CERF 2011 - 21st Biennial Conference of the Coastal and Estuarine Research Federation

Ecosystem-based approach: the **FORWARD** project Framework for Ria **For**mosa **W**ater quality, **A**quaculture, and **R**esource **D**evelopment

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The Project

Coastal Ecosystem Management challenge:

- Protect, optimize, manage in a sustainable manner the various activities and resources of coastal areas such as the Ria Formosa in Portugal

Aims:

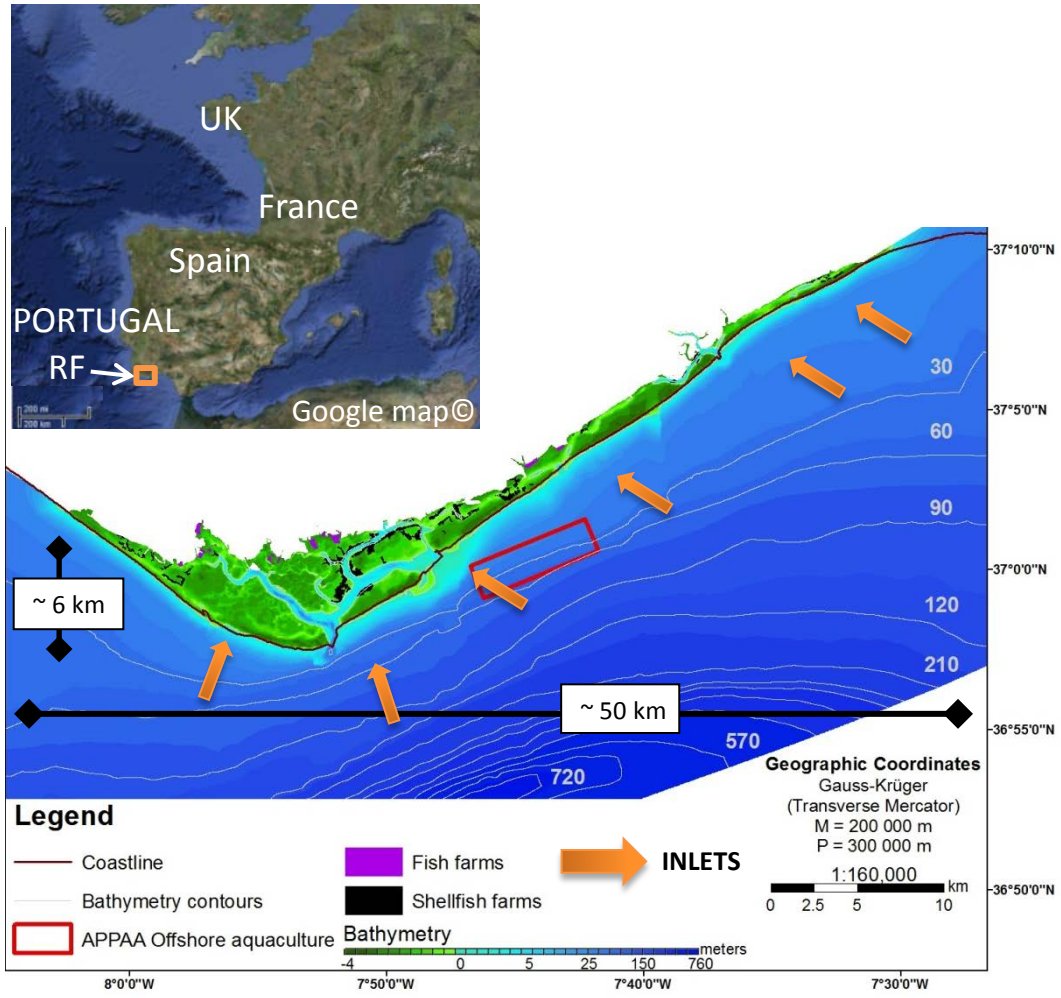
- Assess the ecological integrity of the lagoon (field/laboratory studies, and simulation models)
- To stimulate the development of innovative and technologically advanced activities together with best environmental practices.

Ecosystem Approach to Aquaculture (EAA):

- Integrate ecological and screening models with social and economic aspects
- To provide support for optimal management of ecosystem goods and services in the Ria Formosa.

