



## Moving FORWARD with IMTA Interactions between offshore IMTA and inshore aquaculture

Ferreira, J.G.; Lencart e Silva, J. D.; Nunes, J. P.; Saurel, Camille; Vasquez, F.; Bergh, Øivind; Taylor, N.; Verner-Jeffreys, D.

*Publication date:*  
2013

*Document Version*  
Publisher's PDF, also known as Version of record

[Link back to DTU Orbit](#)

*Citation (APA):*  
Ferreira, J. G., Lencart e Silva, J. D., Nunes, J. P., Saurel, C., Vasquez, F., Bergh, Ø., Taylor, N., & Verner-Jeffreys, D. (2013). *Moving FORWARD with IMTA Interactions between offshore IMTA and inshore aquaculture*. Paper presented at World Aquaculture Society: Aquaculture 2013, Nashville, TN, United States.

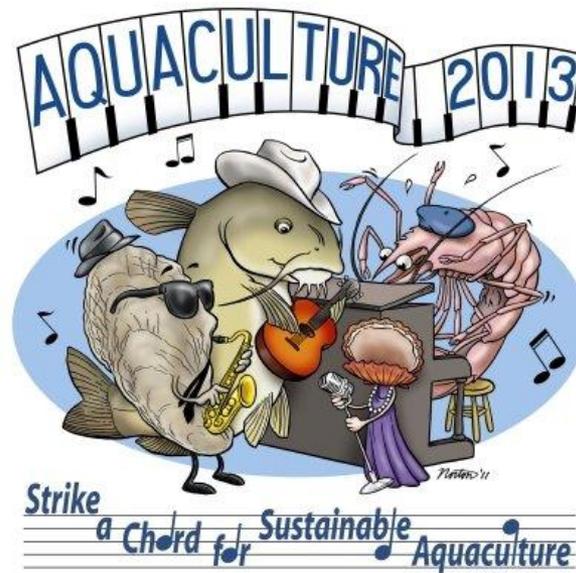
---

### General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.



# Moving FORWARD with IMTA

## Interactions between offshore IMTA and inshore aquaculture

Joao G. Ferreira, João D. Lencart-Silva, João P. Nunes, Camille Saurel,  
Filipa Vazquez, Øivind Bergh, Nick Taylor, David Verner-Jeffreys

**COEXIST**  
Interaction in coastal waters



**FCT**

**FORWARD**



Framework for Ria Formosa  
water quality, aquaculture,  
& resource development

Universidade Nova de Lisboa, Portugal

<http://fojo.org/>

Nashville, Tennessee, February 2013



# Interactions between offshore IMTA and inshore shellfish aquaculture

## Outline of talk

- The FORWARD and COEXIST projects join hands
- Different questions, different models
- IMTA and environmental externalities
- Governance – the part you can't model
- Synthesis

