integrate

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

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AGROCAMPUS OUEST

Freshwater Integrated Multi Trophic Aquaculture

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Interreg Atlantic Area
European Regional Development Fund

EUROPEAN UNION

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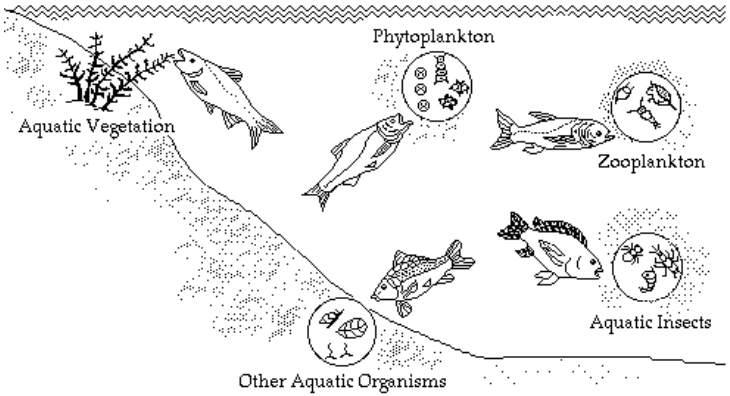
Pôle halieutique

Technical characteristics of Freshwater IMTA system

Based on carp polyculture



Source : agrisujan.wordpress.com

Open system in ponds

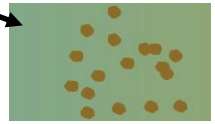
Source : Igsonic.com

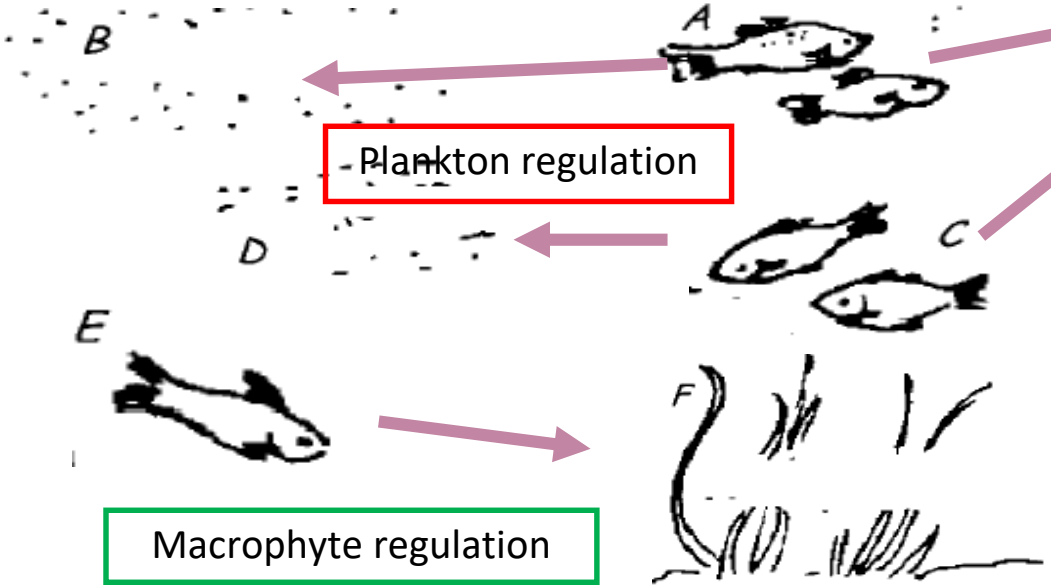
One fed species and three living by consuming waste and the ecosystem consumption : making an other **valuable production**

Pond with carp polyculture: a multi-trophic system

Fed species: common carp
50-60%

Each species has a different ecological niche





Plankton regulation

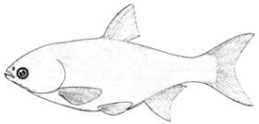
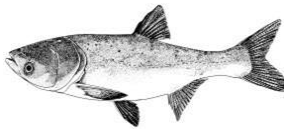
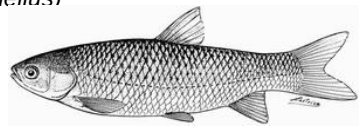
Waste regulation

