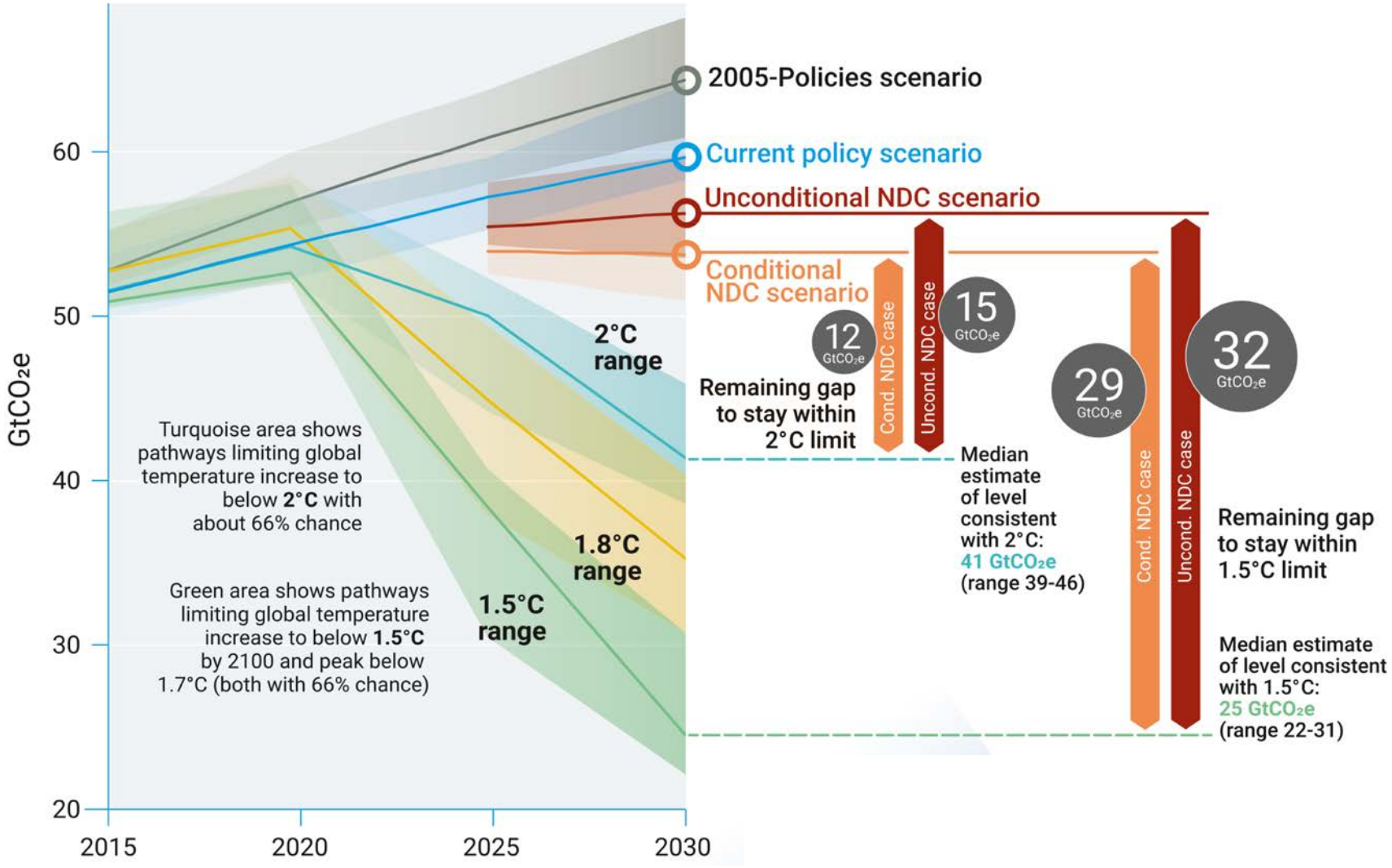
Algae Potential for Carbon Dioxide Reduction and Removal