Only a part of the EAA may be addressed by simulation models

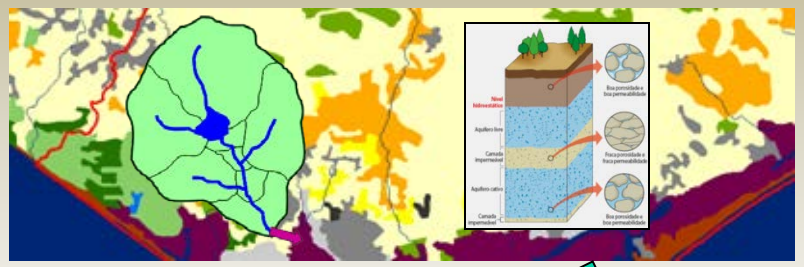
Ria Formosa – Portugal (Europe)



- Lagoon: high socio-economic & natural value. Native clams (*Ruditapes decussatus*)
- 40% of aquaculture products in Portugal (8 kton/y, 44.3 M€/y) originate from Ria Formosa
- 90% of the national production of clams, 26% of oysters.
- Total bivalve production 2750 ton/y for 26 M€/y (36 M$/y)
- 10 000 people involved in the clam industry

Clam culture is an important activity, and over 10 000 people in the Ria Formosa

General model framework



Ecohydrological model: SWAT

Wastewater discharges + Non-point sources

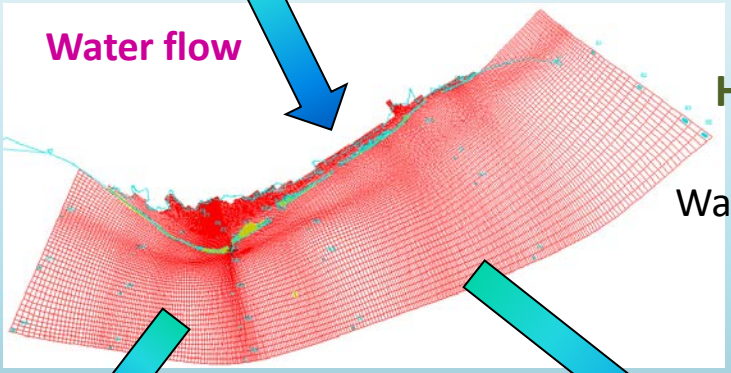
637 km², 331 HRU

COASTAL BASIN

COASTAL WATERS

Nutrient loading

Water flow



Hydrodynamic model

Delft3D – Flow:

Water flux from tide & waves

1600 km², 30 000 cells

Water flow

Water flow

Local scale models

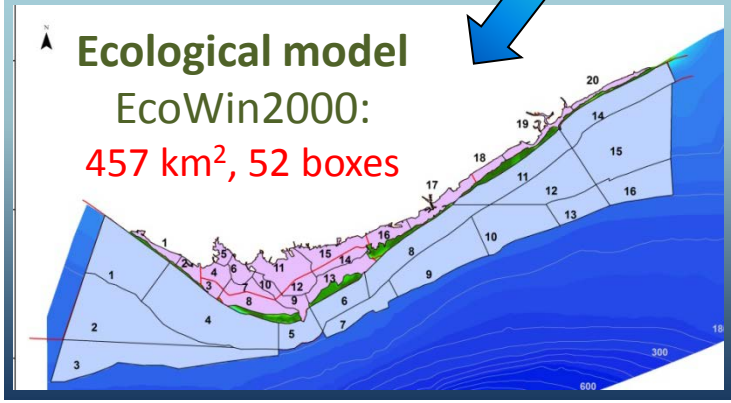
FARM – POND

<5 ha, 5-10 sections

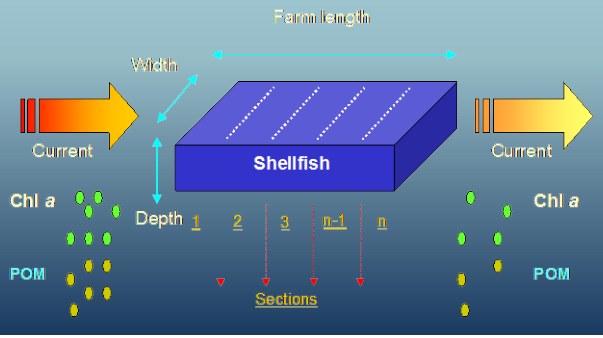
Ecological model

EcoWin2000:

457 km², 52 boxes



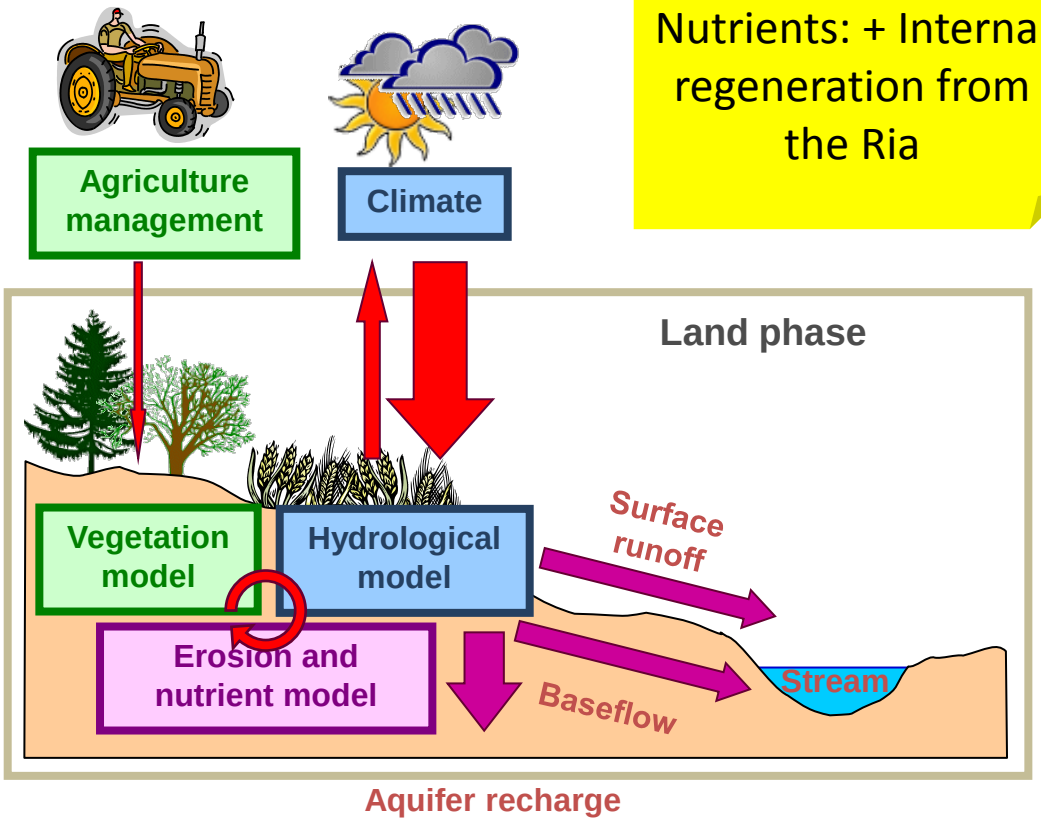
Drivers



Ecohydrological model: **SWAT**

Soil and **W**ater **A**ssessment **T**ool

Hydrological Response Units (HRUs)



Nutrients: + Internal regeneration from the Ria

- 331 **HRU** for the Ria Formosa
- **Criteria**:
