesting



#### 2. Partial harvests:

- Only new growth from the initial planting or the previous harvest is taken, leaving behind sufficient material from each plant for regrowth allowing for multiple harvests, which substantially decreases farming costs
- Partial and frequent harvesting also allows farmers to obtain several crops per year, avoiding complete losses of a single crop while also decreasing the compounding effects of epiphytic and epizootic fouling and other biotic stresses



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### 3 Harvesting



- Harvesting by hand produces the highest quality material, in part because of the opportunity the process provides for some degree of on-site removal of sea-borne contaminants
- Although machine harvesting is faster, it may require more careful off-site separation of undesired material from the harvested crop prior to use or processing
- Large seaweed farming operations use a variety of mechanical harvesters, including winches and cranes, mounted on large boats or barges to remove either the complete planting setup or just the desired new growth from lines and nets



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### Cultivation Protocol for *Saccharina latissima* DIRECT SEEDING METHOD

1. Mature sori are selected from the brownest blades, then cut apart from the blades
2. Sori pieces are thoroughly washed several times using sterile seawater, using a soft brush
3. Once perfectly cleaned, the sori pieces are wiped and transferred into an empty sterile beaker for 24 hours, allowing partial dehydration
4. After 24 hours the beaker is filled with sterile seawater at 12°C while providing manual agitation to stimulate sporulation during 20mn



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### Cultivation Protocol for *Saccharina latissima* DIRECT SEEDING METHOD

5. Once a dark brown colour is observed in the beaker, the spore solution is transferred into a second sterile beaker through a sterile 80µm mesh filter in order to eliminate the majority of organic debris
6. The spore solution is then transferred into a shallow flat container along with the settlement substrate (collector i.e. rope or string depending on the user)
7. The spores settle rapidly, and the settlement substrate (collector) is placed into 500 litre cultivation tanks filled with 1µm filtered seawater which needs to be renewed every third day



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### Cultivation Protocol for *Saccharina latissima* DIRECT SEEDING METHOD

8. Nutrients are added each time the water is renewed. Nutrients such as potassium nitrate ( $\text{KNO}_3$ ) 50 mg/litre of culture and nitrogen orthophosphate dodecahydrate ( $\text{NaH}_2\text{PO}_4 \cdot 12\text{H}_2\text{O}$ ) 7 mg/litre of culture
9. Operations are conducted at  $12^\circ\text{C}$  under 2000 lux irradiance with 12/12 hours of day/night ratio for 23-28 days
10. Once plantlets are visible to the naked eye, the collectors are ready for transfer to sea for the growing phase





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### Cultivation Protocol for *Saccharina latissima* DIRECT SEEDING METHOD

11. Collectors are deployed on cultivation apparatus that can have various designs
12. The culture cycle may last from 6 - 9 months prior to harvesting and depends on site conditions





**LESSON 2 OF  
MODULE 1  
FINISHED**

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