Justine Davids

Major Qualifying Project

Climate Change



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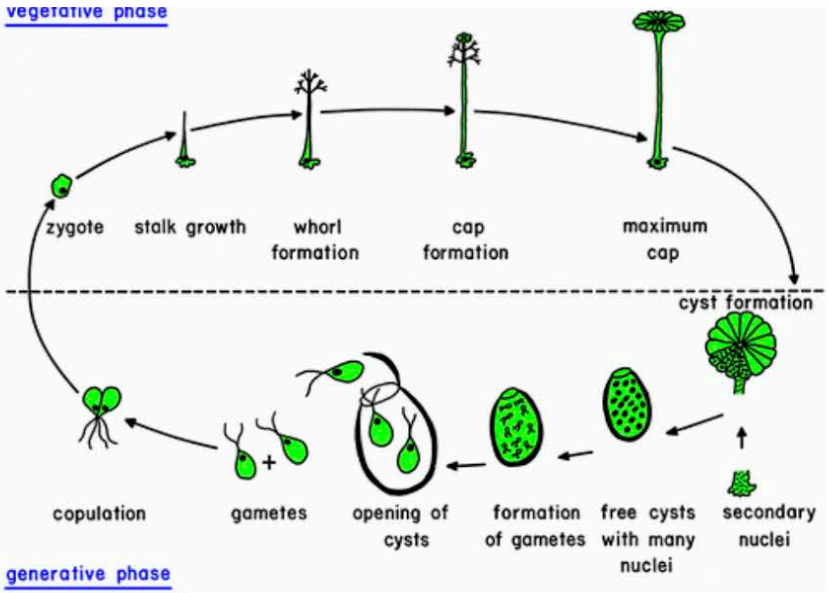
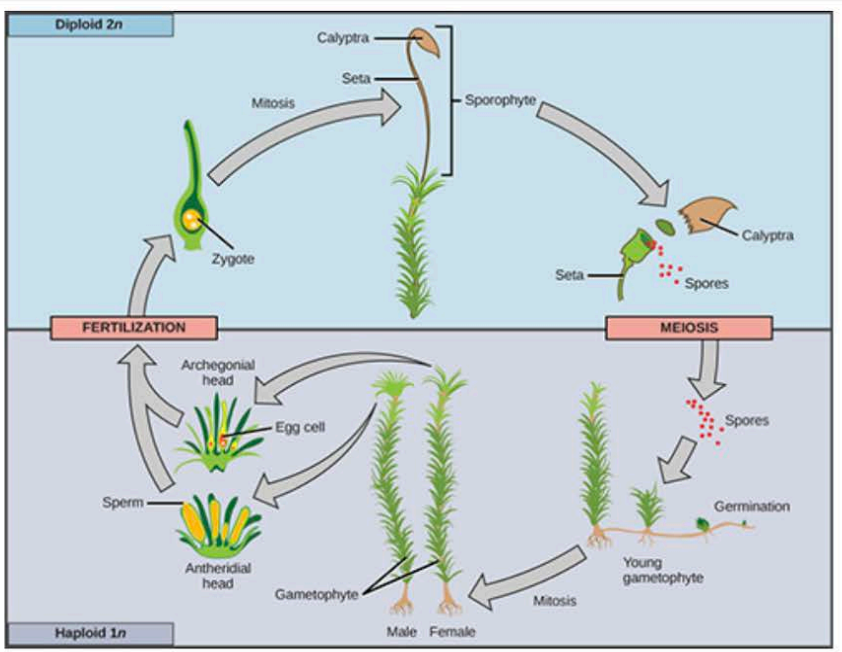
Components Analyzed

- Feasibility
- Scalability
- Co-benefits to the environment
- Potential consequences
- Permanence of storage

What is algae?



Unicellular



Multicellular

Penn State College of Earth and Mineral Sciences. (n.d.). *10.3 Algae Growth and Reaction Conditions.* John A. Dutton e-Education Institute | EGEE 439: Alternative Fuels from Biomass Sources. https://www.e-education.psu.edu/egee439/node/694.

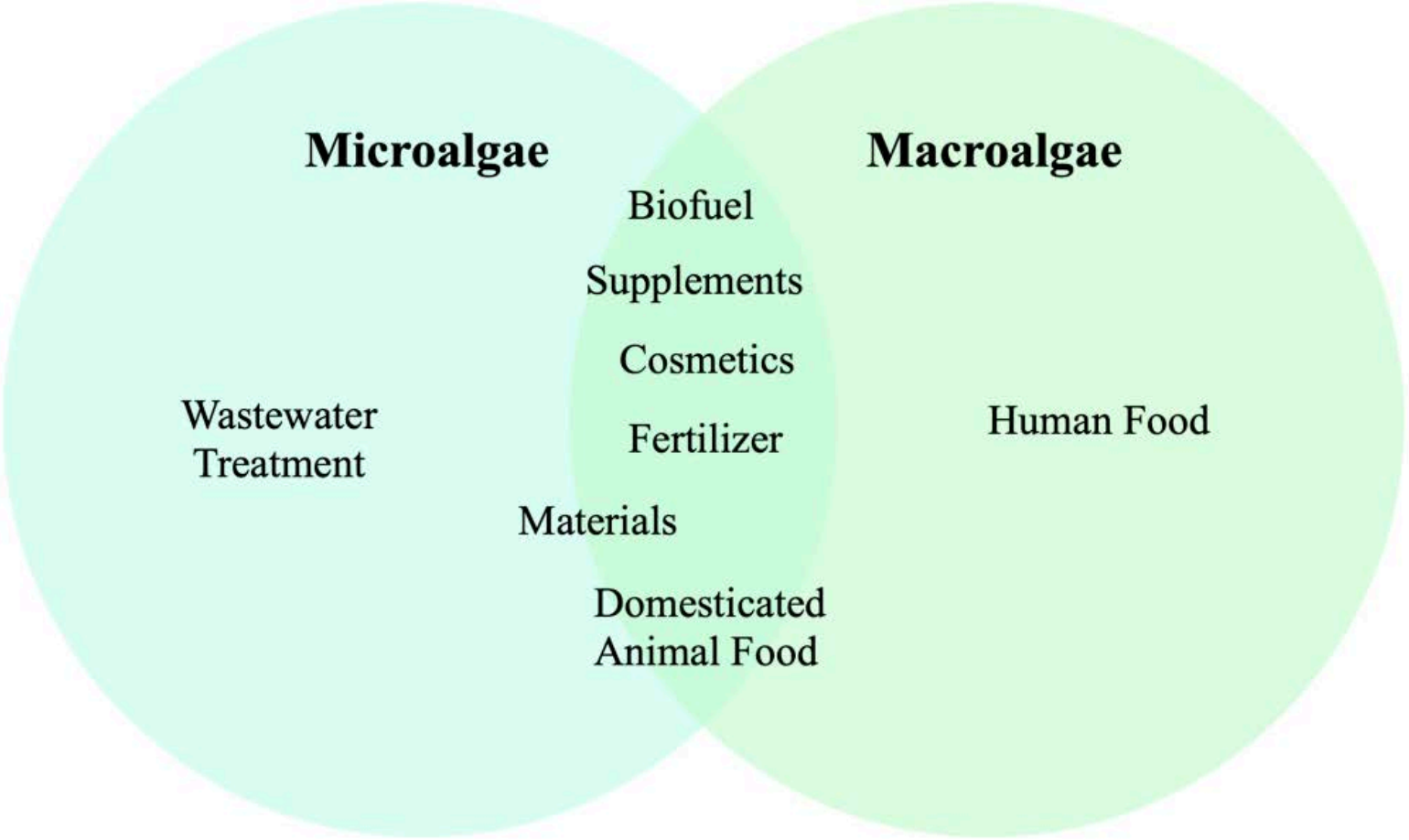
What is algae?