  - Water bodies from WFD
  - Main discharges of WWTPs
  - Transitions between soil types
  - Sampling stations
- **WWTPs**
- **Diffuse sources**

- **First results**:

  Nitrogen (N ton / year):

  WWTPs: 462

  Diffuse sources: 366

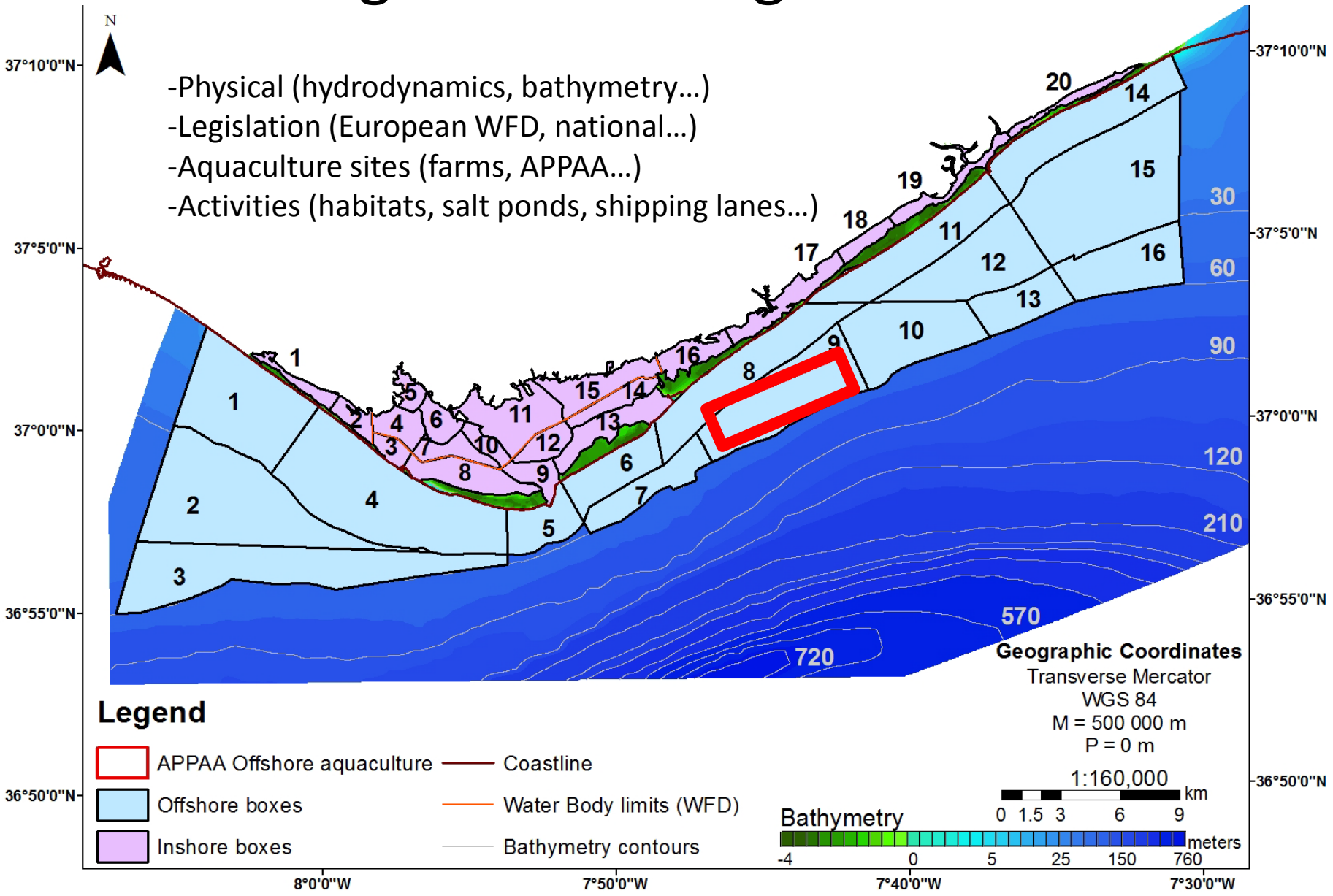
  Phosphorus (P ton / year):

