

Assessing ecological impact and socio-ecological sustainability of coastal aquaculture



INNOVAZIONE FVG PROJECT



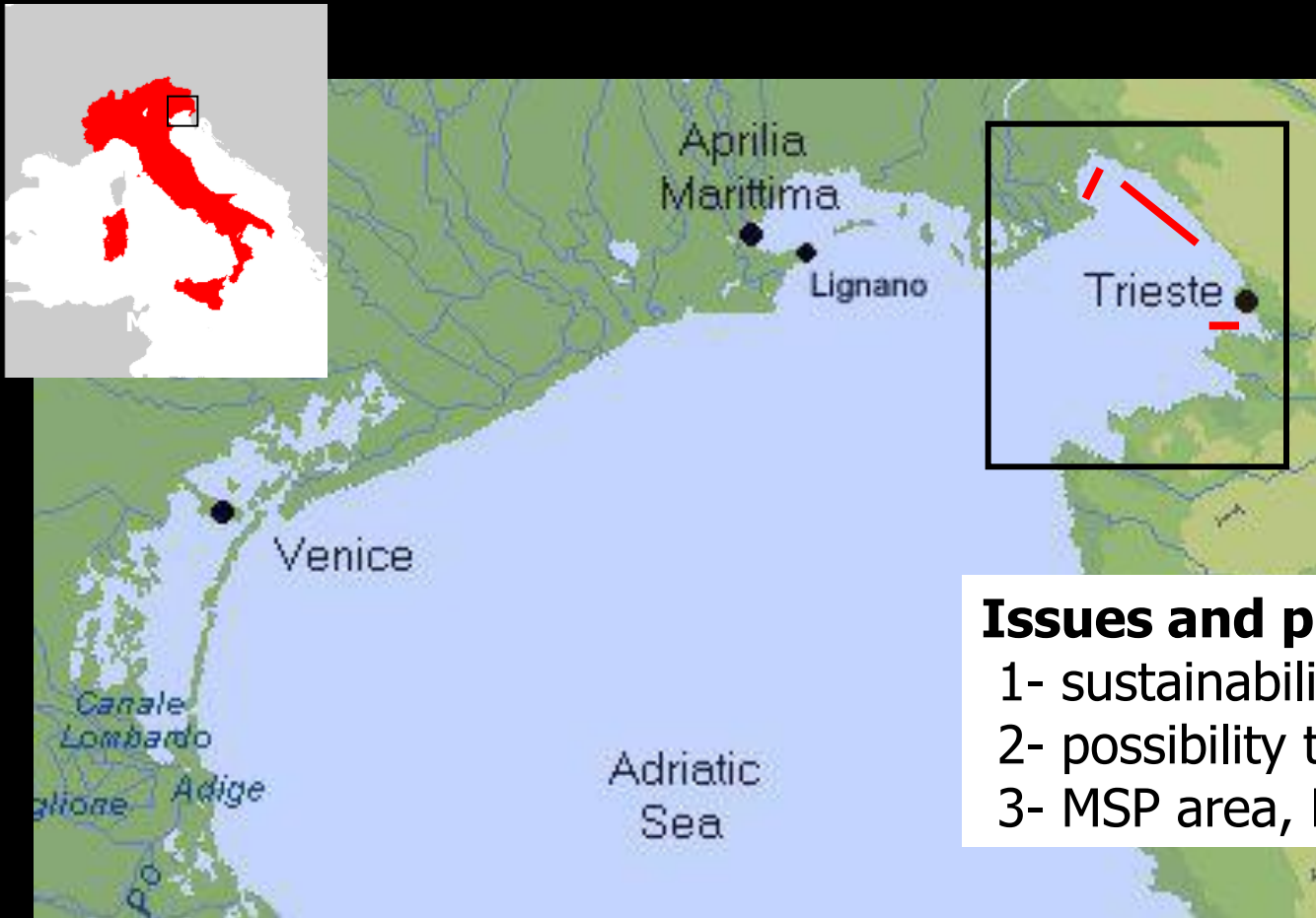
SosteMiTs Project
csolidoro@inogs.it

Endorsed by



Mussel farming in the Gulf of Trieste

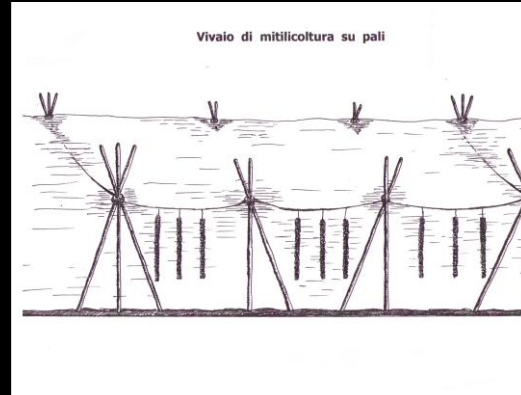
approx. **6'000 ton/year** ;
value **2.0 million €/year**, **100 people**



