

# Intensified Sea-Based Macro-Algae Cultivation For Bio-Refineries



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- The major source for fuel
- Petroleum fuel price is increasing
- Environmental risks
- Intensified pollution
- Releases of carbon dioxide

Bio-refinery

Bio-fuels

## G7 leaders agree to phase out fossil fuel use by end of century

German chancellor Angela Merkel announces commitment to 'decarbonise global economy' and end extreme poverty and hunger

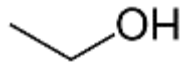


📷 G7 leaders, including Angela Merkel (in pink jacket), and invitees line up for the traditional group photo at the end of the summit. Photograph: Sven Hoppe/dpa/Corbis

The G7 leading industrial nations have agreed to cut greenhouse gases by phasing out the use of fossil fuels by the end of the century, the German chancellor, Angela Merkel, has announced, in a move hailed as historic by some environmental campaigners.

On the final day of talks in a Bavarian castle, Merkel said the leaders had committed themselves to the need to “decarbonise the global economy in the course of this century”. They also agreed on a global target for limiting the rise in average global temperatures to a maximum of 2C over pre-industrial levels.

# Bio-Ethanol Use As Fuel

Ethanol 	23.4 MJ/L
Gasoline	34.9 MJ/L

1 ton bioethanol  $\approx$  0.64 ton of oil

Used as an additive for gasoline in novel cars

# Current Bio-Ethanol Production



Relays mostly on classical terrestrial agriculture :

Corn, wheat and sugar canes



# Terrestrial Agriculture For Bio-Ethanol

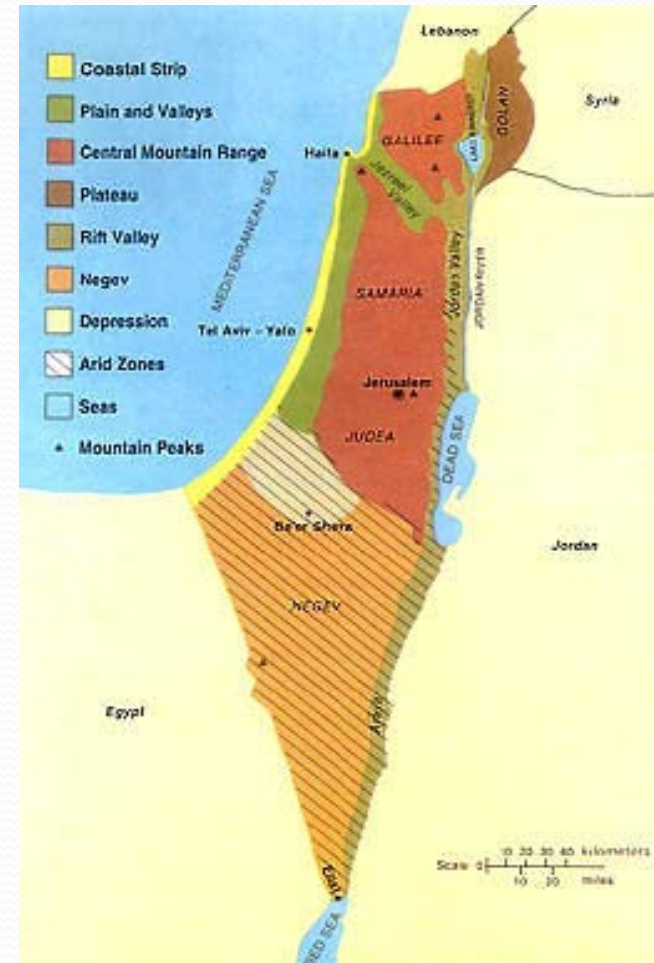
- **Shortage of land**

European Biorefinery Joint Strategic Research Roadmap for 2020:

“A key issue for biomass production in Europe is land availability”

