Oyster and fish integrated aquaculture in earthen ponds for efficient production and environmental conservation

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DIVERSIAQUA

INOVAÇÃO EM AQUACULTURA DE ESPÉCIES MARINHAS

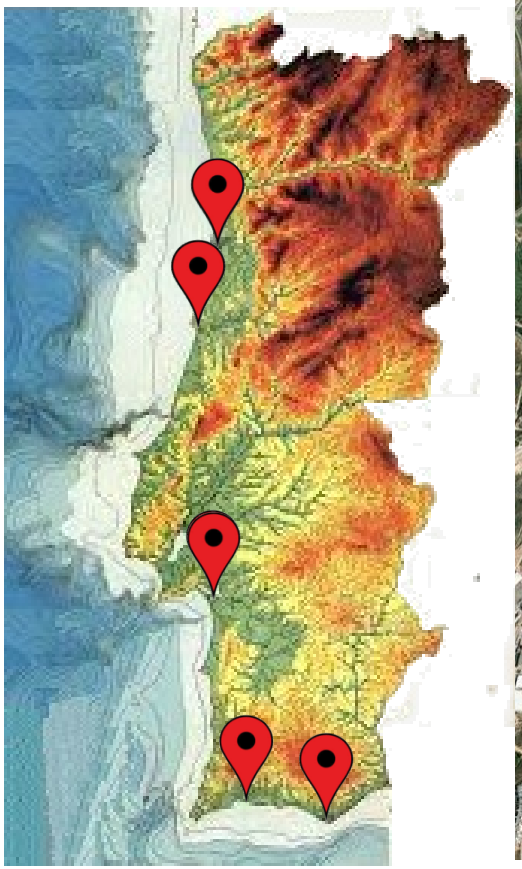
IMTA -EFFECT

Integrated Multi Trophic Aquaculture for Efficiency and Environmental Conservation

COFASP

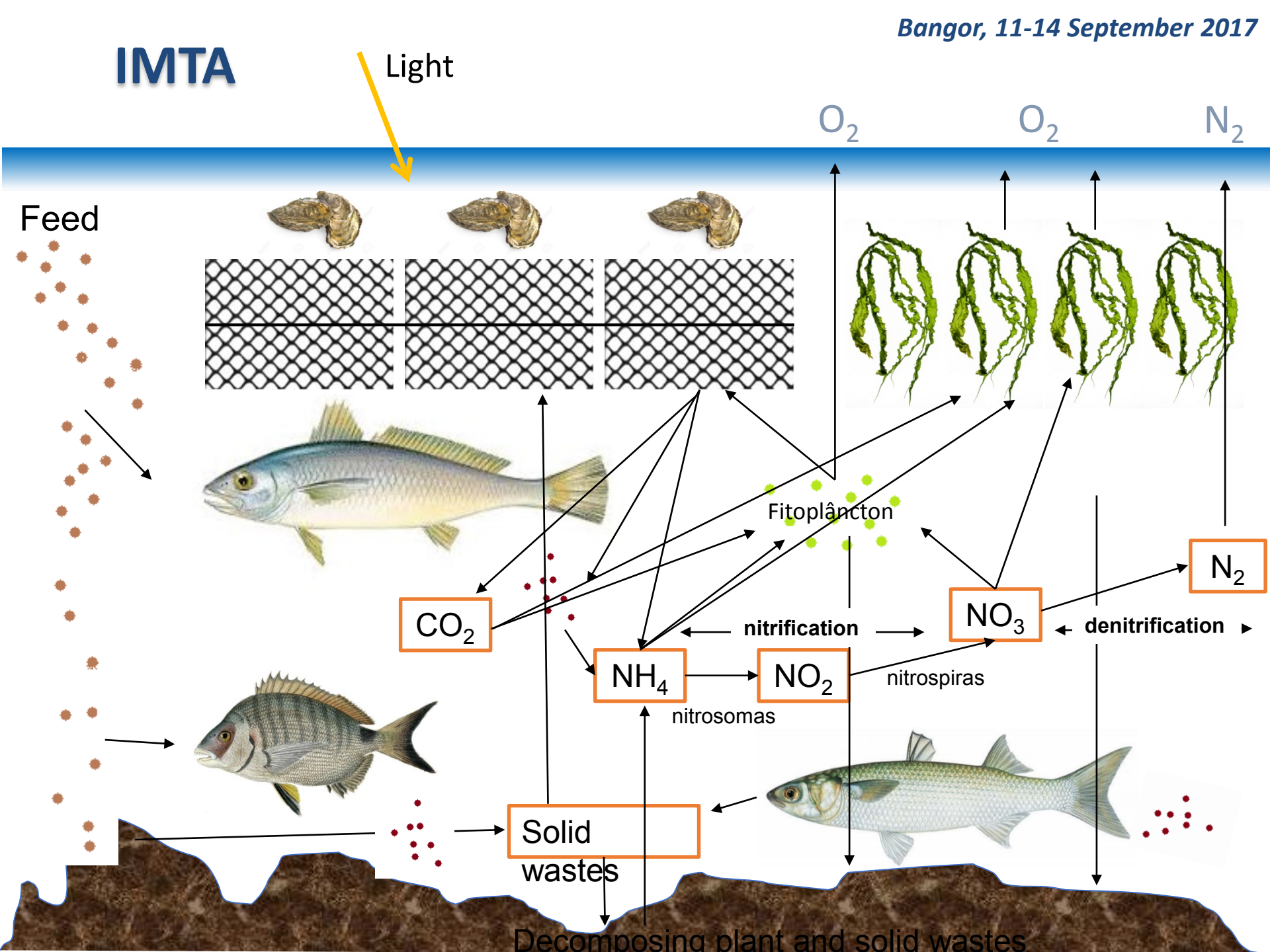
ERA-net

Marine Coastal Aquaculture in Portugal



Earth Pond Aquaculture in Portugal

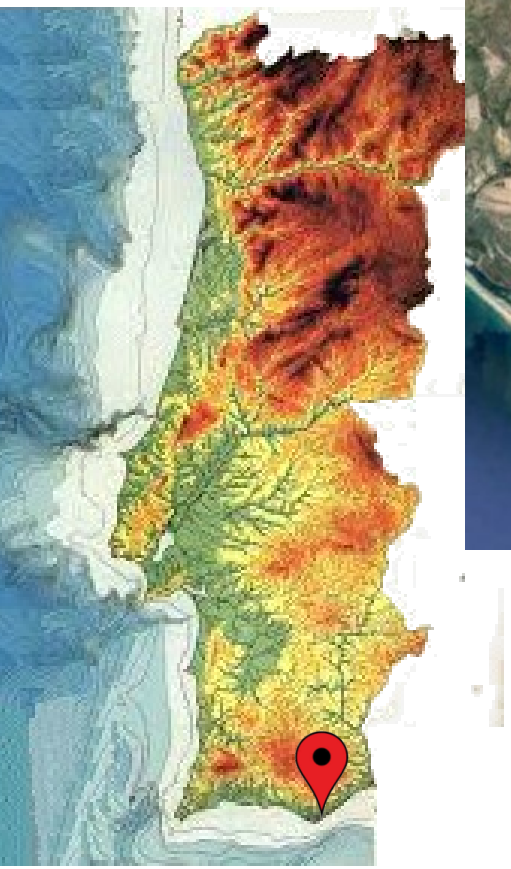
IMTA


Light
O_2
O_2
N_2
Feed
Fitoplâncton
CO_2
nitrification
NO_3
denitrification
N_2
NH_4
NO_2
nitrospiras
nitrosomas
Solid wastes
Decomposing plant and solid wastes