Table 2.1.1. Classification Table (9,10)

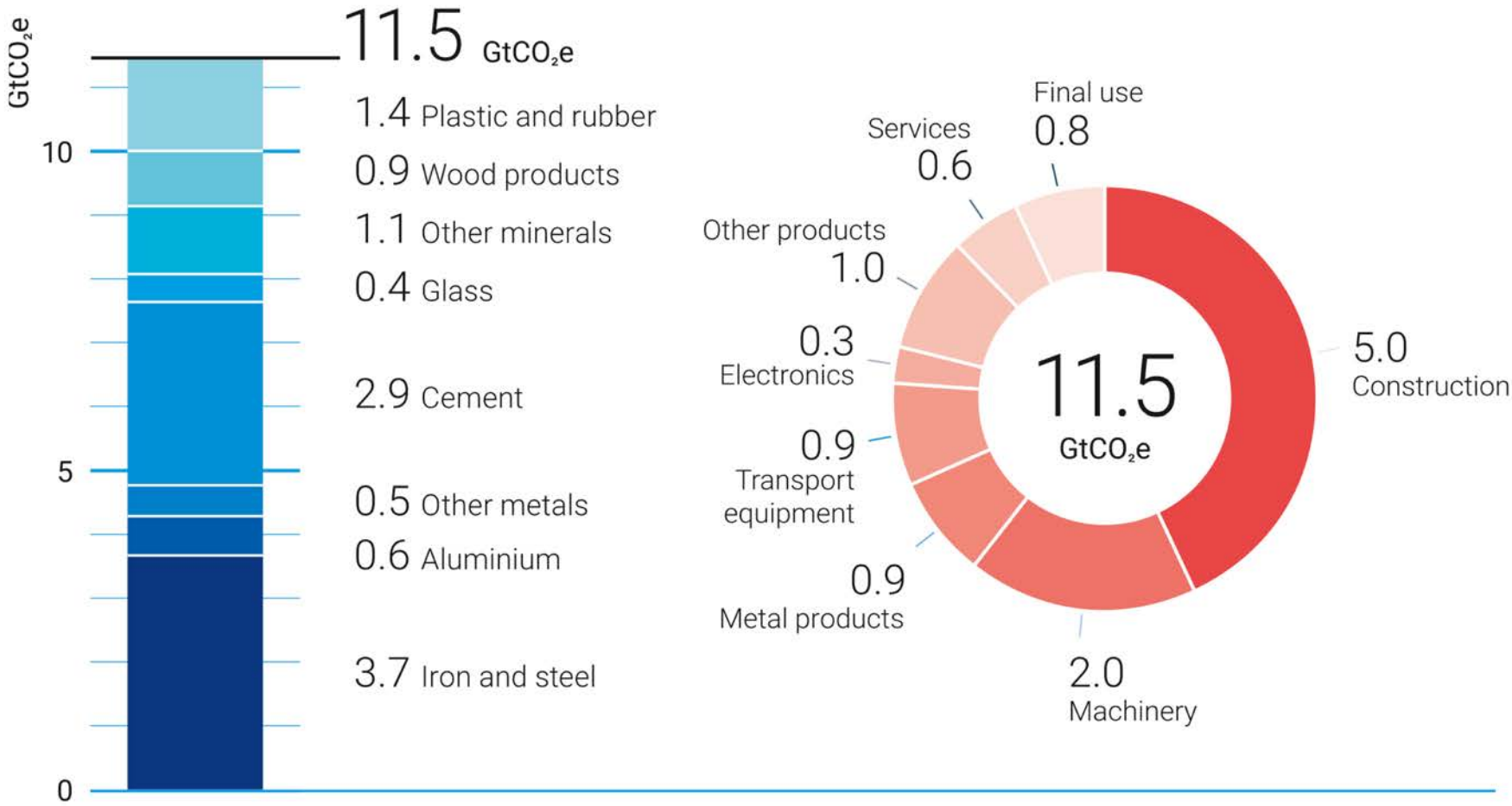
Phylum	Celular	Common Name	Chlorophyll Type	Environment	Reserved Food	Examples
Phaeophyta	multicellular	brown algae	chlorophyll a, chlorophyll c, fucoxanthin, and xanthophylls	• Exclusively marine water • Mainly rocky coasts open seas (cold waters) with root like structures	laminarin	kelp
Rhodophyta	mostly multicellular	red algae	chlorophyll a, chlorophyll d, and phycobilins	• Marine waters tropical, warm waters • Can grow in deep sea	floridean starch	coralline algae
Chlorophyta	mostly unicellular	green algae	chlorophyll a, chlorophyll b, and xanthophylls	• Mostly freshwaters • On land (rocks, trees, and soil)	starch	sea lettuce