Slides

2

3

7

6

1

---

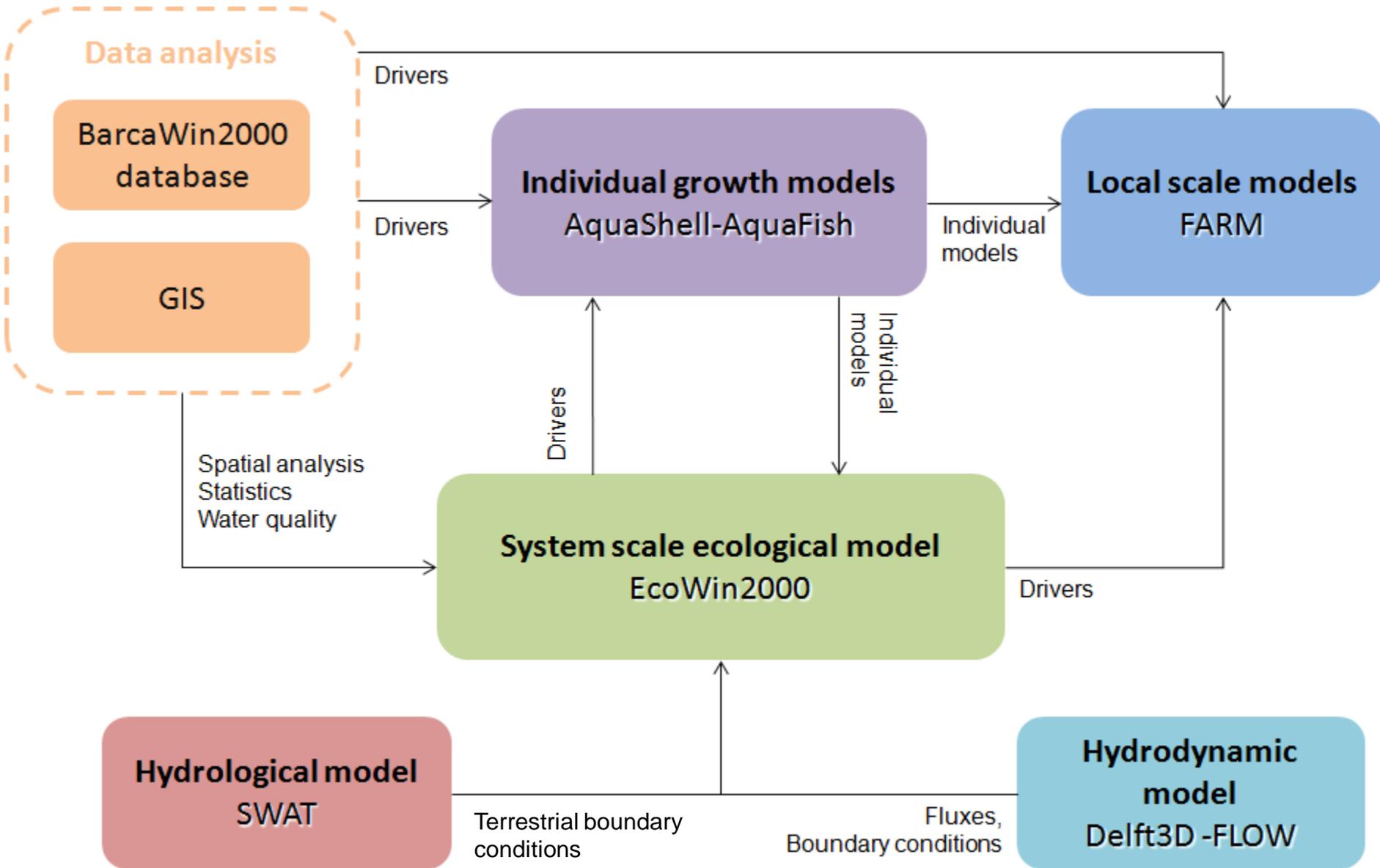
2+19

# The FORWARD project



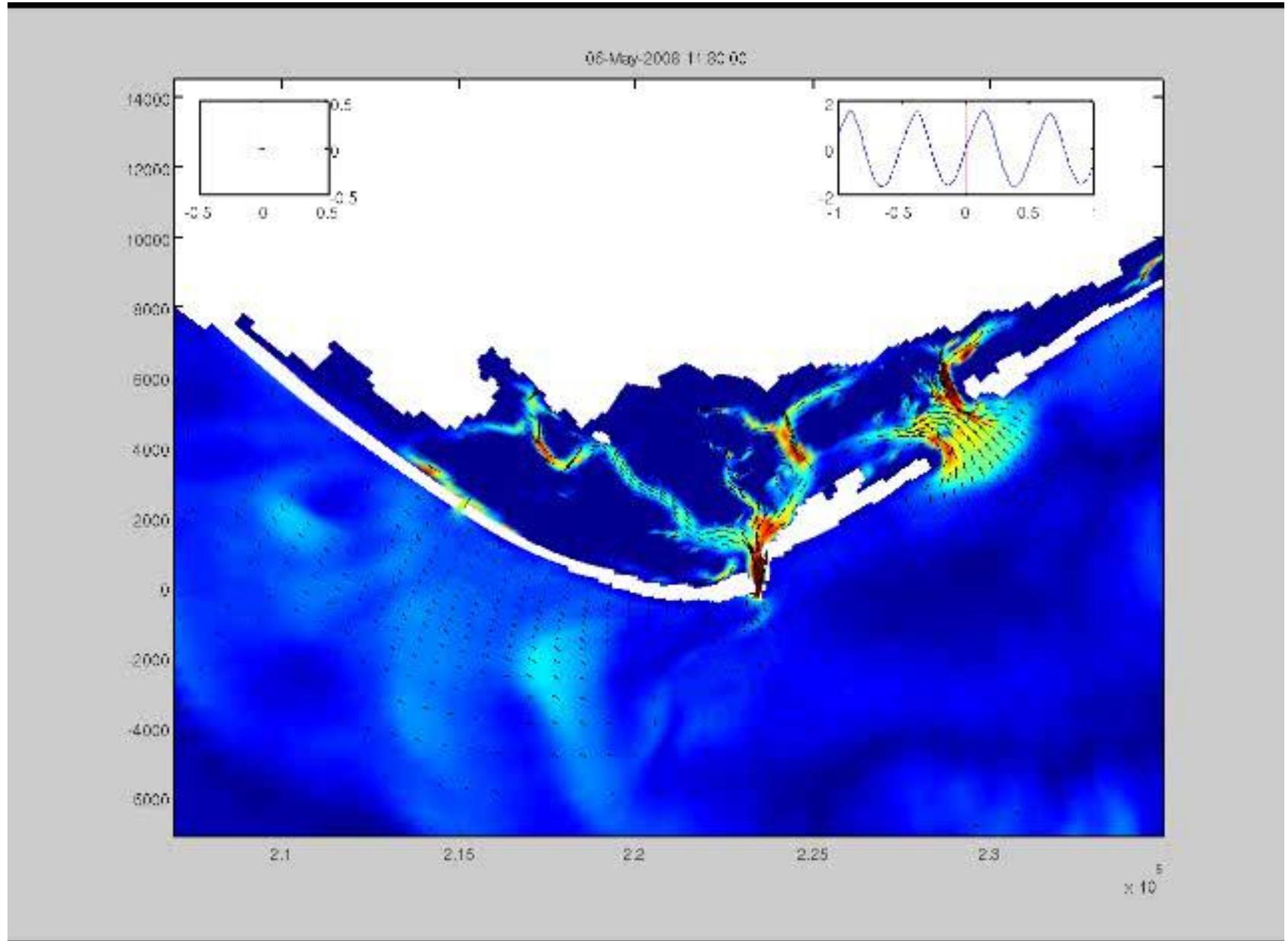
Download the COEXIST/FORWARD book at <http://goodclam.org/forward/>

# FORWARD and COEXIST modelling framework



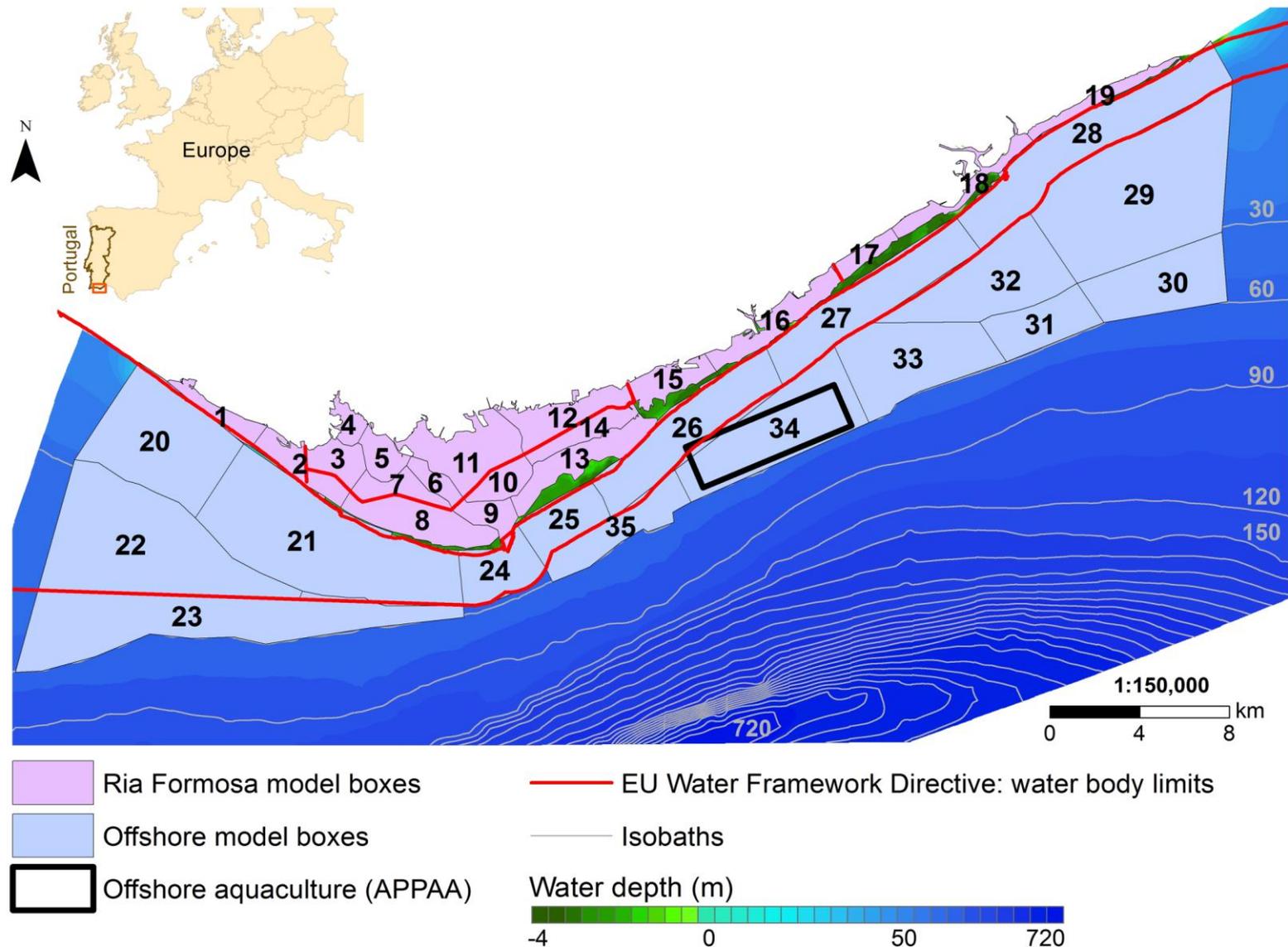
Different models for different questions. Scales are from minutes to decades.