Six years of research

Period	Main Objetive	Project	Tested Species	Main Result
2010	• Study polyculture of bream species; • Can oyster grow in fish ponds? • Which structures to use for oysters?	SEAFARE	• 5 seabream species; • Portuguese oysters; • Sea cucumbers	• Mesh bags much easier with less biofouling; • Acceptable growth but high mortality due to Spawning;
2011 - 2012	• What is the oyster performance in floating mesh bags? • What is the effect of oysters in sediment diversity?	SEAFARE	• Gilthead seabream; • Portuguese oysters	• Higher growth and lower mortality than 2010 but high variations among ponds; • Higher diversity where oysters are present
2013	• Improving technical performance + combination with meagre	SEAFARE	• Meagre; • Gilthead seabream; • Pacific oysters triploids	• Higher growth and survival than previous years; • Structures improved for higher production efficiency
2015	• New structure, two contrasting densities: which give higher revenue and effect in water quality?	DIVERSIAQUA	• Meagre; • Gilthead seabream; • Pacific oysters triploids	• Very good structure efficiency, easier to handle bags inside water, • Higher growth and survival than Ria Formosa Lagoon and previous years
2016	• What is the combined effect of oysters and macroalgae on water quality and phytoplankton density?	IMTA-EFFECT DIVERSIAQUA	• Meagre; • White seabream; • Flathead mullet; • Pacific oysters triploids	• Oysters contribute with nutrients to maintained phytoplankton production; • Oyster commercial size (80 grams) attained in 8 months
2017	• What is the limiting production level of oysters in fish ponds under two oyster densities?	IMTA_EFFECT DIVERSIAQUA	• Meagre; • White seabream; • Flathead mullet; • Pacific oysters triploids	• Dissolved oxygen levels don't seem affected by higher oyster densities. Trial still not finished.

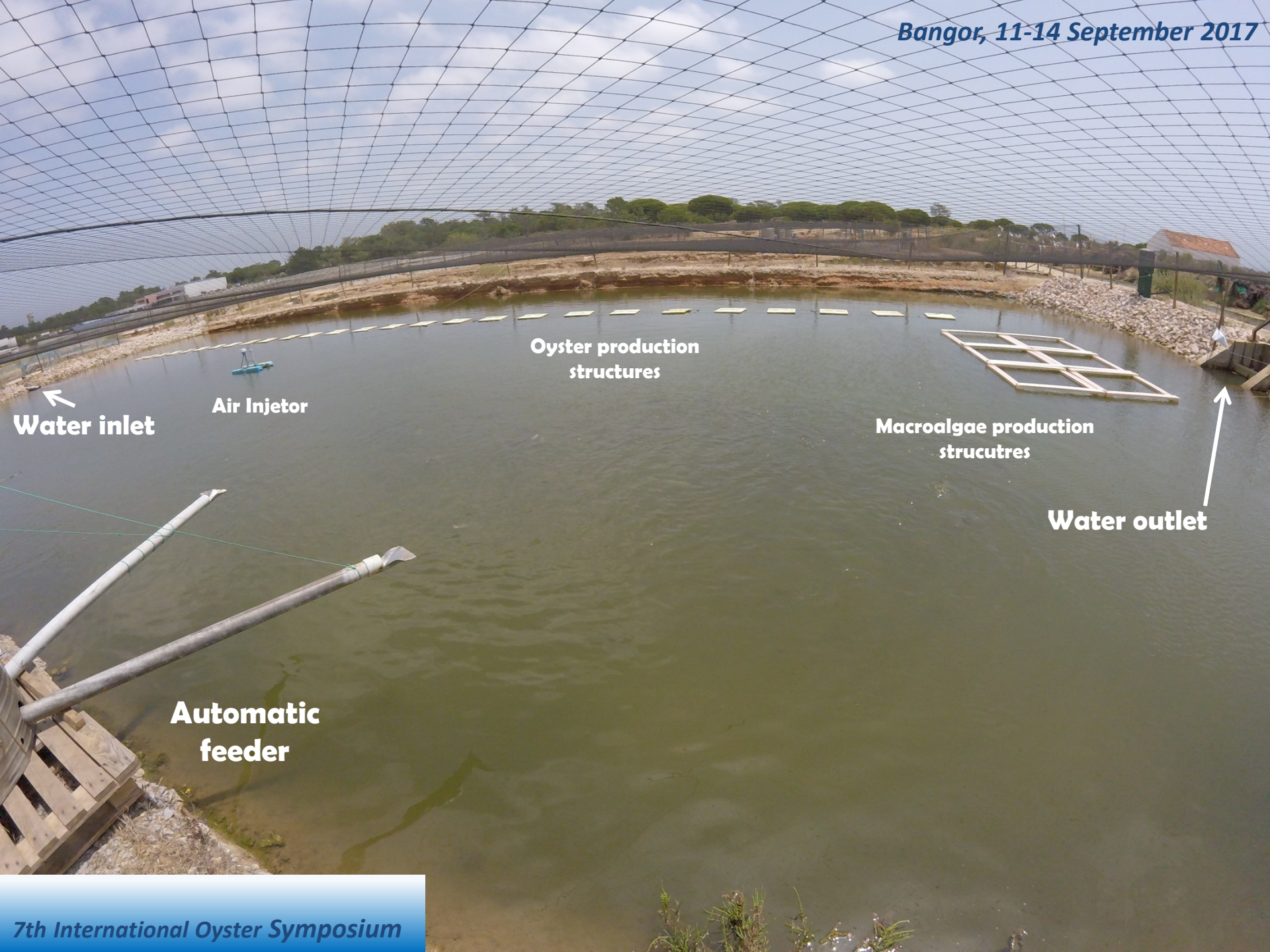
Study site



IPMA – EPPO

Instituto Português do Mar e da Atmosfera – Estação Piloto de Piscicultura de Olhão

Parque Natural da Ria Formosa

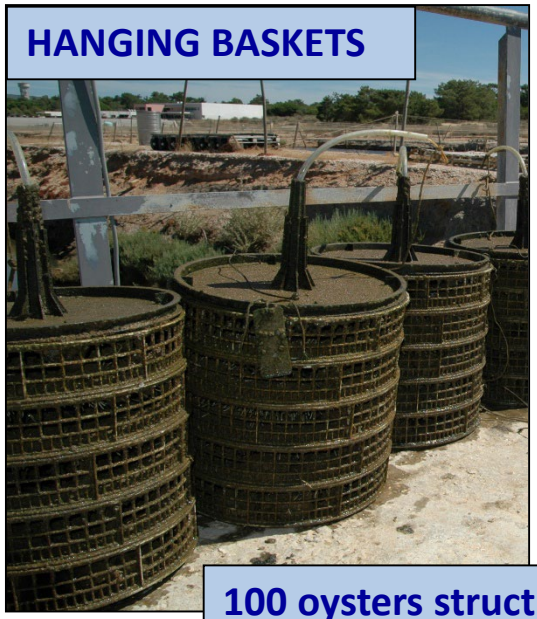

Oyster production structures
Air Injetor
Water inlet
Macroalgae production strucutres
Water outlet
Automatic feeder