Arable land In Israel ~15% and decreasing

- **Lack of sweet water**
- **Compete with food crops**



# Why Off Shore Macro Algae Cultivation?

No need for lands of agriculture



No use of potable water



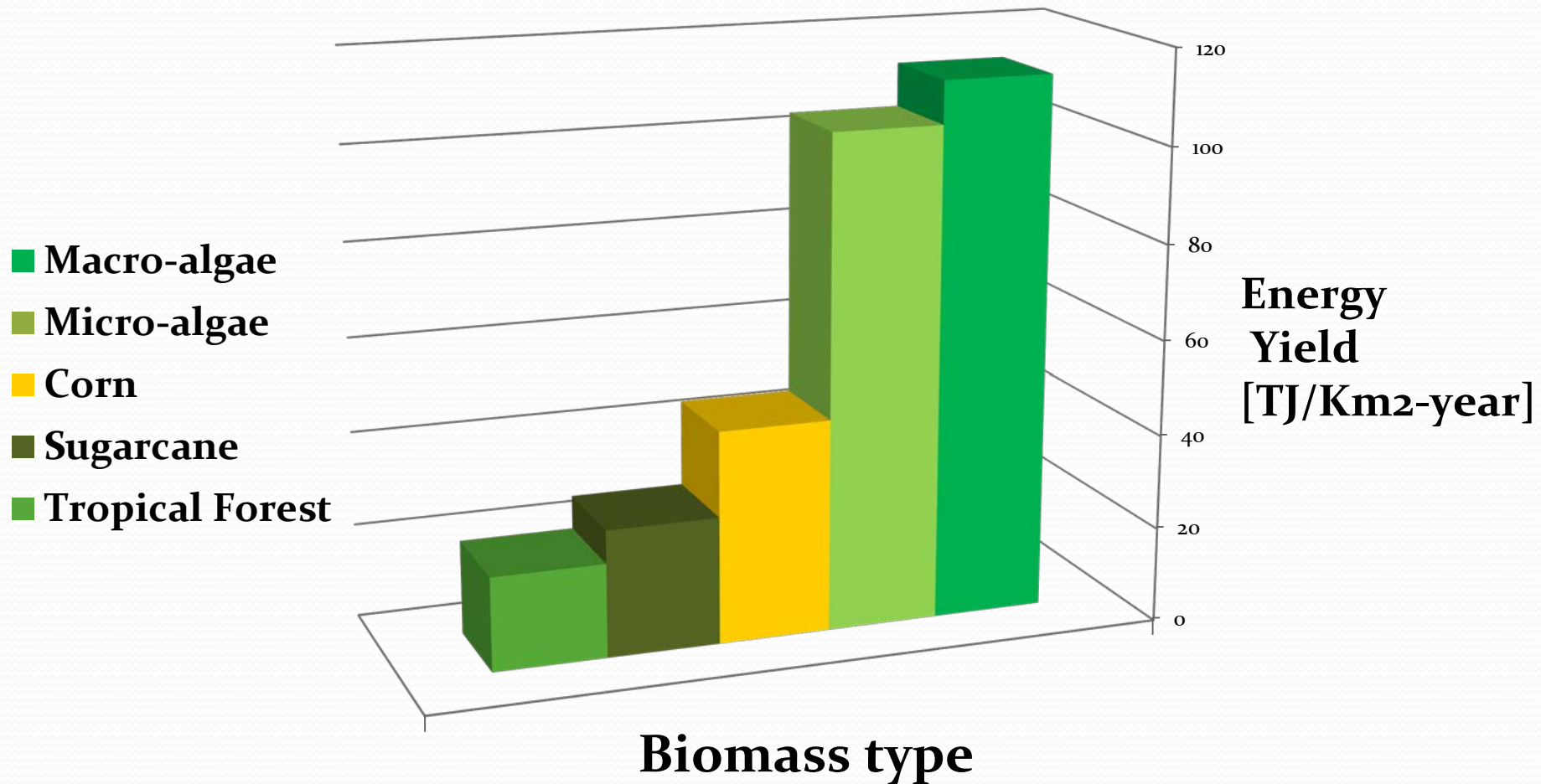
# Why Off Shore Macro Algae Cultivation?



