Long story short on Module Bivalve

What it is?
Why?
How?
Results?
Future?

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Module Bivalve

Simulate bivalves' processes in the aquatic environment

Why?

- Bivalves change the environment
- Bivalve have economic value

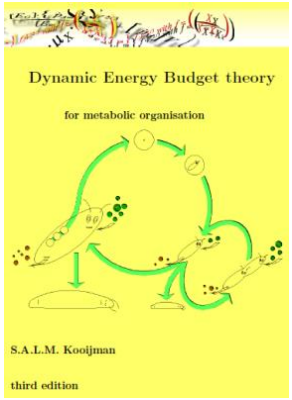
MOHID Water Modelling System

Couple

Size-structured population model

↓

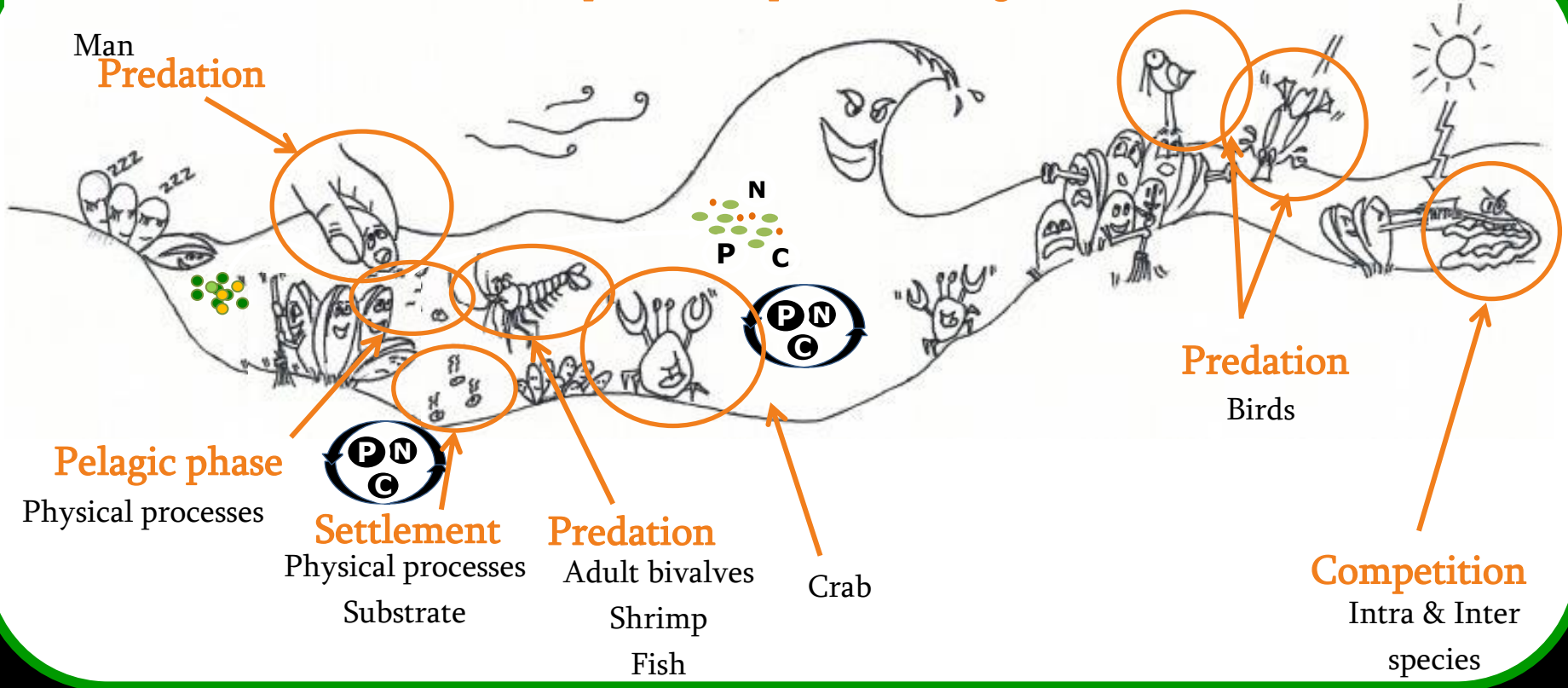
Individual Based Population Model →



Kooijman, 2010

Why do we need a size structure population model?

