Dans le cadre des projets

integrate IMTA-EFFECT

EPURVAL 2

INTEGRATED CULTIVATION OF EUROPEAN SEA BASS *Dicentrarchus labrax* AND *Ulva* sp. IN RECIRCULATING AQUACULTURE SYSTEMS

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AGRO CAMPUS OUEST — DE L'ALIMENTATION AU CADRE DE VIE

CEVA — CENTRE D'ETUDE & DE VALORISATION DES ALGUES

POISSONS D'AQUACULTURE — CIPA — COMITÉ INTERPROFESSIONNEL DES PRODUITS DE L'AQUACULTURE

INRA SCIENCE & IMPACT

ITAVI — L'INSTITUT TECHNIQUE DES FILIÈRES AVICOLE, CUNICOLE ET PISCICOLE

PÔLE MER BRETAGNE ATLANTIQUE

15 et 16 mai 2019

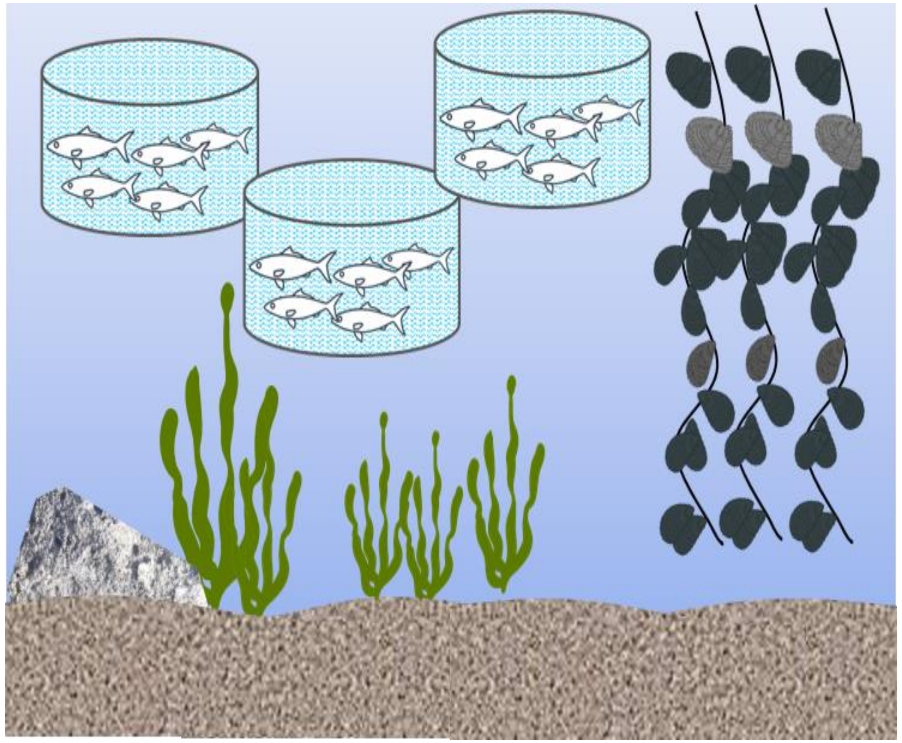
Associer les espèces pour une aquaculture durable : l'aquaculture multi trophique intégrée

Avec la participation de : FILIÈRE MER, COFASP, Interreg Atlantic Area, EUROPEAN UNION, FranceAgriMer, Région Bretagne