Experimented Structures for Oyster growing

Open system with air supply

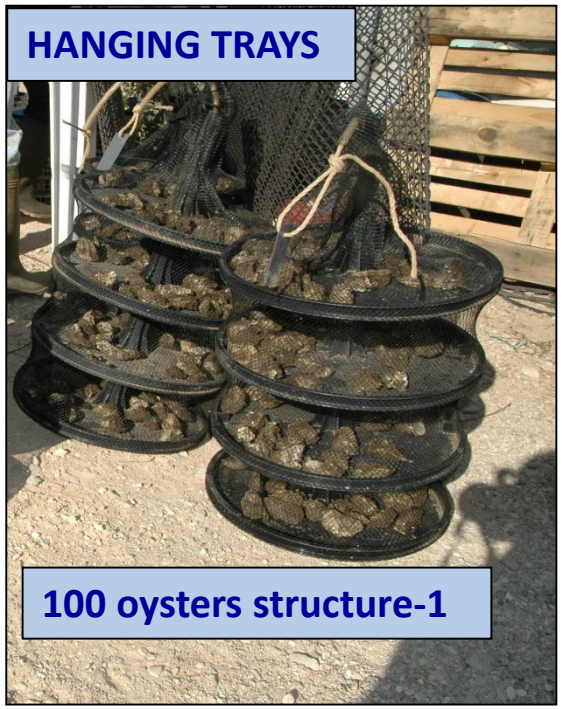
Daily water renovation: 25%

HANGING BASKETS



100 oysters structure^{-1}

HANGING TRAYS



100 oysters structure-1

MESH BAGS

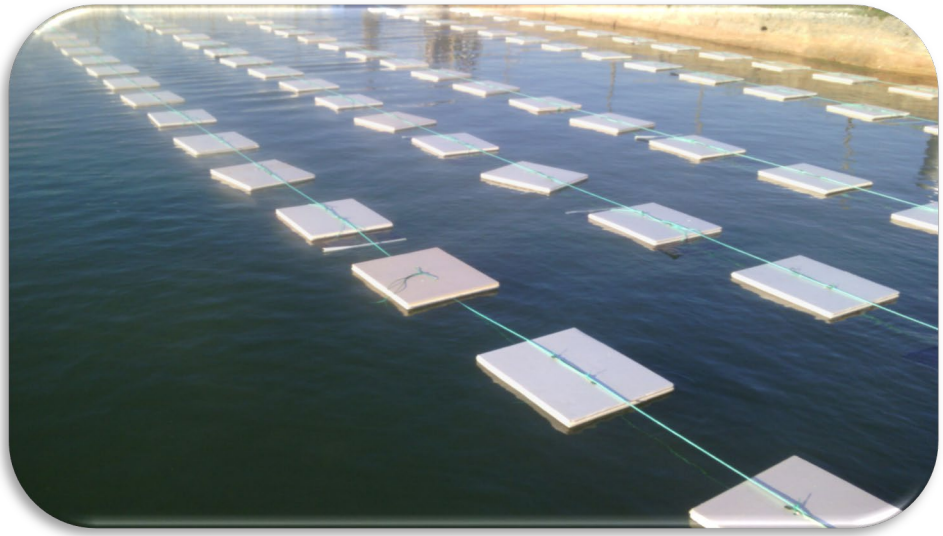
300 oysters bag-1

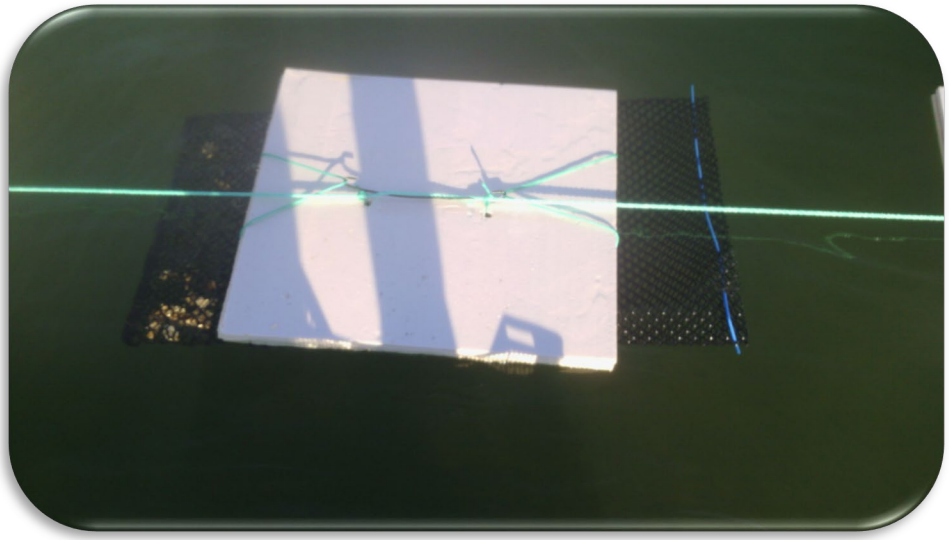
Husbandry

Feed: 2.2 kg day^{-1} tank^{-1}

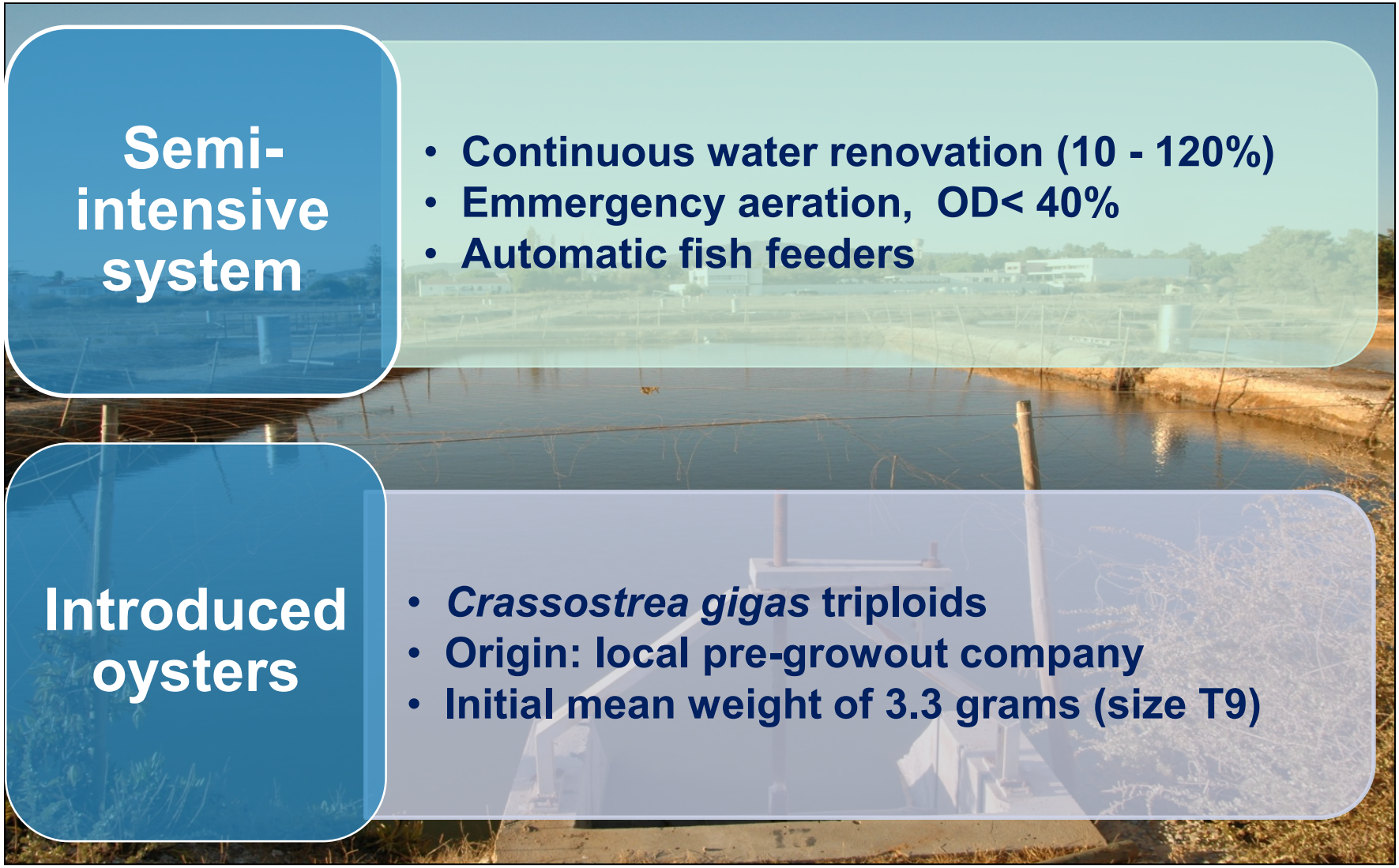
Oyster cleaning: monthly

Experimented Structures for Oyster growing





Rearing conditions



Semi-intensive system

- Continuous water renovation (10 - 120%)