Source 1 and 2 for the purpose of this presentation

What is made out of algae?



Decarbonization



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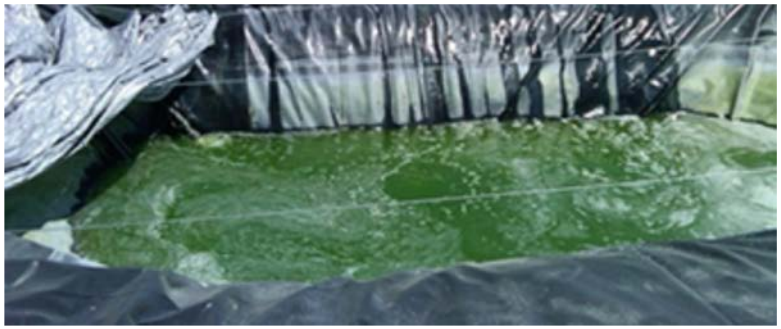
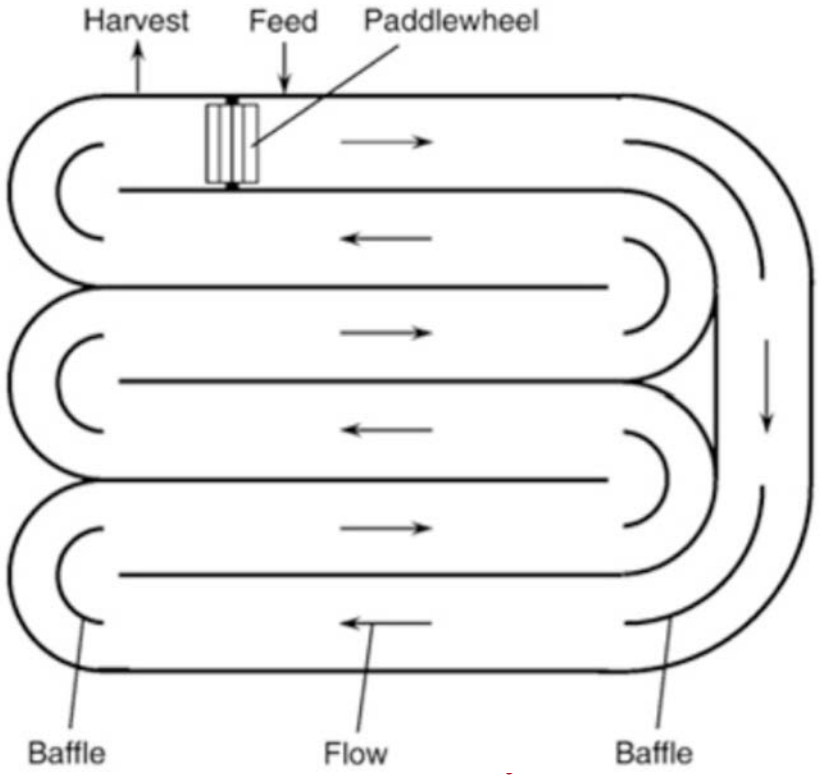
How is microalgae grown?

- Closed system
- Open and outdoor system

Microalgae: Open System





Penn State College of Earth and Mineral Sciences. (n.d.). *10.2 What are Algae?* John A. Dutton e-Education Institute | EGEE 439: Alternative Fuels from Biomass Sources. https://www.e-education.psu.edu/egee439/node/695.

Microalgae: Open system

- Open to the surrounding ecosystem
- Takes up a lot of area
- Worst case of spill: tubs of algae and growth substances

Microalgae: Closed System

Penn State College of Earth and Mineral Sciences. (n.d.). *10.2 What are Algae?* John A. Dutton e-Education Institute | EGEE 439: Alternative Fuels from Biomass Sources. https://www.e-education.psu.edu/egee439/node/695.