Breizh'alg

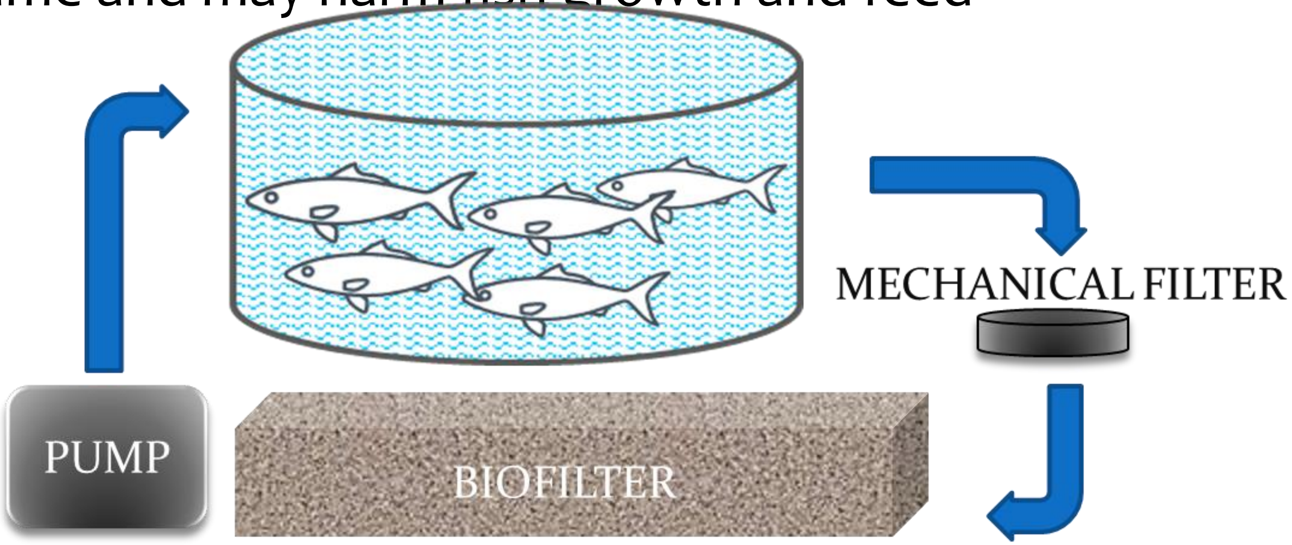
Integrated Multi-Trophic Aquaculture (IMTA)

- IMTA provides the by-products, including waste, from generating (fed) aquatic species as inputs (fertilizers, food) for cleaning (extractive) species.
- IMTA uses multiple species from different trophic levels for reducing wastes and costs (through recycling of wastes) while increasing total productivity (in weight and in value) with respect to feed input and pollution output.
- In Greece Aquaculture occurs in sea cages and IMTA (fish & molluscs) is currently only on experimental stage, in order environmental effects to be minimized and total production to be increased.