- Emmergency aeration, OD< 40%
- Automatic fish feeders

Introduced oysters

- *Crassostrea gigas* triploids
- Origin: local pre-growout company
- Initial mean weight of 3.3 grams (size T9)

Growout management

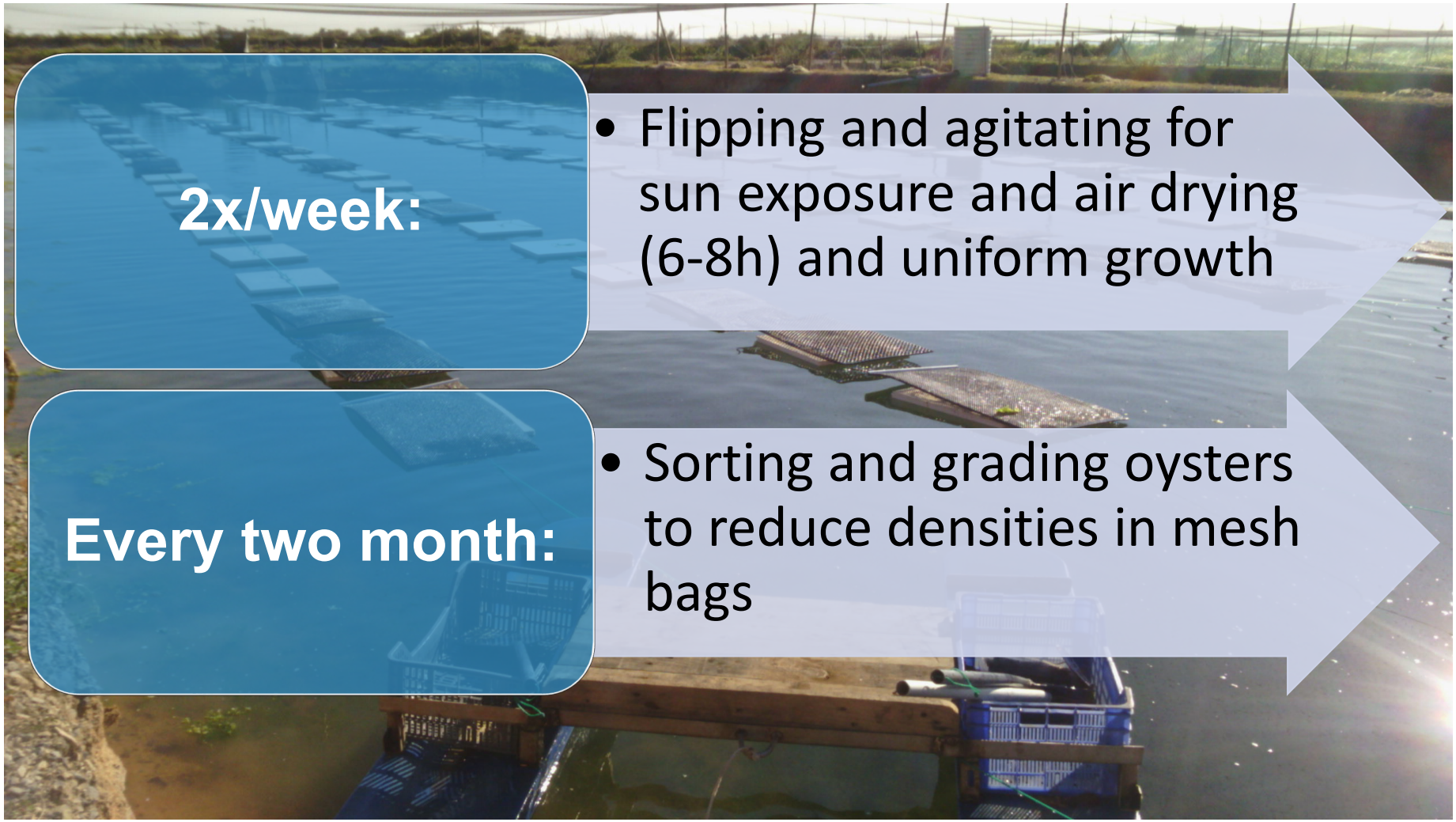
Monitoring

- Temperature
- Dissolved oxygen (Automatic and manual probes)
- pH e turbidity
- Water renewal
- Fish feeding and daily feed ration

Sampling

- Monthly average weight of 250 oysters (5 groups of 5 different bags)
- Mortality in each of the 5 bags manipulated
- Average weight and length (TL) of 100 meagre in March, June and September

