Moving FORWARD with IMTA
Interactions between offshore IMTA and inshore aquaculture

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COEXIST
Interaction in coastal waters

FCT

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

RIA FORMOSA
POLIS LITORAL
REQUALIFICAÇÃO E VALORIZAÇÃO DA ORLA COSTEIRA

Universidade Nova de Lisboa, Portugal
http://fojo.org/

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Interactions between offshore IMTA and inshore shellfish aquaculture

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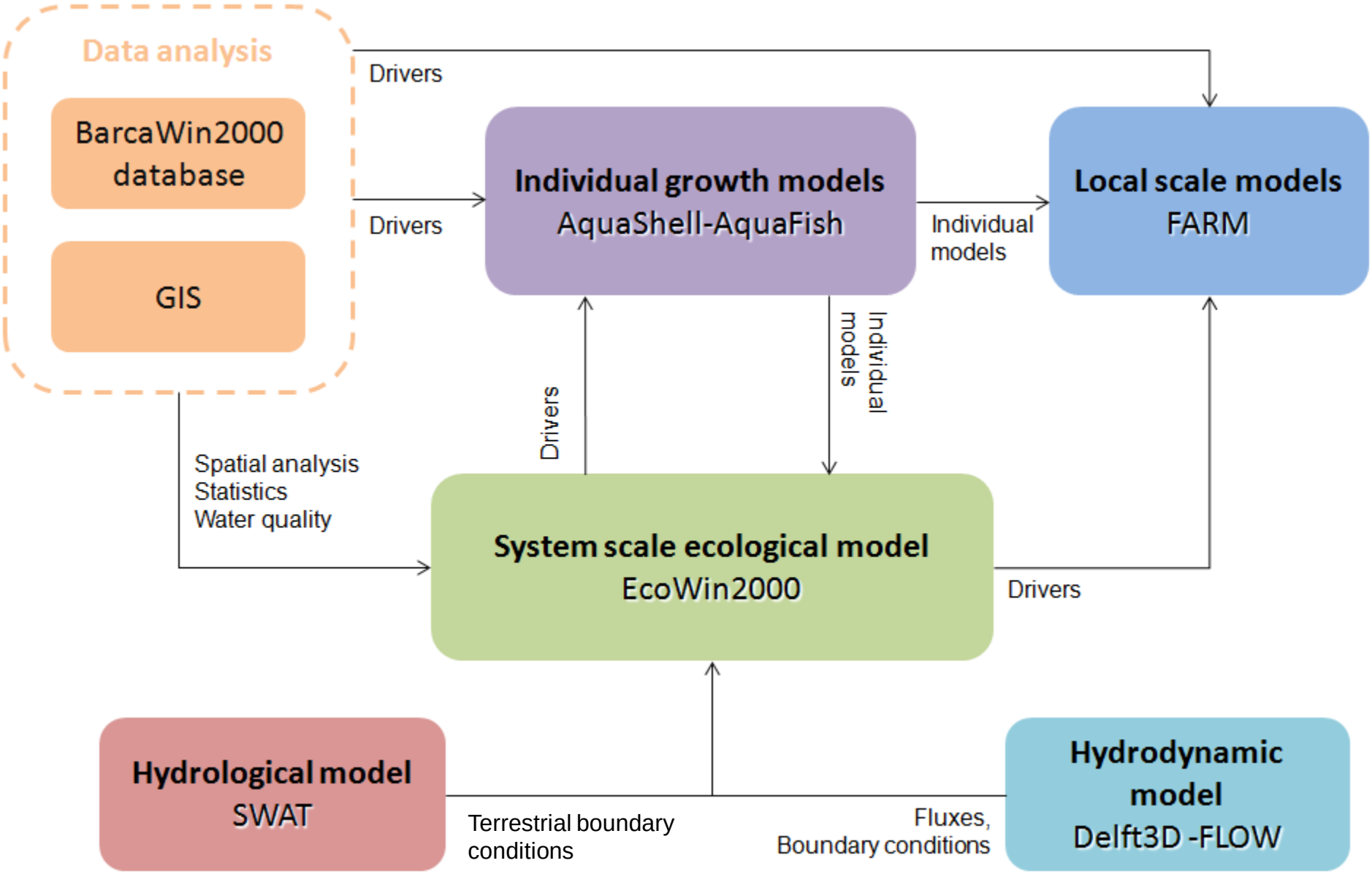
Ria Formosa, Portugal

The FORWARD project

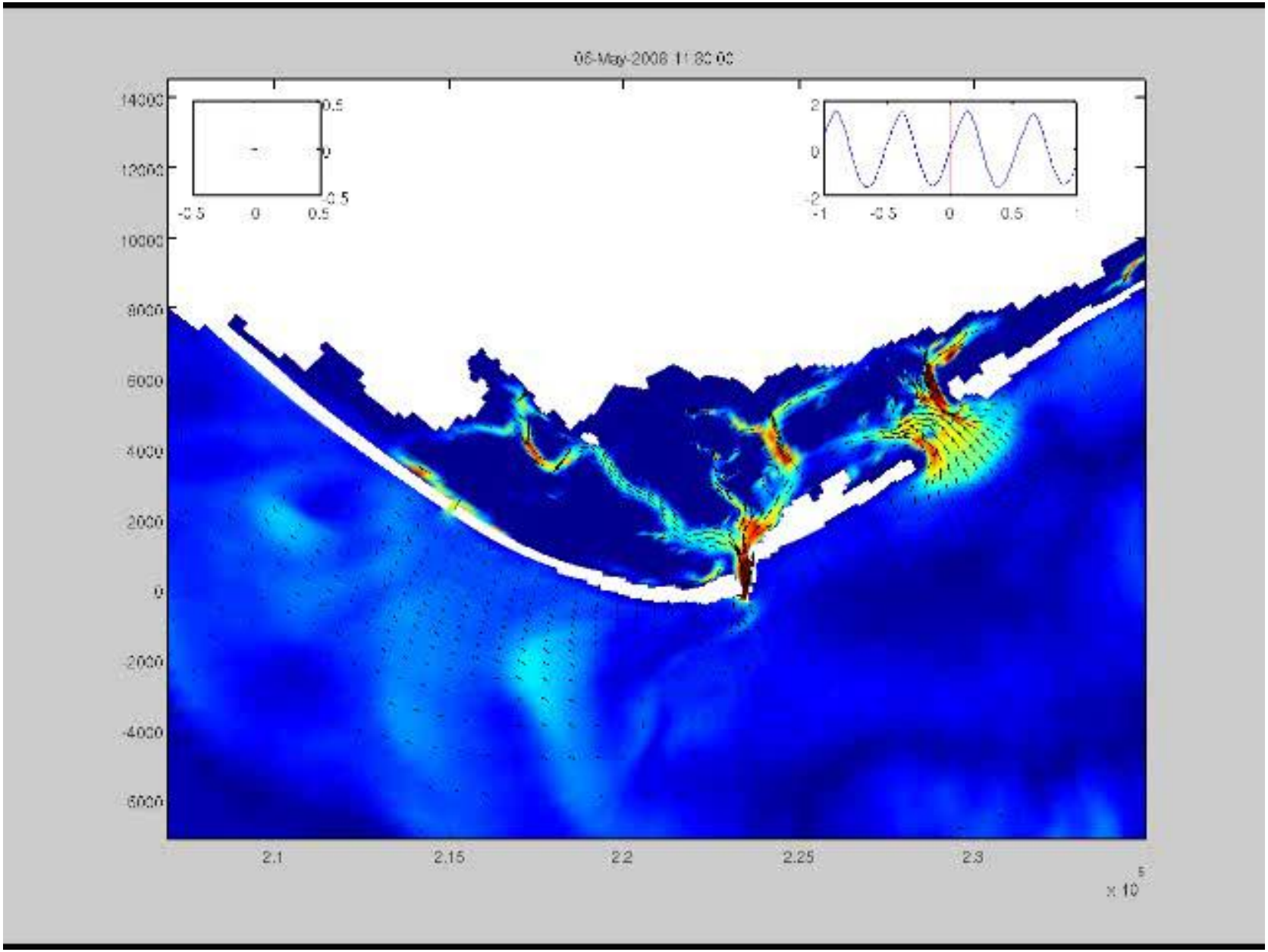
Download the COEXIST/FORWARD book at http://goodclam.org/forward/