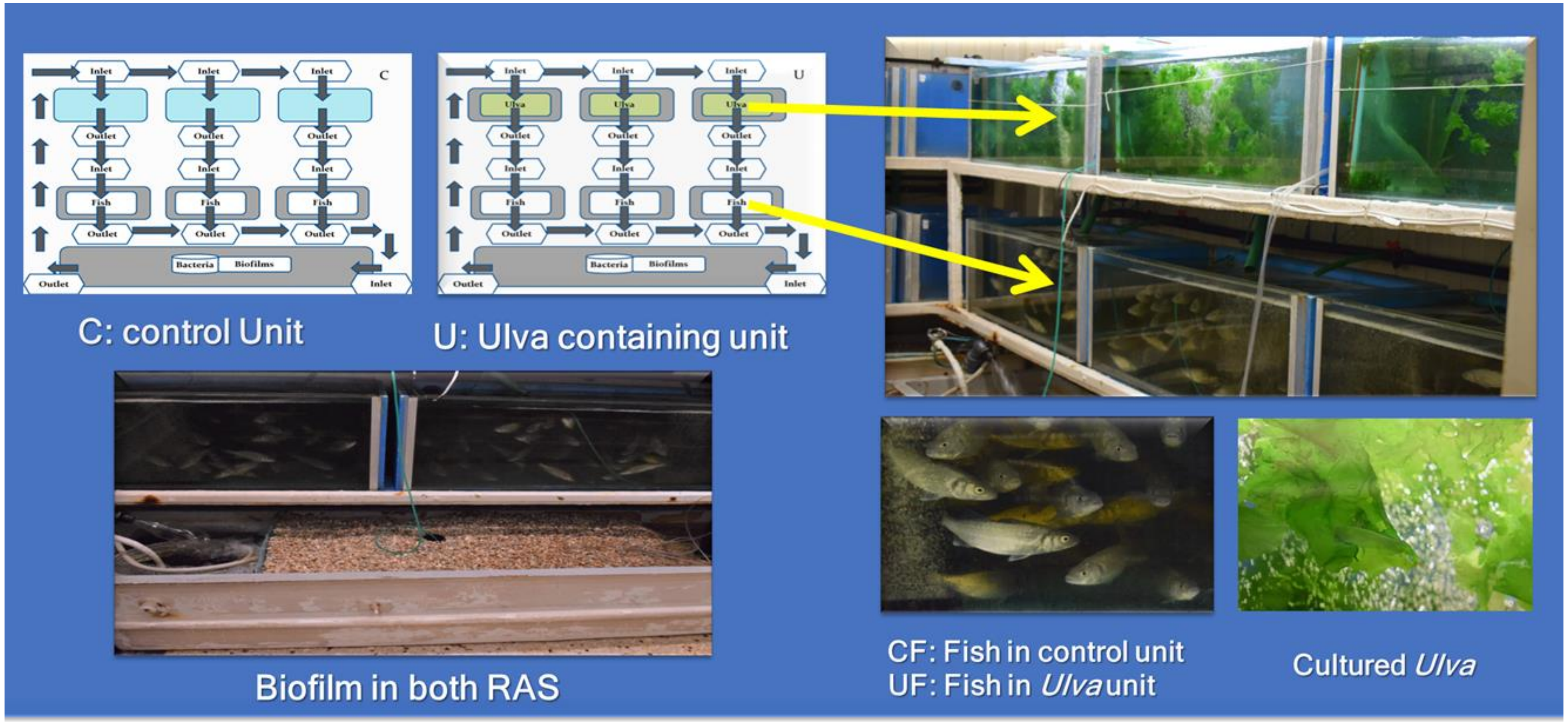
Sea bass and *Ulva* indoor seawater RAS with biofilter

- One potential way to reduce environmental impact, is the increased use of land-based (closed recirculating aquaculture systems -RAS) systems with bacteria biofilters
- In RAS, nitrate accumulates over time and may harm fish growth and feed intake
- Seaweed filtration has the potential to convert N-rich effluents into valuable biomass
- However, the combination of denitrifying biofilters with algal biofilters can be complex and costly



The cultivation of sea bass and Ulva in IMTA-RAS is a case study of the project IMTA-EFFECT (Integrated MultiTrophic Aquaculture for EFFiciency and Environmental ConservaTion).

In this study, *Ulva* sp. and European sea bass (*Dictrarchus labrax*) were co-cultured in RAS, in order to asses the potential of *Ulva* sp. to improve water quality and possible effect on the growth of sea bass.



The tanks (12) were separated in 4 groups

Control-RAS (6)

CW: water tanks without *Ulva*

CF: fish tanks in control unit

Ulva-RAS (6)

UW: water tanks with *Ulva*

UF: fish tanks in *Ulva* RAS

GENERAL EXPERIMENTAL PROCEEDURES

- The experiment lasted 12 weeks.
- Fifty fish were placed in each tank
- Fish were manually fed to satiation twice a day.
- D.O., pH, salinity and temperature were measured every day (except week-end)
- Temperature: 23,0 °C and Salinity: 34,4 psu
- Water samples were taken twice a week.
- Statistical analyses were performed using the Statgraphics software, and one way ANOVA.

DIFFERENCES BETWEEN TWO TRIALS

Dietary fish oil was replaced by a mixture of vegetable oils (50% rapeseed oil: 50% palm oil).

