Can Integrated Multi Trophic Aquaculture (IMTA) work in the Eastern Mediterranean ?

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IDREEM EU-FP7 project

What is special about the E Med?

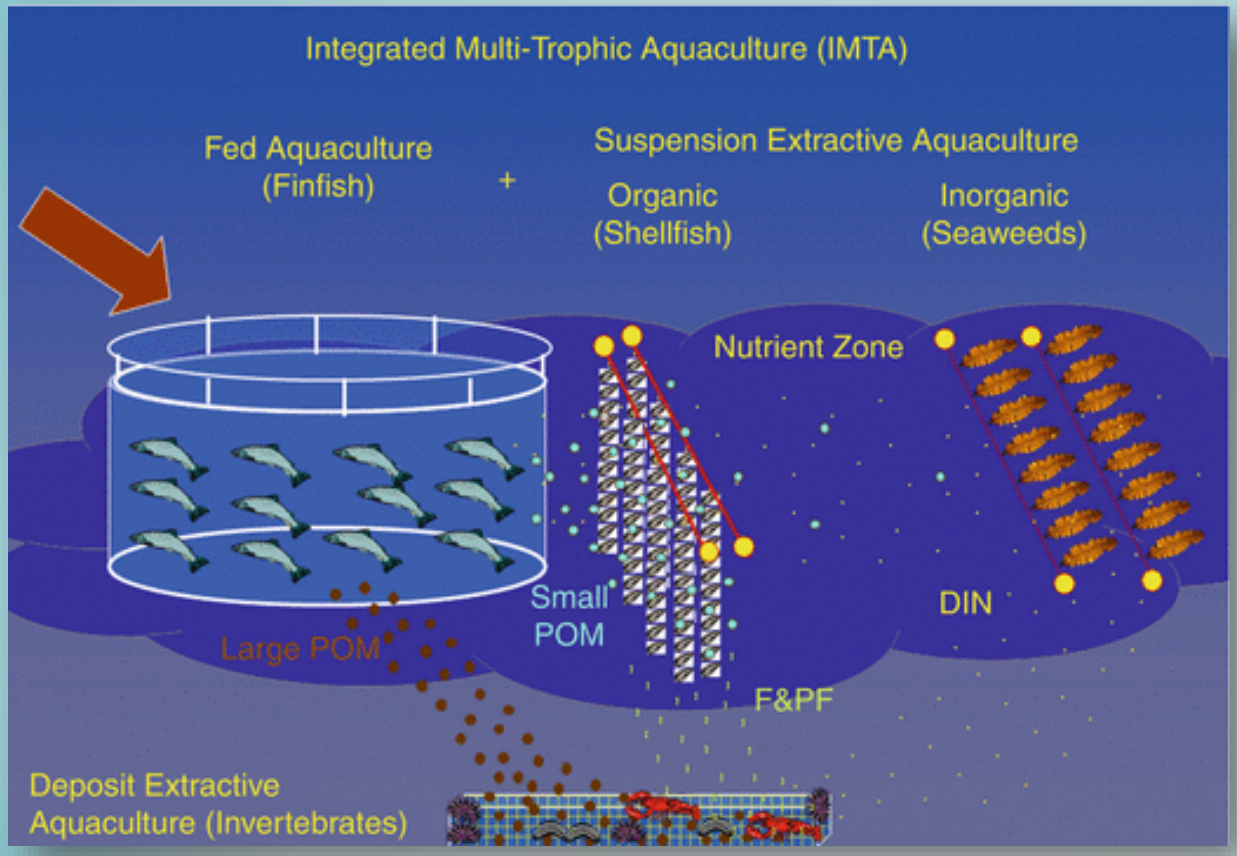
- **Warm** water system (16 – 32° C)
- **Nutrient** levels at detection limits
- **Oligotrophic** (Chl a <0.2 μg L^{-1}), primary production (~200 mg C m^{-2} d^{-1}), N_2 fixation (<0.2 nmol N L^{-1} d^{-1})
- **Seaweeds** only occur there at nutrient hotspots (oases); minor commercial **shellfish**
- Not great prospects for IMTA

So, why the interest in IMTA?

- Plans for large-scale fish **farms** off the coast
- Concerns about large **nutrient fluxes** from aquaculture
- **IMTA** demonstrated in pond-based aquaculture systems in Eilat

Integrated Multi Trophic Aquaculture

Complementary cultivation of species, from different trophic levels, to minimize wastes to the environment