FORWARD and COEXIST modelling framework



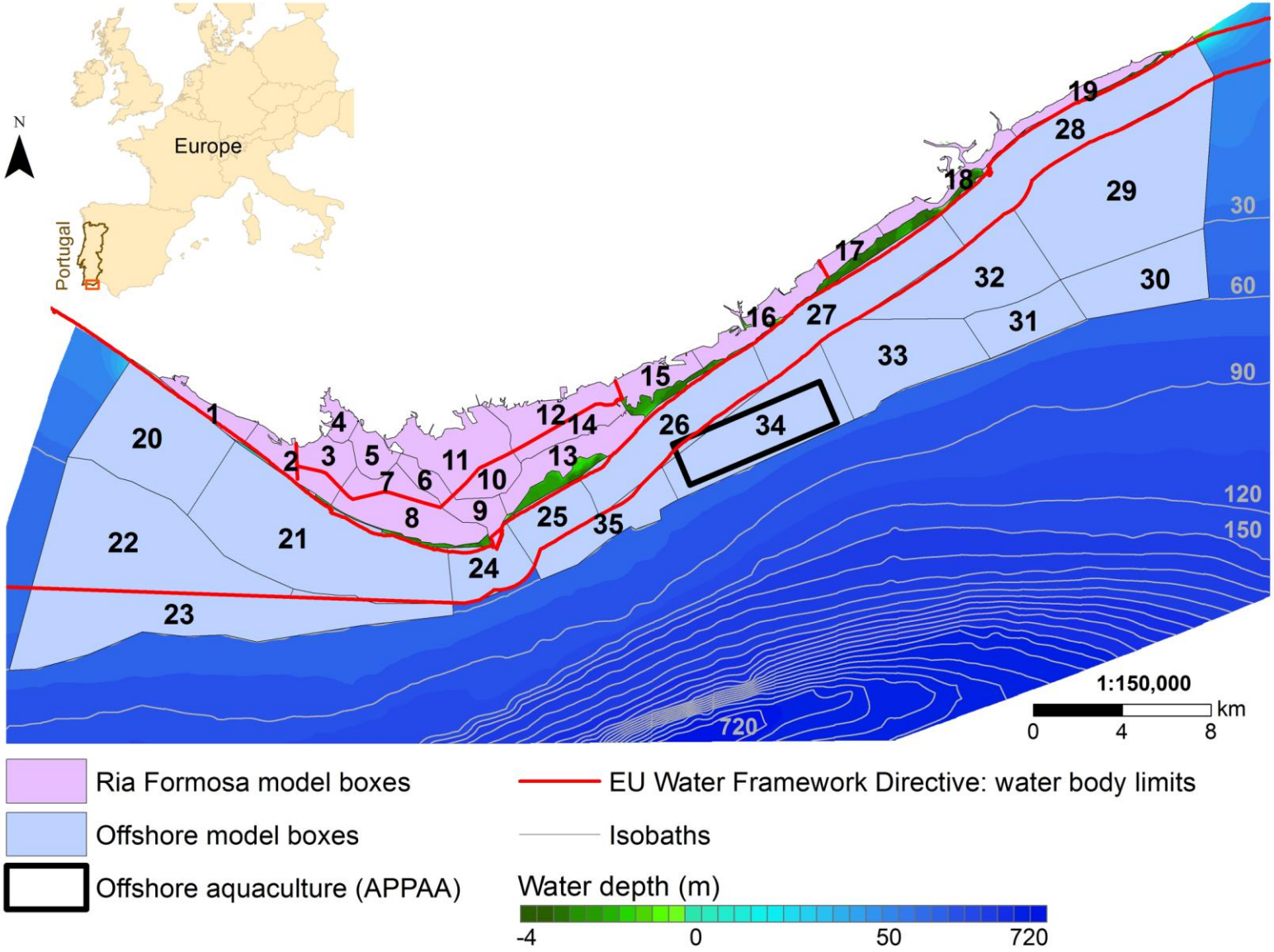
Different models for different questions. Scales are from minutes to decades.

