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Integrate Aquaculture: an eco-innovative solution to foster sustainability in the Atlantic Area

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Integrated Marine Recirculated Aquaculture

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Pôle halieutique

Technical characterization

- **Integrated multi-trophic aquaculture (IMTA)** is a system where the **waste products** from one food production process **assimilated** by other organisms and **converted** into valuable products.

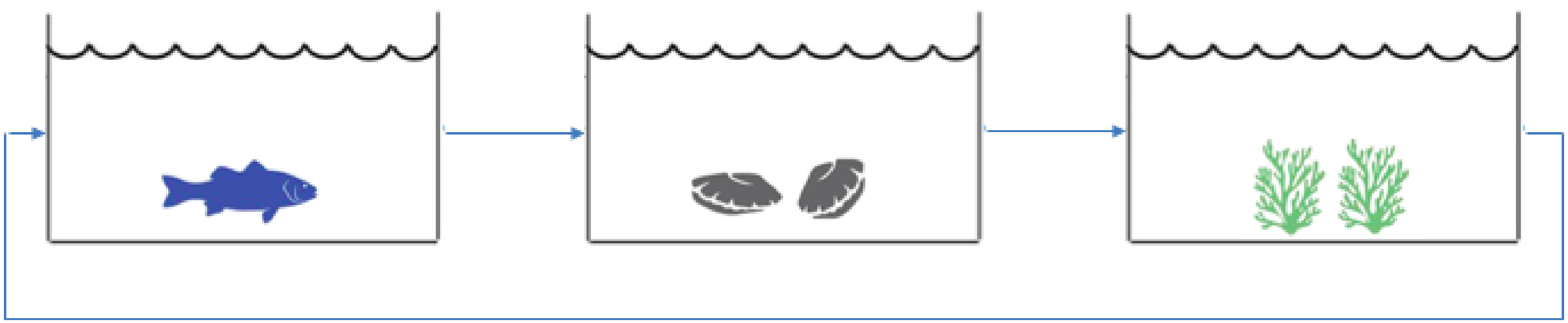
- This process both **eliminates** waste and **increases** the productivity of the food production system

Technical characterization

- **Fed species :** fish / shrimp
- **Mechanical filter :** drum filter / sand filter
- **Biofilter :** nitrifying bacteria

Technical characterization

IMTA + RAS = IMRAS



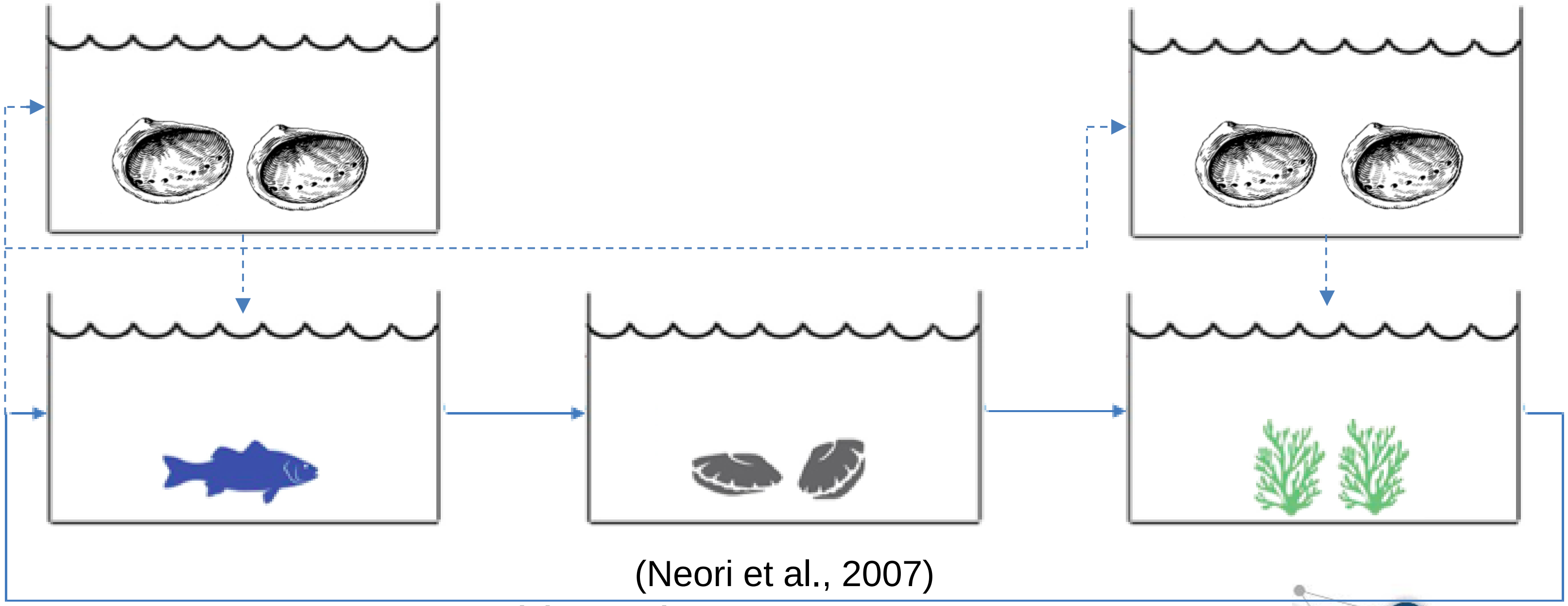
- **Fed species :** fish / shrimp
- **Mechanical filter :** ~~drum filter~~ —> shellfish
- **Biofilter :** ~~nitrifying bacteria~~ —> seaweed