# Connectivity: Offshore- Ria Formosa (circulation model)



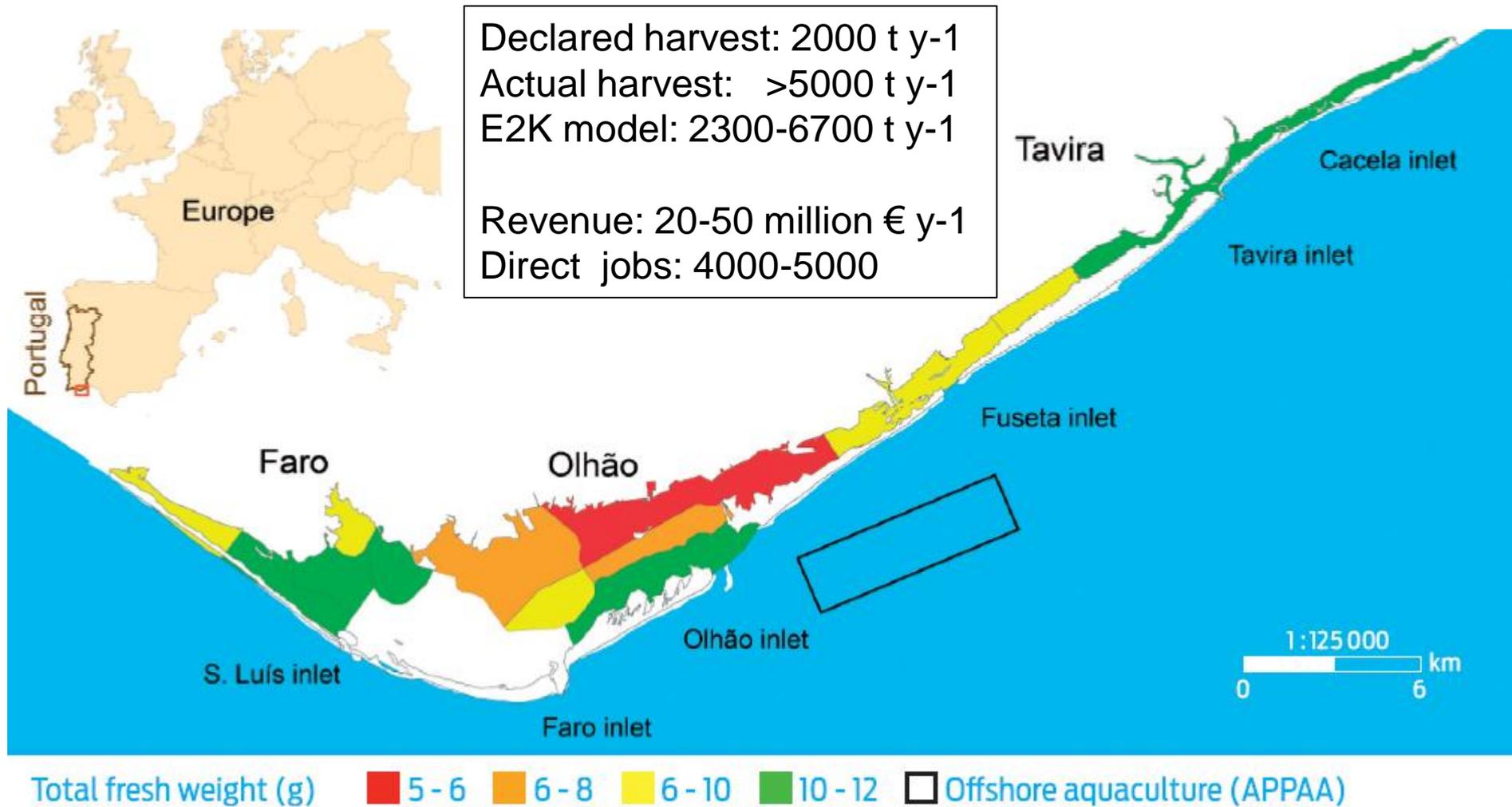
Tidal circulation in the Ria Formosa, Algarve. Water residence time of 1-2 days.

# EcoWin2000 system-scale model – spatial framework



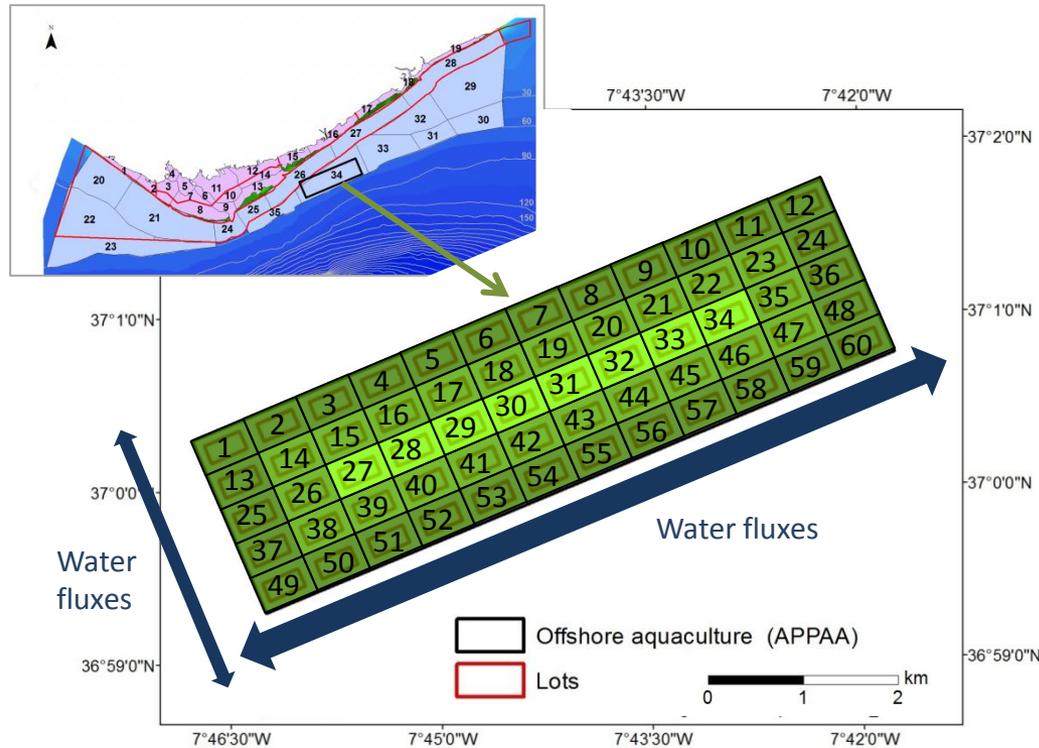
The system is divided into 34 boxes, two vertical layers. Boxes were defined using GIS based on uses, legislation, water quality, and hydrodynamics.

# EcoWin2000 model – system-scale clam production



System-scale carrying capacity is spatially variable, depends on ocean connections.