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

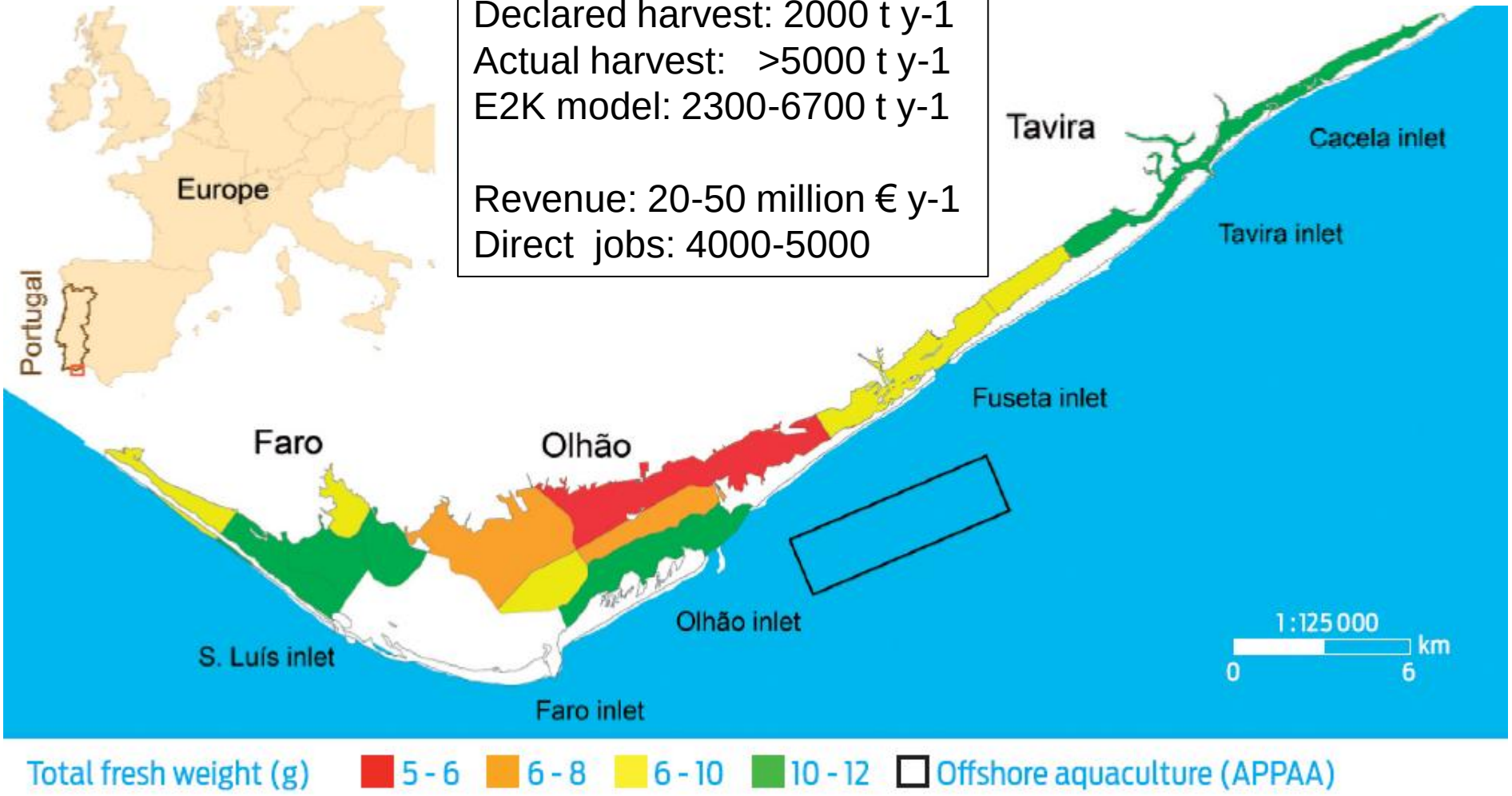


The system is divided into 34 boxes, two vertical layers. Boxes were defined using GIS based on uses, legislation, water quality, and hydrodynamics.

EcoWin2000 model – system-scale clam production

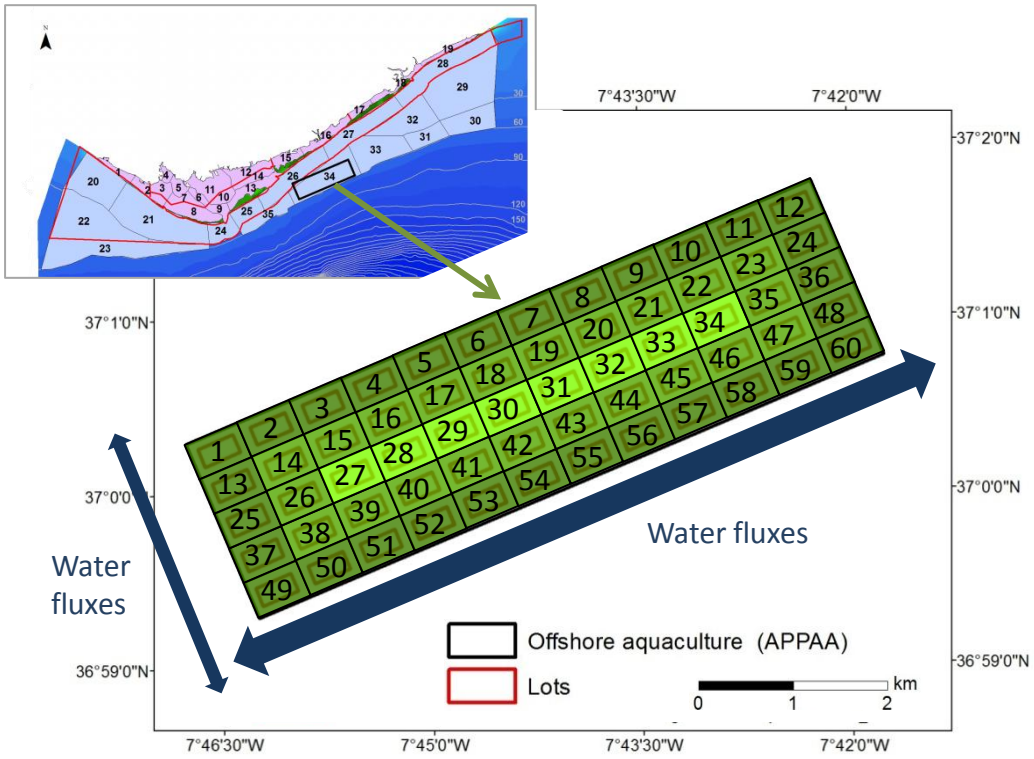
Declared harvest: 2000 t y-1
Actual harvest: >5000 t y-1
E2K model: 2300-6700 t y-1