  WWTPs: 70

  Diffuse sources: 138

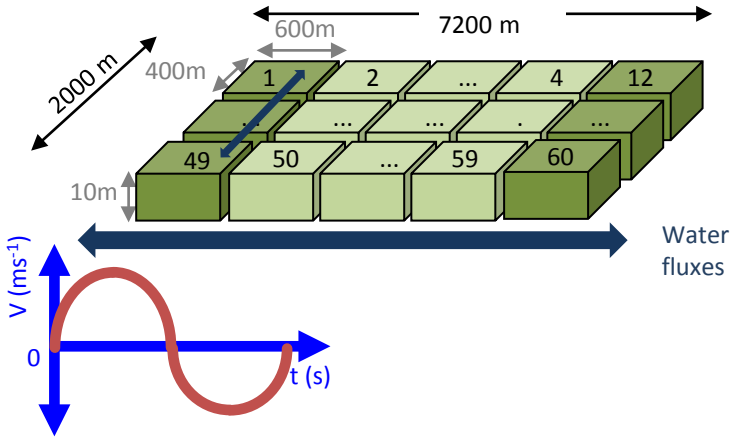
Diffuse sources are over 50% of the total phosphorus input

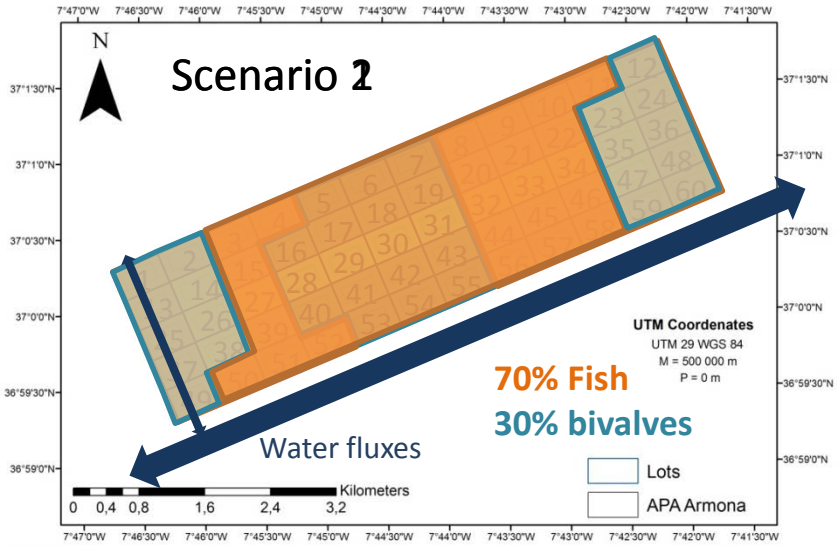
Ecological modelling box criteria



Ecological modelling: EcoWin2000

Example IMTA offshore aquaculture – Offshore box 9





- 60 leases: 12 x 5 boxes
- Simulation: 3 years
- Water fluxes (up to 0.5 m s^{-1})
- Measured environmental data
- Scenarios: 70% fish (gilthead bream) – 30% bivalves (Mediterranean mussels)
- Tests with 2, 10, 30 and 100 t ha^{-1} of mussels