- Initial body weight: 35,42 ±0,476 g)
- Initial fish density: 12,05 kg/m3
- Ulva was renewed every two weeks
- *Ulva* density: 0,97 kg/m²
- Light intensity (on surface of *Ulva* tanks): 450 lux

Dietary fish oil from sardines

- Initial body weight :21,6 ± 0,15 g)
- Initial fish density: 7,36 kg/m³
- Ulva was renewed every week
- Ulva density: 0,71 kg/m²
- Light intensity (on surface of *Ulva* tanks): 758 lux

METHODS

Water quality parameters

- Ammonia nitrogen was determined by the indophenol blue method
- Nitrate nitrogen was determined by Brucine method (EPA 352.1)
- Nitrite nitrogen was determined by Griess reaction method
- Orthophosphate-Inorganic phosphorus was measured with the ascorbic acid method (EPA 365.3)

Proximate composition

- Moisture was determined by the AOAC 950.46 method
- Ash was determined by the AOAC 938.08 method
- Protein and N content was determined by Kjeldahl digestion according to AOAC Official Methods 981.10 &2001.11
- Fat was determined by Soxhlet extraction, according to AOAC Official method 991.36

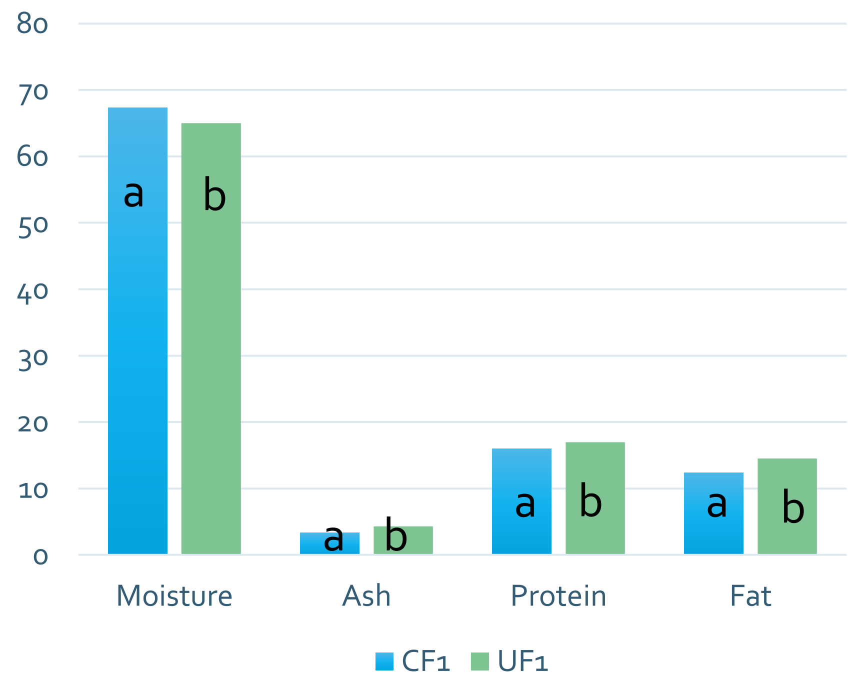
GROWTH PARAMETERS

1ST TRIAL	CONTROL	ULVA	*P-VALUE*
CONDITION FACTOR (K)	1,21±0,008[a]	1,23±0,007[b]	P<0,05
BWI	135,5±4,51	137,5±1,49	NS
SGR	1,02±0,021	1,03±0,007	NS
FCR	1,06±0,033	1,10±0,017	NS
FEED CONSUMPTION	51,01±0,186[a]	53,43±0,193[b]	P<0,001
MORTALITY (%)	4,66±3,712	4,00±1,155	NS