Revenue: 20-50 million € y-1
Direct jobs: 4000-5000



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

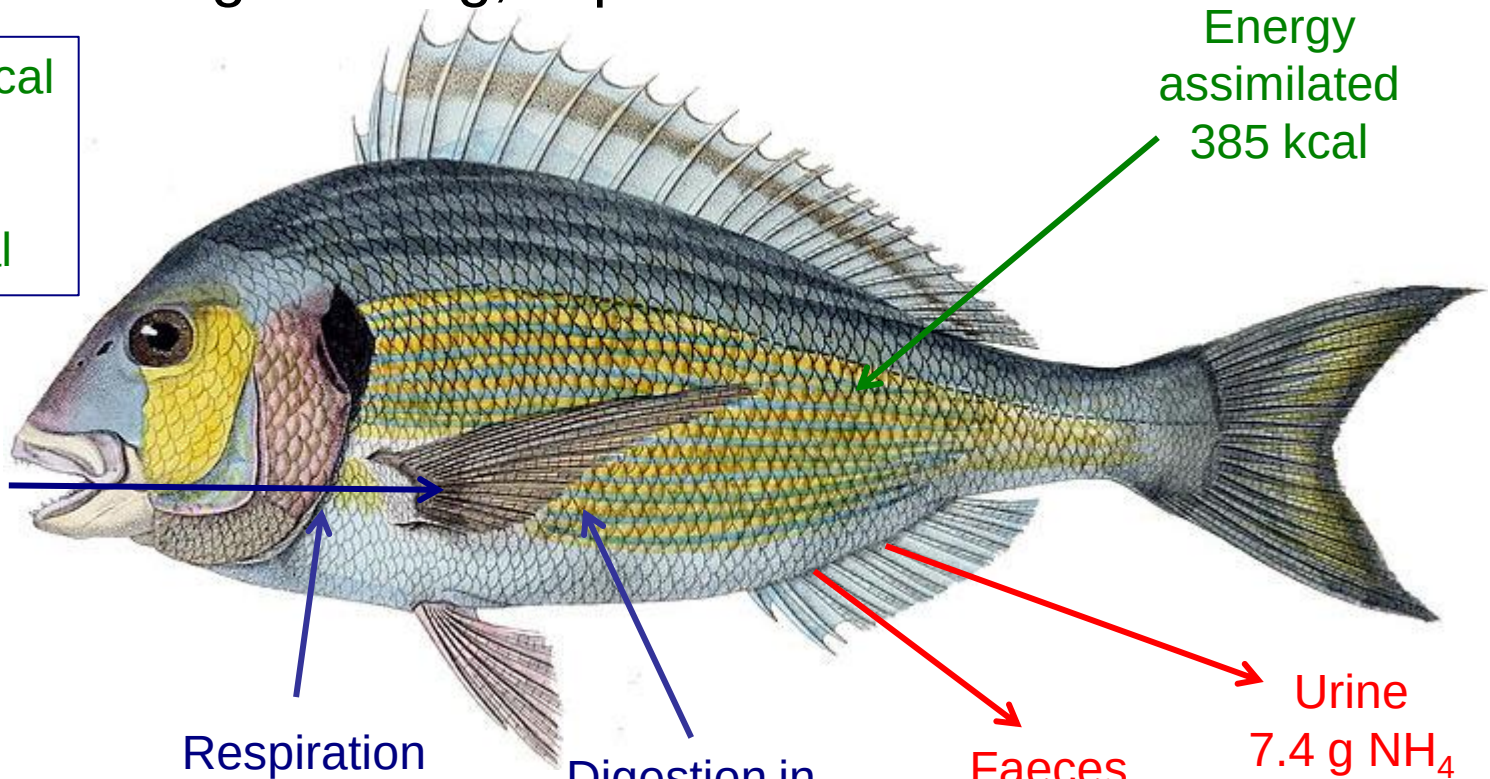
Up to 70% finfish
At least 30% bivalves

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_2

Digestion in the gut

Faeces 126 g DW

Urine 7.4 g NH_4

Feed loss 14 g DW

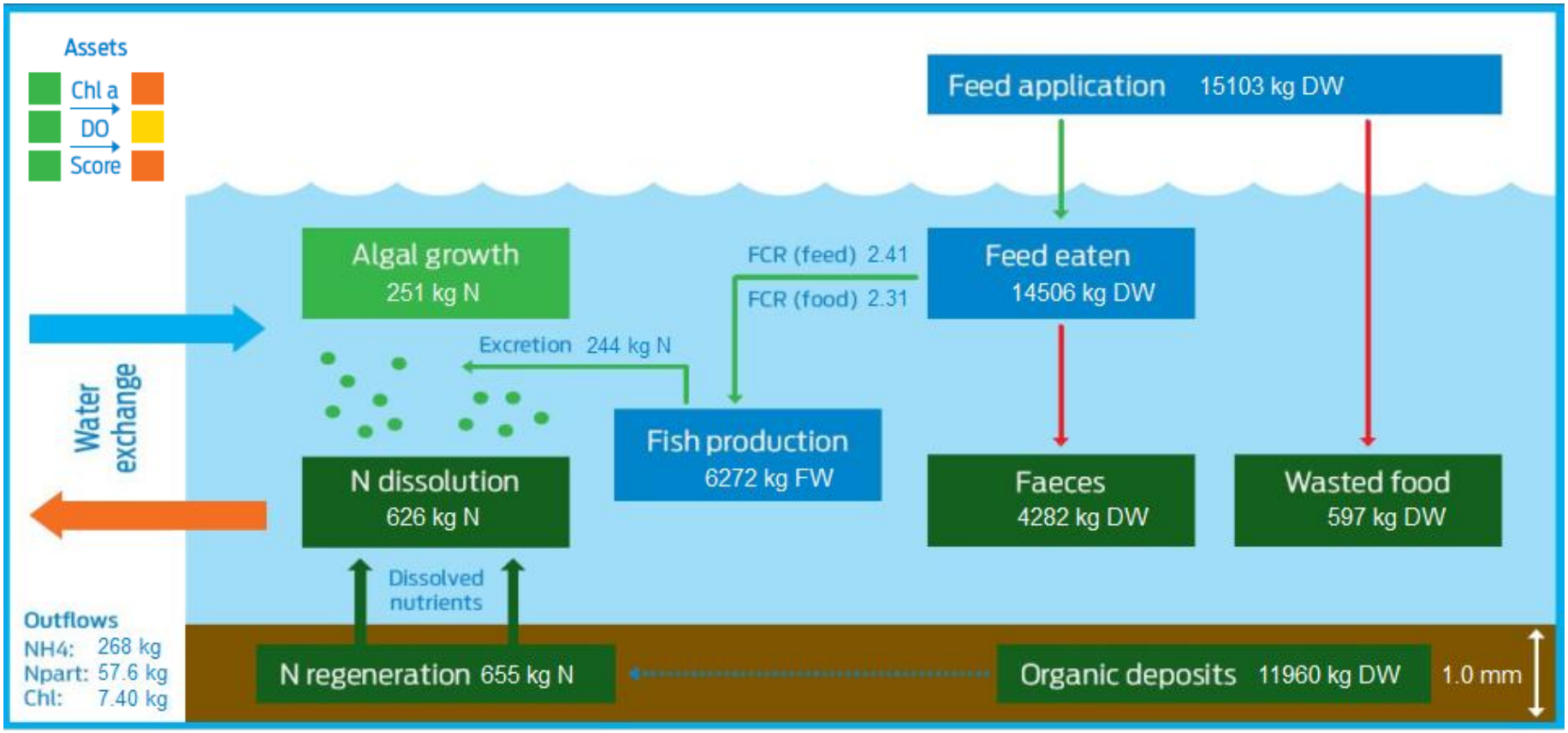
Organic pollution 140 g DW

Inorganic pollution 7.4 g NH_4

Cultivation:414 days
Current: 10 cm s^{-1}
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*)