(shellfish and seaweed: Extractive organisms)

Technical characterization

Diversity of systems

- **2 trophic levels**
  - Fish x seaweed
  - Fish x shellfish
  - Shellfish x seaweed
- **3 trophic levels**
  - Fish x shellfish x seaweed



(Neori et al., 2007)

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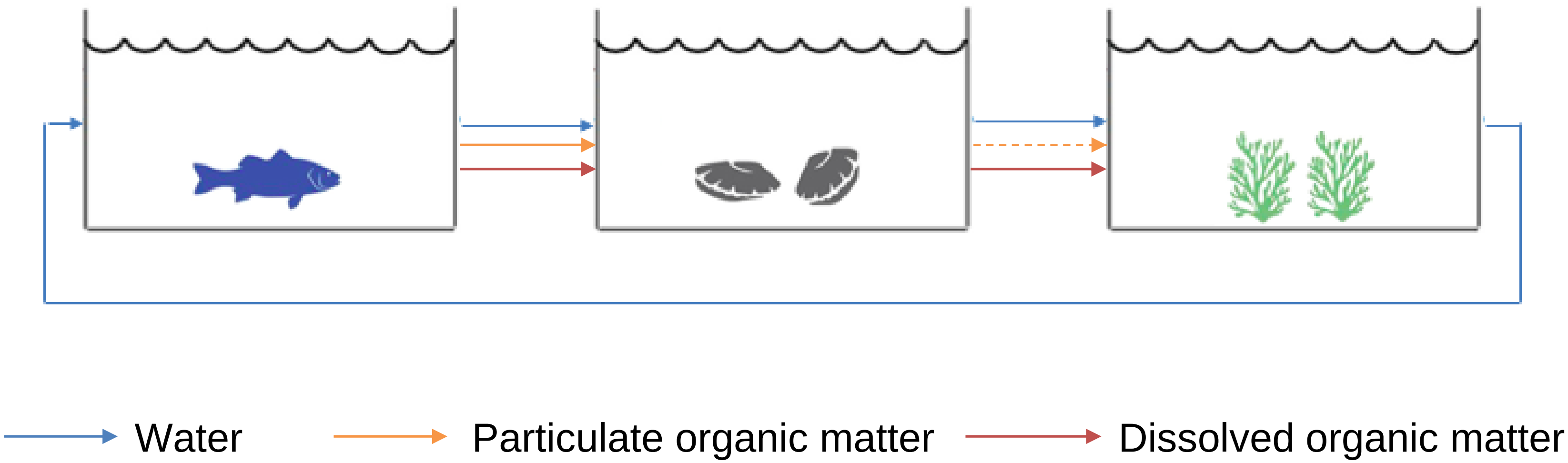
Interactions between compartments