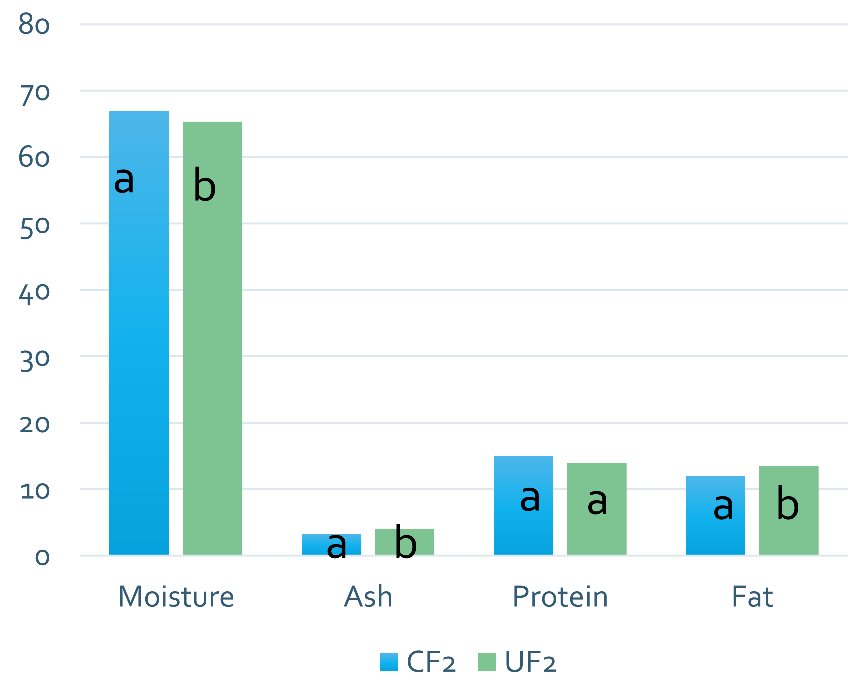
2ND TRIAL	CONTROL	ULVA	P-VALUE
CONDITION FACTOR (K)	1,29±0,005[a]	1,31±0,005[b]	P<0,05
BWI	193,14 ± 4,935	184,52 ± 3,084	NS
SGR	1,26 ± 0,019	1,23 ± 0,012	NS
FCR	1,36 ± 0.015	1,39 ± 0.010	NS
FEED CONSUMPTION	56,74 ± 0,879[b]	55,07 ± 0,765[a]	P<0,001
MORTALITY (%)	0	0	NS

FISH CHEMICAL COMPOSITION

TRIAL 1



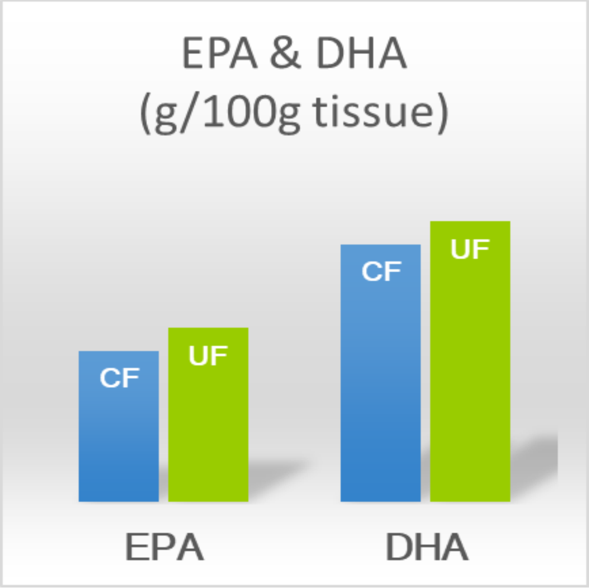
TRIAL 2



Fatty acid profile of sea bass fed VO-based diet

Content (% total lipids)

	CF	UF
Saturated	25,38±0,305[b]	25,09±0,205[a]
Monounsaturated	47,64±0,494[a]	48,15±0,266[b]
Polyunsaturated	26,87±0,341[a]	26,71±0,257[a]
n-3 Polyunsaturated	11,81±0,358[b]	11,44±0,324[a]
n-6 Polyunsaturated	14,23±0,258[a]	14,47±0,270[b]
n-3/n-6	0,83±0,036[b]	0,79±0,035[a]