Issues and problems:

- 1- sustainability;
- 2- possibility to enlarge production
- 3- MSP area, EA2A

traditional activity – cultural heritage



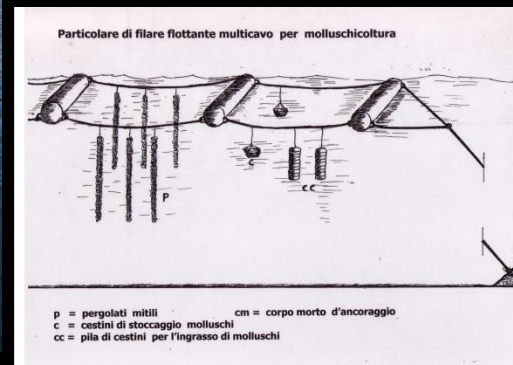
oyster 1800

Mussel (pole) 1930

+ pali 1950

longlines 1970

Singlerope longline 1990



16 enterprises
 Towards
 industrialization
 2.5 Meuro

Framework for analysis

‘ assess the ‘discharge’
 (and its reversibility)
 assess the ‘consumption’
 (contrast with availability)
 Assess socio components

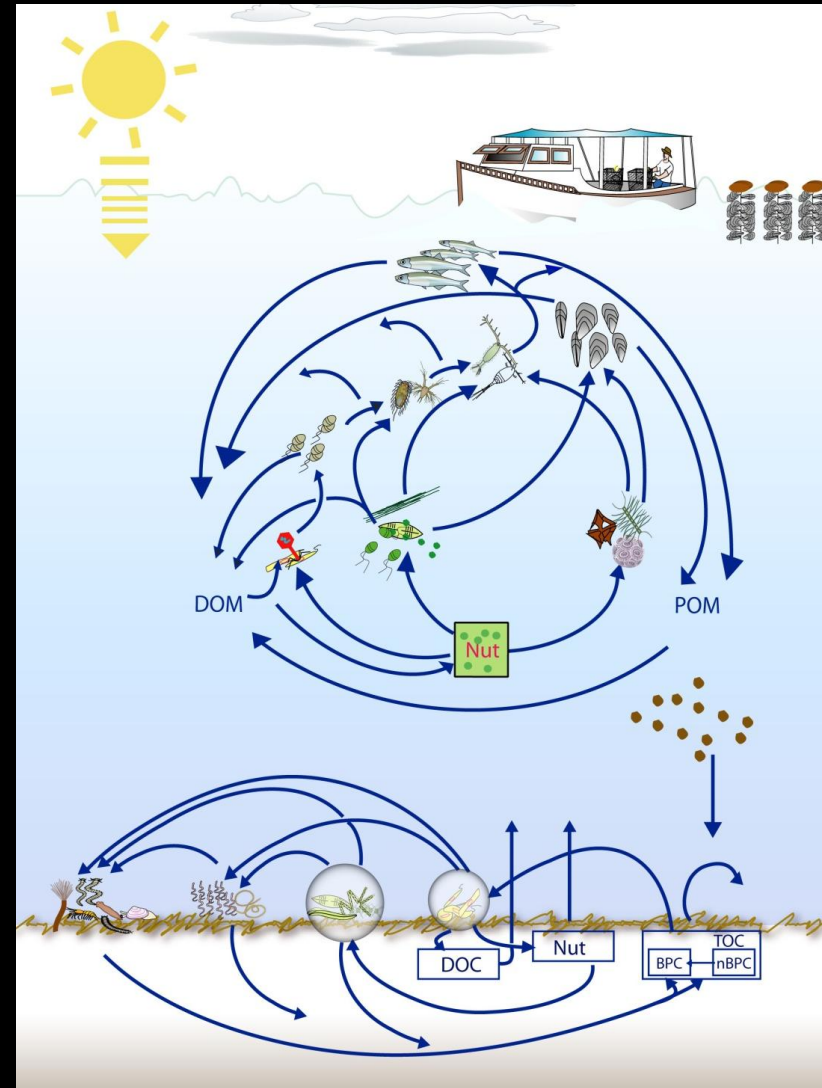
Direct effects