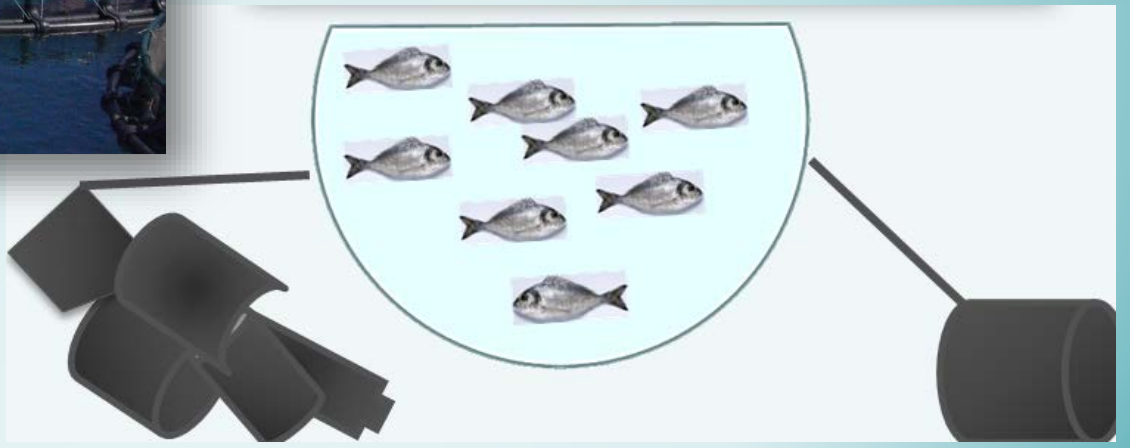


IMTA scheme -

- **Thierry Chopin**
- **Shawn Robinson**
- **Yngvar Olsen**
- **others**

Suf Fish Farm, Ashdod

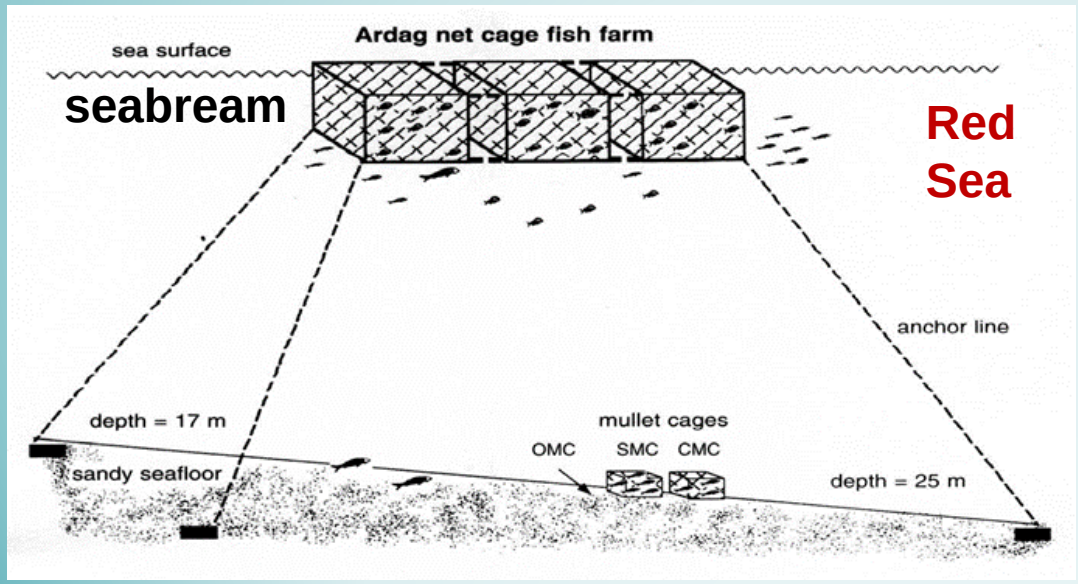
Suf Fish Farm

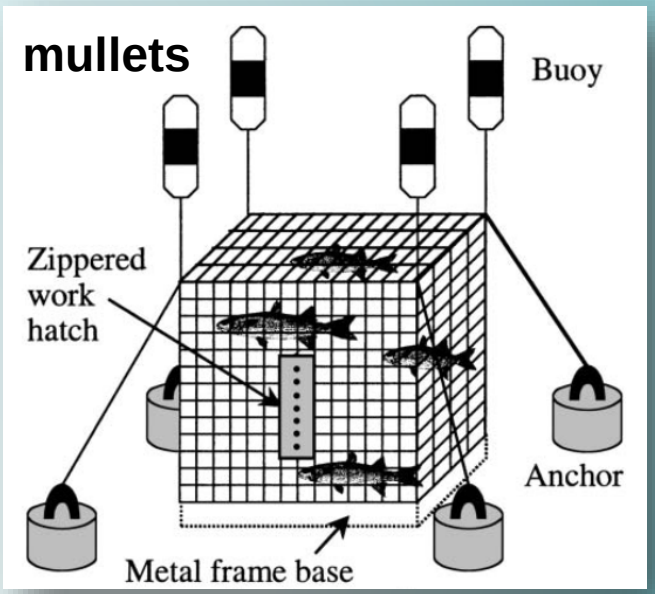


Previous work

- Porter et al. (1996)
- Katz et al. (2002)
- Lupatsch et al. (2003)

These studies showed successful IMTA with grey mullets in open bottom benthic cages in the Red Sea.