Ulva in RAS

Ulva was collected from the Saronic gulf

Sorted and thoroughly cleaned with seawater and weighted after drying

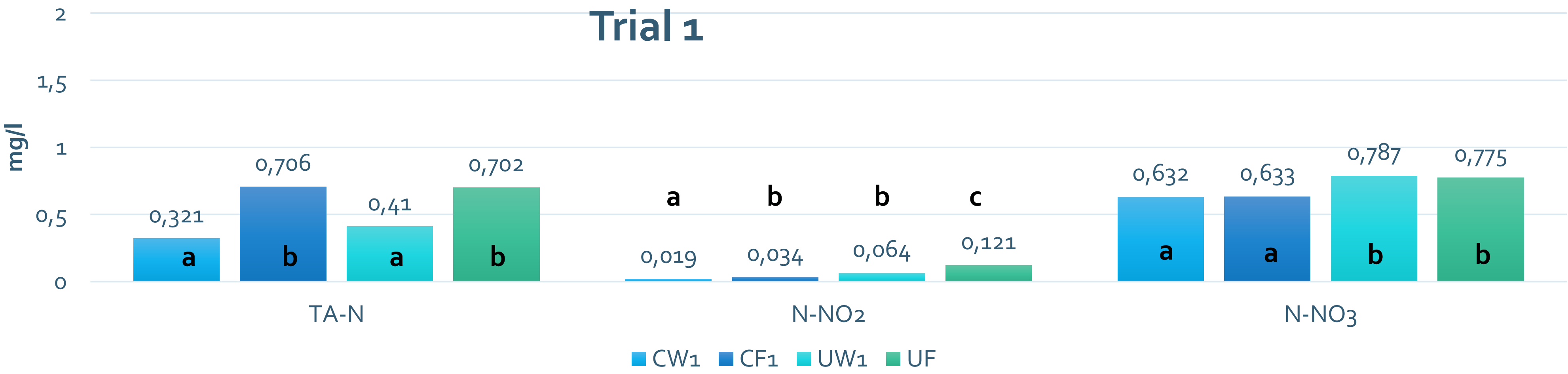
In the upper level tanks (UW), unattached thalli of *Ulva* were kept suspended by air diffusers situated at the bottom of the tanks

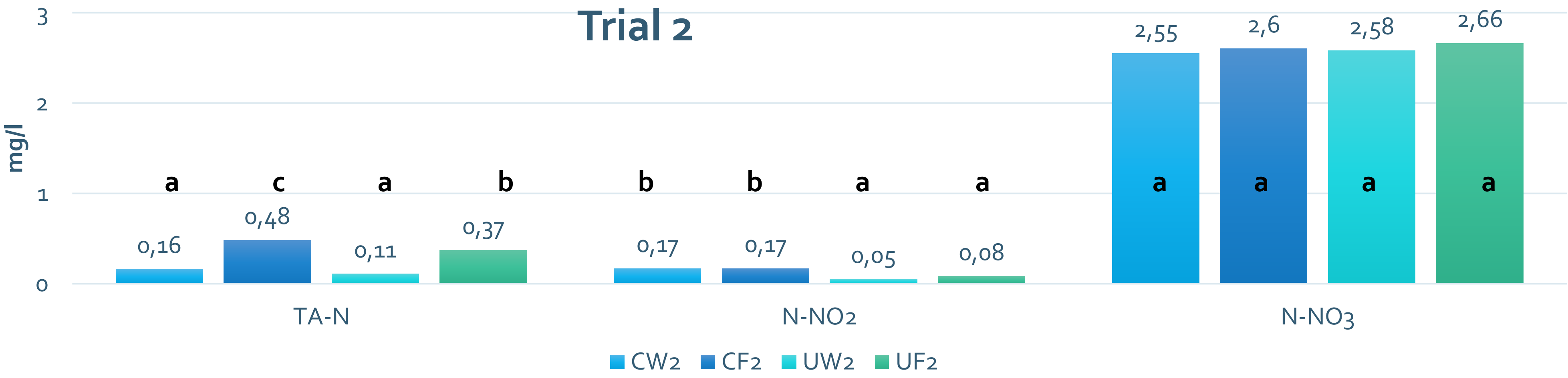
ULVA proximate composition

Trial 1		Ash	Fat	Protein	Carbohydrate[b]	Nitrogen
		(% dry weight)	(% dry weight)	(% dry weight)	(% dry weight)	(% dry weight)
Fresh Ulva		26.82±0.739	0.98±0.090	8.58±0.117	63.09±1.541	1.56±0.023
2 weeks cultivated Ulva		30.62±0.848	0.95±0.094	14.92±0.199	52.40±1.393	2.69±0.042
p-value		*	NS	*	*	*