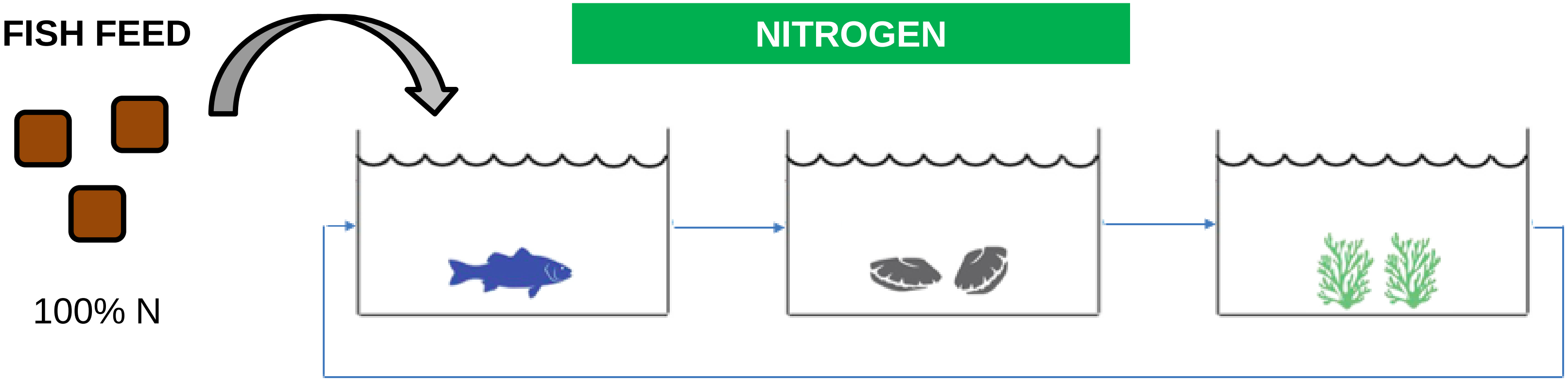
Environmental analysis : nutrients

2 main components :

- Dissolved nutrients (Nitrogen, Phosphorus)
- Particulate organic matter (uneaten pellets and fish faeces)

Environmental analysis : nutrients

PN : Particulate nitrogen
DN : Dissolved nitrogen



	FISH		SHELLFISH		SEAWEED	TOTAL
SEAWATER	PN 54% DN 10%		PN 1.8% DN 24.5%	=	PN 1.8% DN 2.5%	PN 1.8% DN 2.5%
BIODEPOSITS	10-20%		22-30%			32%
YIELD	25-30%		16-20%		22%	63%

(Shpigel, 2012)