Species used in our trials

- Grey mullet, *Mugil cephalus*,

- Purple sea urchin, *Paracentrotus lividus*,

- Sea cucumber, *Actinopyga bannwarthi*

- Seaweed *Ulva lactuca*

Digestibility trials – fish & invertebrates

- Common tool in animal nutrition
- Examine specific feed
- The feed and the faecal matter are analysed for nutrients and chromic oxide (passive tracer)

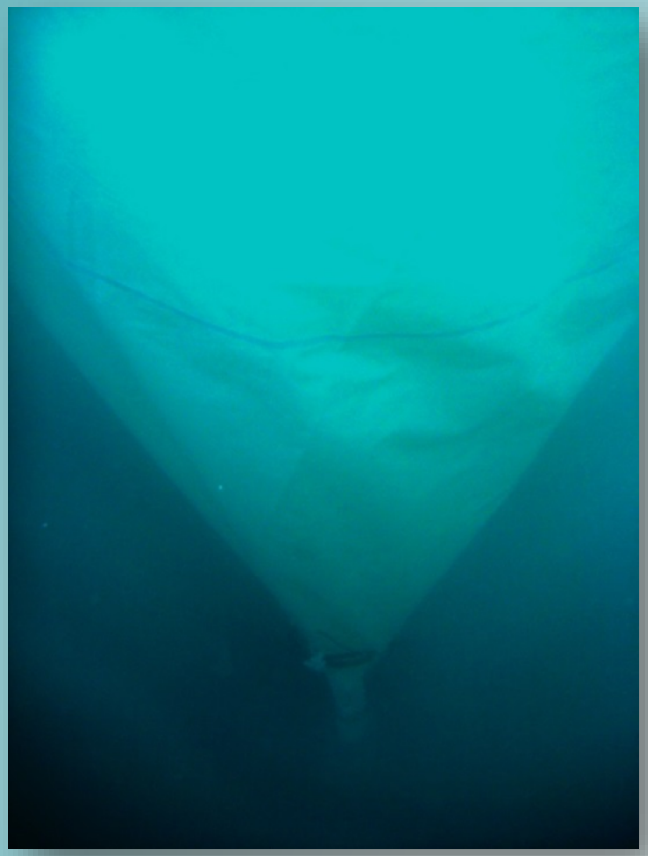
Determine digestibility by quantifying

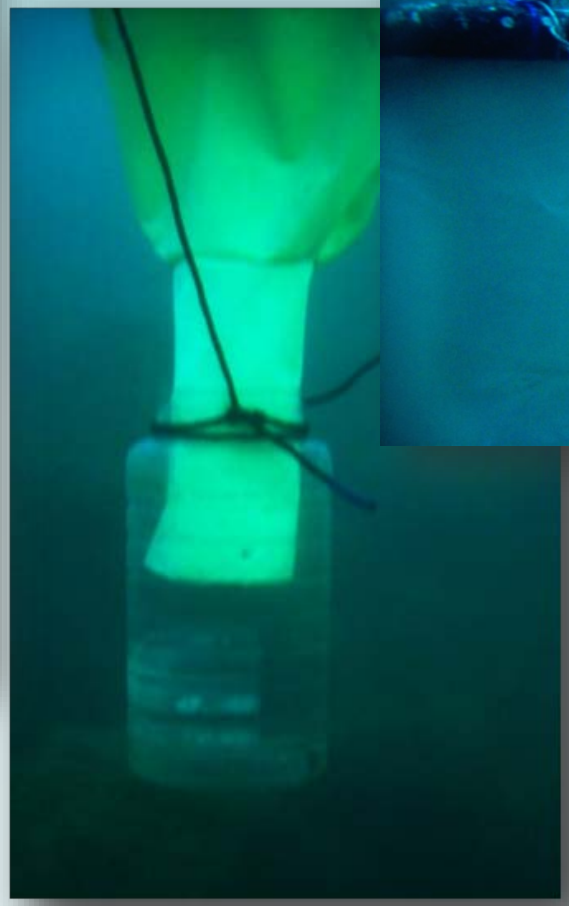
- Protein (nitrogen)
- Ash (organic matter)
- Energy (bomb calorimeter; carbon)
- Lipid

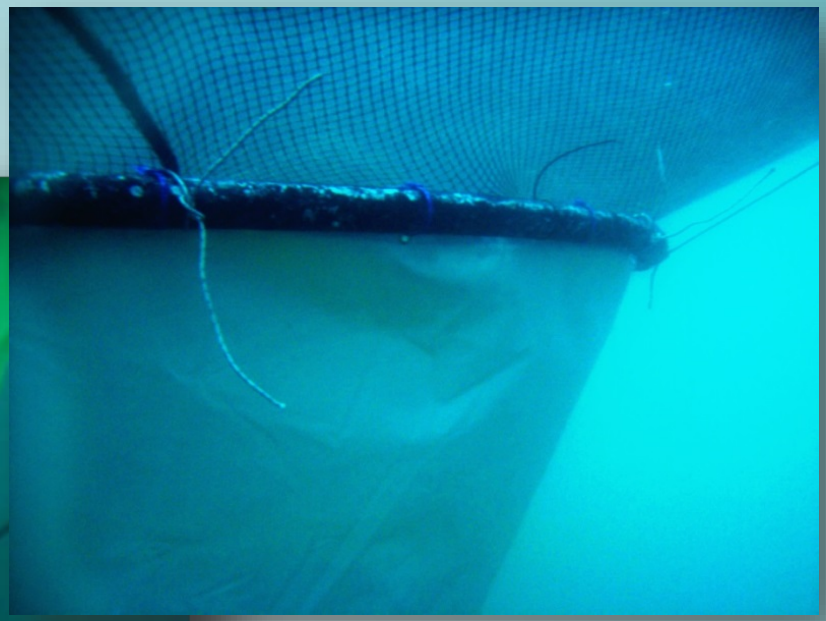
- Calculate Apparent Digestibility Coefficient "ADC":

$$ADC\ (\%) = 100 - 100 \times (\%\ Cr_{Feed} / \%\ Cr_{Faeces}) \times (\%\ Nutrient_{Faeces} / \%\ Nutrient_{Feed})$$