# Goods and services from bivalves



- Removal of organic waste from finfish aquaculture
- Detrital organic material enhances shellfish growth
- Bivalves may act as a firewall to prevent disease spread

Up to 70% finfish

At least 30% bivalves

Several large areas in the Algarve are currently designated for offshore aquaculture

# Mass balance for gilthead cultivation

Weight: 350 g, AquaFish model

Anabolism: 1471 kcal  
BMR: 277 kcal  
SDA: 809 kcal  
Swimming: 0.2 kcal

Energy assimilated  
385 kcal

Food ingestion  
449 g DW

Feed supplied  
463 g DW

Respiration  
0.78 kg O<sub>2</sub>

Digestion in the gut

Faeces  
126 g DW

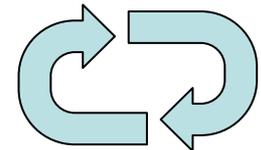
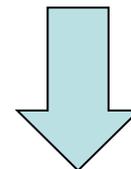
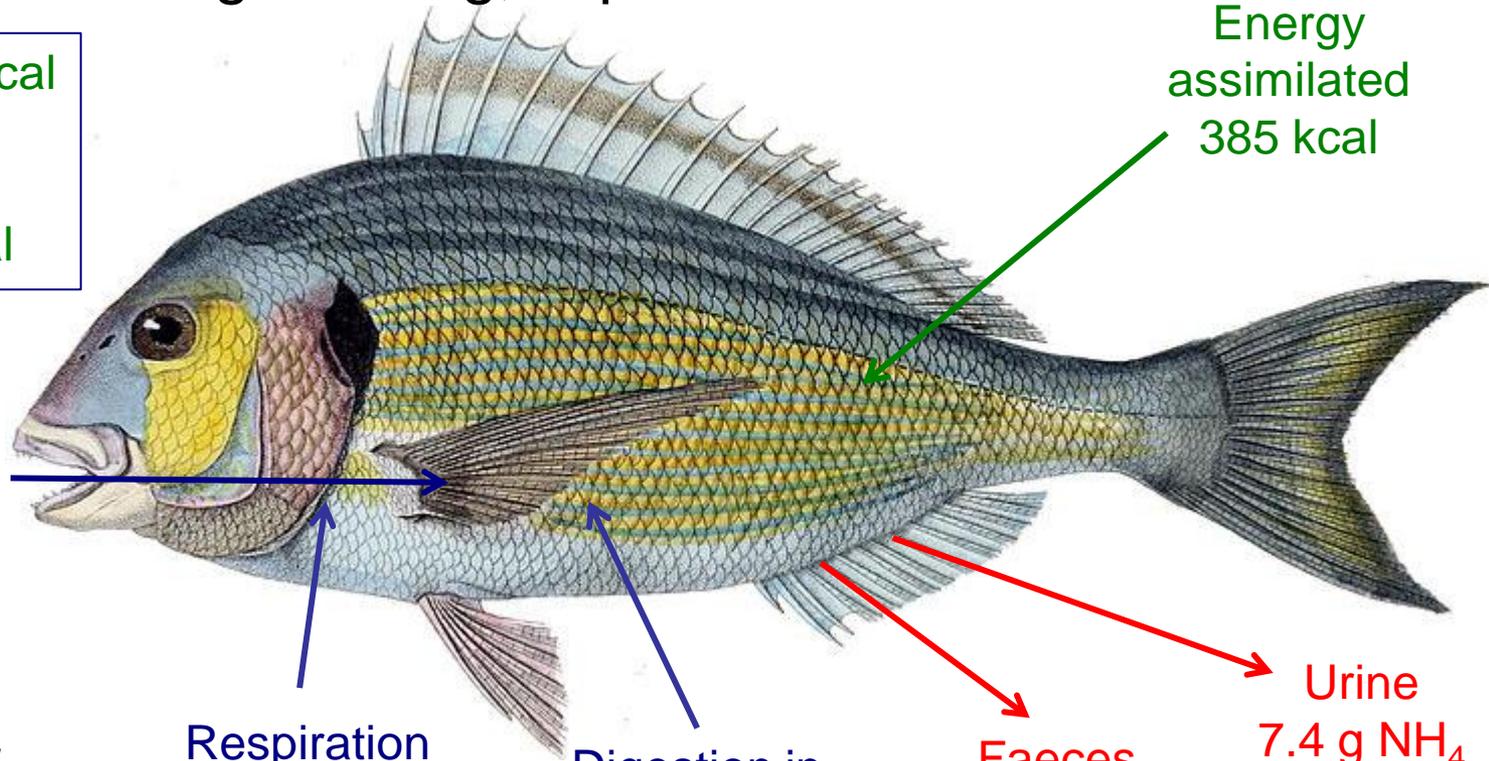
Urine  
7.4 g NH<sub>4</sub>

Feed loss  
14 g DW

Organic pollution  
140 g DW

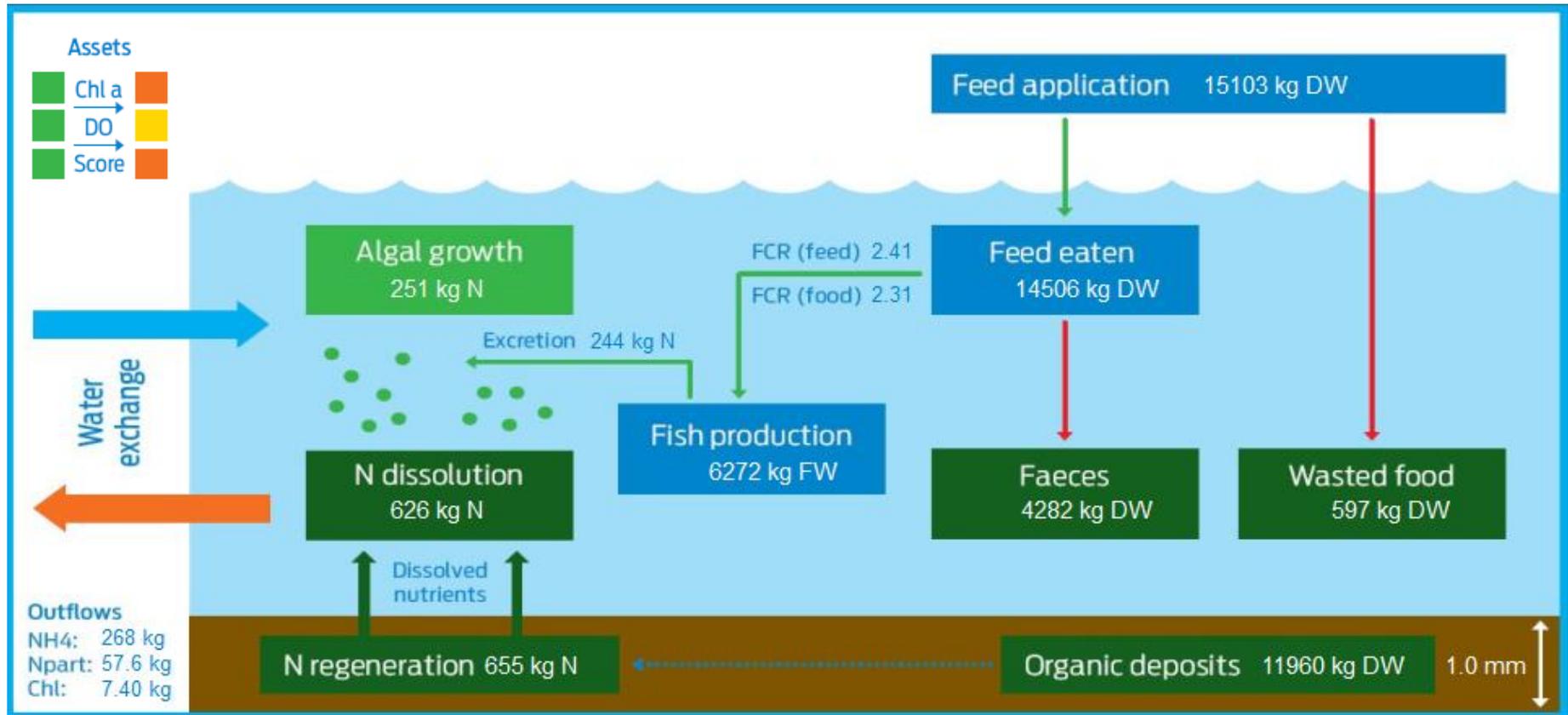
Inorganic pollution  
7.4 g NH<sub>4</sub>