The bivalve processes depend on the organism size



Hydrodynamic processes

Tide, Wind

Fresh Water Discharges

Density driven currents

Abiotic factors

Light

Temperature

Substract

Ecological processes

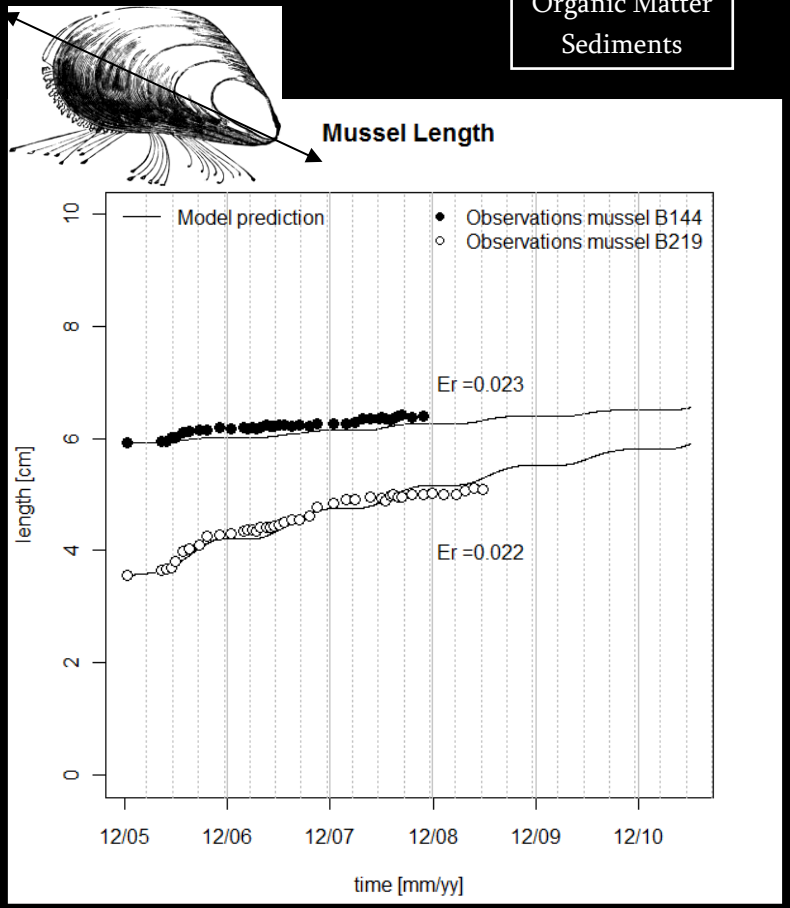
Primary production

Biogeochemical cycles

Predation/Competition

How?

Model validation



Parameter set for blue mussel (Saraiva *et al.*, 2011, JSR)

Individual model validation (Saraiva *et al.*, 2012, MEPS)

Bivalve

Zooplankton
Phytoplankton
Organic Matter
Sediments

FILTRATION

PSEUDOFAECES

INGESTION

Feeding Processes Model
(Saraiva *et al.*, 2011, Ecol.Mod.)

FAECES

ASSIMILATION

RESERVES

SOMATIC MAINTENANCE

MATURITY MAINTENANCE

MOBILIZATION

k

1-k

GROWTH

REPRODUCTION

STRUCTURE

REPRODUCTION BUFFER

MATURITY

SPAWNING

Standard DEB Model
(Kooijman, 2010)

INORGANIC COMPOUNDS

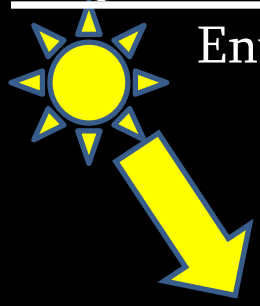
CO_2
H_2O
O_2
NH_3
PO_4

GAMETES

Dynamic Energy Budget (DEB) Theory

Population

How?