Farm Discharge Collector







Feed Preparation

1) Discharge is concentrated &dried

2) 1% Cr_2O_3 & 1.5% binder & water are added and blended

3)The moist mix is extruded through a meat grinder

4) Spaghetti shaped material is dried at 45°C

5) Dry material is chopped in a mixer to form edible pellets

Grey Mullet - *Mugil cephalus*

Feeding & Faeces Collection

9 tanks of 1m^3 each stocked with 23 mullets of ~230g per fish.
Feeding: 1% of biomass per day

Anesthetic applied to enable handling of mullets

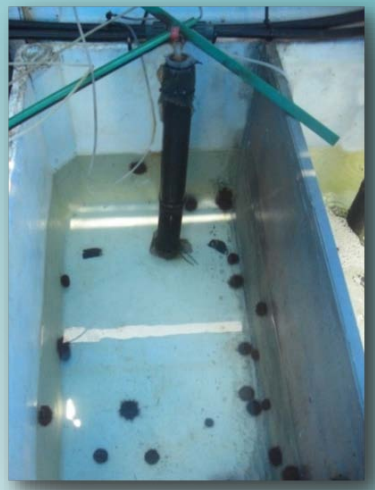
Stripping of faeces from fish performed on a stripping stand

3 replicates of 3.5 g faeces (dry) were collected. (three tanks produced one replicate)

Sea Urchin - *Paracentrotus lividus*

75 sea urchins Transferred from National Centre for Mariculture

3 tanks of 150 liters were stocked with 25 sea urchins of 20 g ±3 each



Feaces were collected by siphoning

3 replicates of 3.5 g faeces (dry) were collected.

Sea Cucumber - *Actinopyga bannwarthi*

Sea cucumber were collected from the wild by a free diver

9 sea cucumbers (430 g ± 111) were divided into three tanks of 150 litres each

Feaces were collected by siphoning - 3 replicates of 3.5 g faeces (dry) were collected.

Digestibility Coefficients (%)

	Grey Mullet	Sea Urchin	Sea Cucumber
Organic Matter %	-17 ± 11	13.9 ± 3.3	26.7 ± 2.0
Protein %	-15 ± 11	11.2 ± 2.8	16.6 ± 2.2
Phosphorus %	-41 ± 10	3.5 ± 9.4	-22.3 ± 3.0
Lipid %	45 ± 5	16.3 ± 6.8	45.9 ± 2.3
Energy %	-16 ± 8	13.8 ± 4.4	24.1 ± 1.7
Dry Matter %	-13 ± 9	3.8 ± 1.4	11.7 ± 1.0

Lessons Learned

We propose that fish farm effluents (feces) need to be 'aged' to have nutritional value for mullets.

This involves:

I. Accumulation of farm effluents on the seafloor

II. Diagenesis (breakdown) of the effluents

III. Microbial enrichment

Suggestions

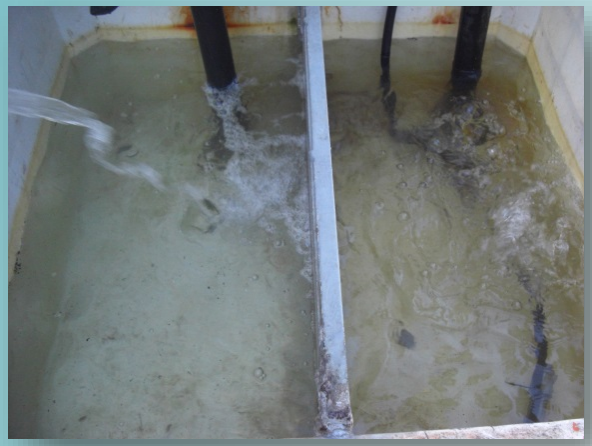
- **Mullets** should be used in IMTA only where fish have access to organically enriched sediments that can age (worked in Eilat; not in Ashdod)