Macrophyte regulation

Trophic relations

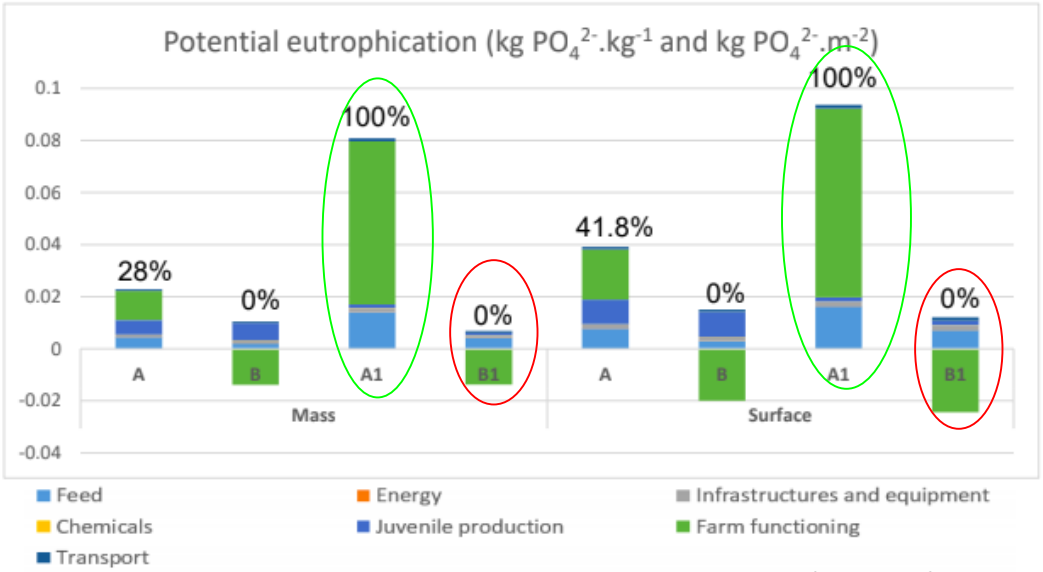
A : Silver carp
B : Phytoplankton
C : Bighead carp
D : Zooplankton
E : Grass carp
F: Aquatic plants

Ecosystem regulation : different species and diets

Common Carp (*Cyprinus carpio*) 	Fed species	Main production Resuspension of sediment → increase pond productivity
Silver Carp *(Hypophthalmicthys molitrix)* 	Eat phytoplankton and Carp waste → **filter feeder**	Control on phytoplankton populations and waste regulation → reduce oxygen consumption
Bighead Carp *(Hypophthalmicthys nobilis)* 	Eat zooplankton and Carp waste → **filter feeder**	Control on zooplankton populations and waste regulation → reduce oxygen consumption
Grass Carp *(Ctenopharyngodon idellus)* 	Eat macrophyte → **herbivorous**	Control macrophyte proliferation → reduced risk of die-off

Source of pictures : FAO

N, P and Organic Matter



Source: Favalier et al, 2019

A1: Traditionnal system
B1: FIMTA

- FIMTA extracts phosphorus off the environment
- FIMTA practices lead to a lowest impact of nitrogen and phosphorus in comparison with traditional system (Favalier et al., 2019).

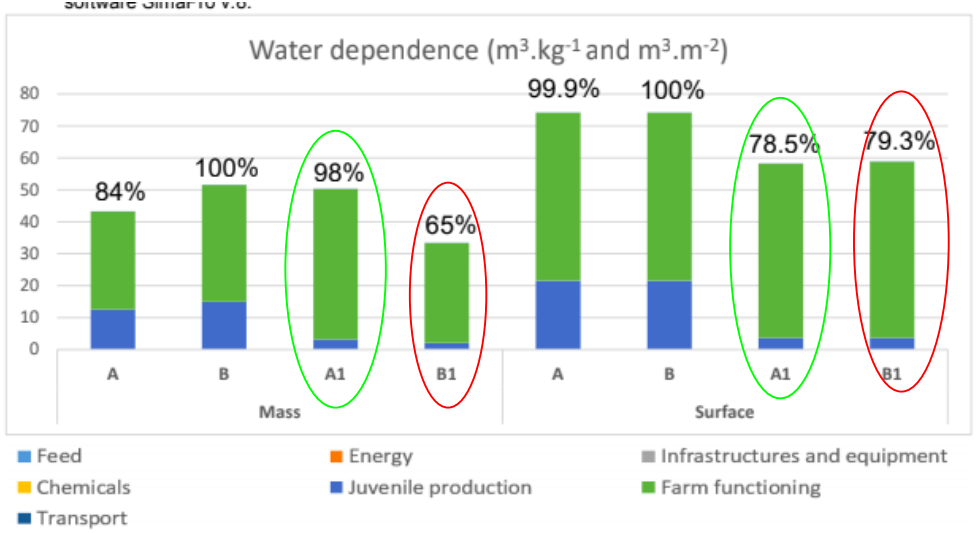
N, P and Organic Matter

- The potential eutrophisation led by FIMTA is negative, it extracts -6.8 to -101.2 kg/yr nitrogen and phosphorus off the environment (Aubin et al., 2014)

- Moreover, 1 ha pond in a year retains 3.8-8.4 kg Phosphorous, 96 – 560 kg Nitrogen and 1100 – 1600 kg Suspended Solids (Knösche et al., 2000).