Indirect effects

LCA approach

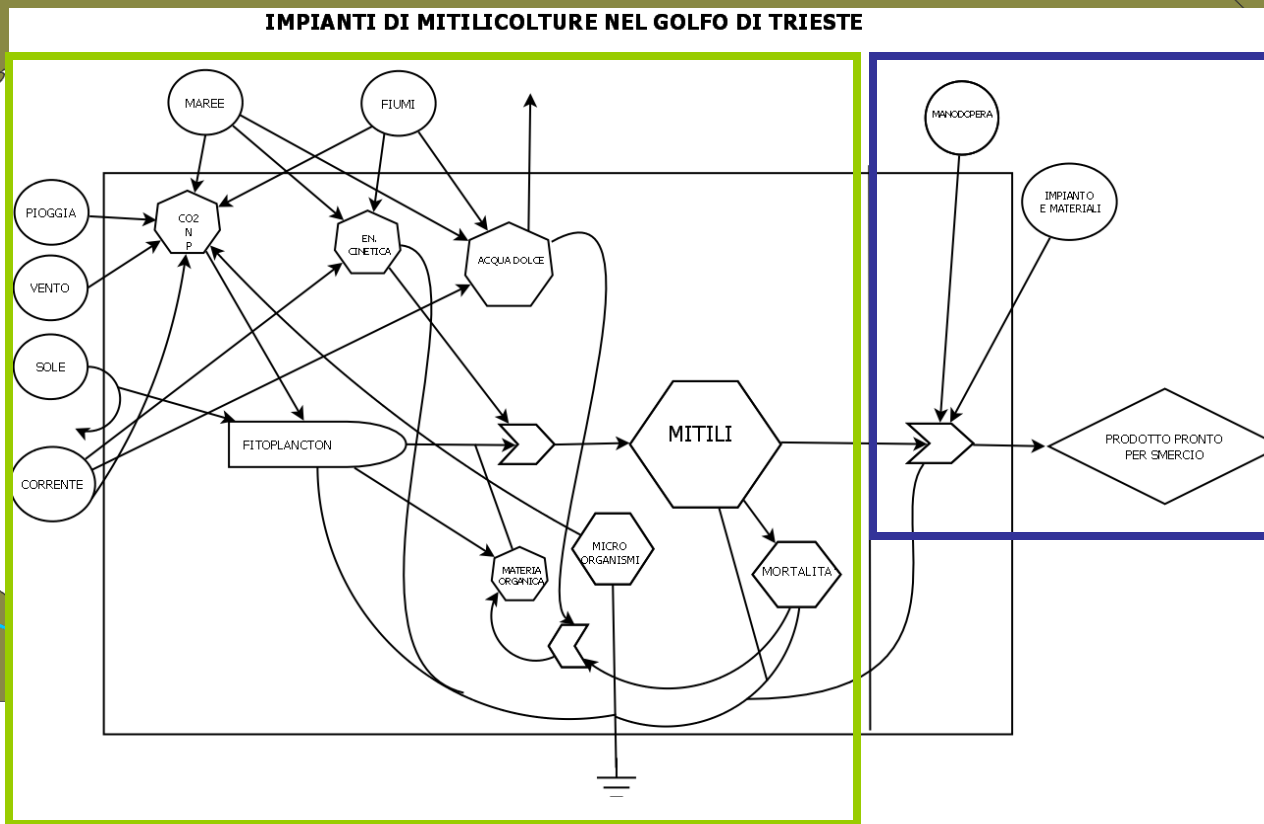
Upscale at ecosystem level

Social and economical impliactions



How much is it? The environmental cost

eMergy Balance and Ecological Footprint



eMergy = total energy (natural and anthropogenic, converted in solar energy) used to sustain a process

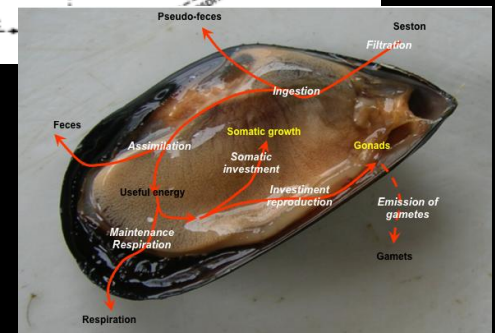
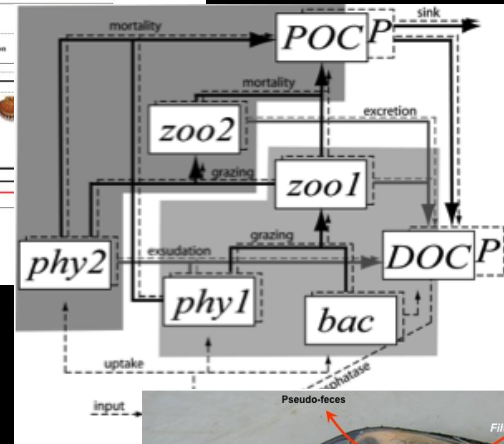
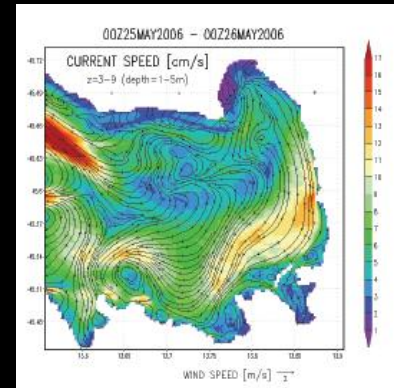
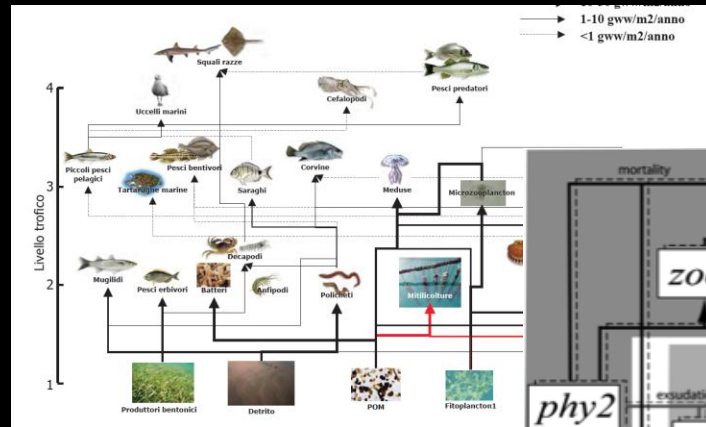
Enable to compare 'environmental load' of different resources