Environment

Cohorts

DEB

DEB

DEB

DEB

…

DEB

Reproduction

Individual based population model

Number of cohorts
Number of individuals
Their size, age, condition

Population processes

Mortality
- Age
- Natural mortality
- Predation
- Starvation

Individual

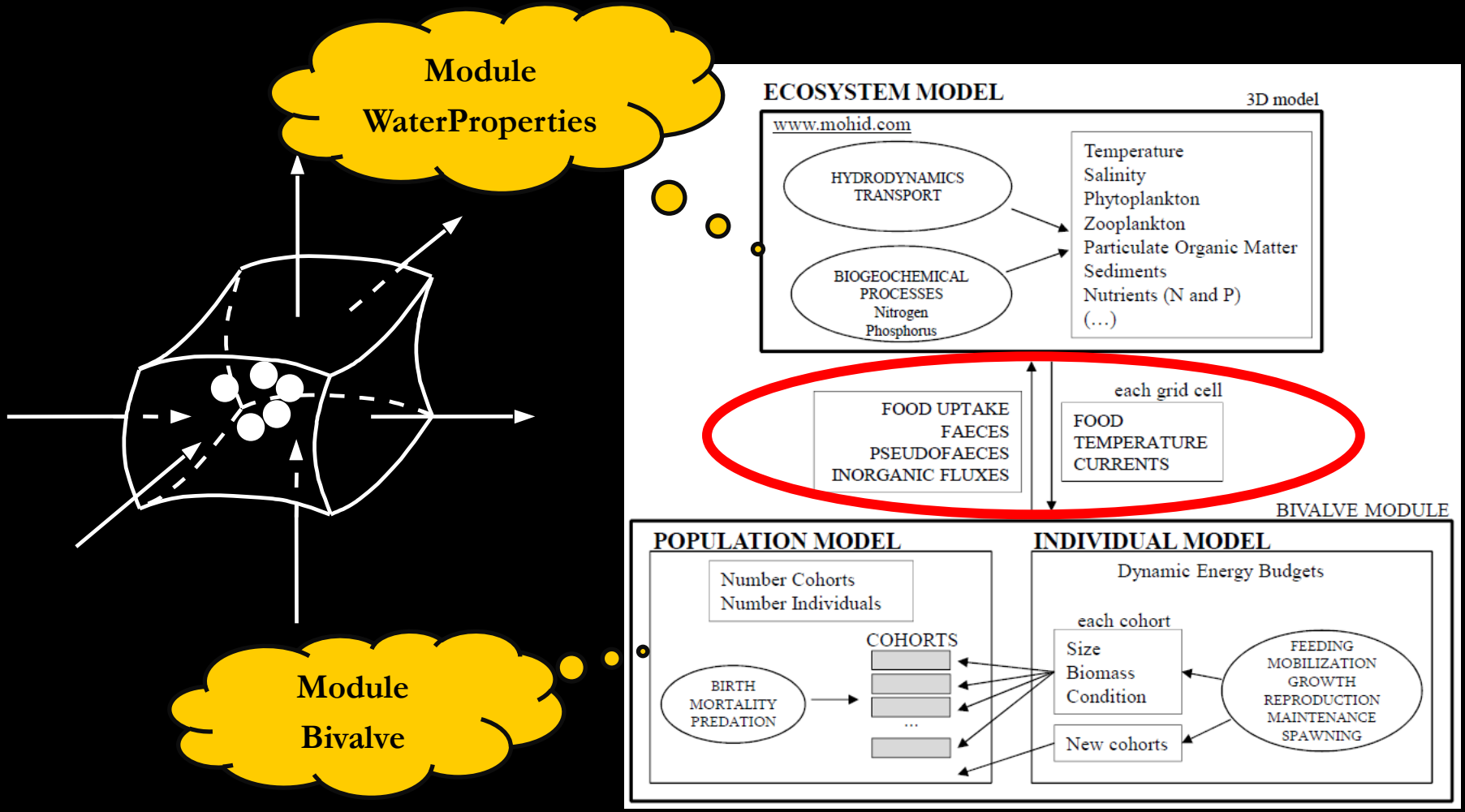
Population

- Aging → Age limit
- Initial Egg Mortality → Viability of the gametes
- Background Mortality → Diseases, storms, local food depletion…
- Extreme Starvation → After long periods of starvation (not enough food to cope with maintenance costs)
- Velocity → > 0.5 m/s
- Settlement → Settlement probability

Predators →
- . Predator identification
- . Predator abundance
- . Predator intake rate
- . Predator size range preference

Sofia Saraiva

Bivalve model AND Ecosystem model



Results?

Study and quantify the dynamics of bivalve communities and their influence on the pelagic system

Balgzand, Wadden Sea, The Netherlands

. Intertidal area, 50 km^2, in the Wadden Sea

. Ecological relevant: stopover for migrating birds and nursery ground for North Sea fish

. Bivalves are a major component (more than 50% of the macrozoobenthos)

. Long term sampling program (since 1970)

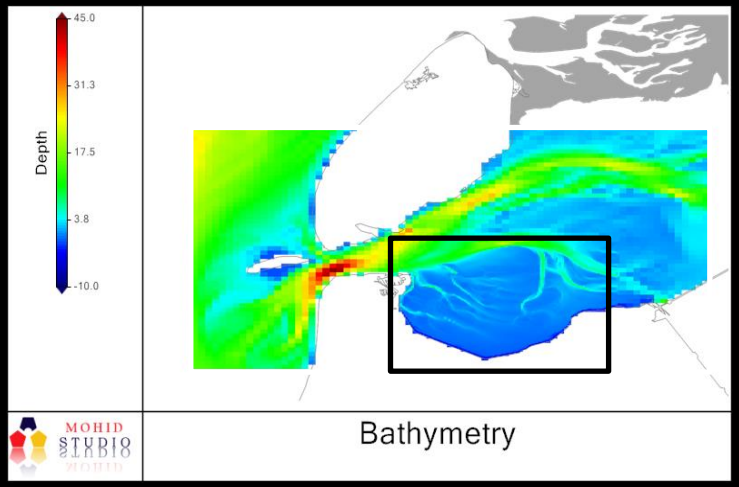
. Many research projects

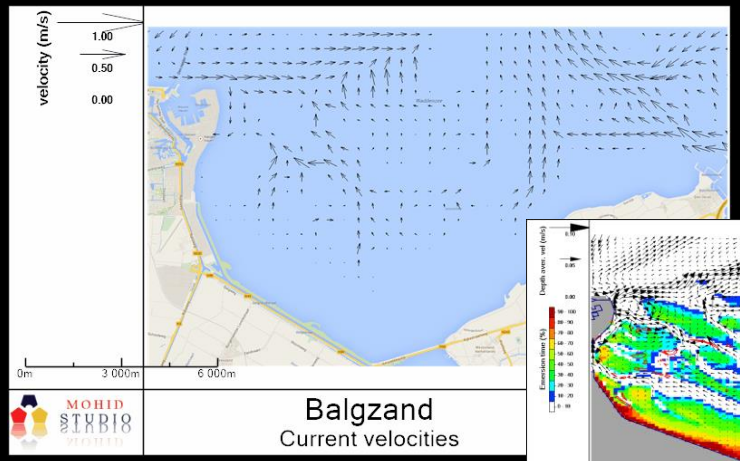
. Deltares OpenEarth website

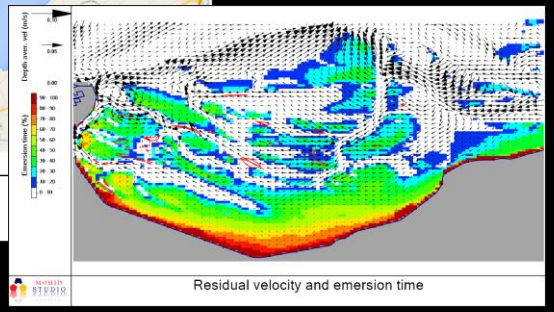
Good study area for the implementation of the integrated modelling tool