- **Sea urchins** & **sea cucumbers** show good potential for IMTA

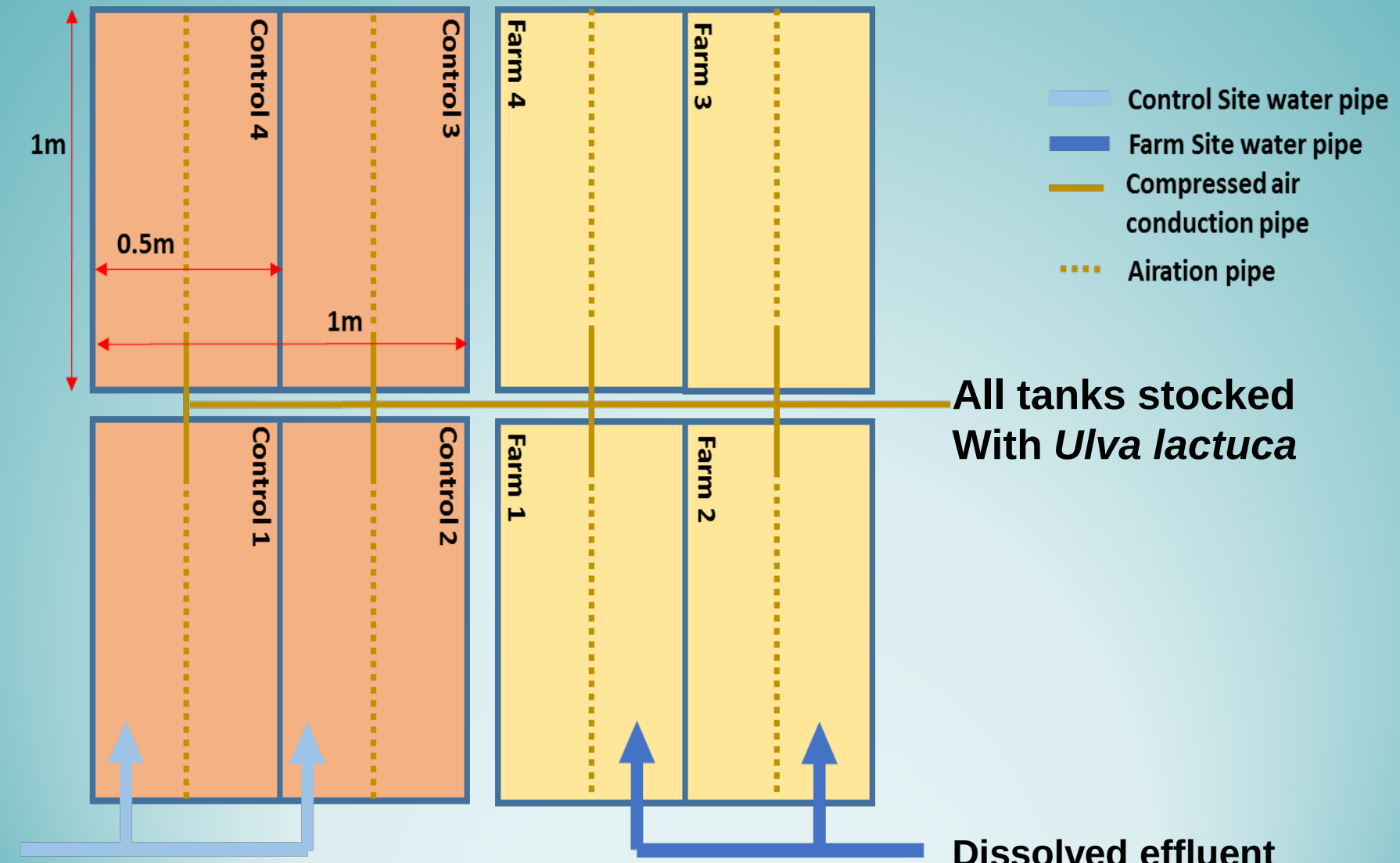
- **Digestibility trials** **should be done** on candidate IMTA species prior to field trials to determine if they can digest farm effluents