Cultivation: 414 days  
Current: 10 cm s<sup>-1</sup>  
Biomass: 350 g FW  
Length: 29 cm  
FCR: 1.3  
ADC (N): 82%



# FARM model for culture of finfish

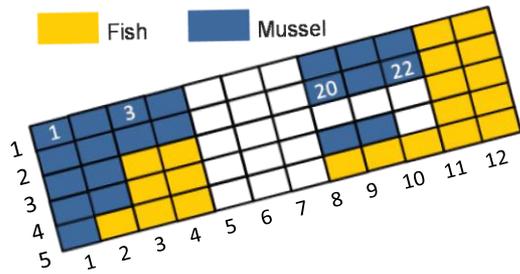
## AquaFish model – gilthead bream (*Sparus aurata*)



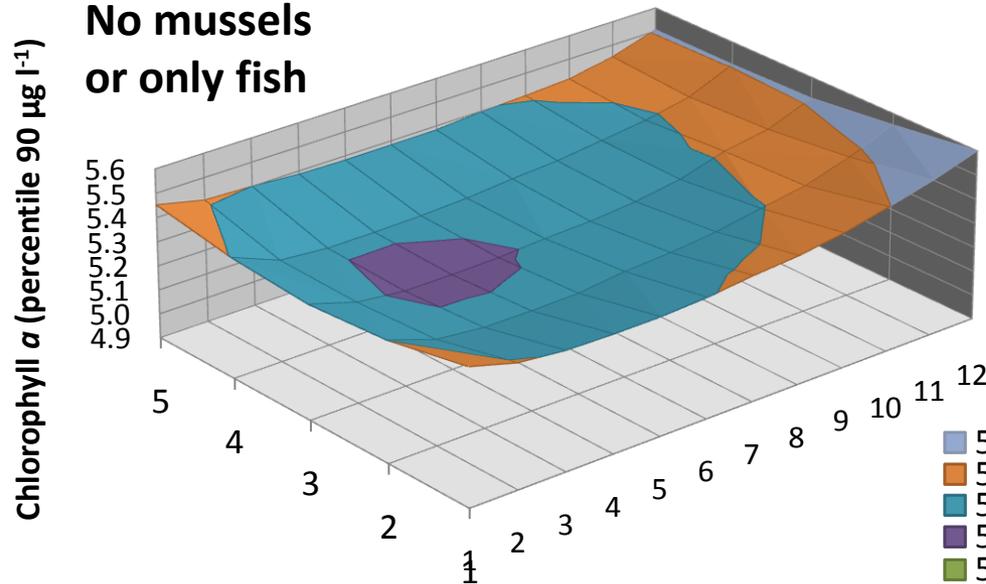
Mass balance for gilthead pond culture - models are important for optimization

# EcoWin2000 model analysis

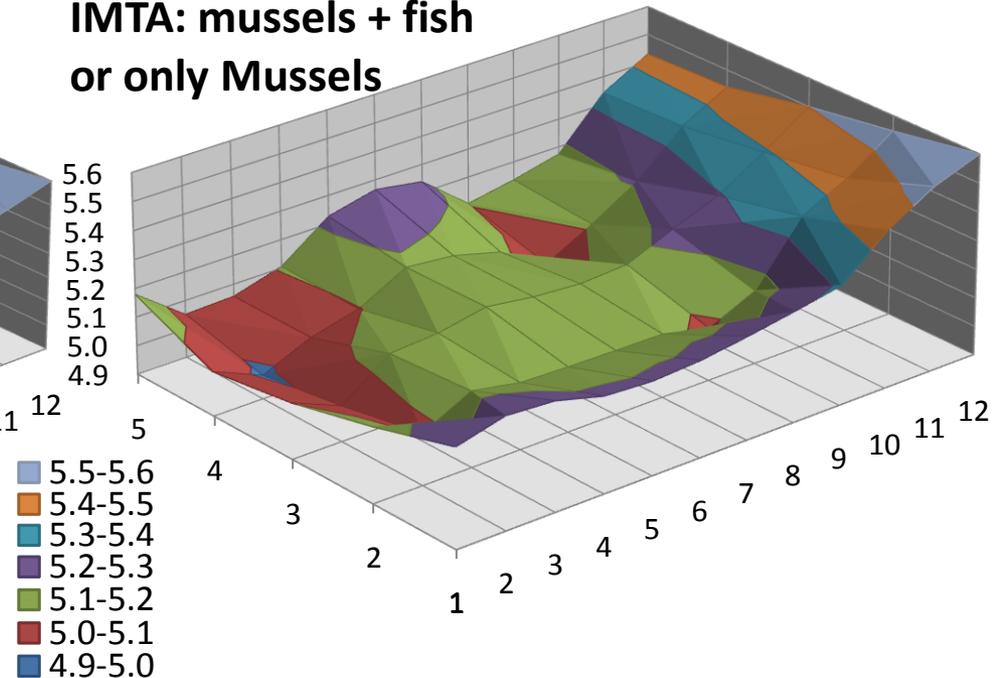
## Food availability in the offshore IMTA area