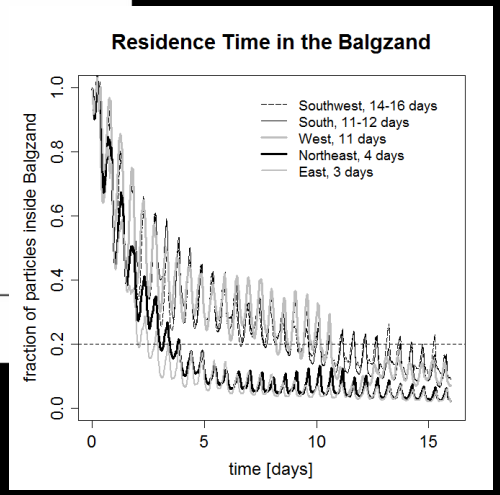
Saraiva et al., EcoMod 359 (2017) 34-48

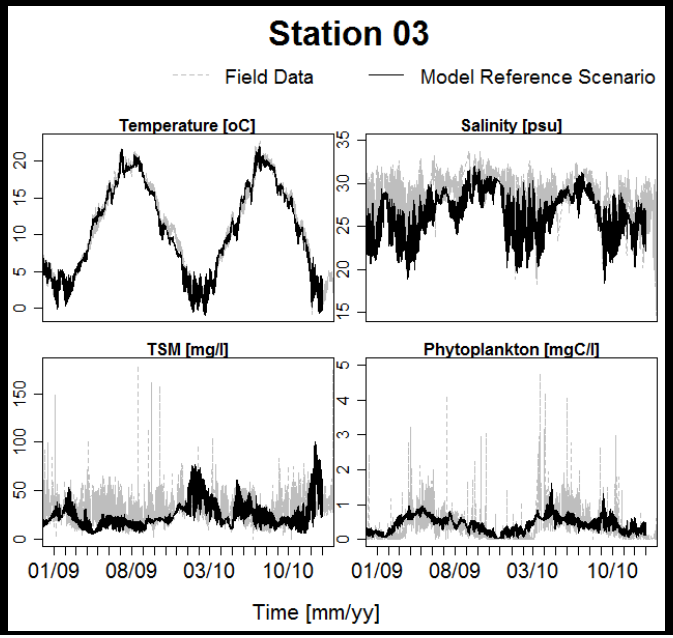
Methodology