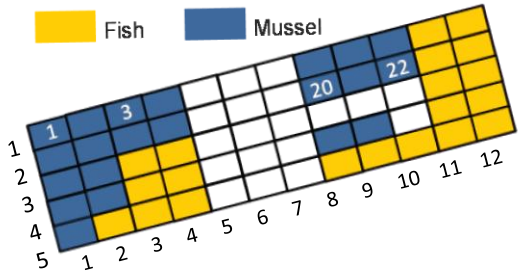


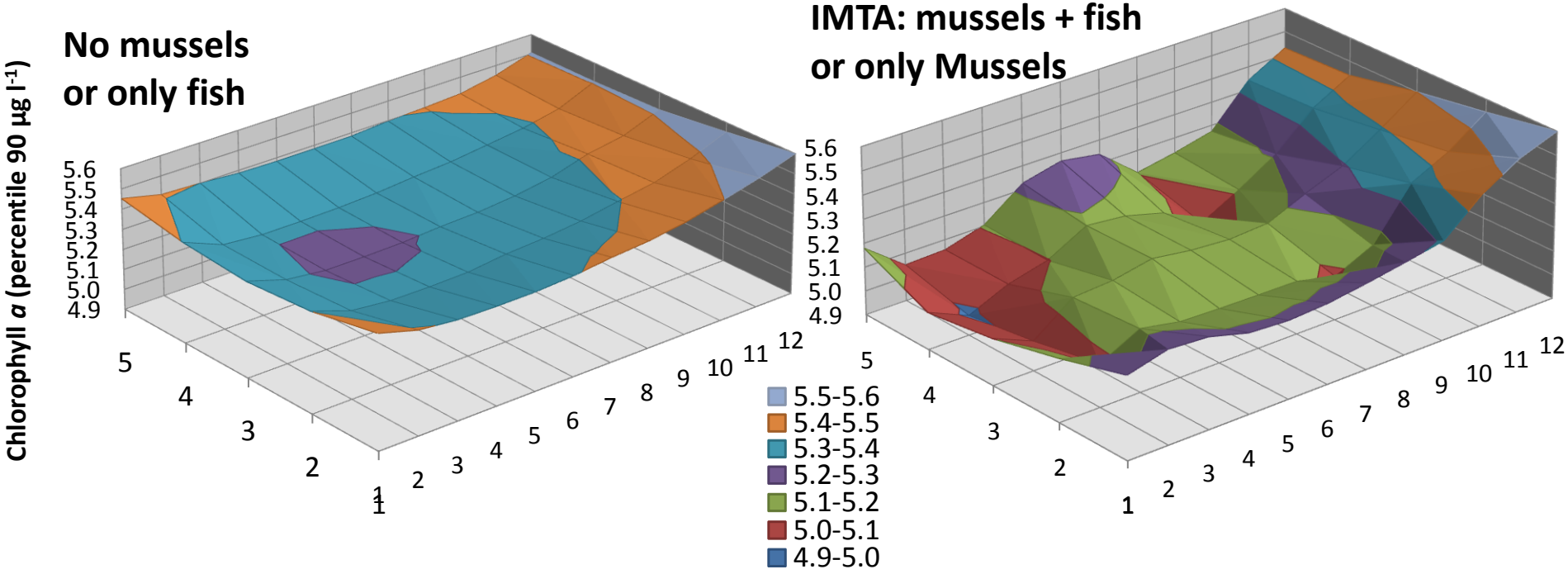
Mass balance for gilthead pond culture - models are important for optimization

Ferreira et al, 2012. Aquaculture 358–359 (2012) 23–34.

EcoWin2000 model analysis

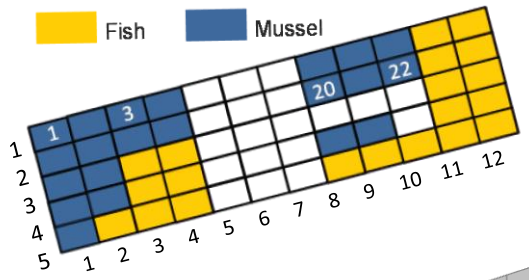
Food availability in the offshore IMTA area