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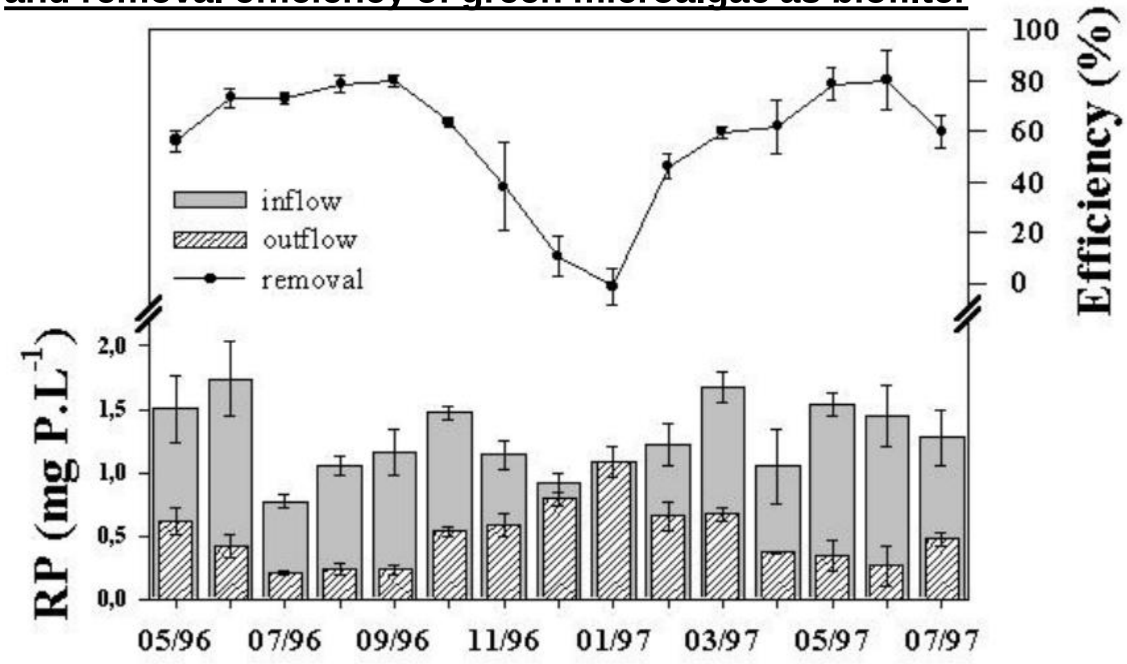
Environmental analysis : nutrients

PHOSPHORUS

Monthly (mean ± SE) Reactive Phosphorus (RP) concentration and removal efficiency of green microalgae as biofilter



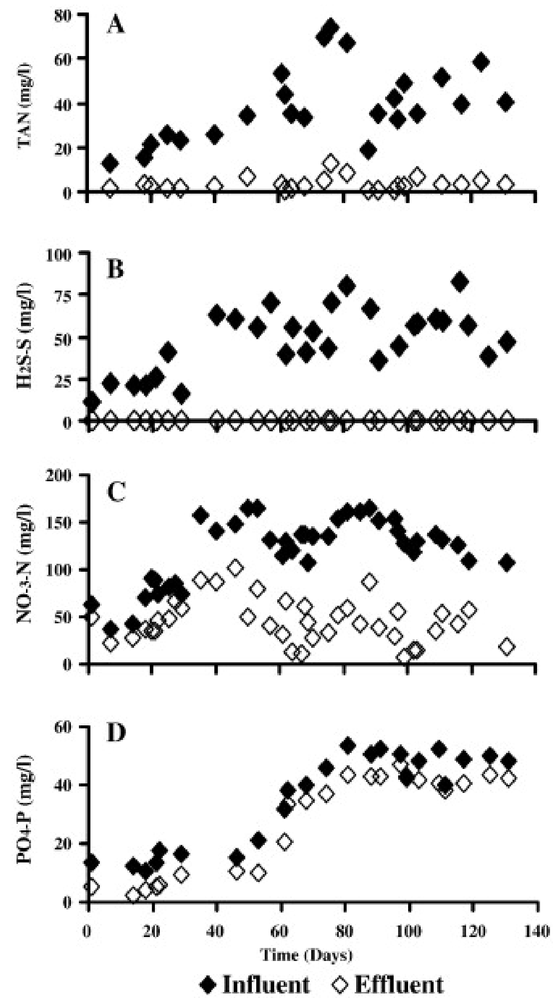
(Pagand *et al.*, 2000)

IMTA, the real solution ?

RAS with seabream

- Classic RAS are already good at extracting nutrients from the water

—> But nutrients are only converted, and not extracted !