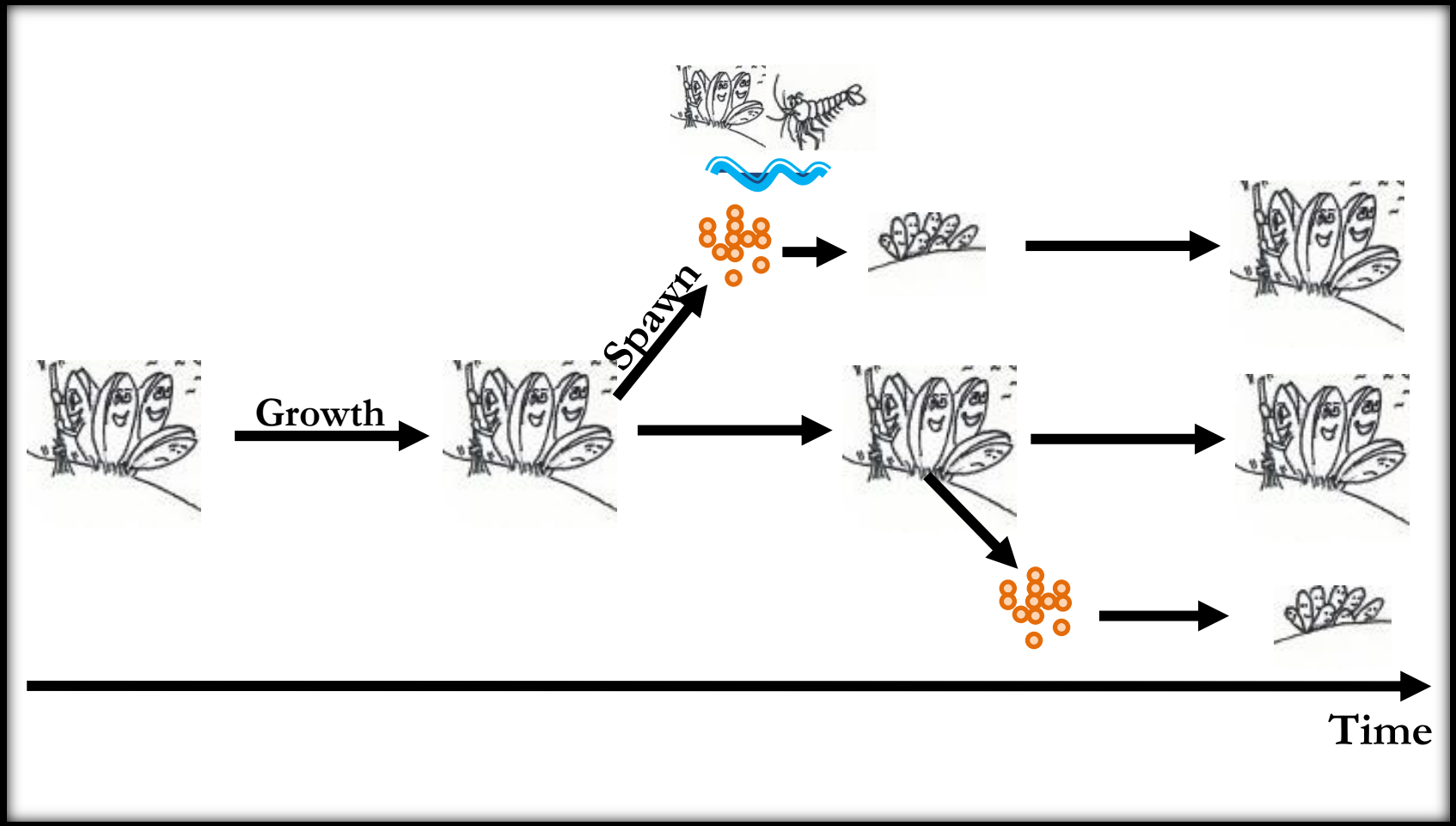






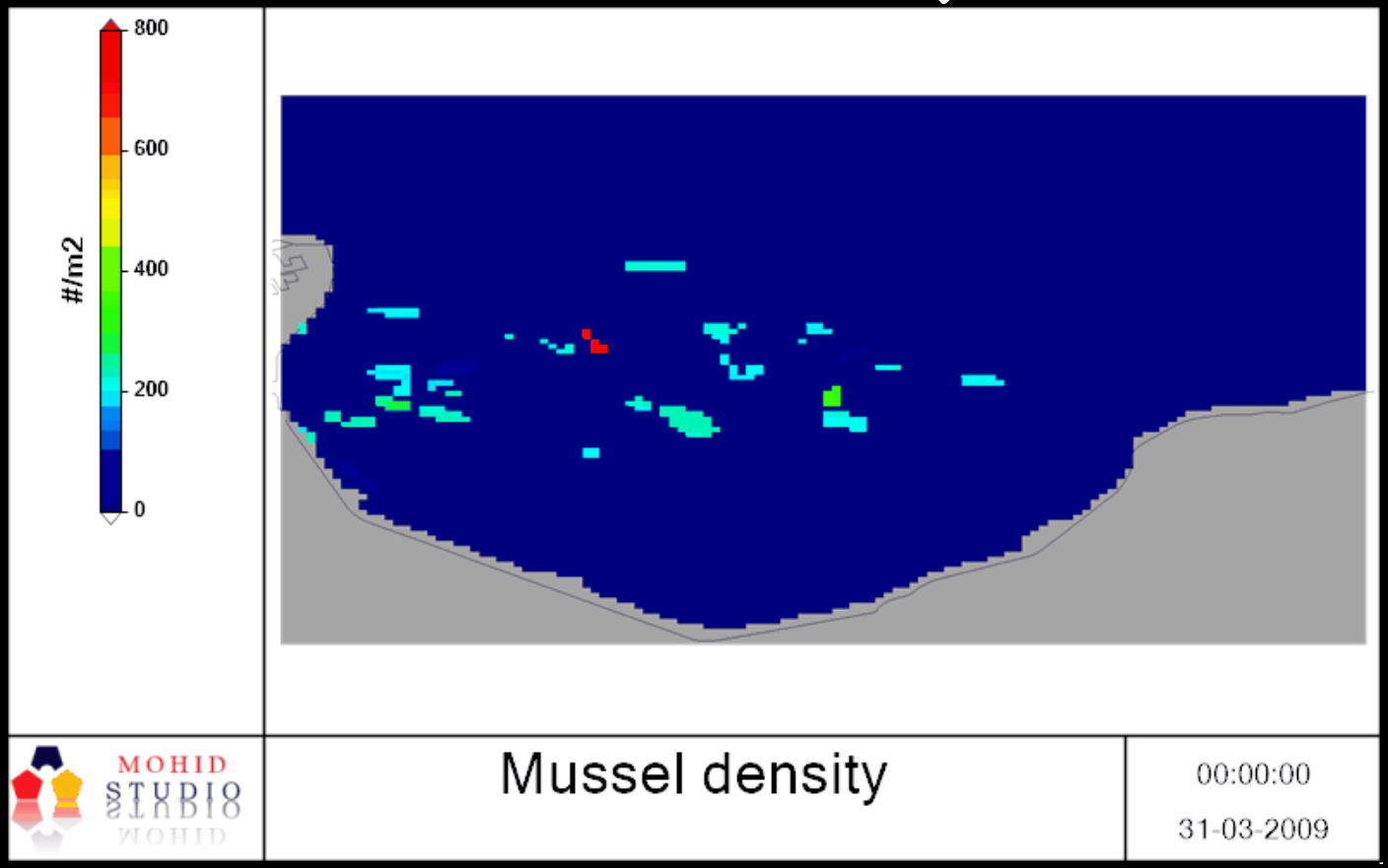


Mussel density



Results

Mussel Density