High growth rates

5400 ton/square Km per year  
Twice as much corn

# High Level Of Energy Yield



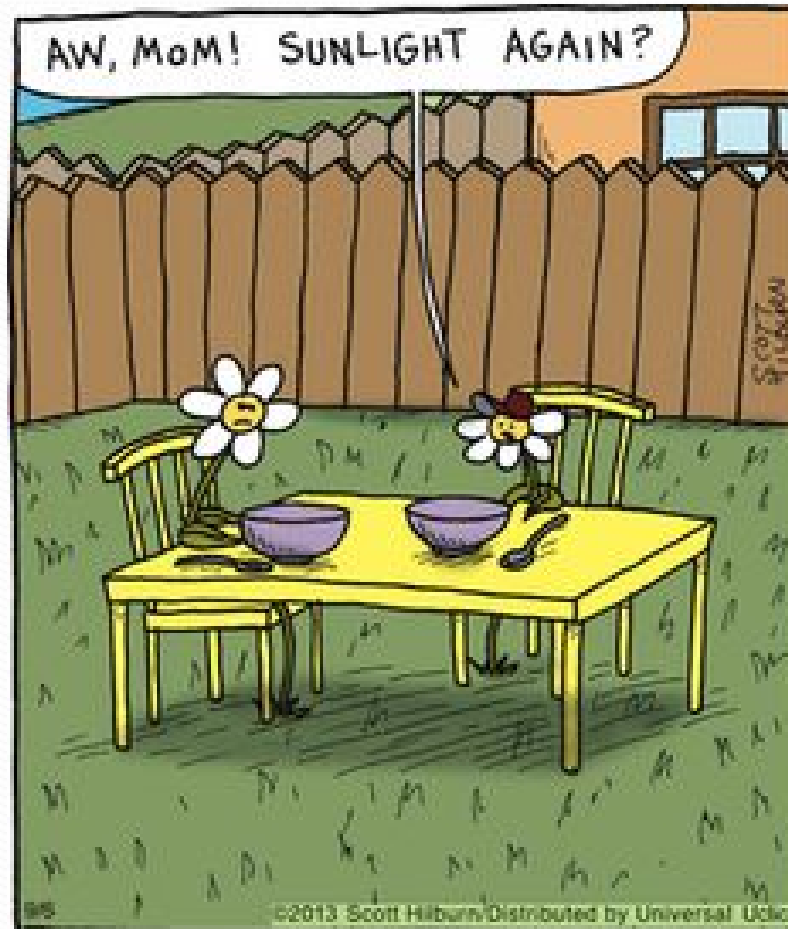


# Challenges

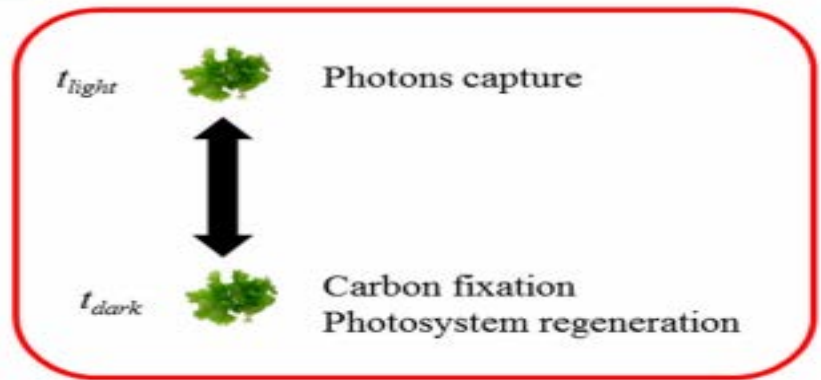
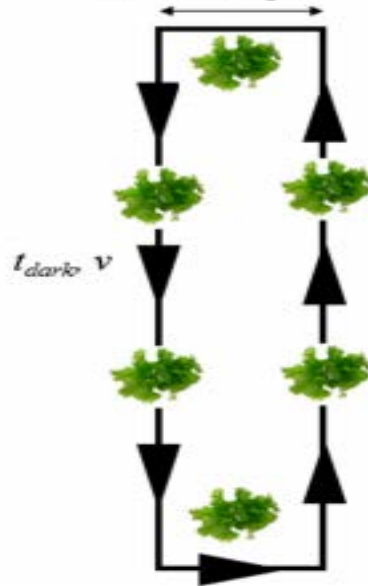
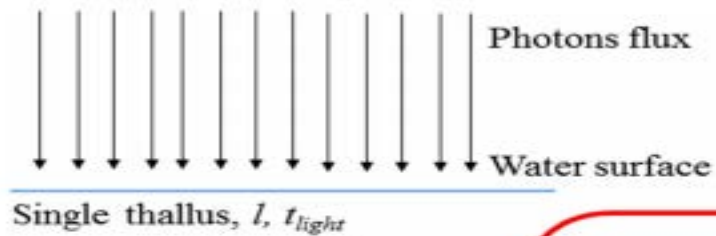
- Reduce the total areas required for the biomass production
- Increase the total energy efficiency of the biorefinery
- Increase the growth of biomass per area of installed macro algae off-shore farm.