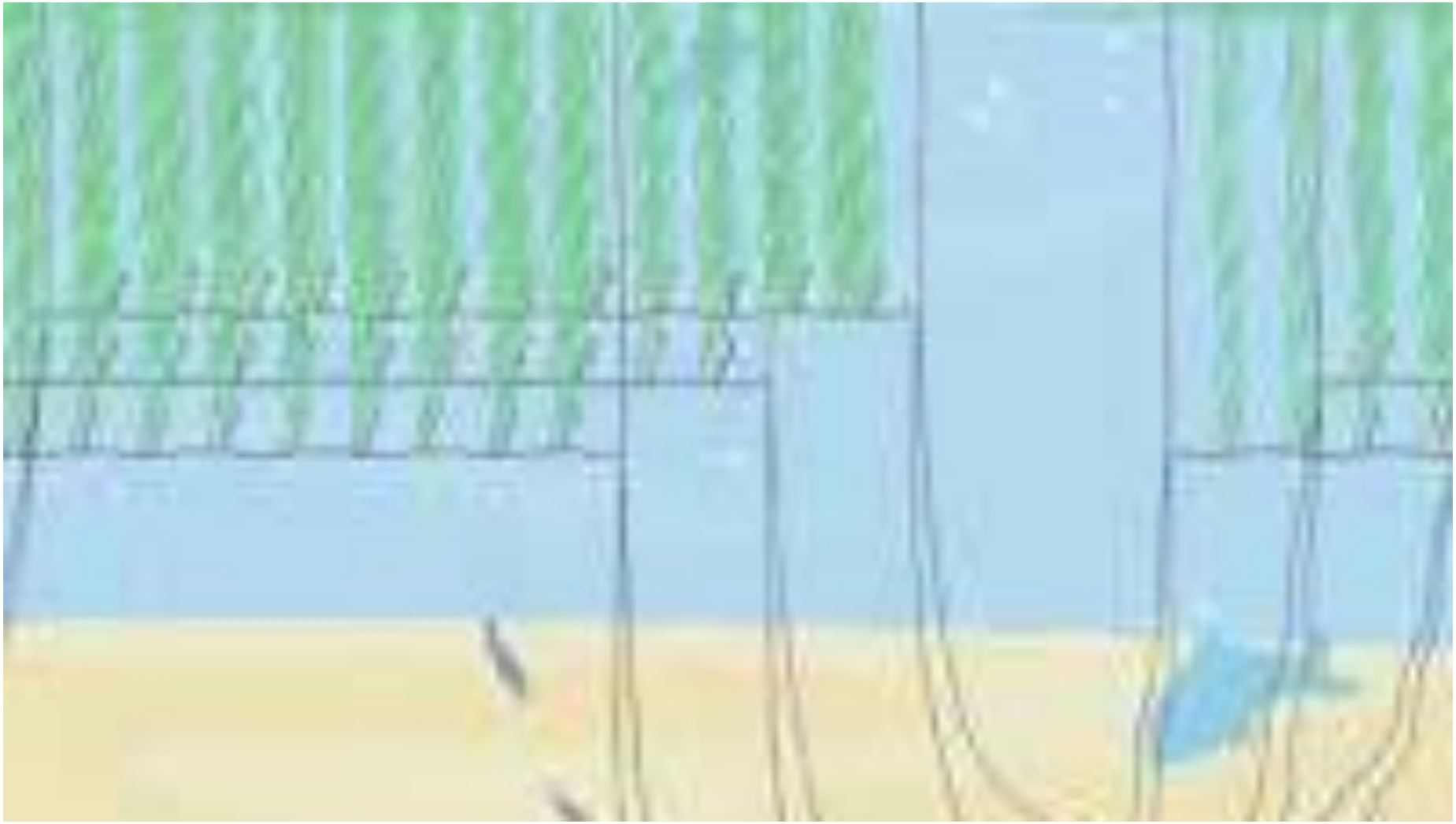
Microalgae: Closed System

- Closed to elements
- Takes up less area with optimized production
- Worst case of spill or crack of a tube: can have intermittent shut off valves or emergency holding tanks
  - Less impact since it is contained

How is macroalgae grown?

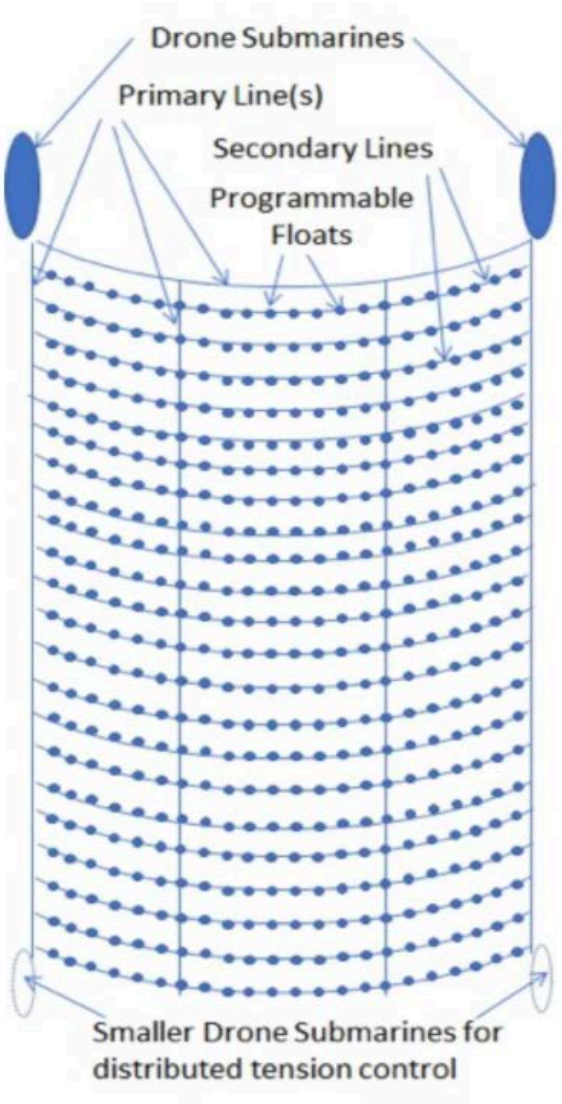
- Focusing solely on ocean growth options
  - Coastal
  - Deep Sea