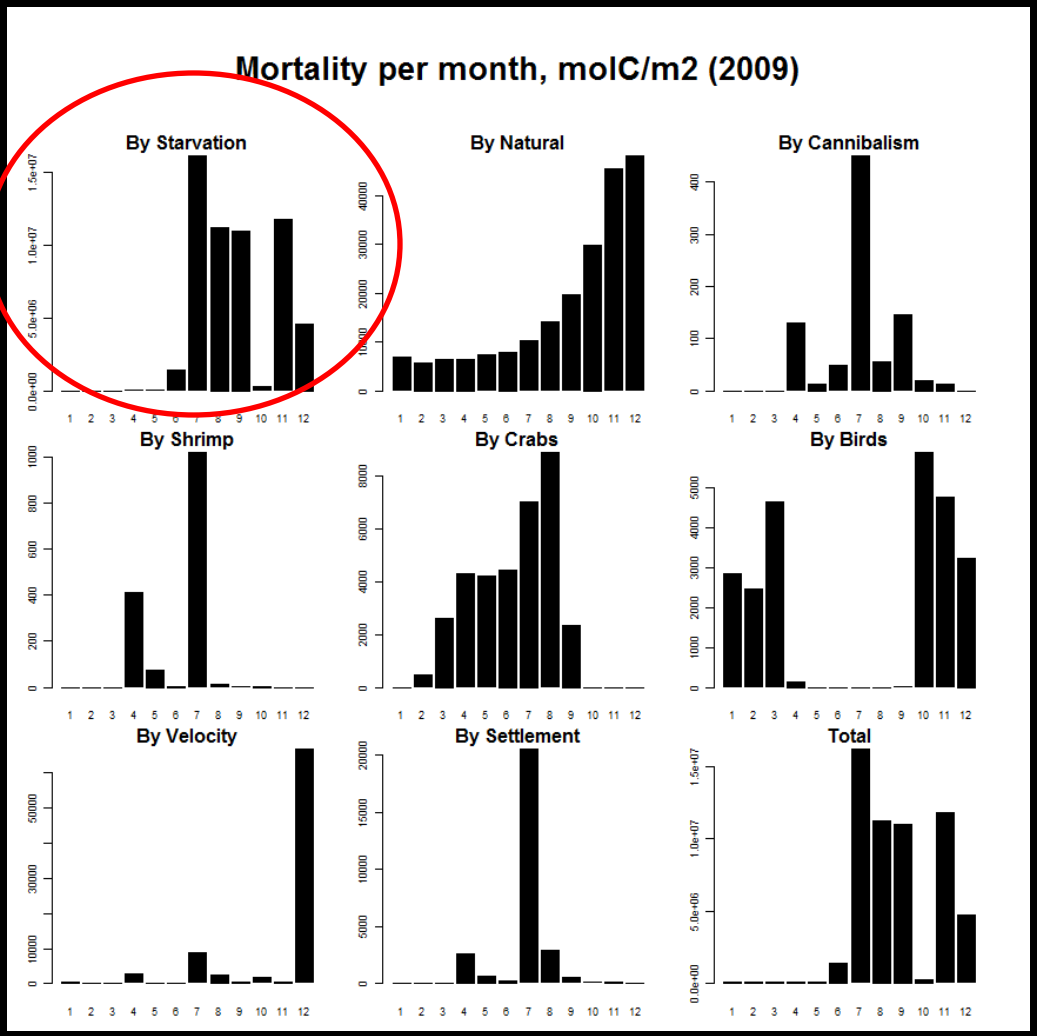
. The spawning season starts exactly when temperature rises above the threshold (9.6 C)