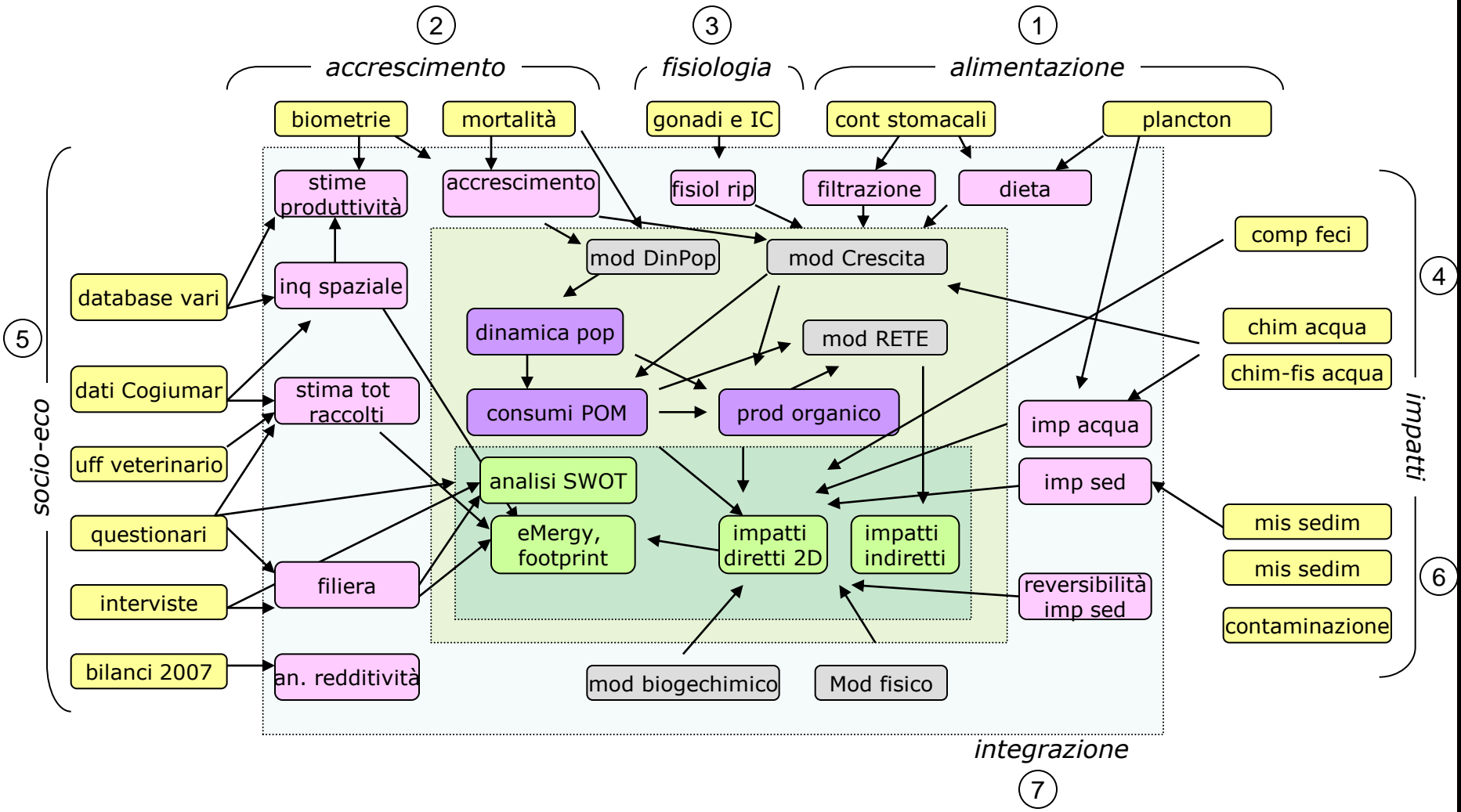
Castello di Miramare

SCALING UP : From physiological components, to individual, to population, to ecosystem. From farms to gulf