First results: Bivalve production at different mussel densities:

Scenario 1: +25% harvest

Scenario 2: +23% harvest

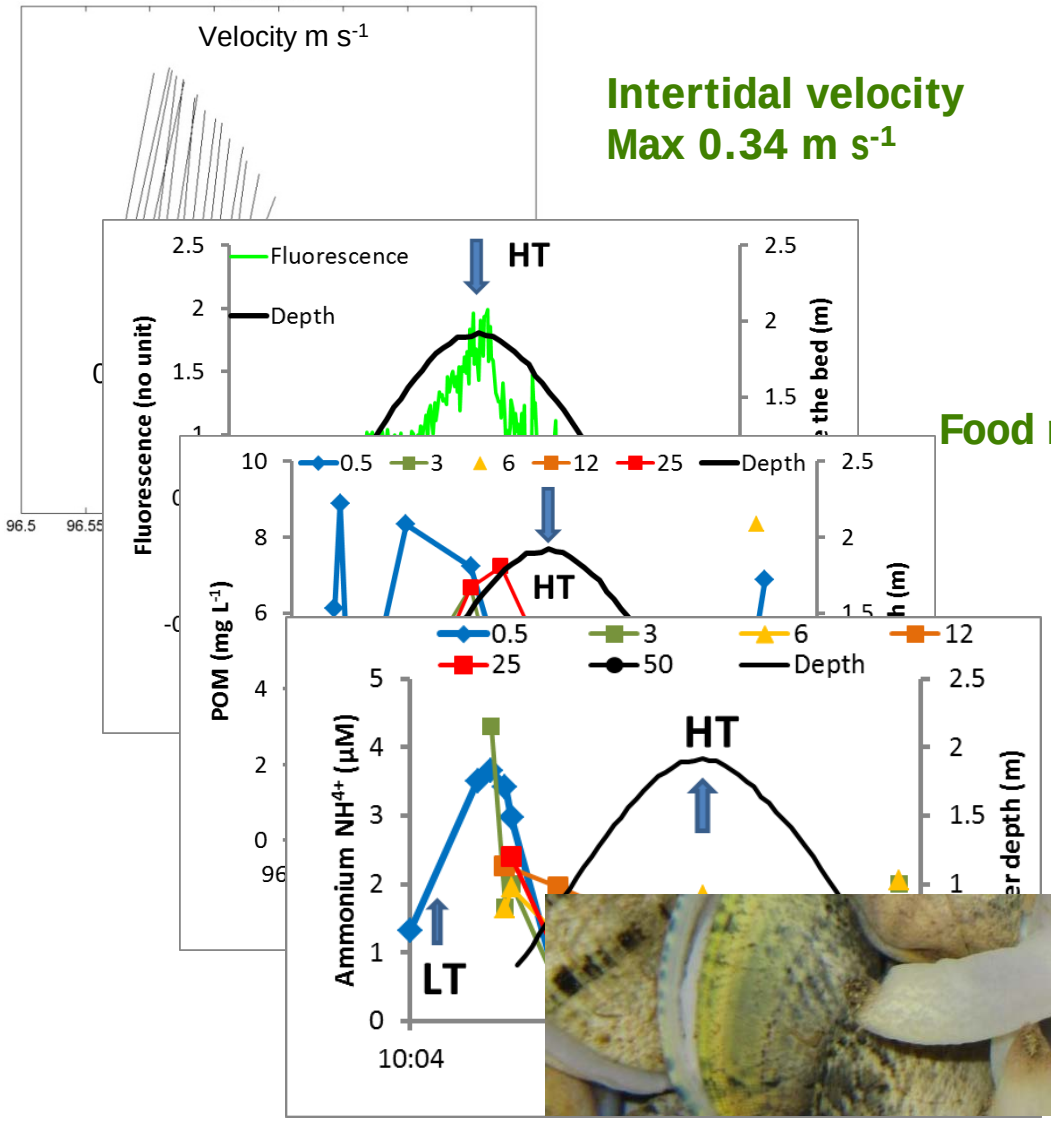
Offshore aquaculture- EcoWin2000 model

Annual mass balance for ecosystem services by shellfish

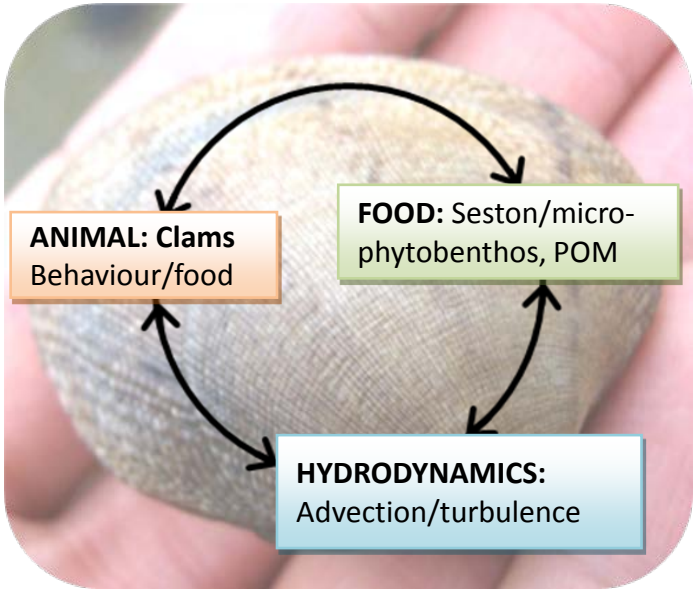
Item	Value
Carbon	
Detrital POM removal (t C y^{-1})	176
Phytoplankton removal (t C y^{-1})	1758
Total POM removal (t C y^{-1})	1935
Nitrogen	
Detrital POM removal (t N y^{-1})	27
Phytoplankton removal (t N y^{-1})	273
Total POM removal (t N y^{-1})	301
Ecosystem services	
Population equivalents (PEQ)	91216
Externality value* (millions of USD)	3.6