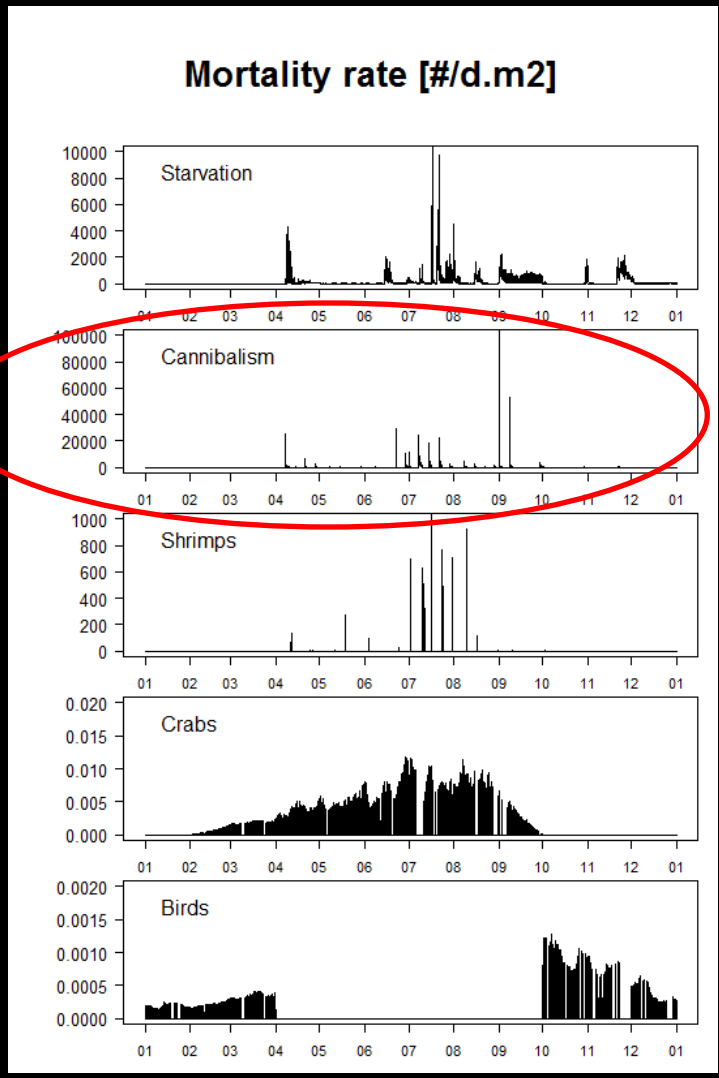
. Spawning events are almost continuous during spring, summer and beginning of autumn

. Dispersion is important

. Only a few new born cohorts persist, most of the new cohorts die in the first month

Balgzand





. Most of the new cohorts die in the first month

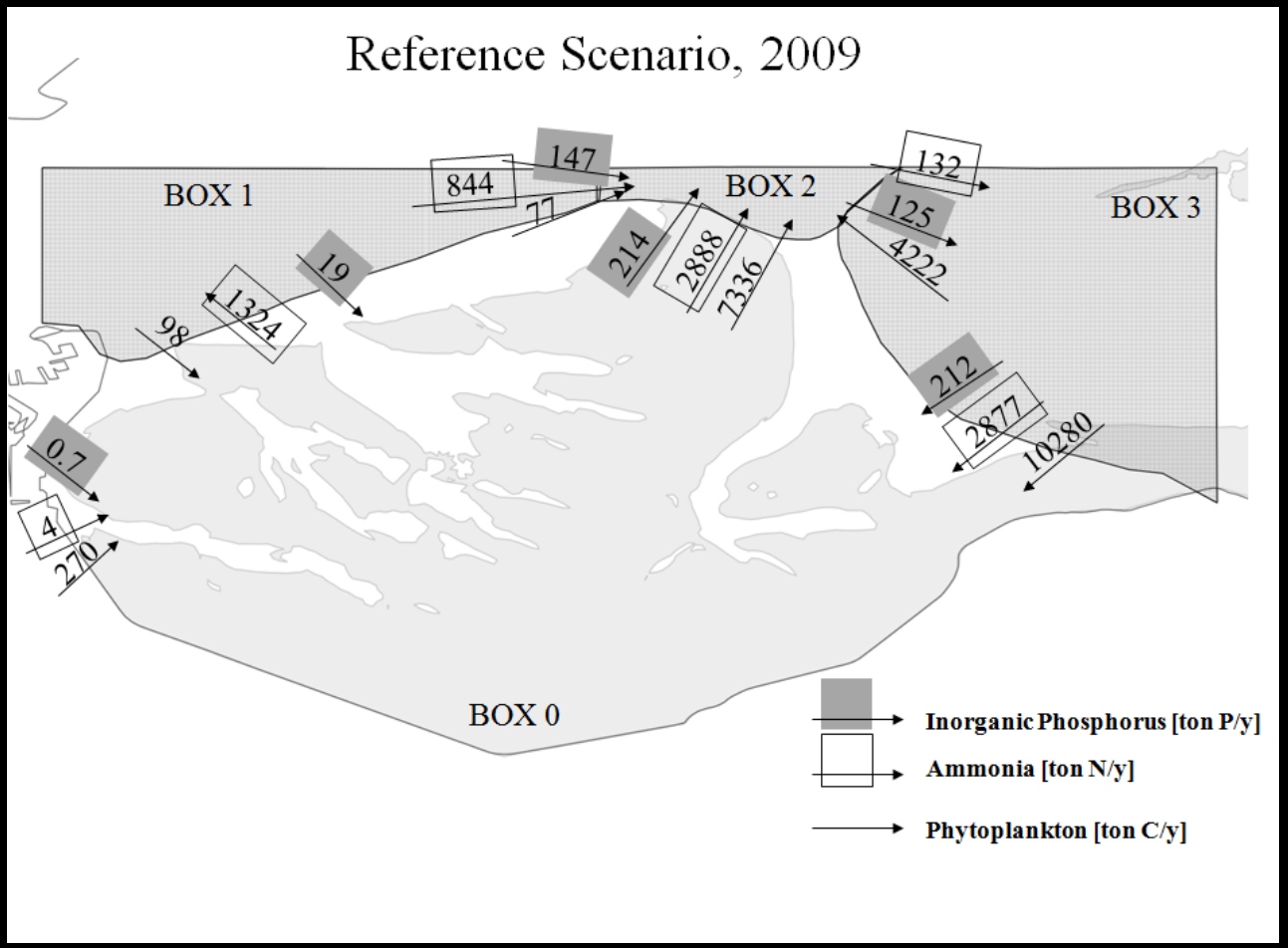
. Starvation is the main cause of biomass loss (98%) total predation is about 0.1%