Oysters tending



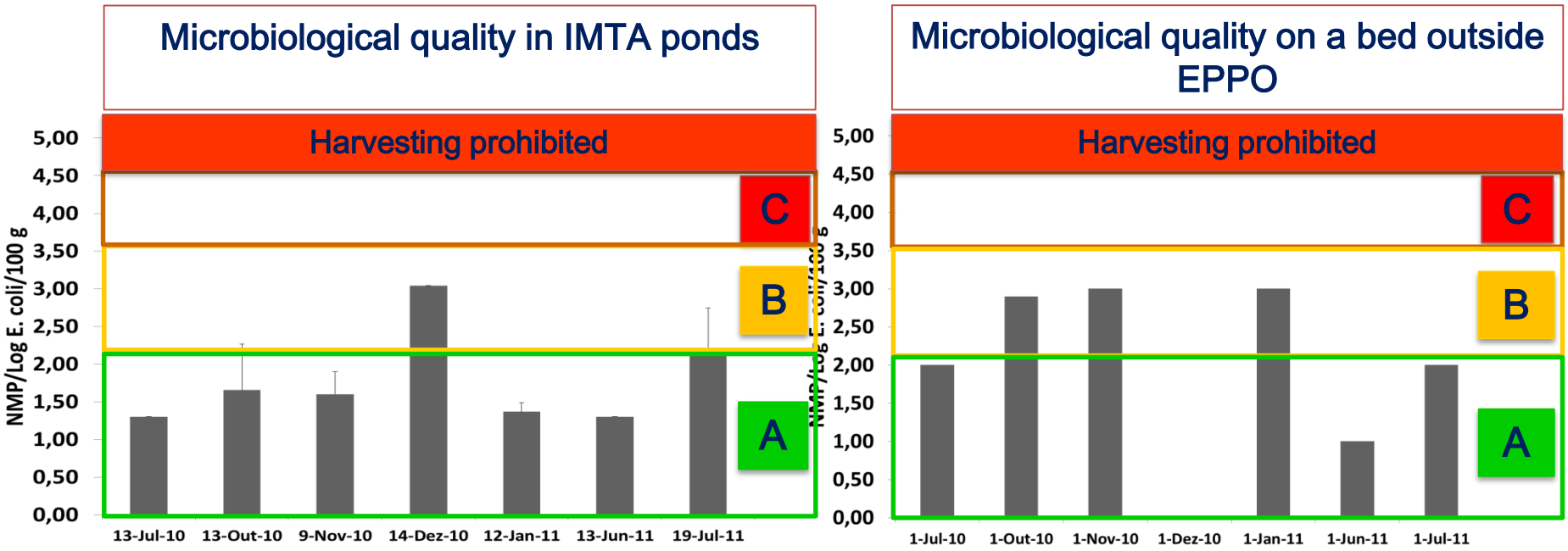
2x/week:

- Flipping and agitating for sun exposure and air drying (6-8h) and uniform growth

Every two month:

- Sorting and grading oysters to reduce densities in mesh bags

Oyster microbiological quality



A	Ready for consumption
B	Purification, relaying or cooking by an approved method
C	Relaying or cooking by an approved method

(Annex II, Chapter II of Regulation (EC) 853 and 854/2004, as amended by Regulation (EC) 1021/2008)

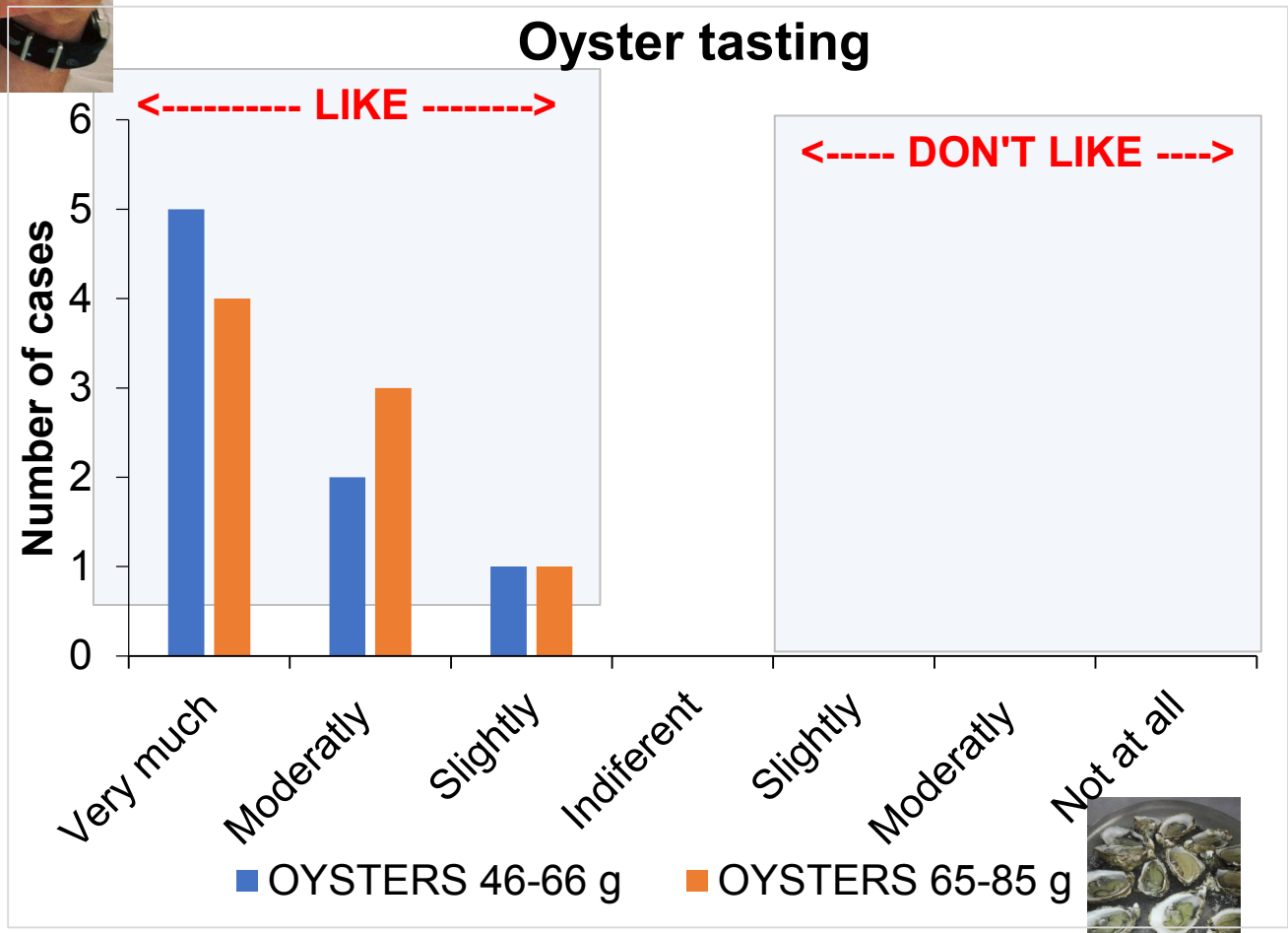
Better microbiological quality of the IMTA oysters compared to Ria Formosa lagoon