Macroalgae: Coastal



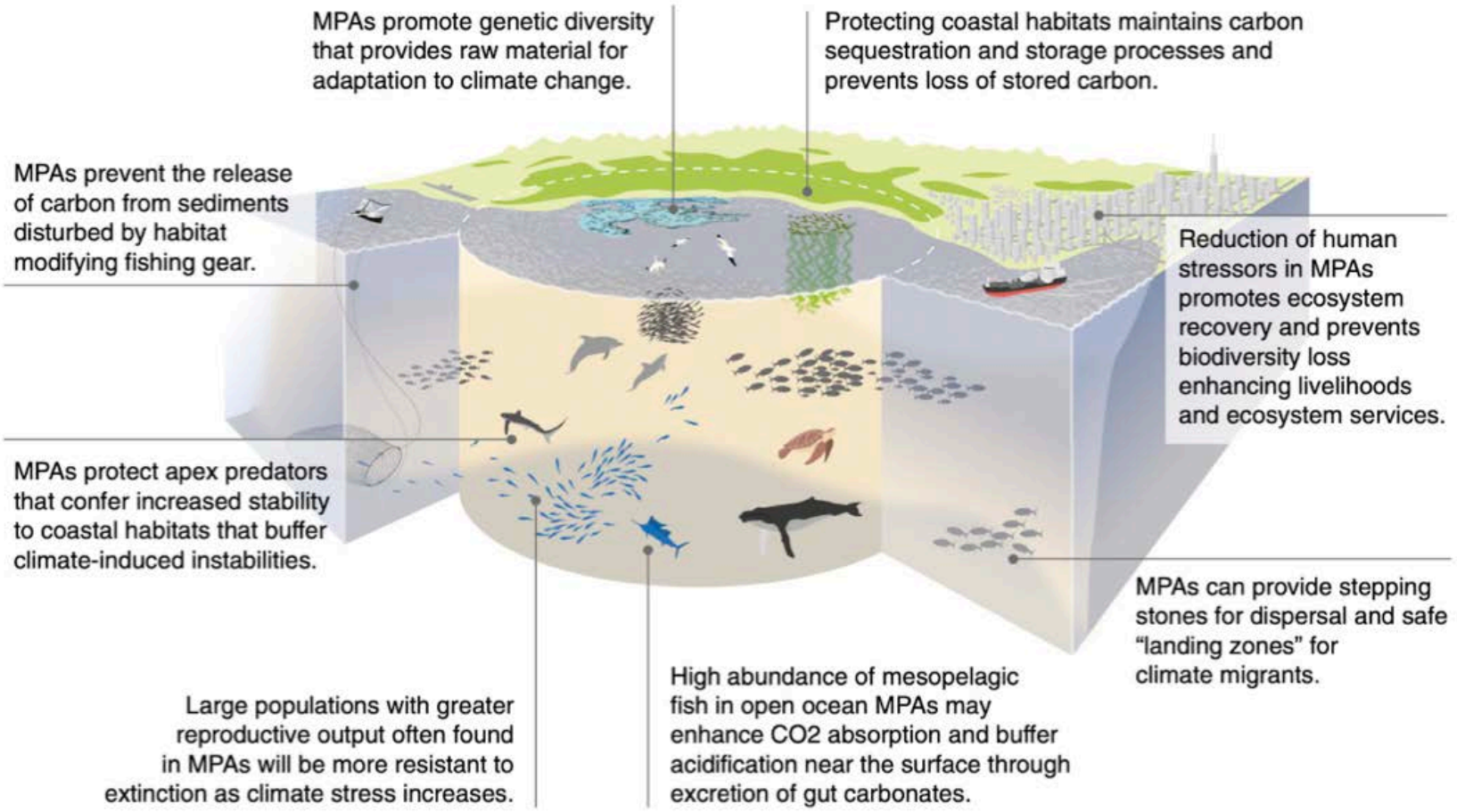
Ocean Rainforest. http://www.oceanrainforest.com/systems

Macroalgae: Deep Sea



Marine BioEnergy, Inc. (n.d.).https://www.marinebiomass.com.