**No mussels  
or only fish**

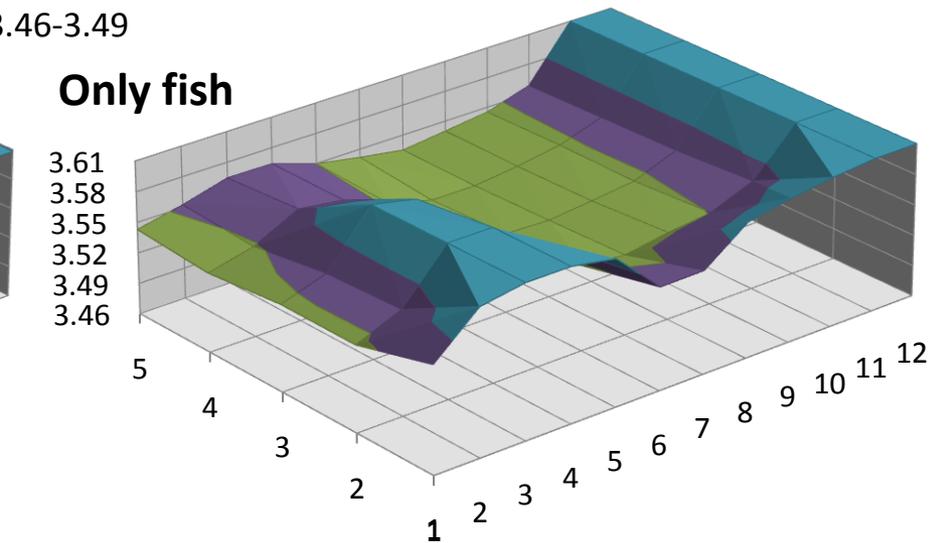
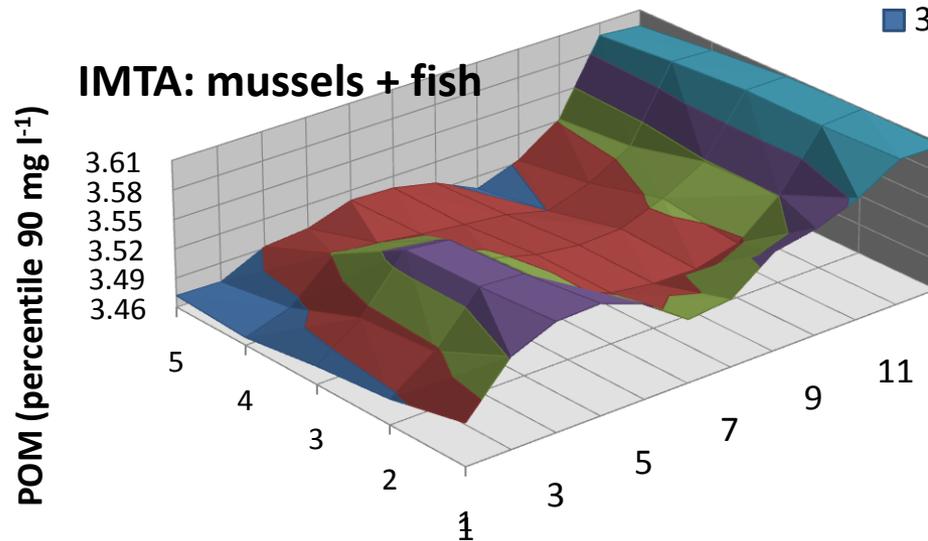
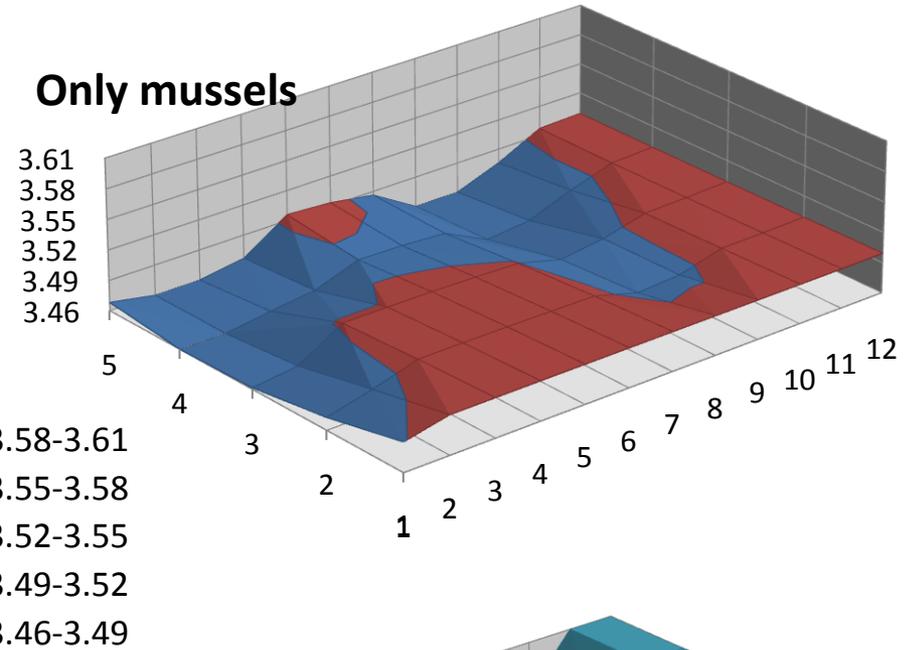
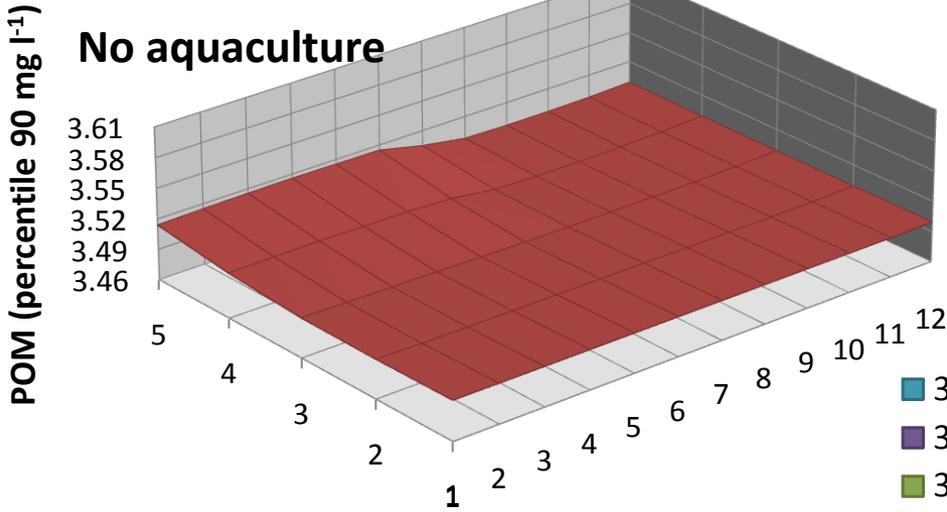
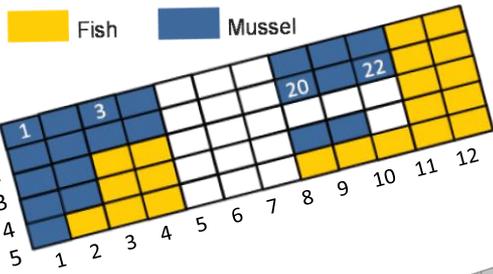