Oyster palatability

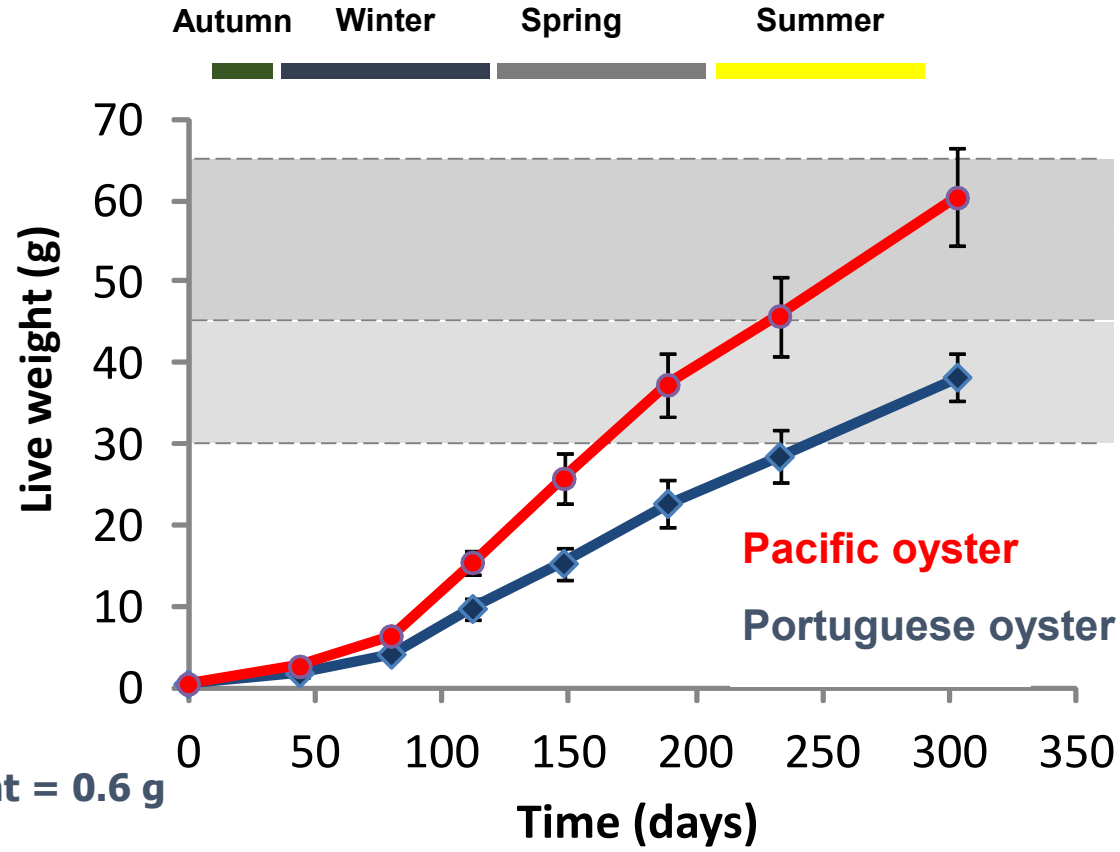
Composition of testing board:

Eight male from 40 to 54 years old with 10 or more years of professional experience

- 4 cooking chefs (1 of them with higher education)
- 1 chef of purchases - 2 restaurant/bar/wine chefs
- 1 enogastronomy specialist (with higher education)



Comparison of performances



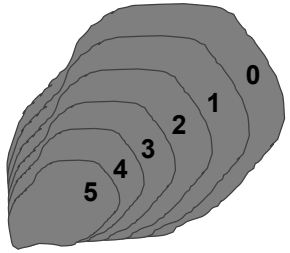
Initial weight = 0.6 g

Higher grow rate for the Pacific oyster that attained commercial sizes 3 months earlier than Portuguese oyster.

Commercial Sizes

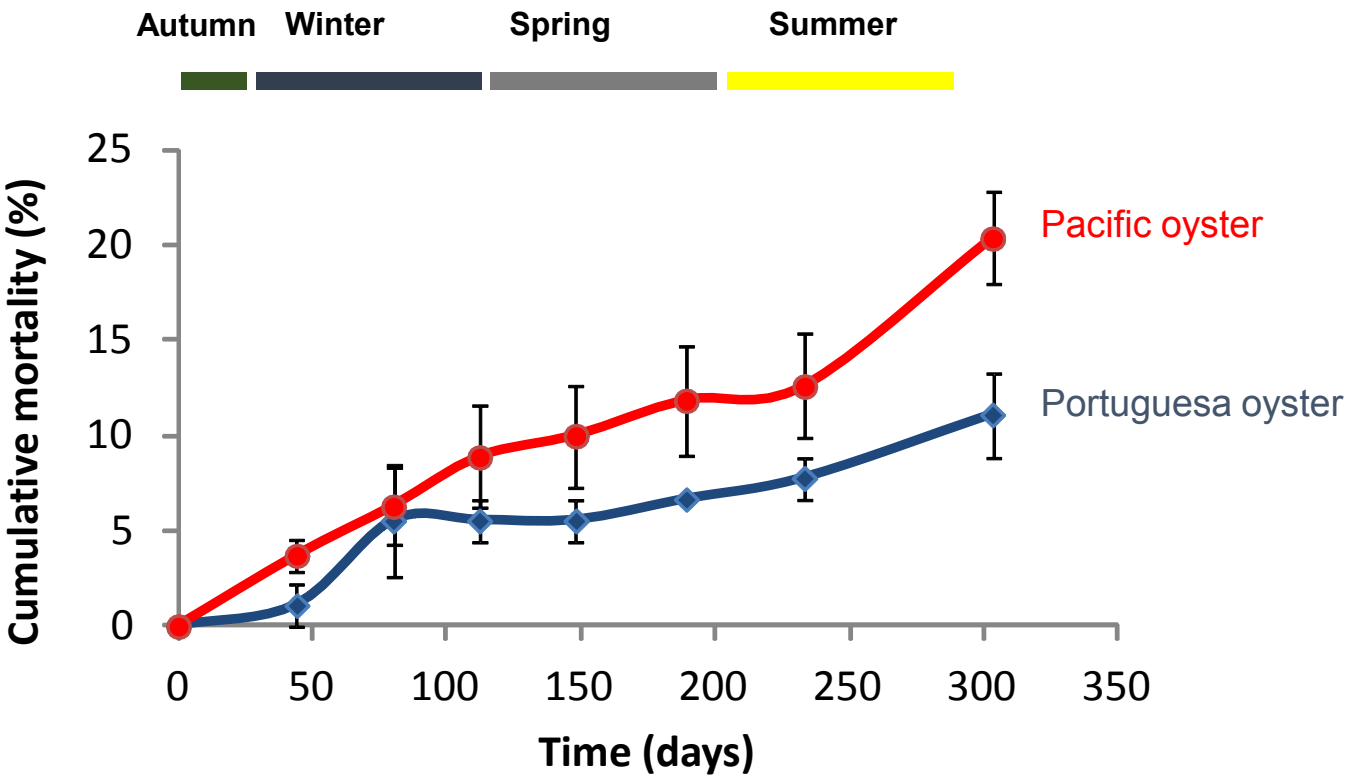
Size 4

Size 5



Size 5: 30-45g
Size 4: 46-65 g
Size 3: 66-85 g
Size 2: 86-110 g
Size 1: 111-150 g
Size 0: > 150 g

Comparison of performances



Higher mortality for the Pacific oyster (2x higher than Portuguese oyster)