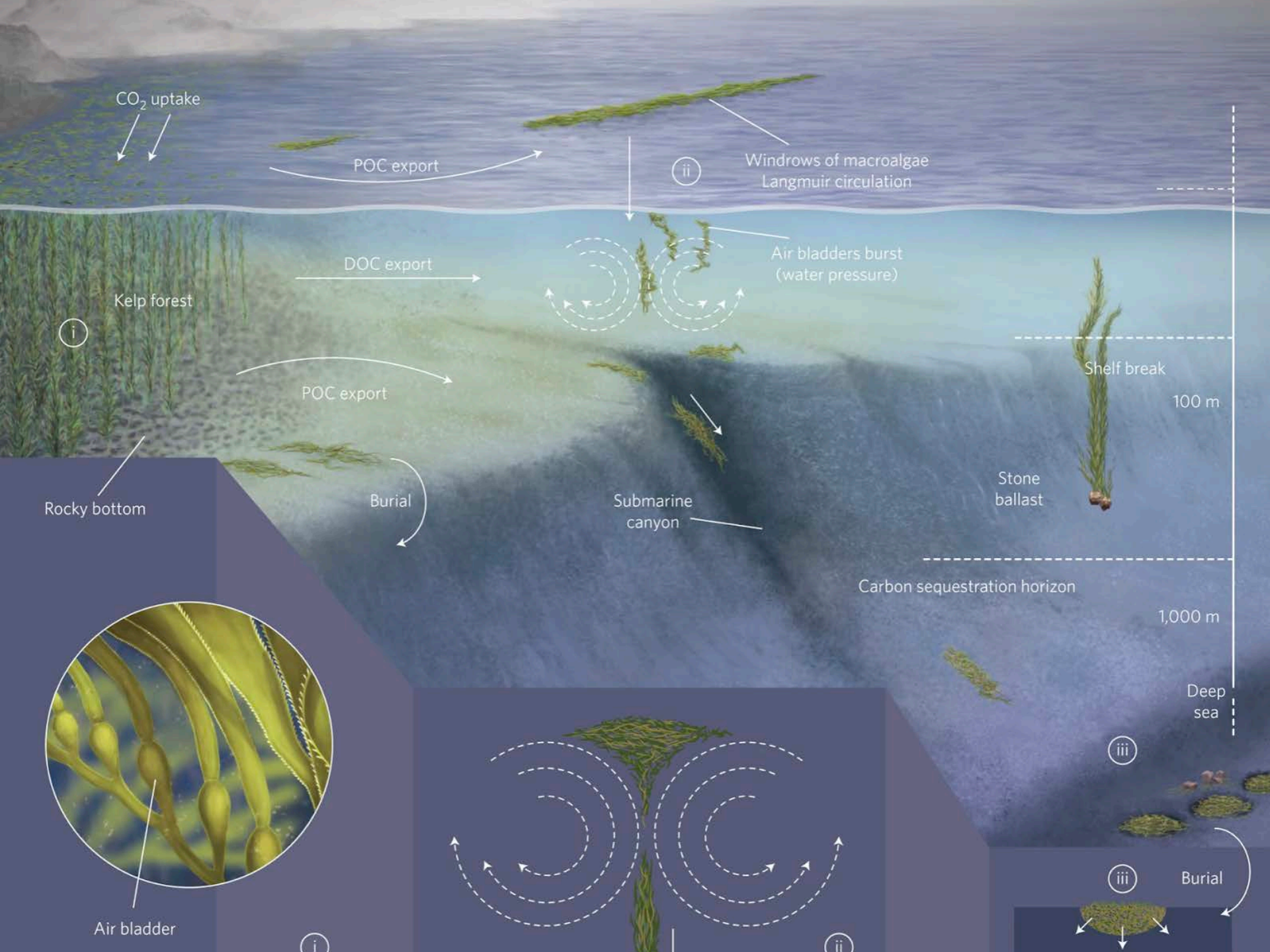
Moral Hazards



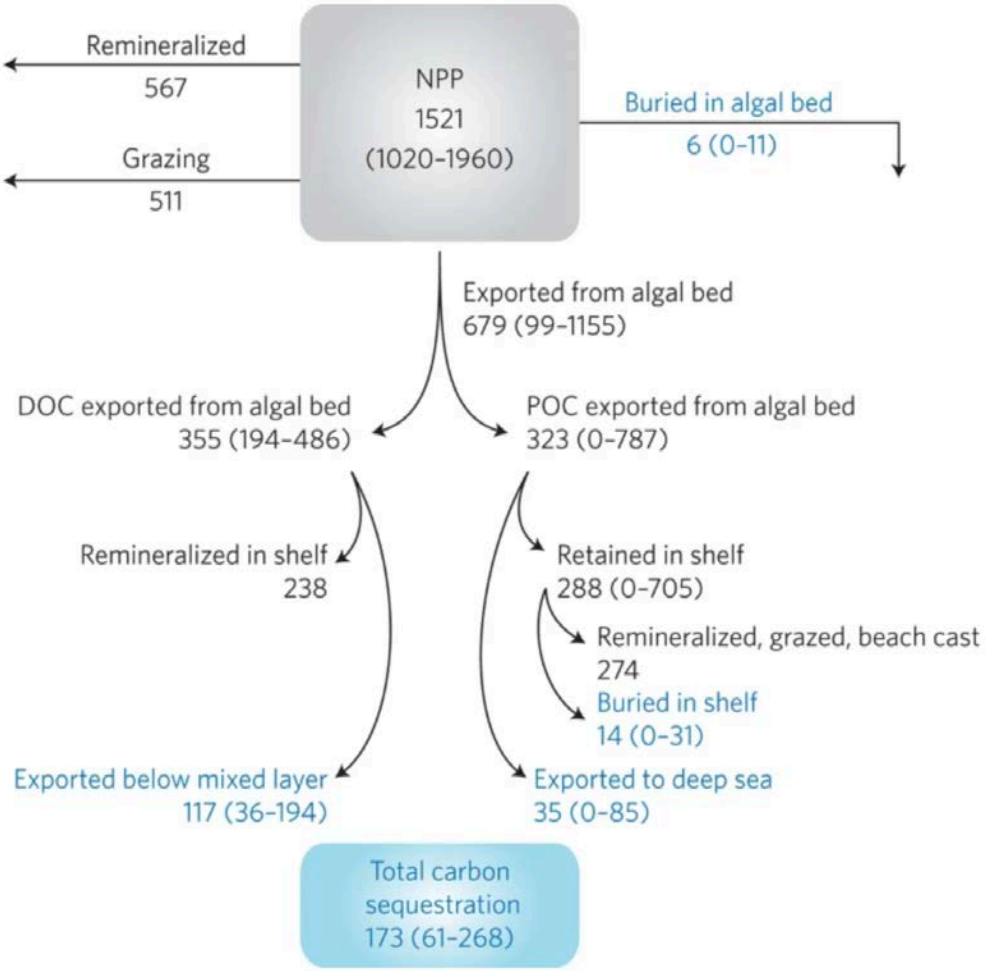
Source 3

How it relates to carbon dioxide

- Decarbonize sectors
- Negative emission potential


CO_2 uptake
POC export
ii
Windrows of macroalgae
Langmuir circulation
Air bladders burst
(water pressure)
DOC export
Kelp forest
i
POC export
Shelf break
100 m
Stone
ballast
Rocky bottom
Burial
Submarine
canyon
Carbon sequestration horizon
1,000 m
Deep
sea
iii
iii
Burial
Air bladder
i
ii

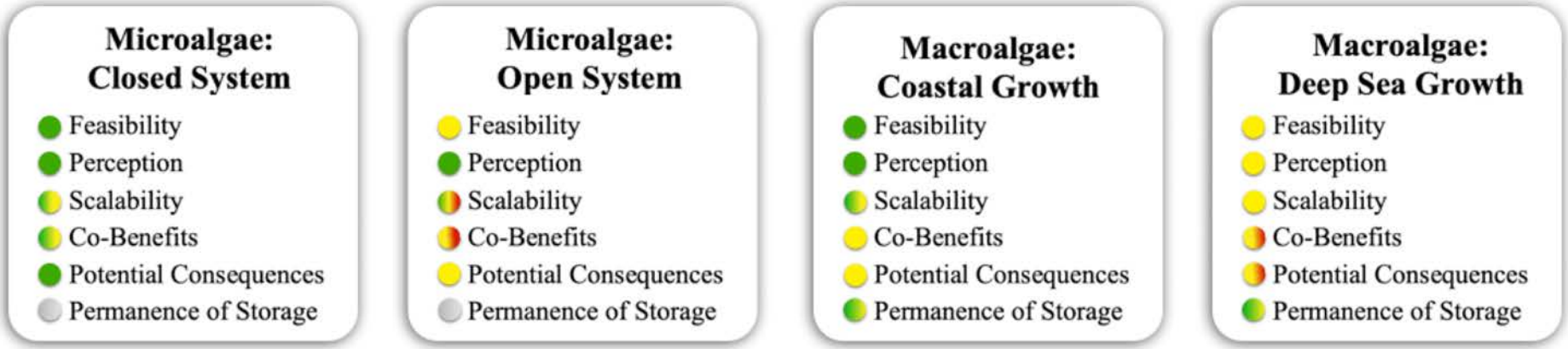
Macroalgae



*All Values are in MtC/year

Both this slide and the previous are from Krause-Jensen, D., Duarte, C. (2016). Substantial role of macroalgae in marine carbon sequestration. *Nature Geosci* 9, 737–742. https://doi.org/10.1038/ngeo2790.

Evaluation


Microalgae: Closed System
Feasibility
Perception
Scalability
Co-Benefits
Potential Consequences
Permanence of Storage
Microalgae: Open System
Feasibility
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Macroalgae: Coastal Growth
Feasibility
Perception
Scalability
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Potential Consequences
Permanence of Storage
Macroalgae: Deep Sea Growth
Feasibility
Perception
Scalability
Co-Benefits
Potential Consequences
Permanence of Storage

Concluding remarks

- Most well rounded is the potential for reduction
  - Closed system microalgae
  - Coastal macroalgae

WPI

Thank you!

Sources Denoted by Number

1. Penn State College of Earth and Mineral Sciences. (n.d.). *10.2 What are Algae?* John A. Dutton e-Education Institute | EGEE 439: Alternative Fuels from Biomass Sources. https://www.e-education.psu.edu/egee439/node/693.
2. Lakna. (2019). *What is the Difference Between Red Brown and Green Algae*. PEDIAA. https://pediaa.com/what-is-the-difference-between-red-brown-and-green-algae/.
3. Roberts, C., O'Leary, B., McCauley, D., Cury, P., Duarte, C., Lubchenco, J., … Castilla, J. C. (2017). Marine reserves can mitigate and promote adaptation to climate change. Proceedings of the National Academy of Sciences of the United States of America, 114(24). https://www.pnas.org/content/pnas/114/24/6167.full.pdf