- FIMTA reduces the environmental impacts directly through the uptake of dissolved nutrients by primary producers (e.g. plankton, algae) and of particulate nutrients and organic matter by suspension feeders (e.g.Bighead carp) (Cheng, 2014)

Water consumption



Source: Favalier et al., 2019

A1: Traditionnal system

B1: FIMTA system

- Each system lead to different impact per kg of fish produced but not per m^2
- FIMTA use less water than traditional system to produce 1 kilogramme of product but usually consume more water per square

Water consumption

- Polyculture of carp = Between 78,702 and 219,985 m^3/yr/ha (Aubin et al., 2014)

- The quantity of water for rearing fish is more efficient than a traditional system (Favalier et al., 2019)

Energy expenditure

- Not enough data available

- Impact of energy often depends on feed, production system and species (Hornborg et al., 2014)

- Considering the fact that carps are fish with low trophic level (Cheng 2014) and FIMTA rely on natural production (Yeo et al., 2004), we hypothesised that we have the same level of energy consumption with those reports by Troell et al. (2014) : 1-25 J/J (energy use per protein energy output) for various carps pond

Analysis of productivity gains and food optimization

Intensive carp monoculture in Asia : 5 to 90 t/ha/yr (Jian-Fang Gui et al, 2018)

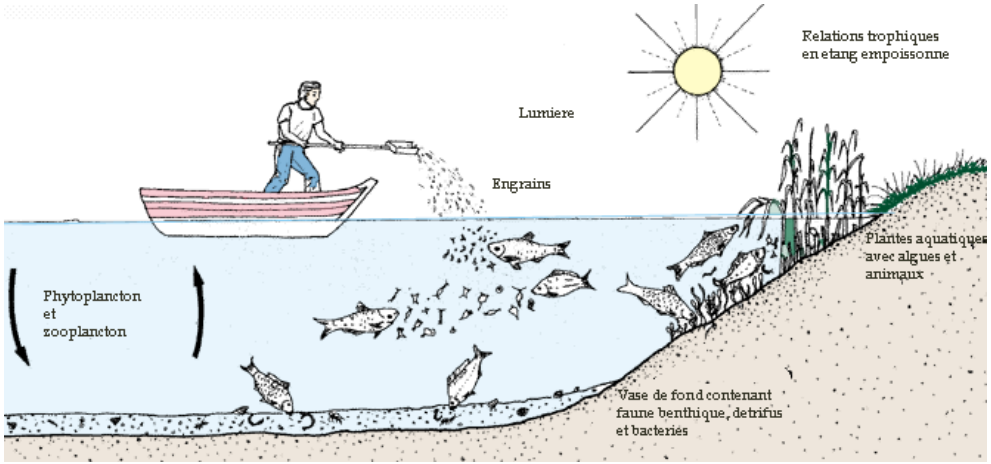
Lorraine (France) polyculture : carp (*Cyprinus carpio*), common roach (*Rutilus rutilus*), rudd (*Scardinius erythrophthalmus*), tench (*Tinca tinca*) and pike (*Esox lucius*) : Total Yield = 0.16 to 0.72 t/ha/yr (Aubin, 2014)

Eastern Europe : Monoculture yields = 0.7 to 2 t/ha/yr (depending on manuring) (Woynarovich, 1979)