. But cannibalism has an extreme influence -> very high values of instantaneous mortality rate (10^5)

.The intense effect of cannibalism associated with the shrimps predation can result in the extinction of cohorts

Results

Mass fluxes exchange between areas



Results

Mussel Beds effect on pelagic system

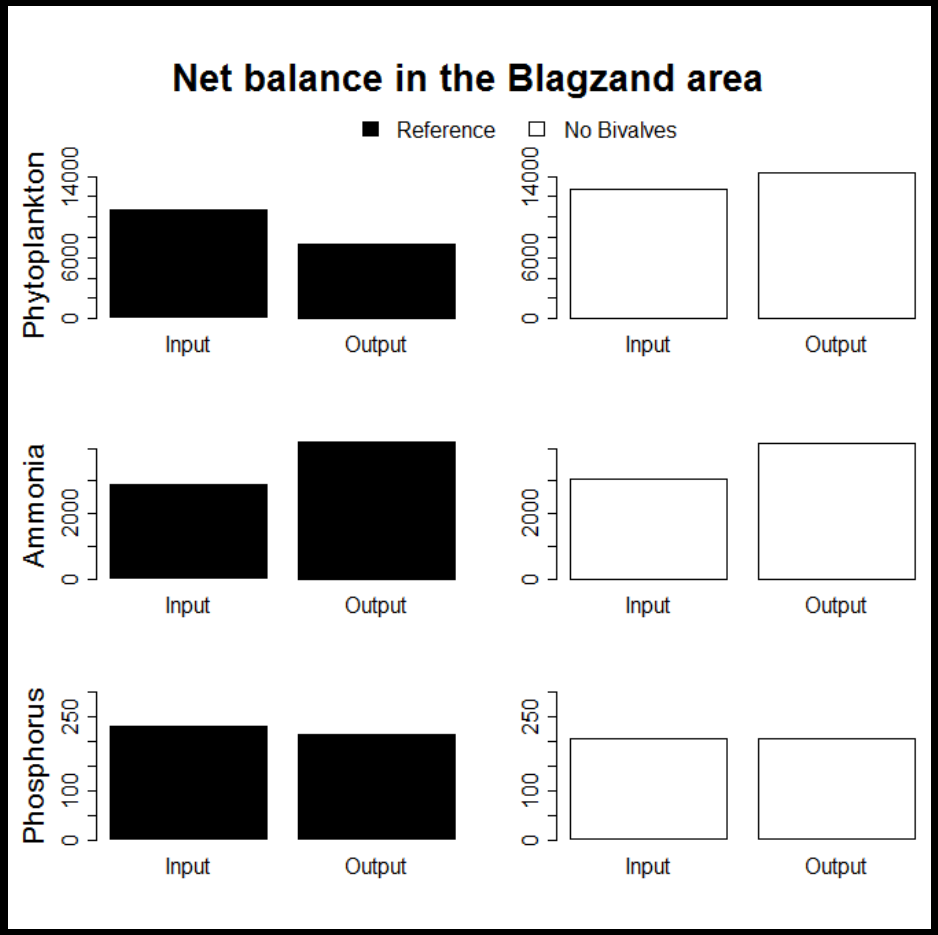
. Without mussels: output flux would be 15% more than the input flux

. The Balgzand is an area of intense primary production, that would even exports biomass without mussels

. Phosphorus: net consumption in both scenarios (but more intense in the scenario with mussels)

. Ammonia: net export in both scenarios

. Suggests intense recycling of ammonia, by mineralization of organic matter



Conclusions at the Balgzand

- There is no single mortality factor for the bivalve population dynamics regulation:
  - in the larvae stage, predation by adult mussels and shrimp (top-down) is very important and controls the persistence of the new cohorts
  - starvation (bottom-up) is the main responsible for bivalve biomass loss over the year.

- By using a scenario without mussel beds, the Balgzand is:
  -sink of phytoplankton (would be a source without mussels)
  -source of ammonia (mussel intensify the export)

➡ Quantification only possible with the complex model

Module Bivalve main features

- Use several bivalve species
- Account for several predators
- Complete life cycle with only one model
- Switch on/off processes
- Switch off population for aquaculture applications
- Bivalve DEB model ≈ other organisms DEB model!

What's next?

Sustainable shellfish production under climate change: Ria de Aveiro and Tagus estuary

and Ria Formosa

Short Term

- Pacific oyster (validating, comparing with data from individual organisms experiments) - Ria Formosa, collaboration with CIMAR, Porto
- Oyster growth in the Lima estuary, Portugal

Mid Term

- Predict the potential for bivalve production (optimal areas, species and food)
- Predict settlement areas for management purpose

Fish Module

Thank you!!

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