(Tal *et al*., 2012 ; Cahill *et al*., 2010)

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Seaweed vs Biofilter

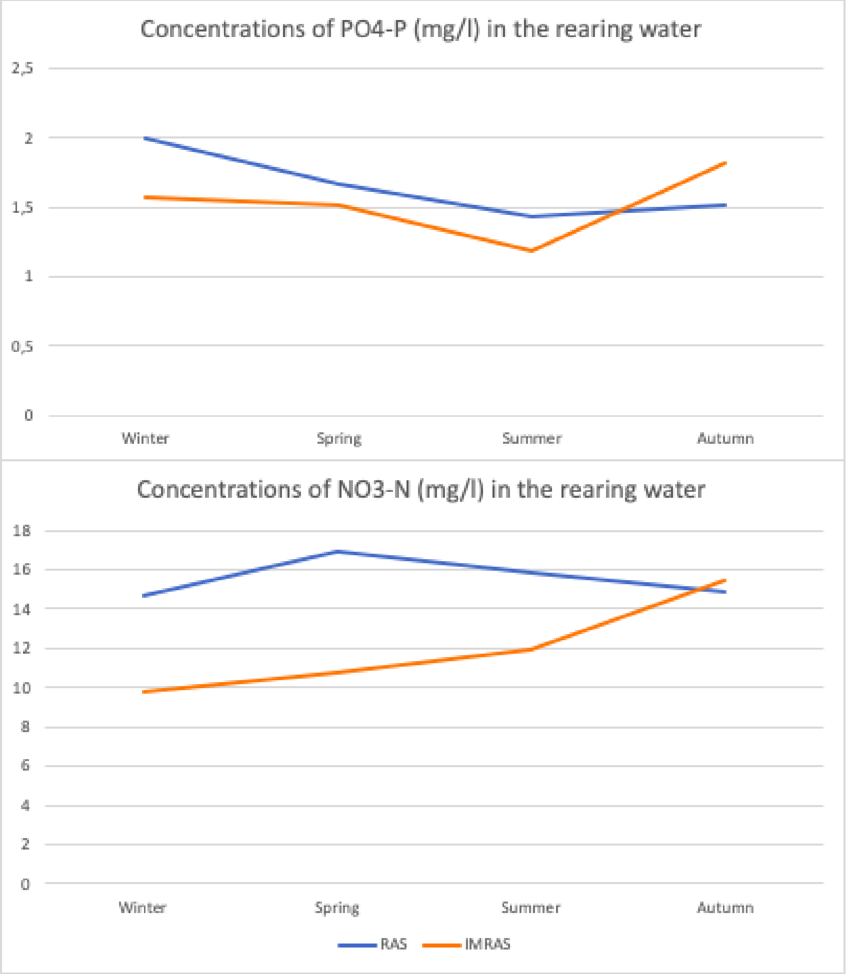
Seaweed has shown better results than biofilter

x

→ Unlike the bacteria, seaweed biofilters produced economically valuable biomass.

→ Seaweed requires a greater amount of surface area and land

(Metaxa *et al.*, 2006)



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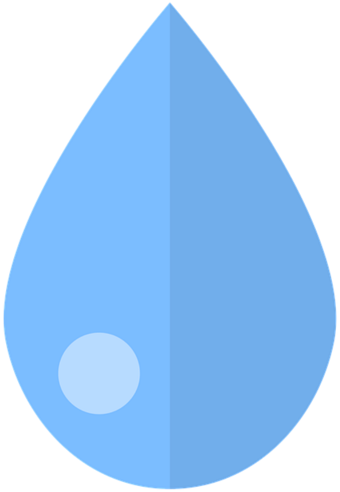
Environmental analysis : water

Monoculture RAS = 1 m^3/kg (Martins et al., 2010)

Lower waste production + Lower feed conversion ratio
= Less water consumed

IMTA ⟶ less water consumed (Martins et al., 2010)
= Increase in overall water residence time (less renewal)
= Fewer inputs



Environmental analysis : energy

Classic RAS = high energy consumption
Close to 300 MJ/kg
86% = on-site consumption (Aubin *et al.*, 2009)