Trial 2		Ash	Fat	Protein	Carbohydrate	Nitrogen
		(% dry weight)	(% dry weight)	(% dry weight)	(% dry weight)	(% dry weight)
Fresh Ulva		31.58±0,723	0.85±0.096	12,47±0.493	58.24±1.971	2.00±0.189
1 week cultivated Ulva		31,63±0.524	0.83±0.083	17.94±1.184	49.07±1.354	2.87±0.079
p-value		NS	NS	*	*	*

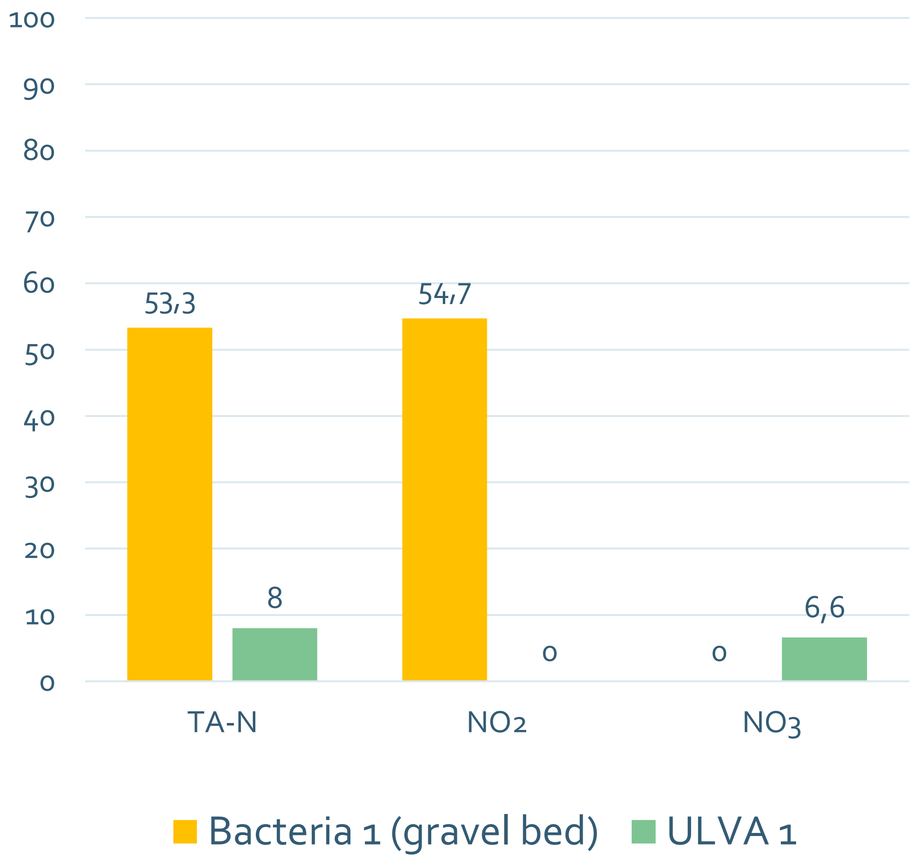
N- in water, all forms



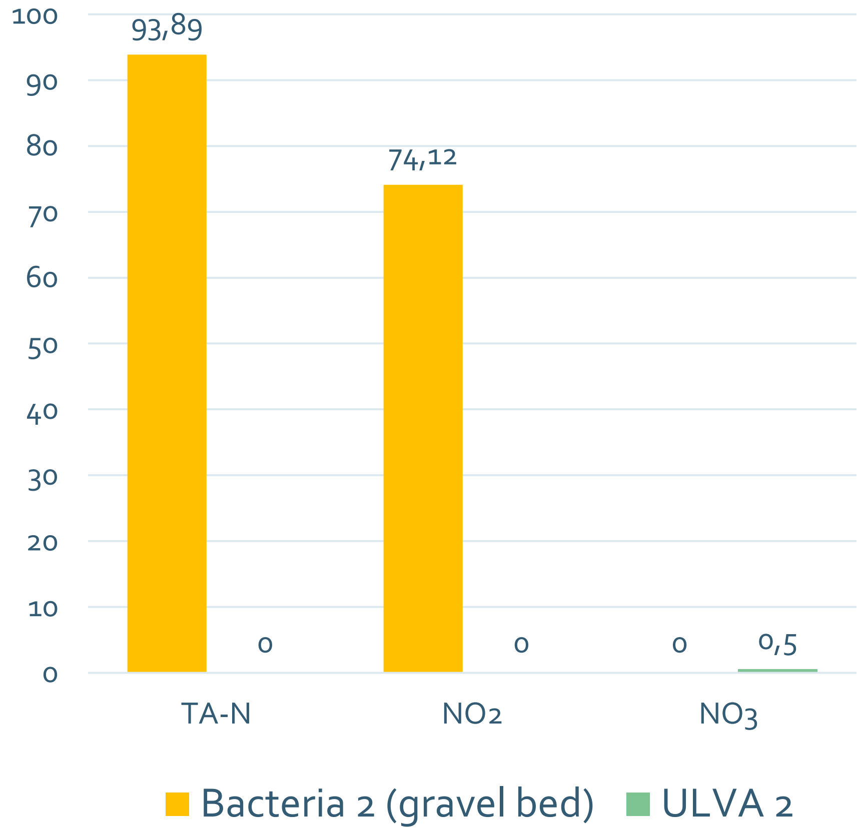


N-removal by biofilters

Trial 1



Trial 2



P- in water, orthophosphates

Role of *Ulva* in sea bass growth

- Body Weight Increase (BWI), Specific Growth Rate (SGR), Feed Conversion Rate (FCR) and mortality did not show significant differences
- Fish in Ulva-RAS showed increased feed consumption when fed VO-based diets and decreased when fed FO-based diets compared to control fish.
- Fish in *Ulva*-RAS showed increased condition factor (K), regardless of feed consumption
- Protein content was significantly different between UF and CF in both trials and seems to be related to feed intake.
- Fat content was higher in UF in both trials
- In fish fed VO-diets, the % content of EPA and DHA in total lipids was lower in UF, however the total amount of these fatty acids in 100g of tissue was higher in UF as a result of higher fat content

Role of *Ulva* in RAS water quality

- When TA-N levels were elevated (Trial 1), there was a removal of ~8% for ammonia from Ulva while the bacteria gravel bed retained ~53%.
- During the 2nd Trial where the bacteria gravel bed retained almost all ammonia (up to 93,89%), Ulva had no effect.