Bottom quality/Benthic Fauna

Tanks: / Data:	Fish	IMTA	Fish	IMTA	Fish	IMTA
Mai 11	GOOD	HIGH	MODERATE	HIGH	GOOD	HIGH
Set 11	GOOD	GOOD	GOOD	HIGH	HIGH	HIGH
Dez 11	GOOD	HIGH	GOOD	GOOD	GOOD	HIGH
Mar 12	GOOD	HIGH	GOOD	HIGH	GOOD	GOOD
Jun 12	GOOD	HIGH	GOOD	GOOD	GOOD	HIGH
Set 12	GOOD	HIGH	GOOD	HIGH	GOOD	HIGH

M-AMBI Index (Borja et al., 2004; Muxika et al., 2007): program AMBI v4.1 (http://www.azti.es)

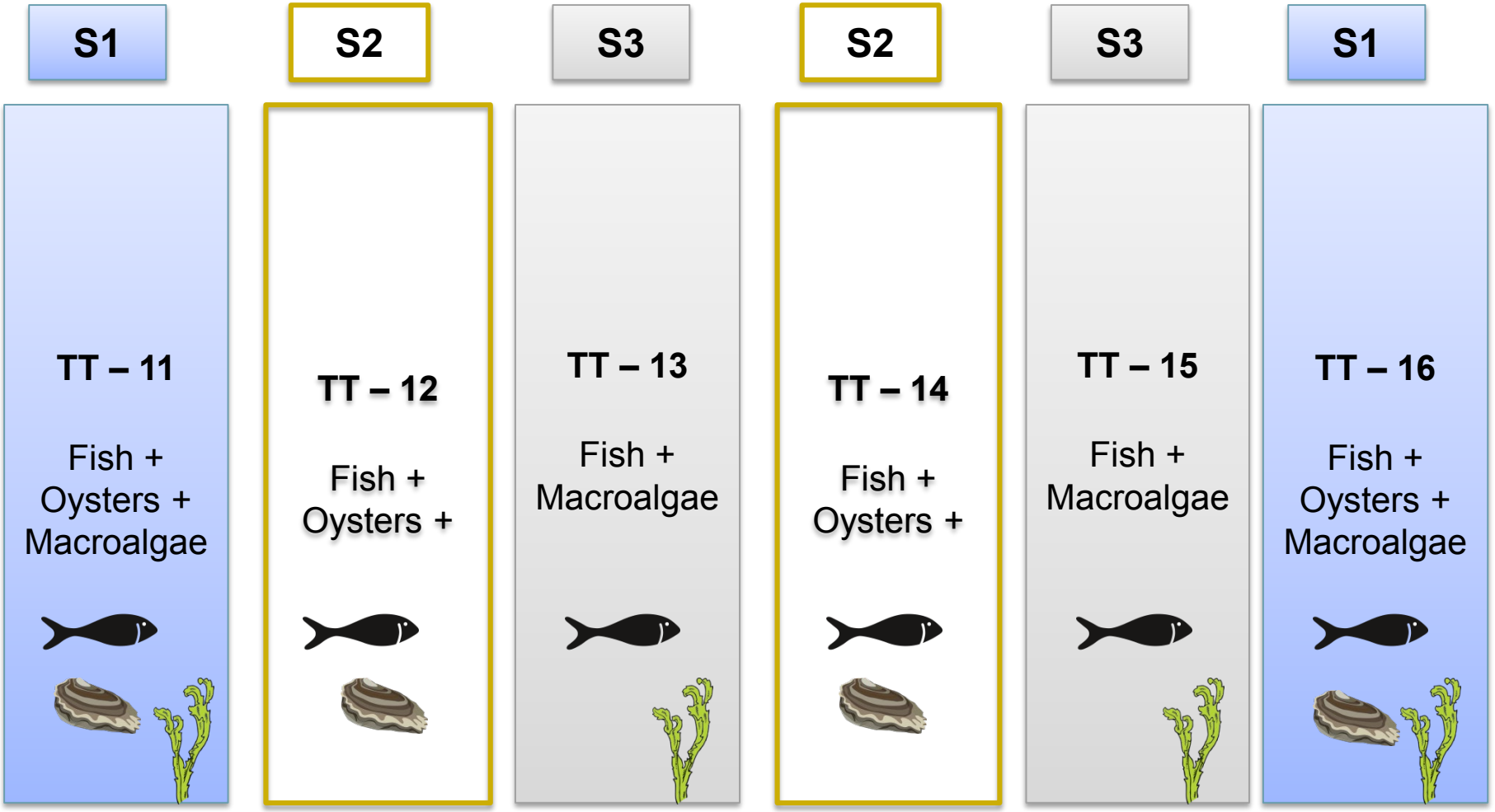
Results: Water quality

Parameter	LFHO	HFLO
Temperature (ºC) (n = 906)	23,4 ± 4,36 (13,0 – 30,4)	23,5 ± 4,33 (13,1 – 30,4)
Salinity (PSU) (n = 906)	35,9 ± 0.79 (35,36 – 37.31)	36,0 ± 0.79 (35,39 – 37.41)
Dissolved oxygen (mg/L) n = 906	↑ **5,9 ± 1,88 ***** **(3,89 – 10.88)**	**5,5 ± 1,94 ***** **(3.47 – 12.91)**
pH n = 906	↑ **8,0 ± 0.31 **** **(7,66 - 8,72)**	**7,9 ± 0.33 **** **(7,23 – 8,73)**
Turbidity (FNU) n = 906	↓ **5,3 ± 2,32 ***** **(1,2 – 12,5)**	**18, 4 ± 4,44 ***** **(7,9 – 31,3)**
Chlorophyll *a* (µg/L) n=27	↓ **9.2 ± 11,09 *** **(0.9 -44.9)**	**18.6 ± 21,18 *** **(0.9 -63.0)**