**Economically efficient**

# Photosynthetic Efficiency



# Enhancing The Energy Yield



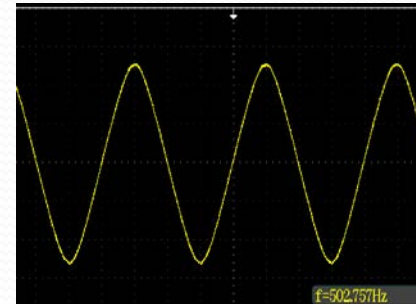
Mixing can improve the biomass growth and the total energy efficiency

# First Step

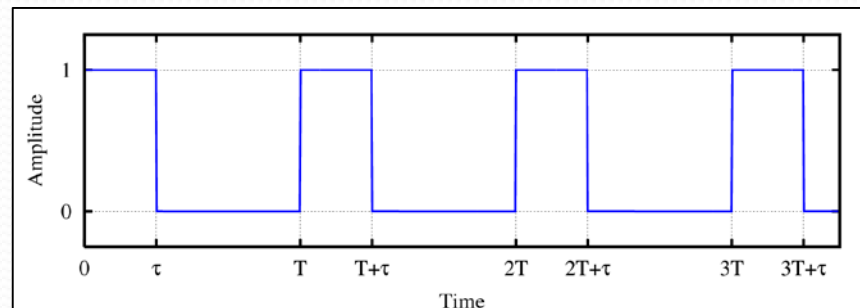
## Understanding the light influence



**Intensity**

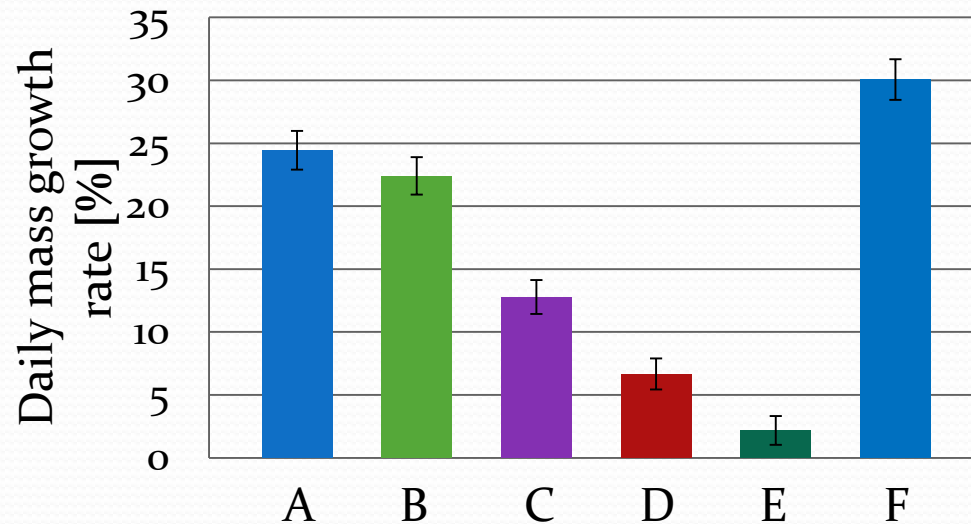
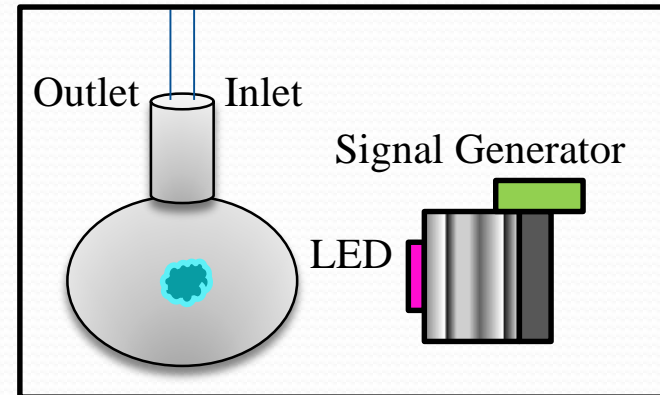
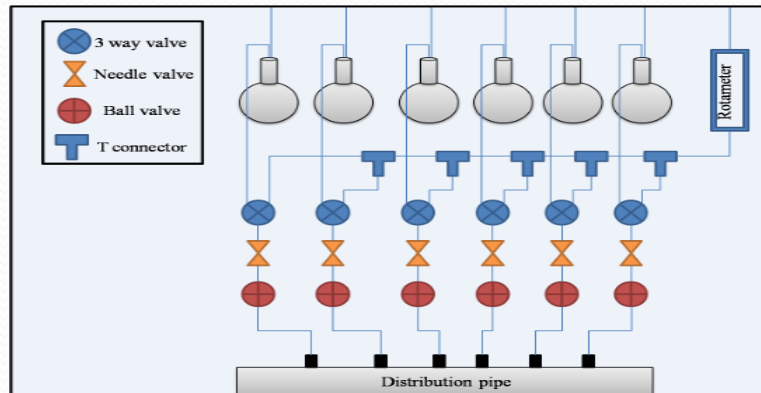