No information about marine land-based IMTA

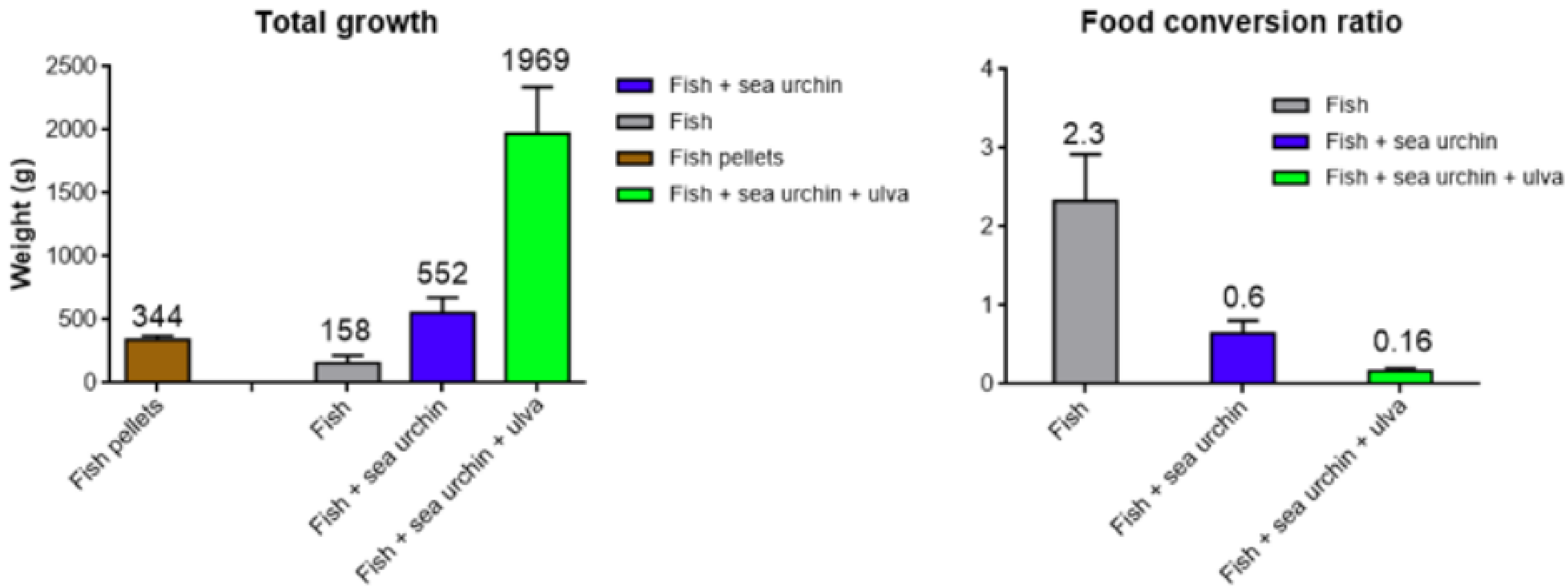
~~**Energy consumption for biofilter**~~ → **Energy Consumption Ex : Algae lamps** **+ or - ?**

Analysis of productivity gains

- **Diversified products**
  - Production of fish + shellfish + seaweed
  - In particular seaweed enriched in proteins (Shpigel *et al.*, 2017)

- An overall yield **two to three times higher** than the one of a standard monoculture.

Analysis of productivity gains



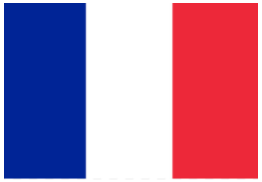
IMTA improves :

- The productivity of the system
- The FCR

(Miard & Simide, 2017)

Economic analysis

2 case studies (Bunting and Shpigel, 2009)



Seabass ⟶ Microalgae ⟶ Oysters + Clams

Sea urchin ⟶ Shrimp ⟶ *Salicornia* spp

3 scenarios were developed for **each country**

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Economic analysis

France

1

Baseline scenario
(with construction)

PBP	**IRR**
34.4y	< 0

2

No construction costs
(redevelopment)