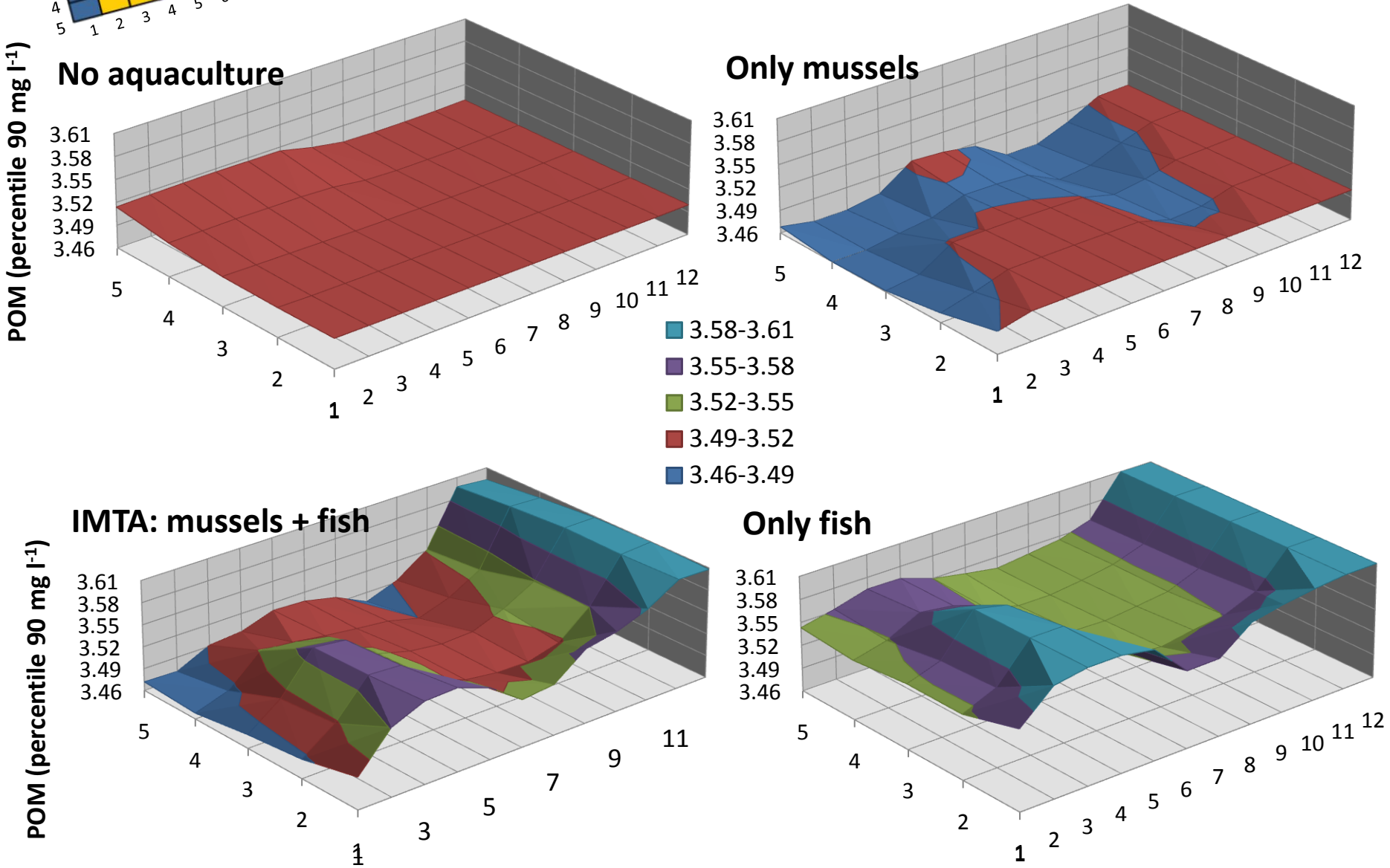




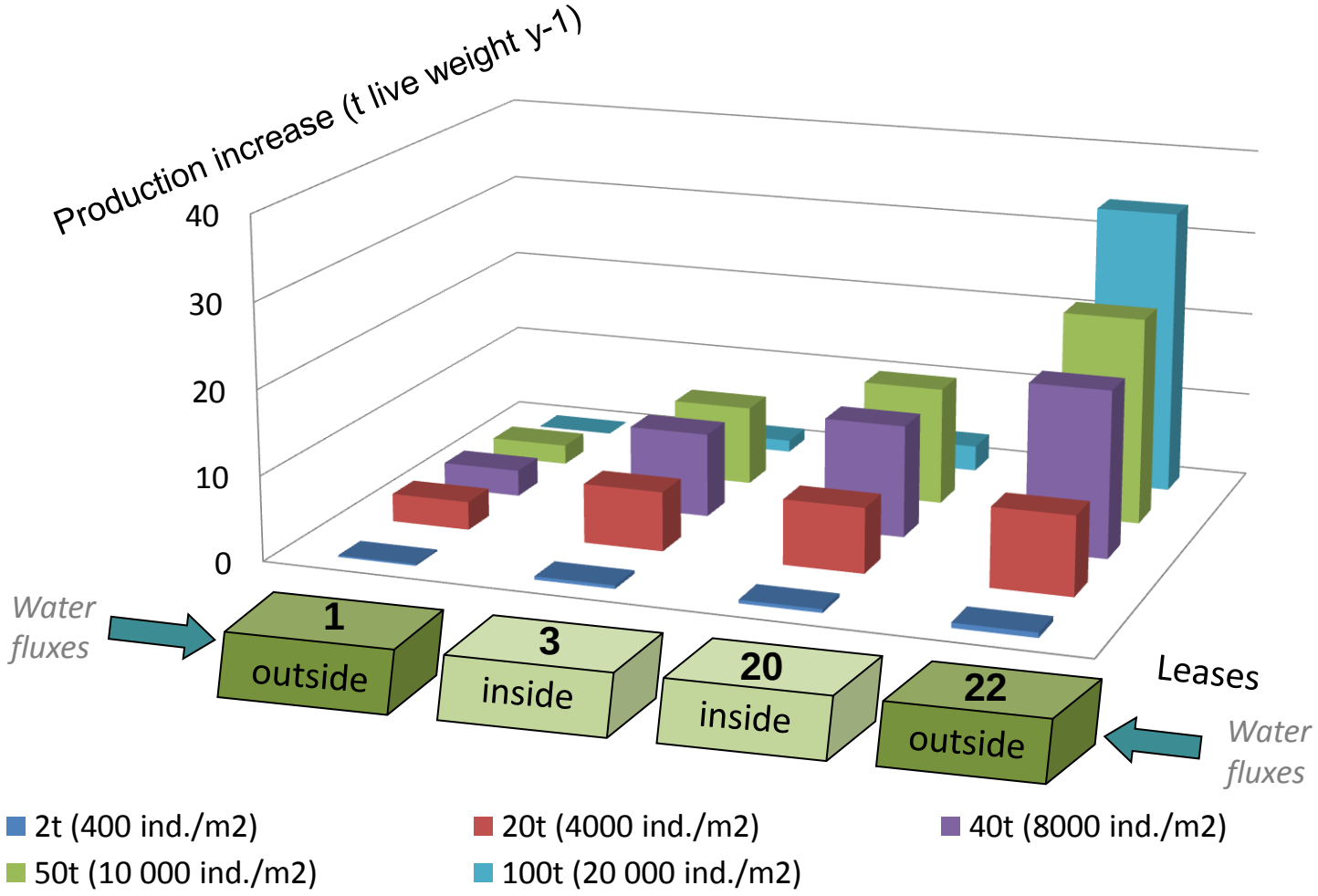
The effect of monoculture and IMTA on food depletion can be clearly distinguished. Chlorophyll *a* percentile 90 is used as a proxy.

Positive externalities of shellfish culture

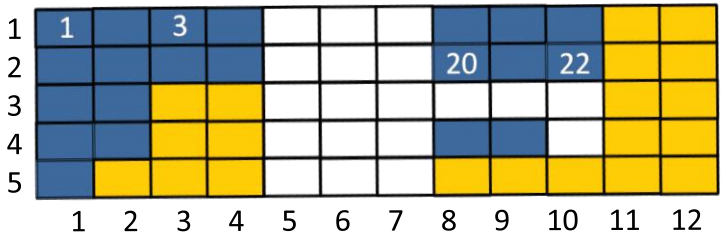




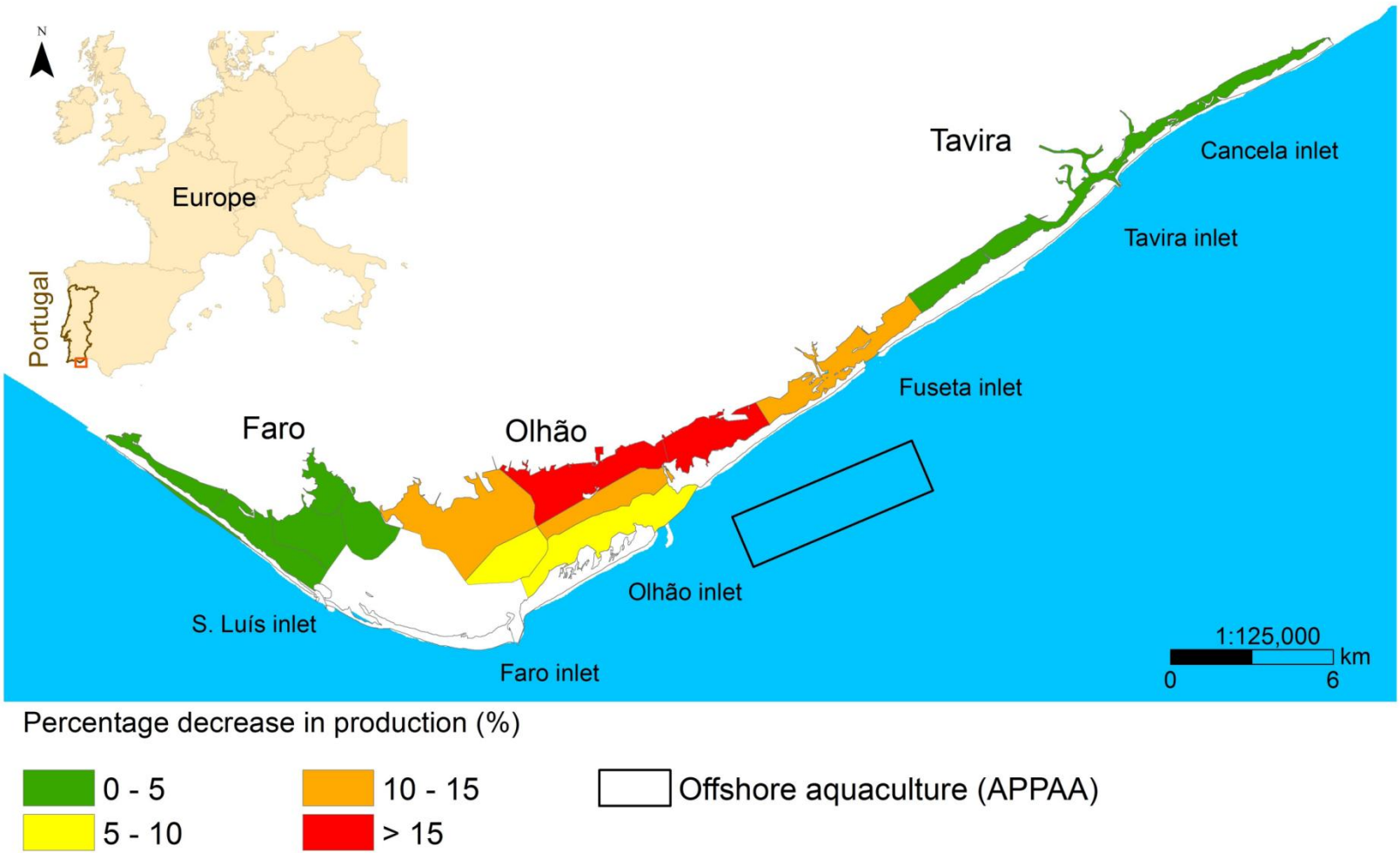
Simulation of enhanced mussel production with IMTA