**Frequency**



**Duty cycle**

# Continues Vs Pulsed Light Experiments

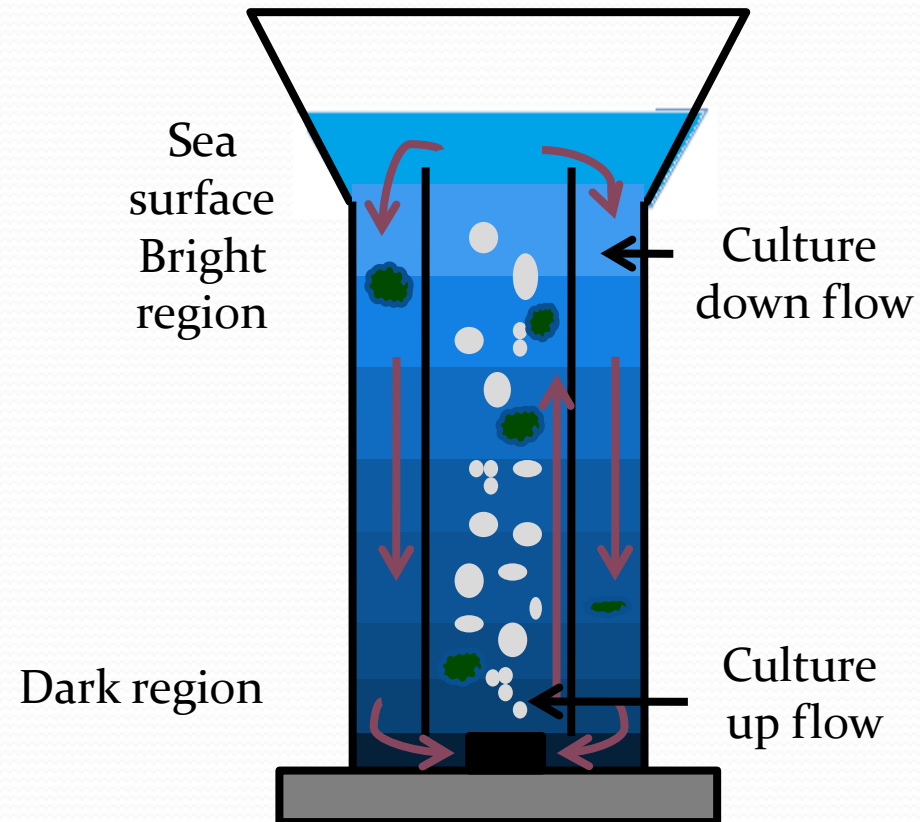


A+F : control  
 B : 50%  
 C : 25%  
 D : 10%  
 E : 1%

# Airlift Photo-Bioreactor



- Air flow is used to mix algae from depth to sea surface and back
- Attractive for processes with organisms (plant cells, algae)
- Energy efficient
- Renewable energy sources; wave energy device



# Nutrients Supply And Uptake Of Macro-Algae

- Suitable composition, precise quantities and timing.
- Precise fertilization
- Artificial upwelling systems
- Critical cost – energy required for pumping.