IMTA with Soluble waste

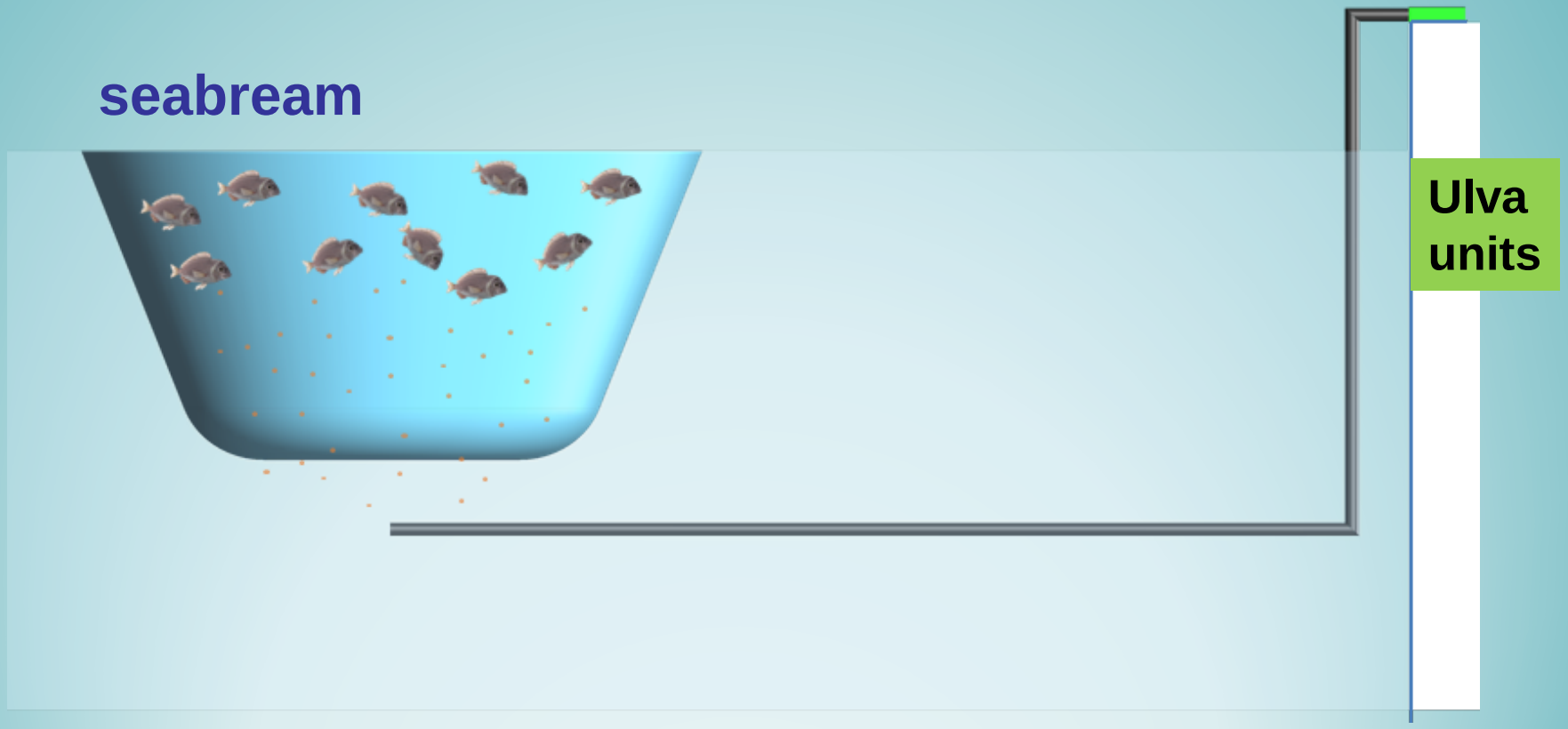
Feasibility trial with Ulva



Ulva system

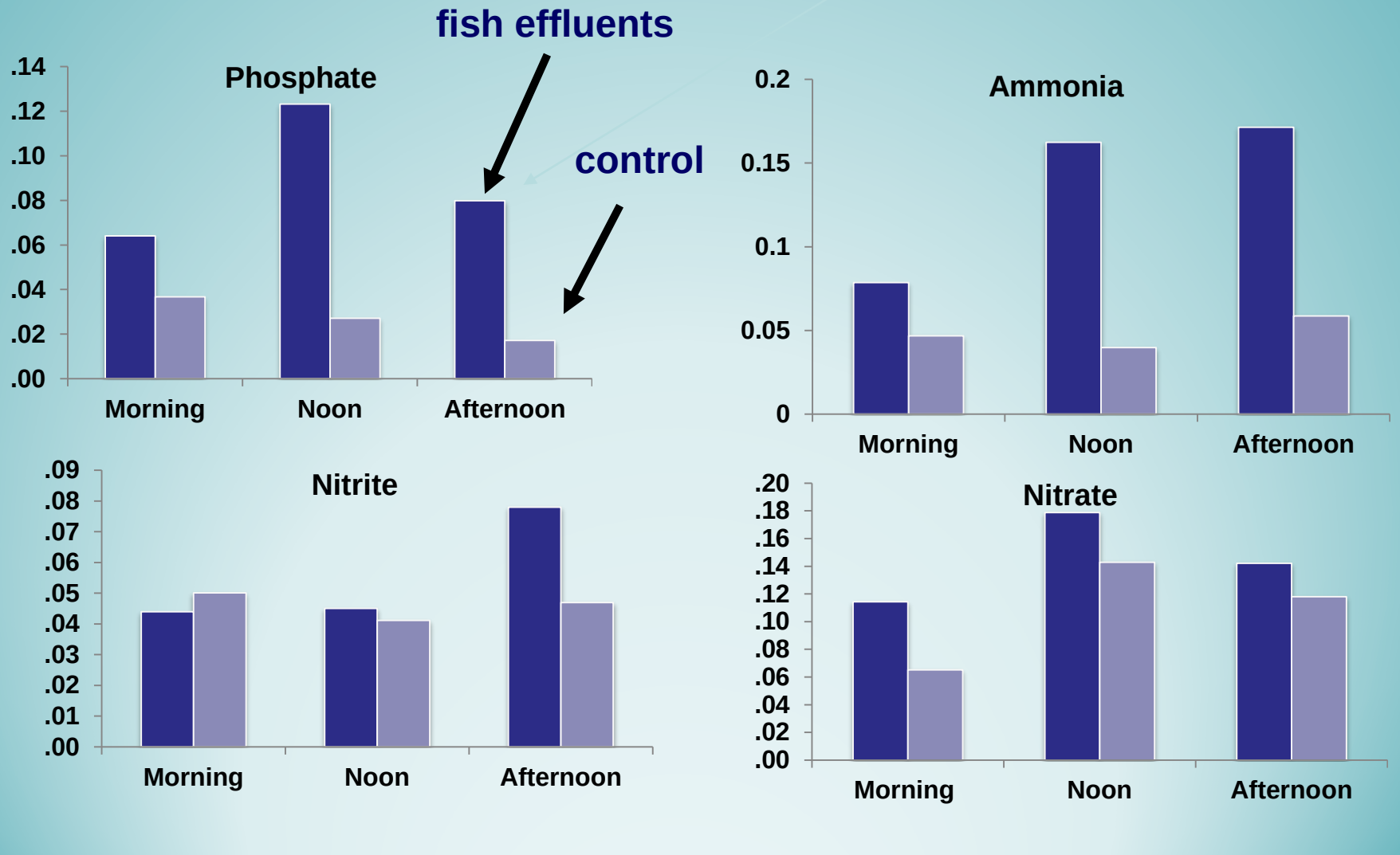

1m
0.5m
1m
Control 4
Control 3
Farm 4
Farm 3
Control 1
Control 2
Farm 1
Farm 2
Control Site water pipe
Farm Site water pipe
Compressed air conduction pipe
Airation pipe
All tanks stocked With *Ulva lactuca*
Clean seawater
Dissolved effluent From Fish cage