PBP	**IRR**
7.6y	3.6%

3

+ 20 % premium

PBP	**IRR**
4.1y	19.4%

Israël

↘ Mortality **+** ↗ Productivty

=

↘ PBP ↗ IRR

1

Baseline

PBP	**IRR**
4.5y	18%

2

Decline in market prices

PBP	**IRR**
6.9y	8.3%

PBP = Payback period
IRR = Intern return rate

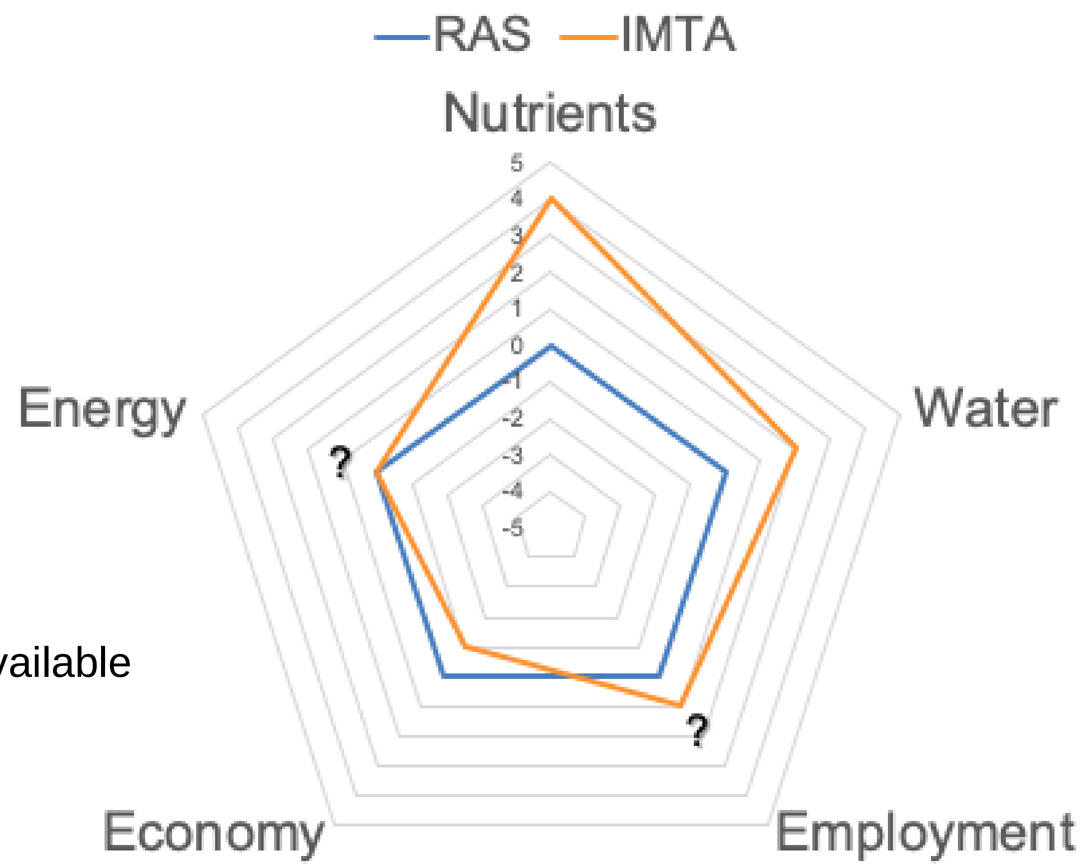
(Bunting and Shpigel, 2009)

Economic analysis

Technically viable when :

1. Construction and labour costs are reduced (Shpigel, 2012)
2. Production is optimized (Neori *et al.*, 2001 ; Shpigel, 2012)
3. Production is accorded to markets and seasonal needs (Neori *et al.*, 2001)
4. Development of consumer acceptance (Shpigel, 2012)

Benchmark



?: data not available

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	ASSETS	LIMITS
Technical	• Efficiency : nutrients uses • Efficiency of seaweed biofiltration	• Diversified products → Complexity • Risks : structure, disease, seed supply • Space requirements
Environmental	• Nutrient recycling • Reduced demand for feed from pelagic marine fisheries and terrestrial crops	• Efficiency compared to classic RAS?
Economic	• Marketing advantages (green) • Diversified products → less risky • Job creation	• Complexity: marketing, operations • Social acceptance, public perception • Disappointment of expectations • Market threats

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MANY THANKS

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