- *Ulva* seems to have no effect on nitrites reduction, since the bacteria gravel bed retains a high percentage of this nutrient.
- *Ulva* does not reduce significantly the levels of nitrates and phosphates, as it was expected, but on the contrary in some cases higher levels of PO_4 and NO_3 compared to controls, were observed.
- It is therefore possible, that *Ulva* demineralisation process has an additive effect on PO4 and NO3 concentrations.

Conclusions / Future prospects

- *Ulva* could be used as an additional biofilter in RAS for improving water quality when NH_3 is abundant.
- Indoor cultivated *Ulva* showed no biomass increase, probably due to nutrient rather than light limitation, therefore RAS could not be used as an *Ulva* production system.
- However, *Ulva* cultured in RAS shows improved quality, due to the decreased carbohydrates and the higher protein content.
- Fish in *Ulva*-RAS show stress tolerance (data not shown) and an increased condition factor.
- *Ulva* seems to contribute to fish welfare, which are probably recruiting dissolved or suspended matter related to *Ulva* presence.
- Therefore we can assume that the presence of *Ulva* has a positive effect on sea bass nutritional (EPA & DHA content) and physiological status, although not being a dietary component.
- Hence, the co-culture of sea bass and *Ulva* could result in a higher nutritional value of both species.
- Further investigation should be driven towards the effects of *Ulva* on fish health and welfare.

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Merci de votre attention