Analysis of productivity gains and food optimization

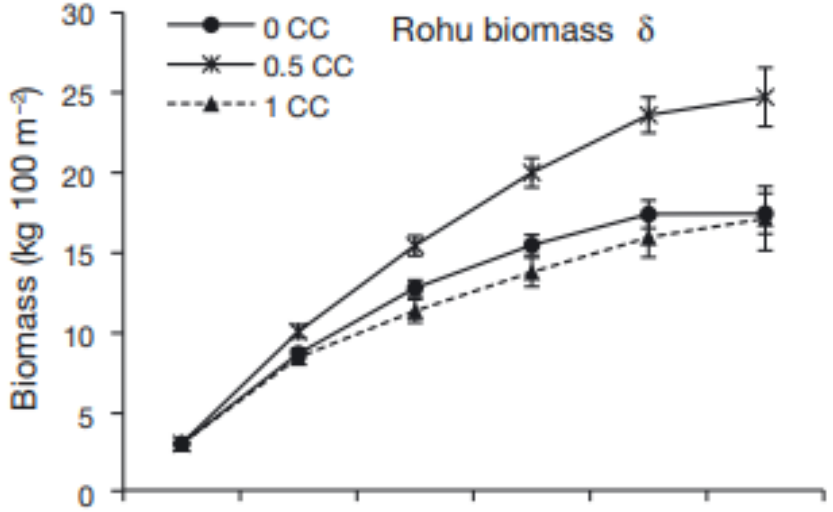
Carps digging the sediment and resuspending nutrients (“Bottom-up effect”) boosts the primary production of ecosystems and productivity co-cultured fish (herbivorous fishes) (Rahman, 2015a)

Carp digging the sediment and suspending nutrients from it



Source : FAO

Productivity gain of Rohu (herbivorous cyprinid) with addition of carps



Source : Rahman, 2015b

Rohu biomass increases significantly faster with 0.5 carp/m² (0.5 CC) than without carp added (0 CC) or 1 carp/m² (1 CC).

Economical analysis

Diversified production = diversified income,
less affected by changing prices, diseases, weather conditions...
⇒ resilience

POISSON	MOINS DE 10 KG	DE 10 KG A 50 KG	DE 51 KG A 100 KG
Carpe 1 été	8.06 € HT 8.50 € TTC	6.82 € HT 7.20 € TTC	5.88 € HT 6.20 € TTC
Carpe 2 et 3 étés	6.64 € HT 7 € TTC	5.97 € HT 6.30 € TTC	5.21 € HT 5.50 € TTC

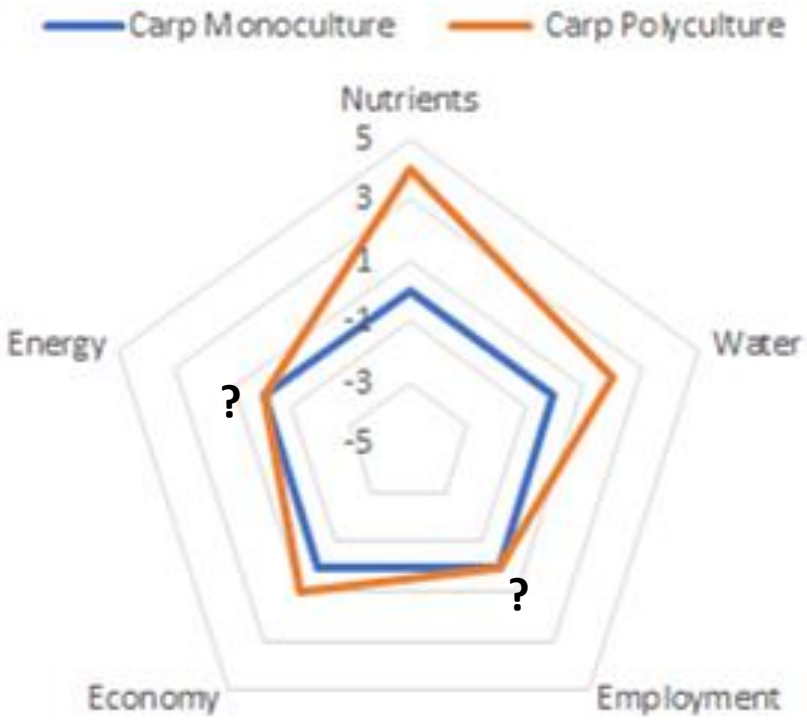
Price of alive carp in France adapted from : Société Relot frères aquaculture continentale

Carp from China = 0,83 €/kg in 2002 (FAO)
From Eastern europe = 2 to 3 €/kg (EUFOMA, 2016)

France can't be as competitive :
Valorisation of freshwater fishes = living fish
Price of living carp = 5 to 16 €/kg in France

⇒ Less overall productivity but less costs (feed efficiency) and more resilience
Polyculture fish production cost should be <2€/kg to be profitable.

Benchmark



? : No data available

Freshwater IMTA

	ASSETS	LIMITS
Technical	Less food for more production Reuse of wastes	Predation at early stages Need for space
Environmental	Less wastes and less nitrogen discharge Wetland ecosystem preserved because less eutrophisation	Escape of fish Difficulties in fish managing (which production for which species)
Economic	Multiple productions → resilience Not all species need to be fed	Low surface efficiency if extensive Find a market for carp production in west Europe

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MANY THANKS

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