1 PEQ : 40 USD y^{-1} (Lindahl et al., 2005)

In situ Experiments



Intertidal velocity
Max 0.34 m s^{-1}



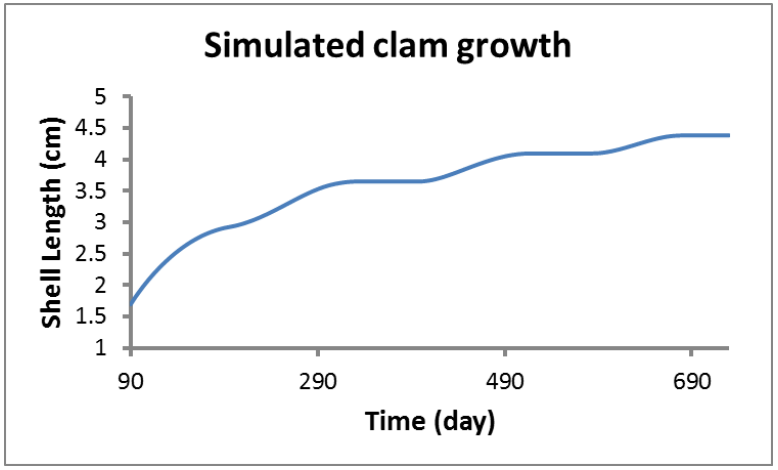
Food reduction with turning tide

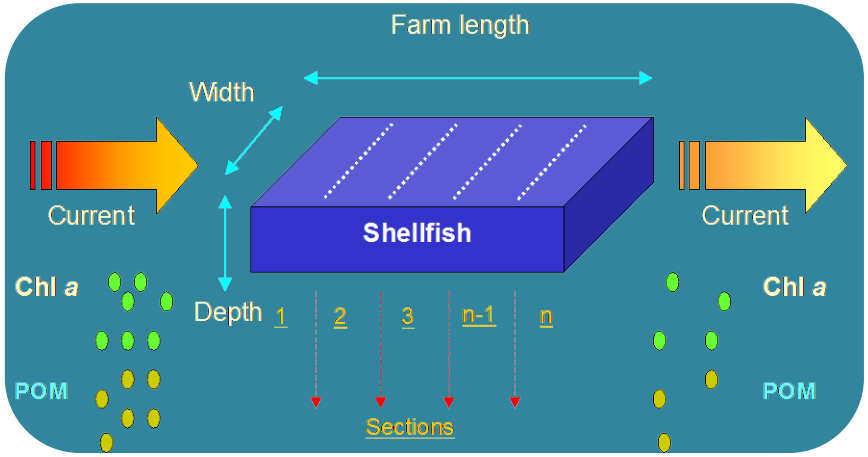
High [POM] with Chl *a* ~5% POM

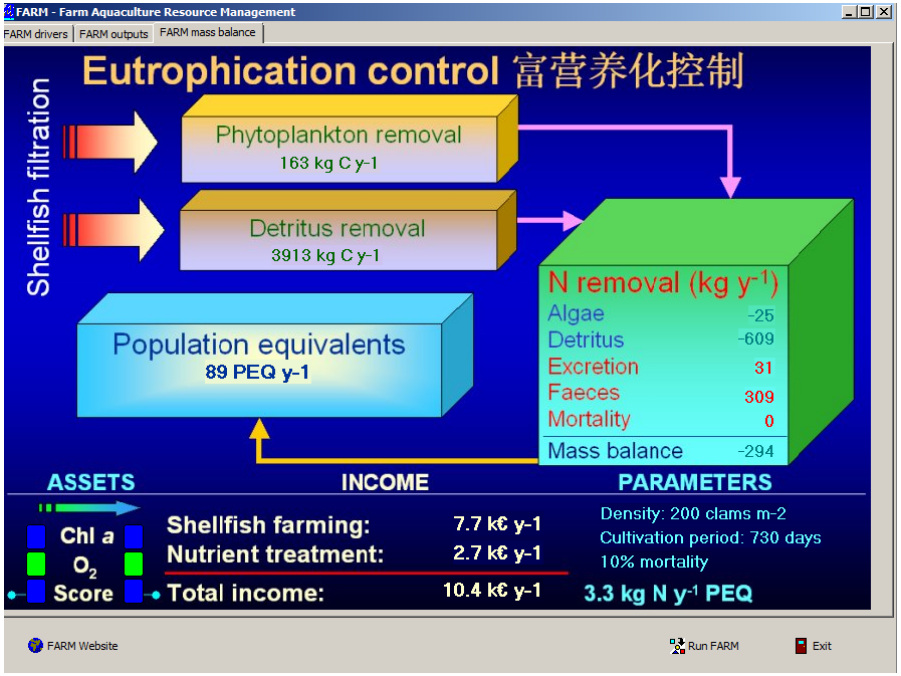
Export of nutrients during the flood – internal recycling

Filtration rates
1.23 ± 0.5 (L g^{-1} h^{-1})

Individual and FARM models



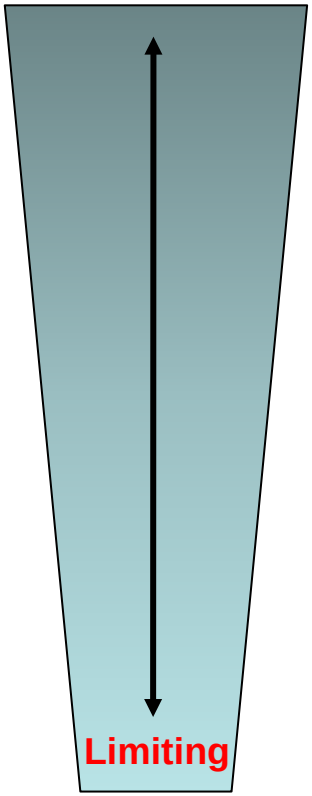




Calibration of the individual clam growth model for integration in FARM and in system-scale models

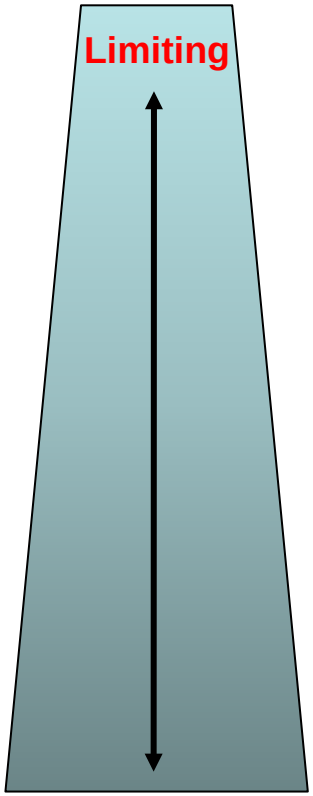
There is much more to aquaculture carrying capacity than production…