Ulva system



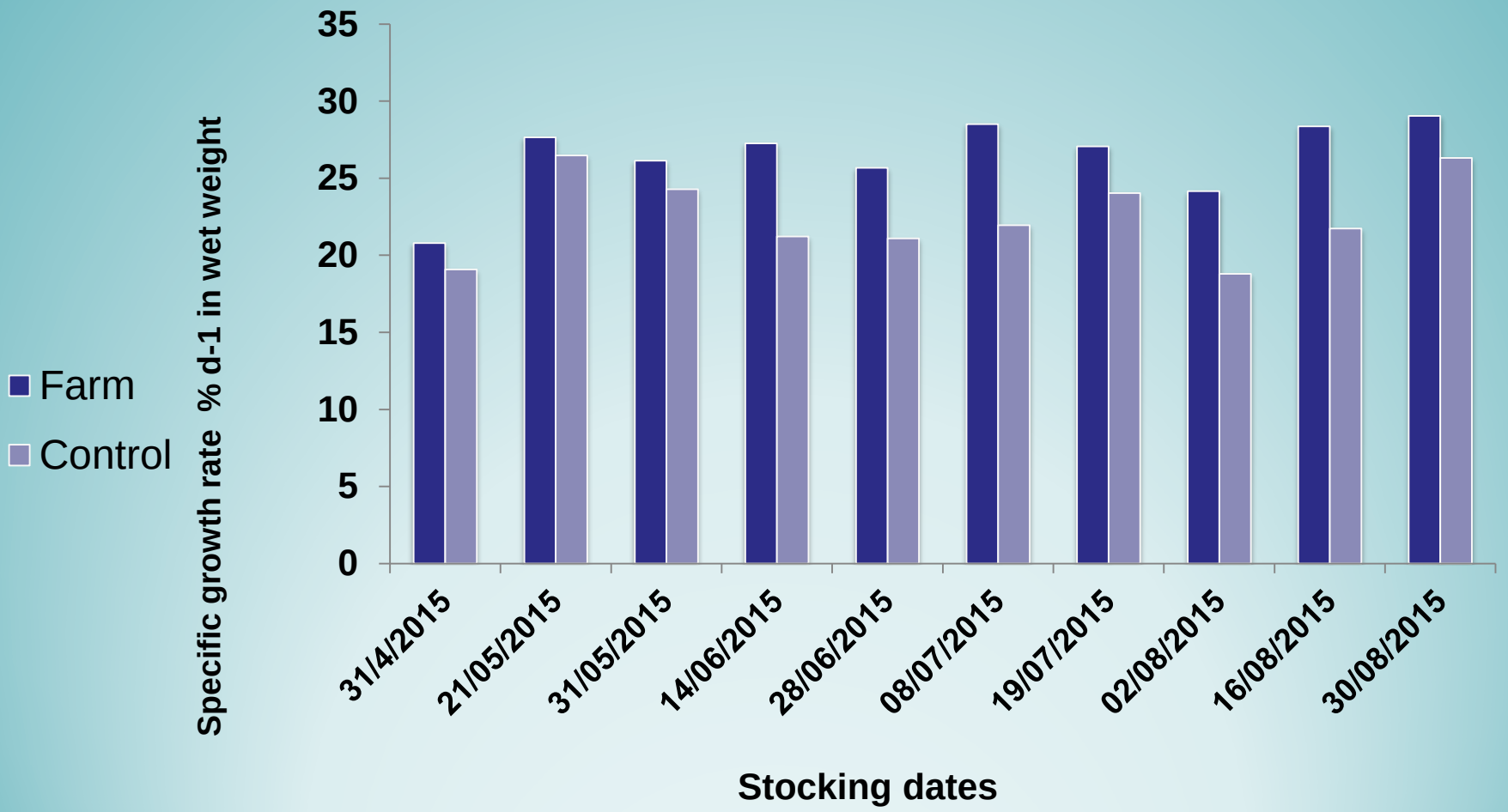
Removal of nutrients by Ulva

Δ[Nutrients] (in vs out) at 08:00, 12:00, 16:00

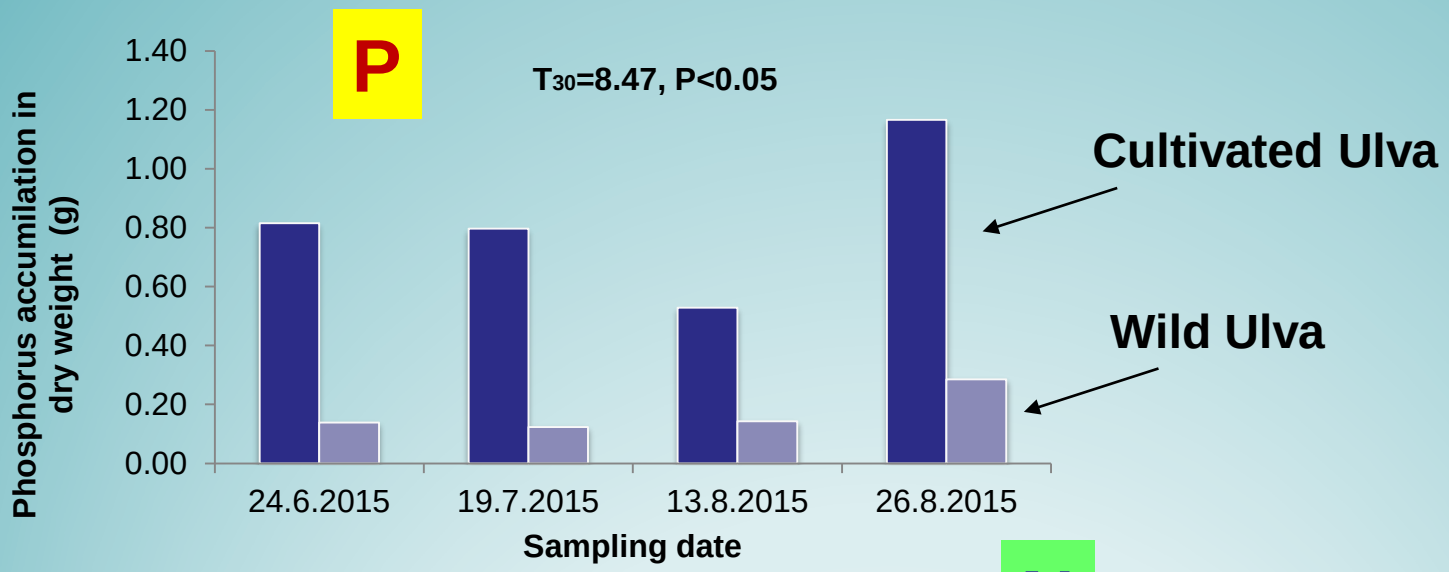


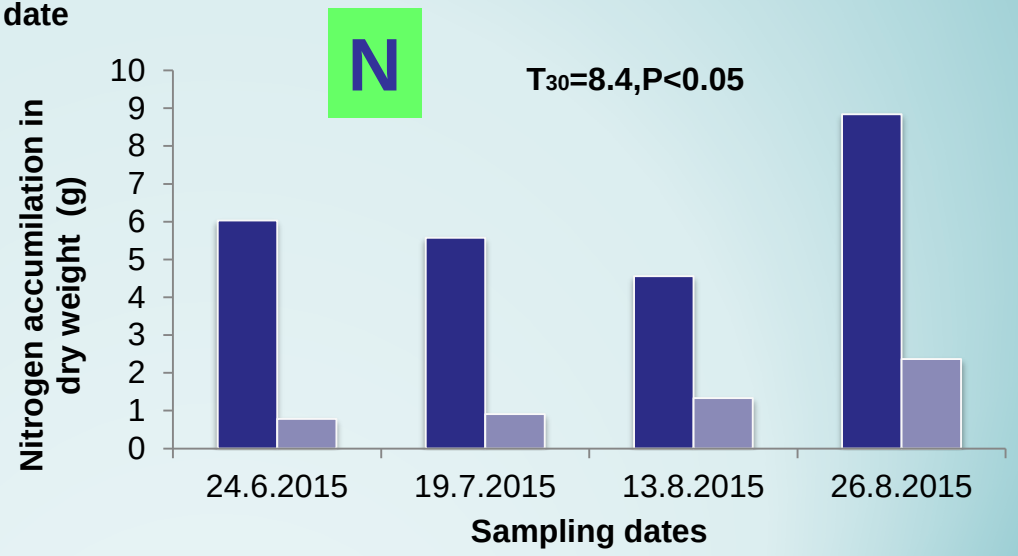
Increase in Ulva biomass

Daily growth rate of Ulva – 10 replicates



Ulva composition – N, P





Lessons learned

- *Ulva lactuca* grown on dissolved farm effluents had better growth rate, nutrient retention and filtration rate than Ulva grown on clean seawater

- *U. lactuca* removes **ammonia** more efficiently than nitrate

- *U. lactuca* is able to grow at the **high summer temperatures** ~ 31ºC in the Eastern Med

Conclusions

- IMTA is possible in oligotrophic waters
- IMTA products may have added value via labelling (eco-label)
- **In addition to the** environmental benefit, all of the **tested** species have potential markets and may be cultivated commercially


Thank you!
photo - Danielle Angel


THANK YOU