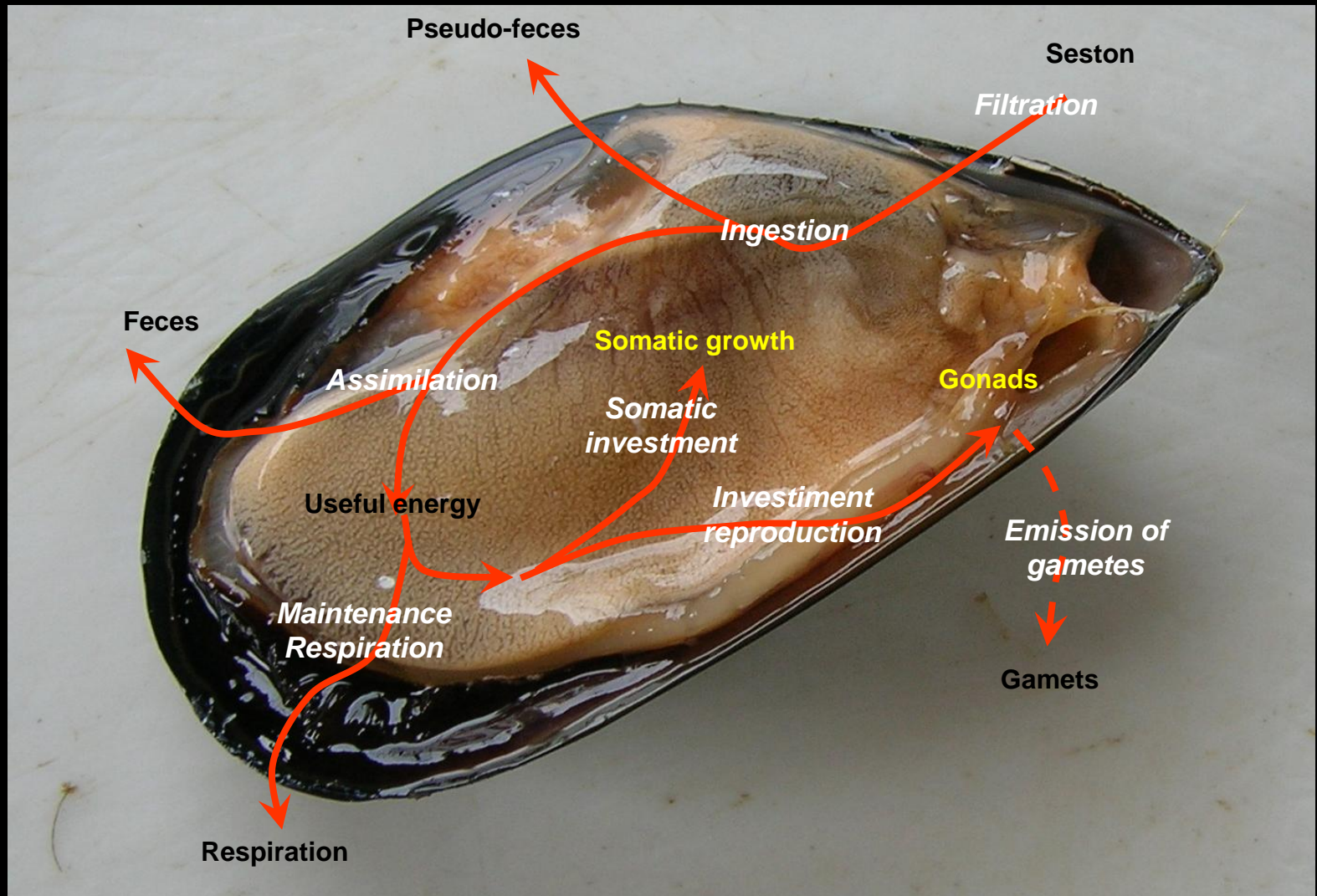


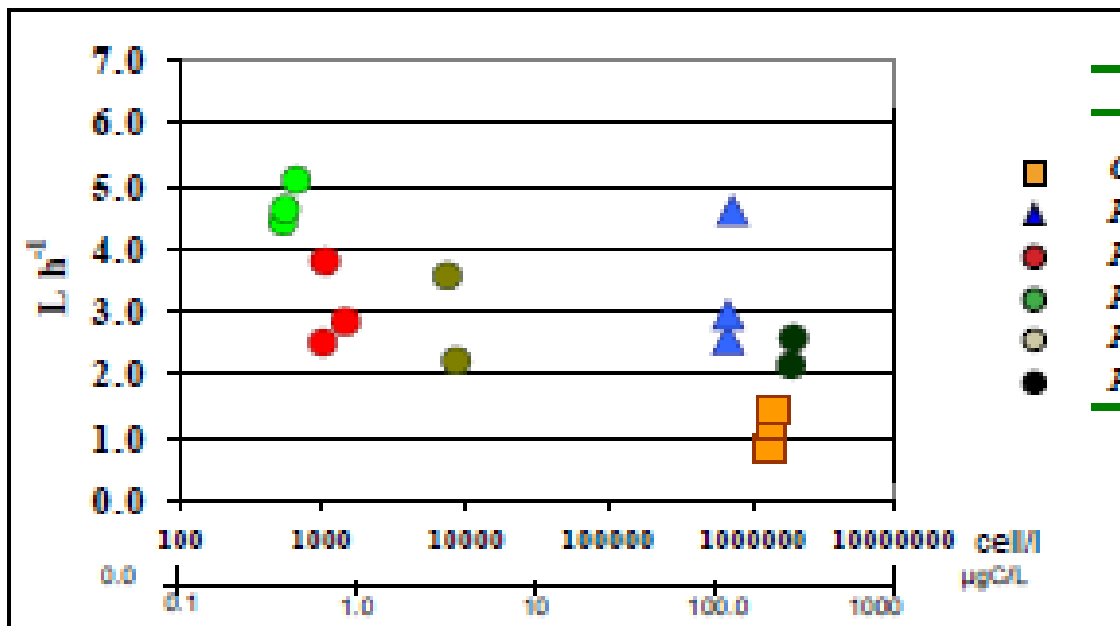
gulf (ecosystem)
 many farms
 1 farm
 1 individual /cohort



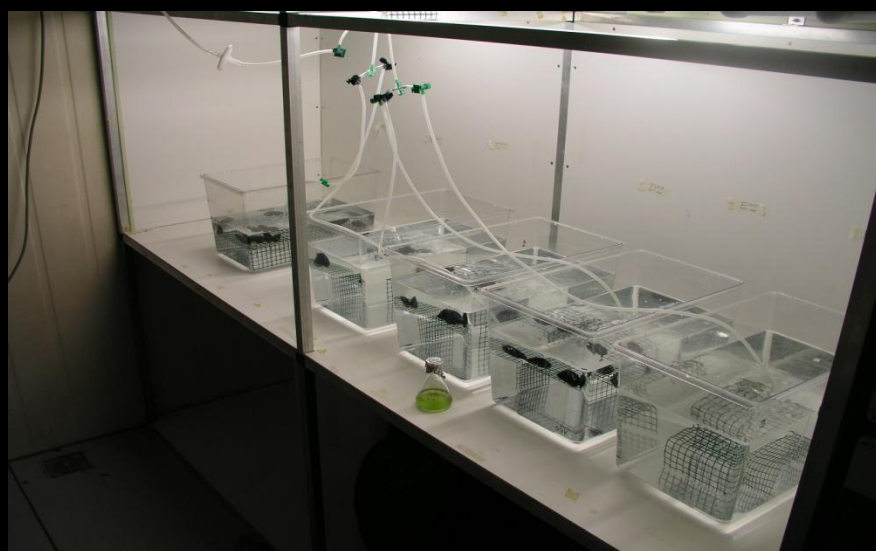
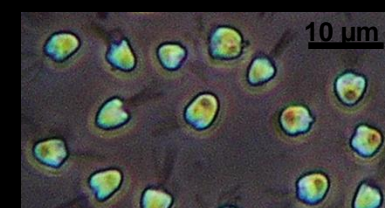
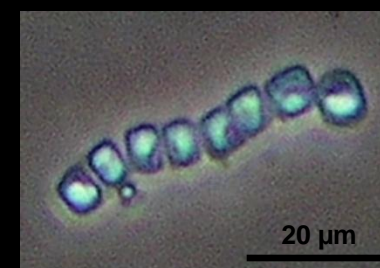


physiology





Prede	GR media
<i>Cyclotella</i> sp.p.	1,11
<i>Prorocentrum micans</i>	3,01
<i>Prorocentrum minimum</i> Esp. A	4,68
<i>Prorocentrum minimum</i> Esp. B	2,86
<i>Prorocentrum minimum</i> Esp. C	2,32
<i>Pyramimonas</i> sp.p.	3,35





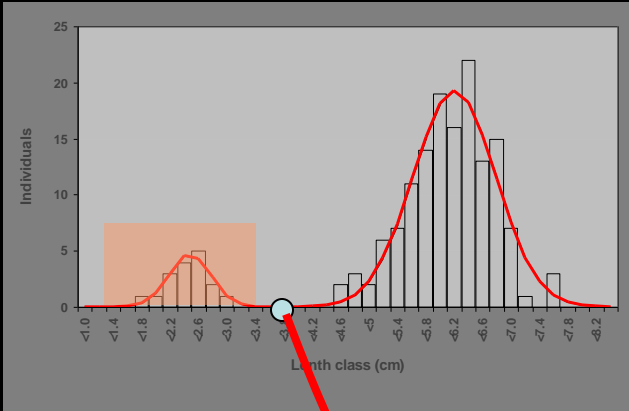
**Growth in farm-like conditions:
Biometric measures
(monthly, 8 cohorts, 3 areas)**