**IMTA: mussels + fish  
or only Mussels**



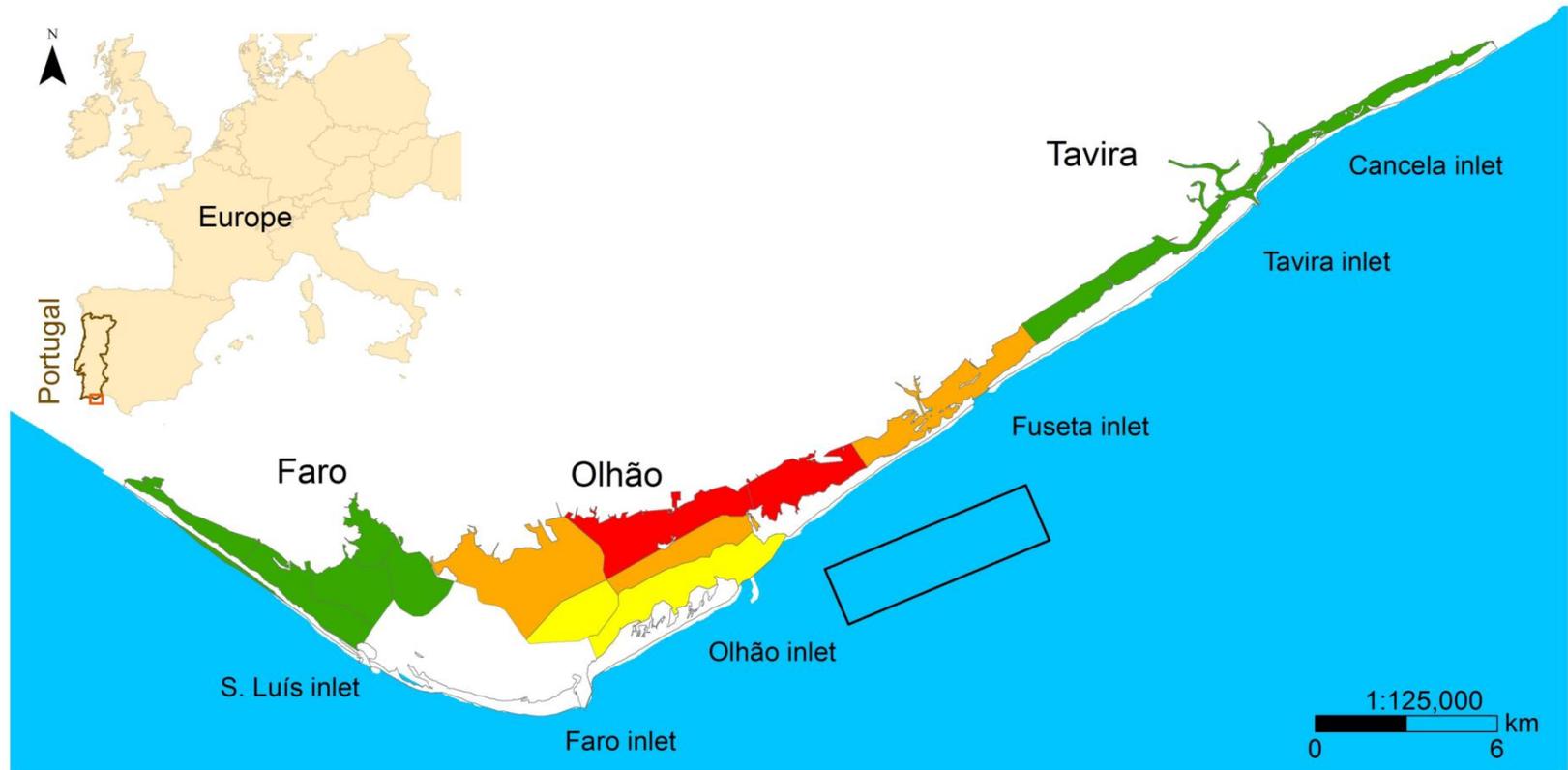
The effect of monoculture and IMTA on food depletion can be clearly distinguished. Chlorophyll a percentile 90 is used as a proxy.

# Positive externalities of shellfish culture





# EcoWin2000 - Simulated change in clam harvest due to offshore aquaculture of mussels



An annual loss of 120 t of clams (1.2 million €) is offset by 13,000 t of mussels

## The FORWARD and COEXIST projects - Carrying capacity Social aspects and governance - The other 50%...

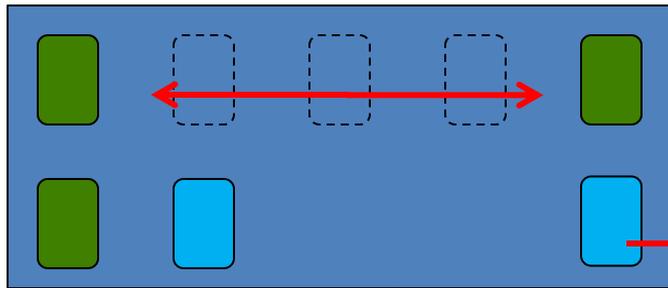
- Even if you solve 50% of the problem, you still need to resolve the other half
- Social aspects and governance cannot be modelled, but are very important
- Examples: moving animals among regions can spread disease; small leases can conflict with each other; governance issues over the use of machines; obstacles to certification
- Lots of plans, no practical results – respecting multiple uses (third principle of EAA): the Paper Park syndrome
- Good governance is a major element of success

**Mathematical models can address part of the issues, but that still leaves the rest...**

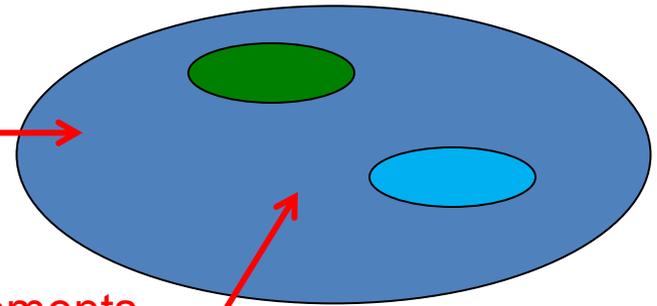
# Disease modelling approach



Integrated Multi-Trophic  
Aquaculture (IMTA)



Wild stocks  
Wild fish reservoirs



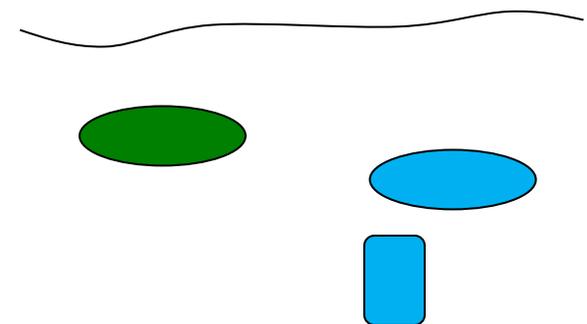
Anthropogenic stock movements  
Finfish escapes/migrations  
Hydrodynamic connectivity