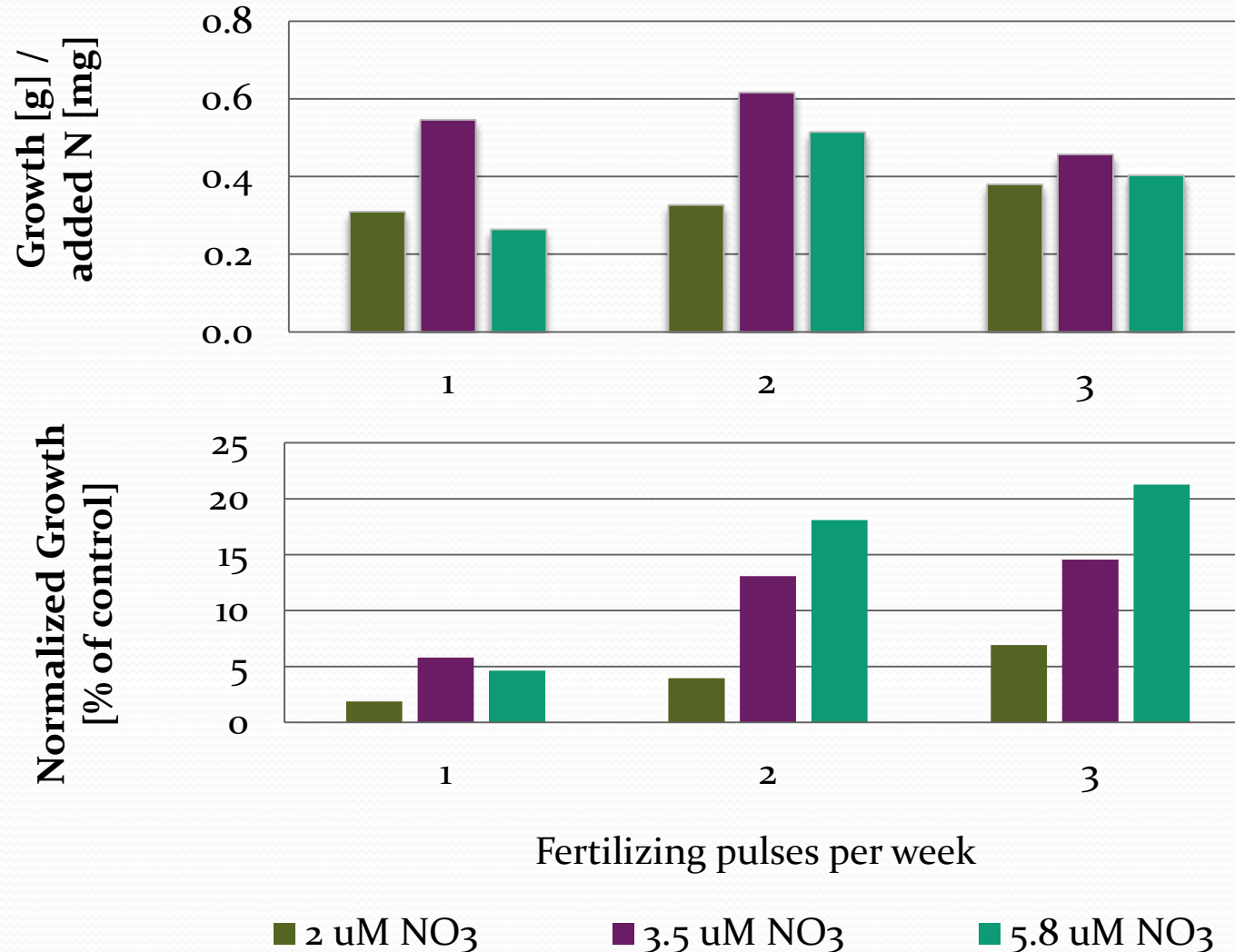
# Nutrients Supply And Uptake Of Macro-Algae

- 12 Vertical transparent sleeves.
- 35 Liters of artificial sea water.
- Different conditions:  
Nutrients concentrations  
Fertilizing pulses per week.
- 4 Repetitions, 3 weeks per experiment.





# Nutrients Supply And Uptake Of Macro-Algae



# Summary

- **Macro algae is a promising alternative to fossil energies .**
- Macro algae growing does not compete with food culture (no need for land or sweet water).
- **Mixing can improve the total energy gain.**
- Development of **novel technologies** to generate **bio-energy** .

# Future Work

- Hydrocarbon content analysis for *Ulva* growing under low nutrient concentrations.
- Wave energy device to circulate macro algae (laboratory scale).
- Design and perform experiments to test the mutual effect of macro algae - mass transfer – gas - liquid hydrodynamic in airlift photo bioreactor.

# Thank you!