200 ind: length (mm)
30 ind: largeness (mm);
weight (g ww)
dry, wet, ashfree (g ww)

length

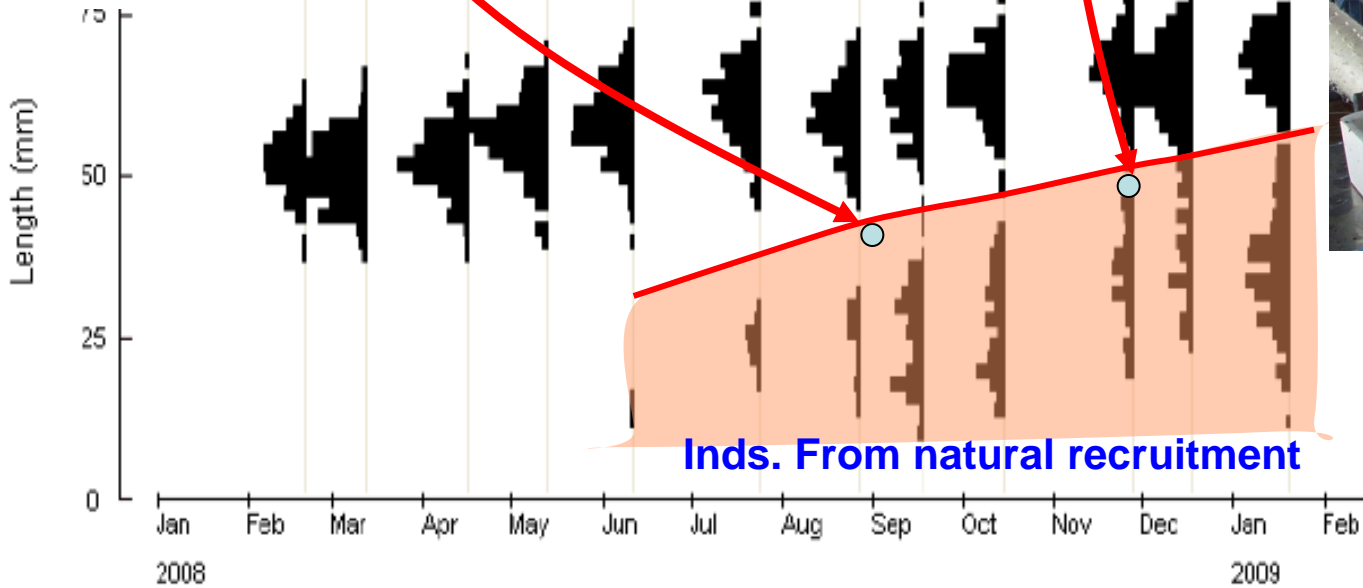
Cohort dynamic after assigning natural recruitment individuals to a different cohort



...30000 ind...