Mussel (blue) lease 22 performs best due to the adjacent finfish culture (yellow), even at high mussel stocking densities.



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



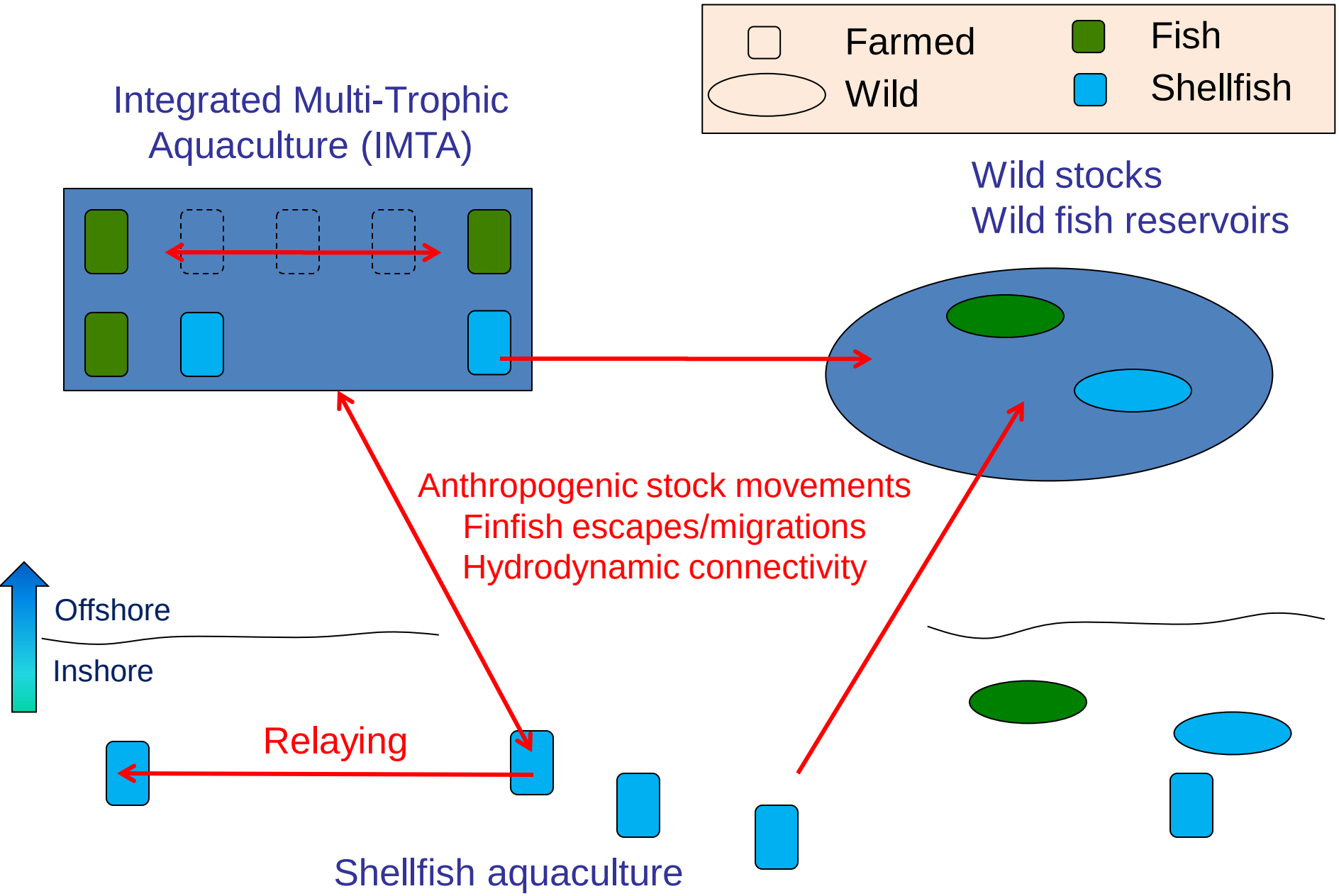
An annual loss of 120 t of clams (1.2 million €) is offset by 13,000 t of mussels