Economic impact

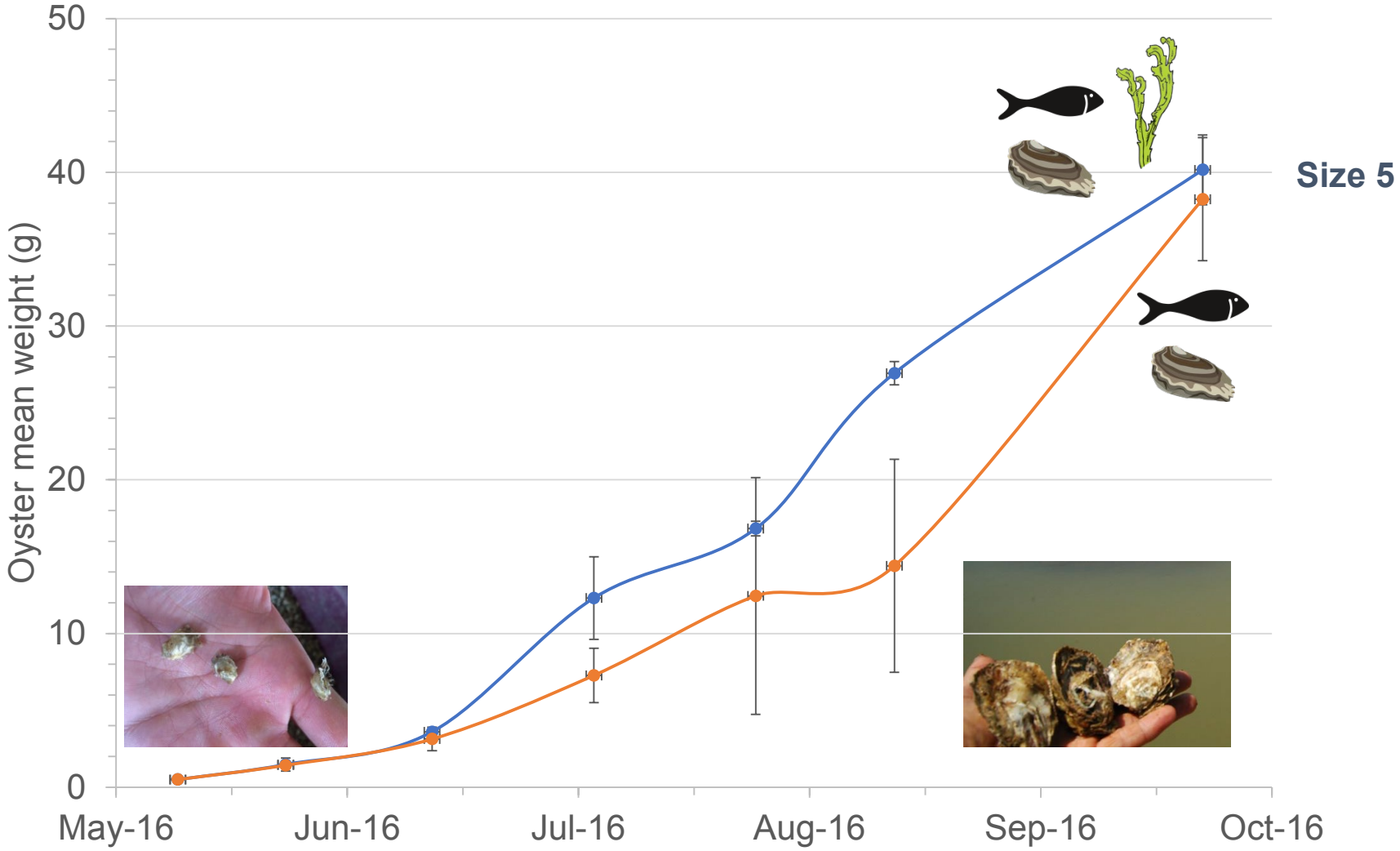
	TREATMENT	
	FISH	OYSTER
Revenue (10^3 Euros)		
Meagre	211,95	111,38
Oysters	16,2	86,4
Total	228,15	197,78
Cost (10^3 Euros)		
Meagre juveniles	28,26	14,85
Oysters	1,99	10,6
Feed used	82,43	45,29
Aeration	0,79	0,47
Wasted Nitrogen	88,9	48,75
Wasted Phosphorus	4,25	2,33
Total	206,62	122,29
Total profit (10^3 Euros)	21,53	75,49
Cost per Kg of produced biomass (Euros)	3,94	2,28

Last experimental conditions

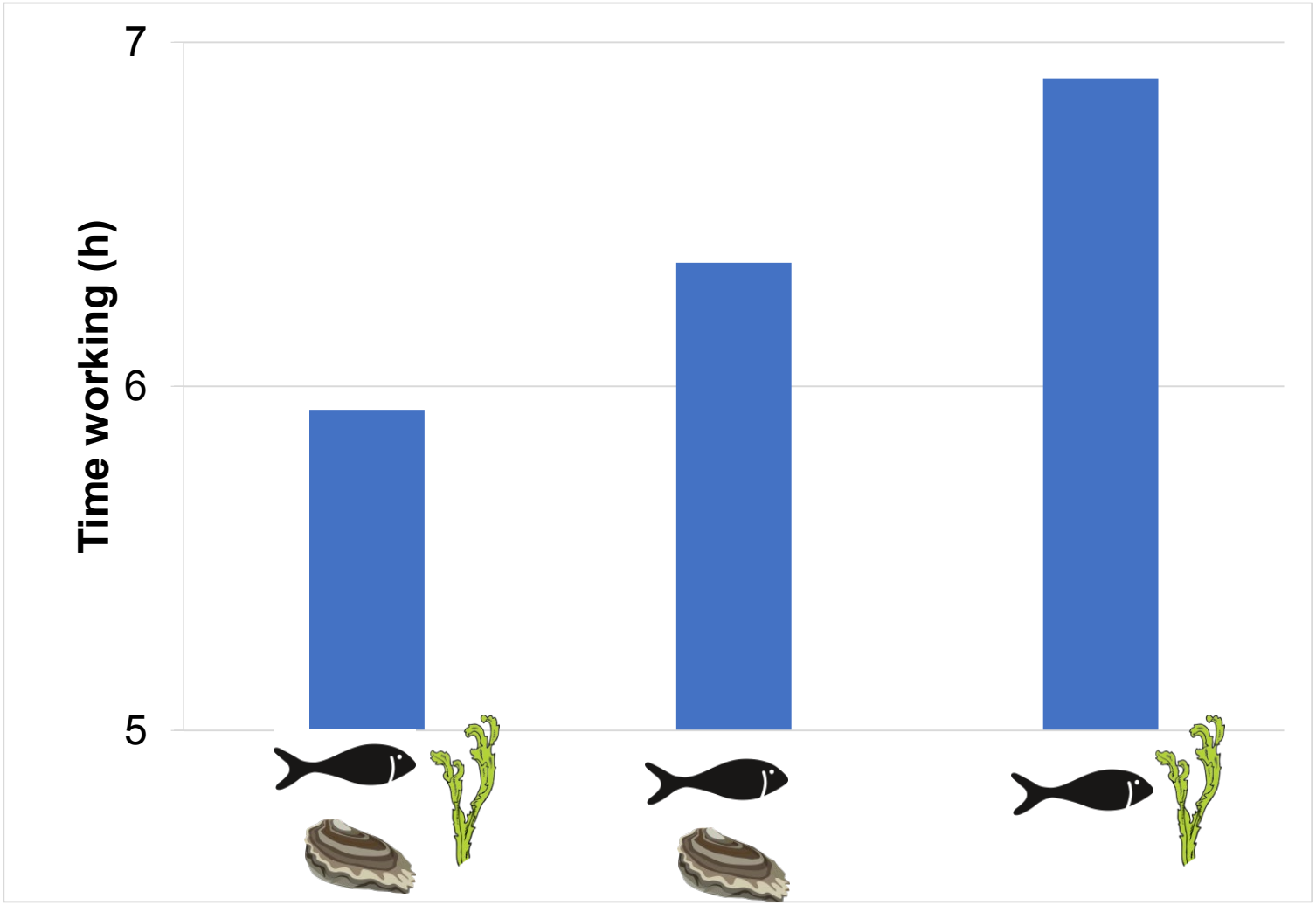


A ≈ 500 m$^{2;}$; V ≈ 750 m^3

Results – OYSTER mean weight



Results – Time of Air Injector



Conclusions

The proportion of oysters to fish should be determined by their selling price

Thank you!!!

Questions?