US, Europe, Canada



The four pillars of carrying capacity

Southeast Asia, China



Realities, awareness, legislation, and governance vary around the world

Social and legal components

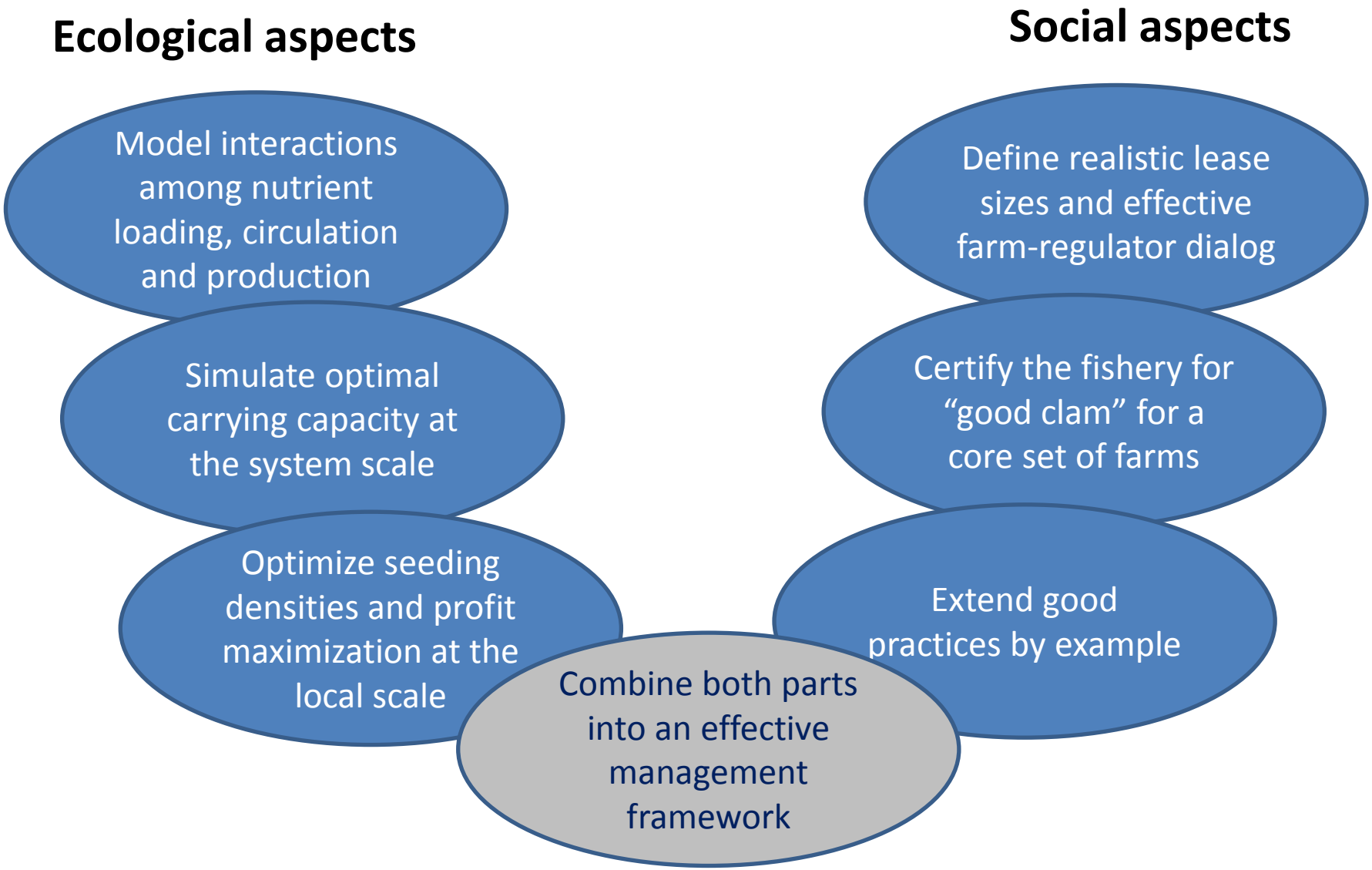
Preoccupations

- Some farms - poor culture practice
  - Contravene Natural Park regulations
  - Delimit lease areas with inappropriate materials
  - Alter the farm height above datum
- Lack of business organization
  - Small plots
  - High number of farmers/leases
  - Transfer of leases
- Link between regulatory institutions and the aquaculture activity
- Future use of the models in development in FORWARD
- Management of farmers' expectations

Actions

- Analyse and improve the governance frameworks, including regulators, farmers, and other stakeholders
  - Harmonization of the Natural Park legislation with sustainable aquaculture development
- Establish a monitoring system to assess level of compliance with regulation
- Add value to the fishery through certification

Improve management



Synthesis

Activities and products

- Clam cultivation in the Ria Formosa is two hundred years old. Shellfish harvest in the Ria dates back to Al Andaluz
- Ecological models, governance models – solving the 50% of the problem you like best does not solve the problem
- Many coastal systems show similar problems – social conflict is often more of a management challenge than ecological understanding
- Written products from FORWARD include a book and scientific papers (see ecowin.org/smile for an example)
- Digital products include the various models, a legacy program so local managers can apply them, and a GIS based interface to help keep things simple for everyone

http://www.polislitoralriaformosa.pt/forward/index.php

Thanks for your attention…

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Polis Litoral Ria Formosa (Portugal)

RIA FORMOSA
POLIS LITORAL

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