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

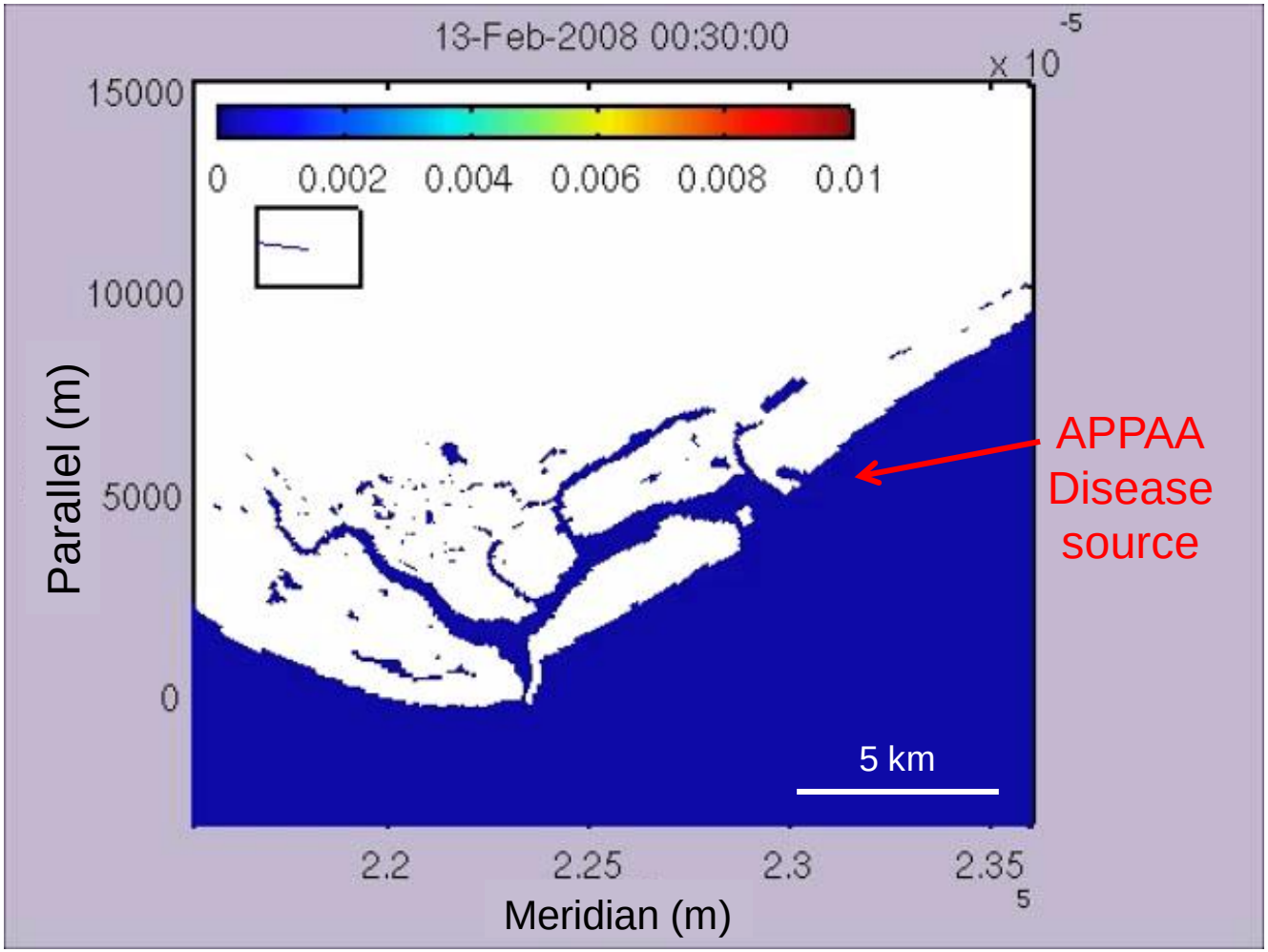
Mathematical models can address part of the issues, but that still leaves the rest…

Disease modelling approach



Virus Particle tracking:

Ratio between concentrations at XYZ and emission concentration



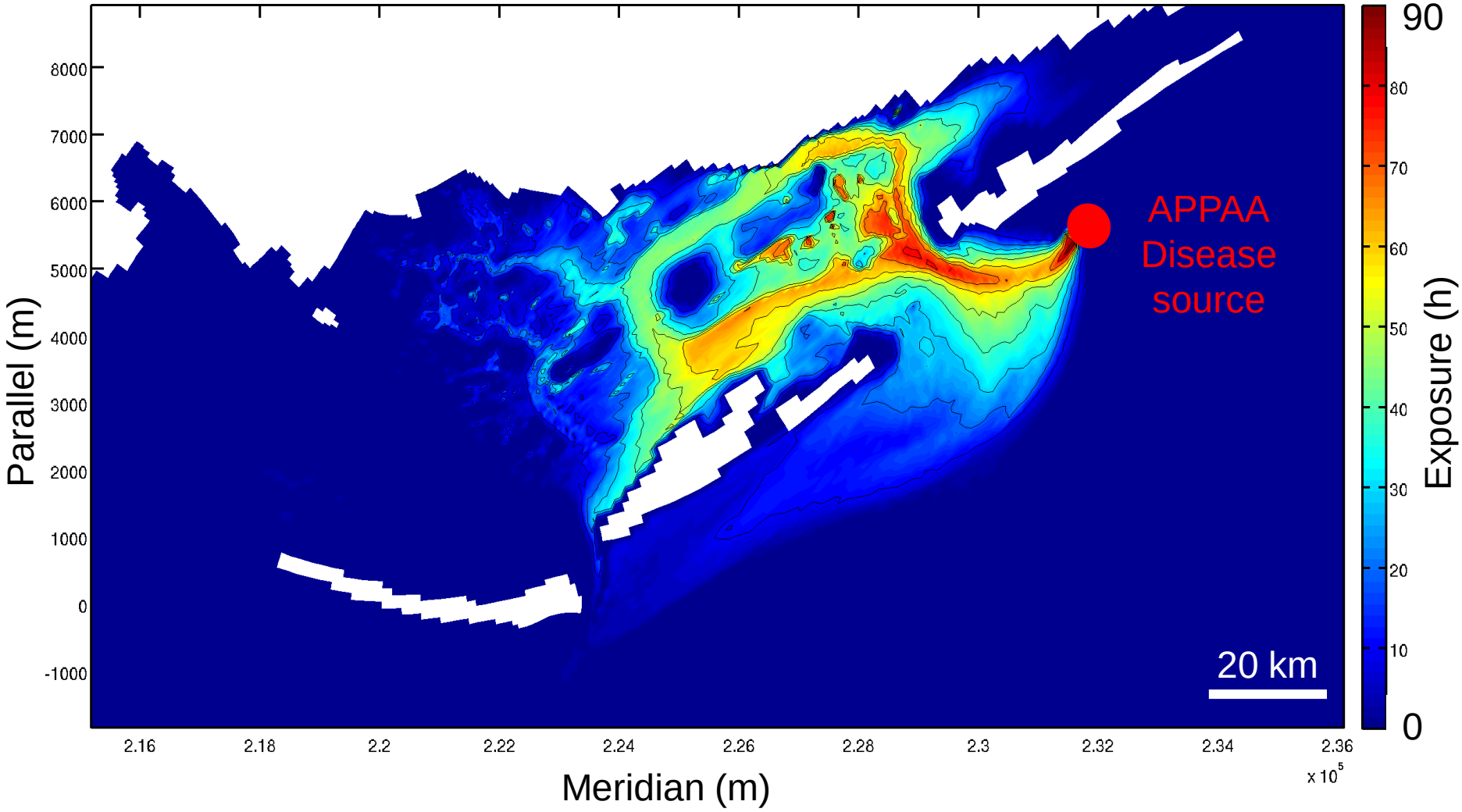
- Disease source: APPAA
- Virus concentration:

Up to $2x10^6$ 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 19th 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/