Relaying

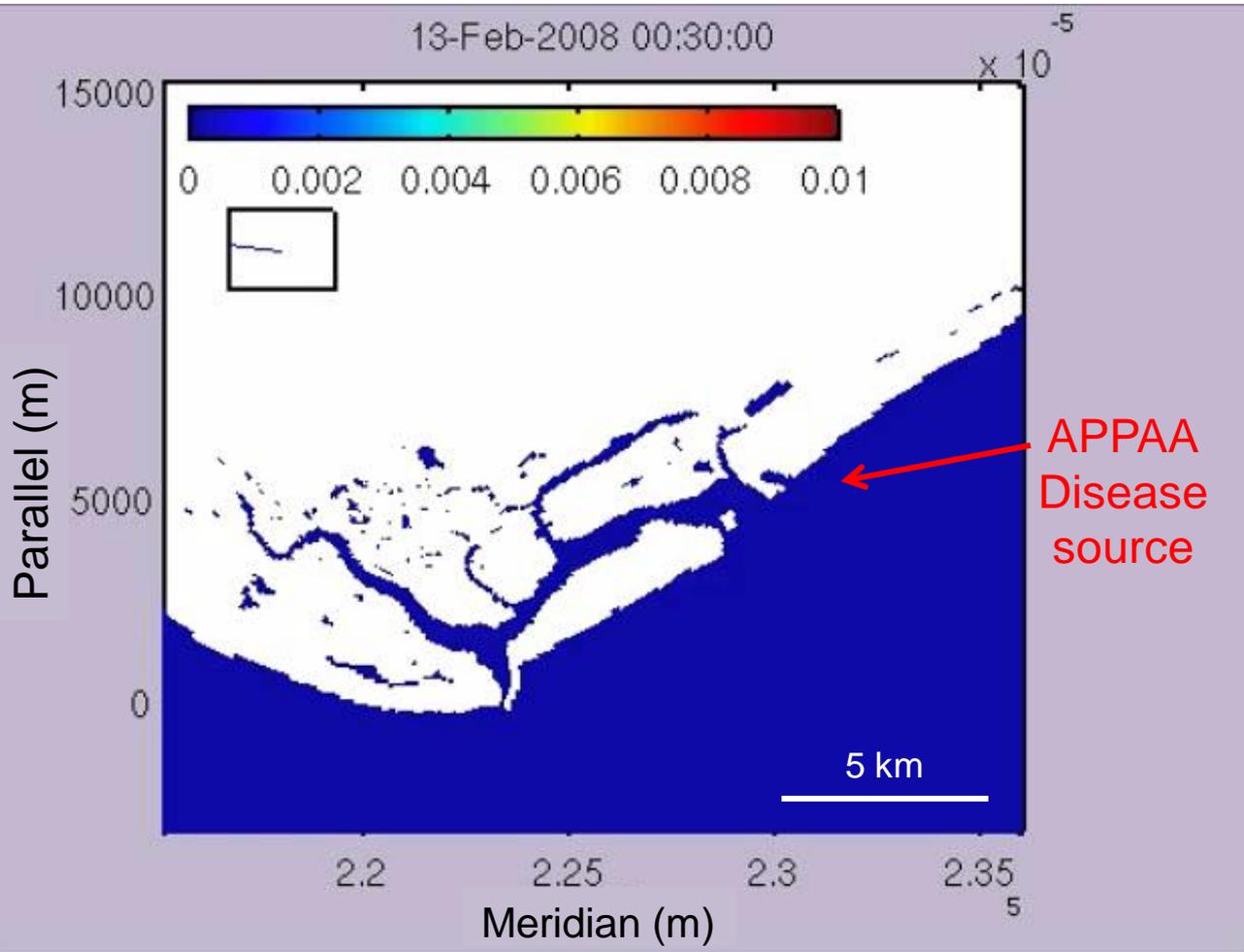


Shellfish aquaculture



# Virus Particle tracking:

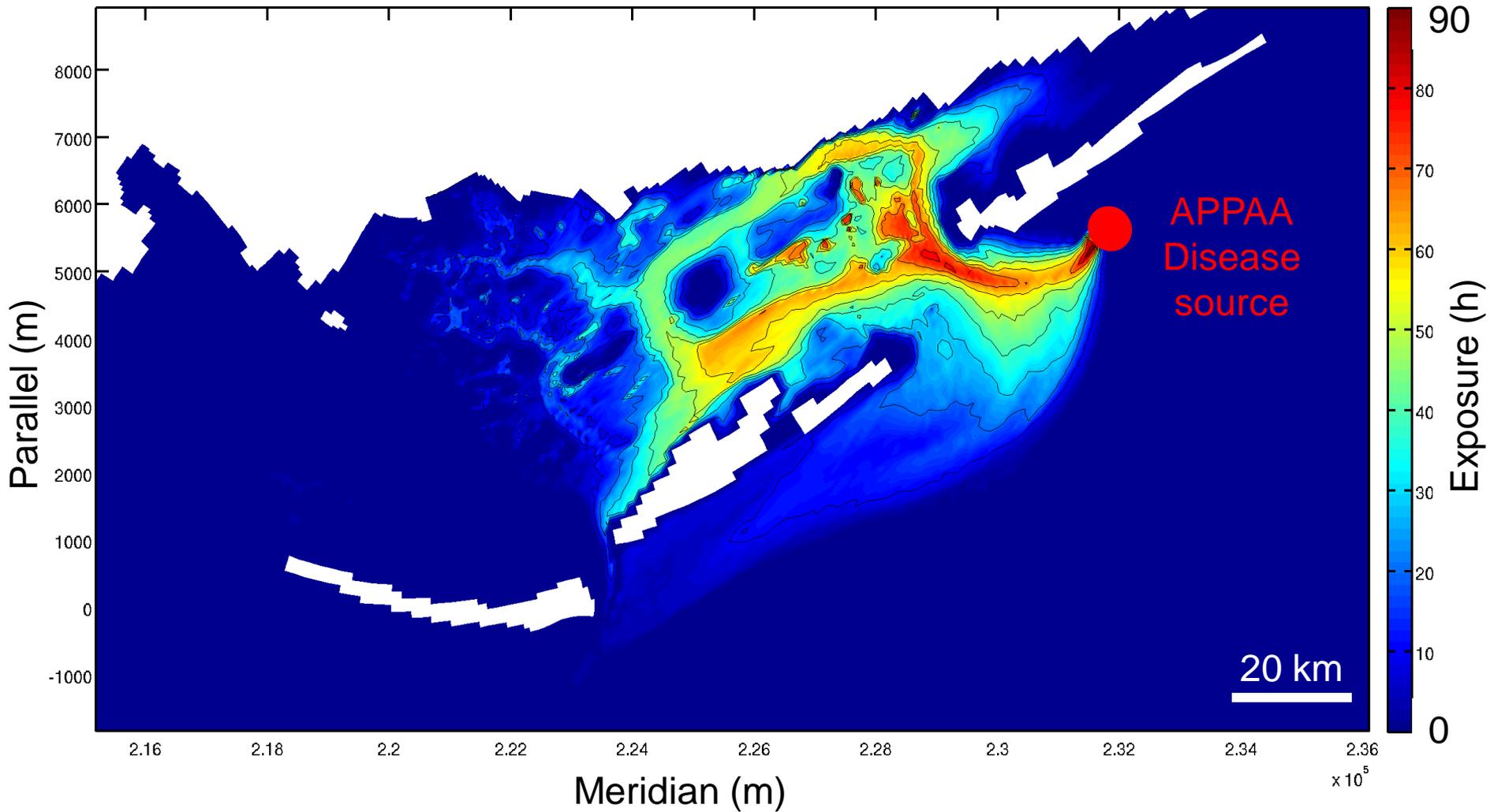
Ratio between concentrations at XYZ and emission concentration



- Disease source: APPAA
- Virus concentration: Up to  $2 \times 10^6 \text{ ml}^{-1}$
- Forcing functions wind and tide
- No decay
- 6 day model run
- Release in mid-water layer

Background virus release the first 2 days, high release on days 3,4 and 5, then a reduction by a factor of a hundred on the last day.

# Virus exposure



Number of hours of exposure to 0.5% of the shedding concentration as a measure of potential infection.

# The revenge of the killer mussels...



Huge mussel fouling in the summer of 2012. Spat from offshore culture?

# The revenge of the killer mussels – part II



February 19<sup>th</sup> 2013: mussel fouling on untreated fish culture nets. The nets sank under the weight of mussels.



# Synthesis

- A set of models that address different issues, at different time and space scales, can be very valuable for coastal management;
- Disease prediction is a key aspect of aquaculture, but disease spread is difficult to model deterministically;
- Risk-based approaches and stochastic simulations can be combined with growth models to address disease;
- We cannot model the vagaries of the human mind—but for sustainable development, we need to factor them in;
- Sound governance, and stakeholder-driven participation, are key factors in making the public understand that IMTA can and should be a positive sum game.

[Read the book! http://goodclam.org/forward/](http://goodclam.org/forward/)