# SPECIMEN	89	204	154	190	156	158	147	195	215	157	260	265
# SP IN COHORT	89	204	154	190	153	141	127	104	139	98	198	121



Inds. From natural recruitment

SUITE OF MODELS

Socio-eco climatic scenarios

Human and SES

Food web model

gulf vs ecosystem

hydrodyn model

Many farms (gulf) vs BGC

Bio-geochemical model

Population dynamic model

1 farm vs **BGC**

Bioenergetic mussel growth model

1 individual /cohort vs BGC

hydrodynamic model mitgcm

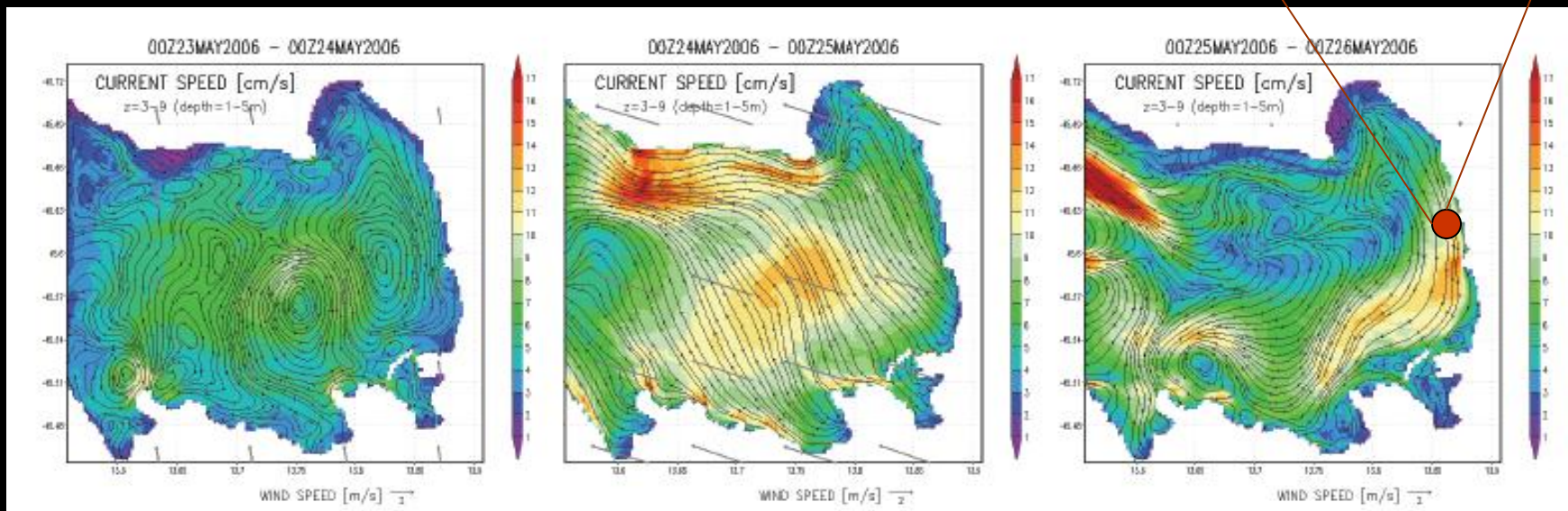
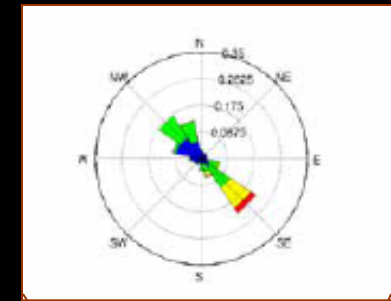
Finite volume non hydrostatic

50x50m 21 lev , z coordiantes

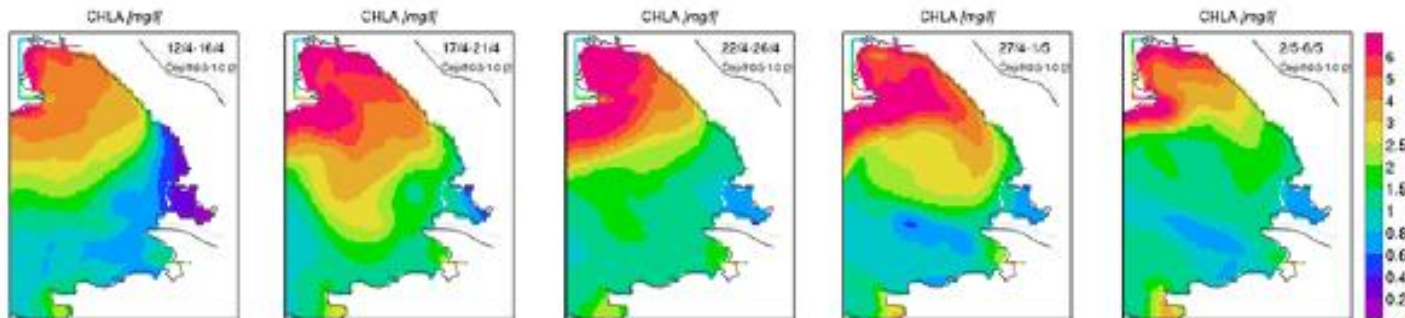
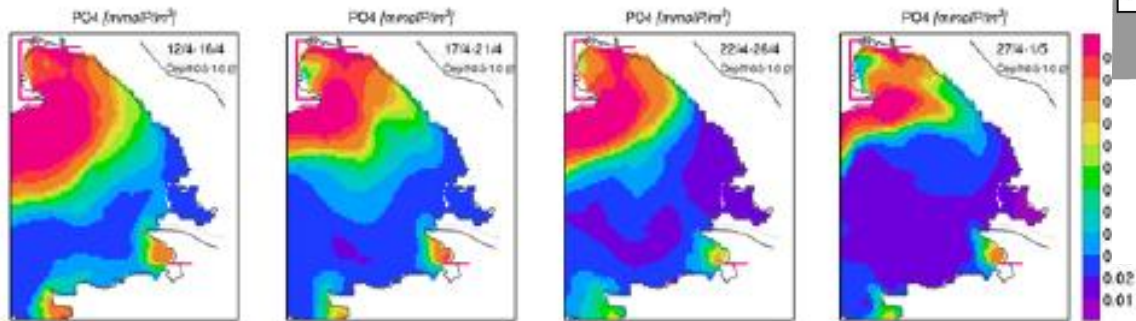
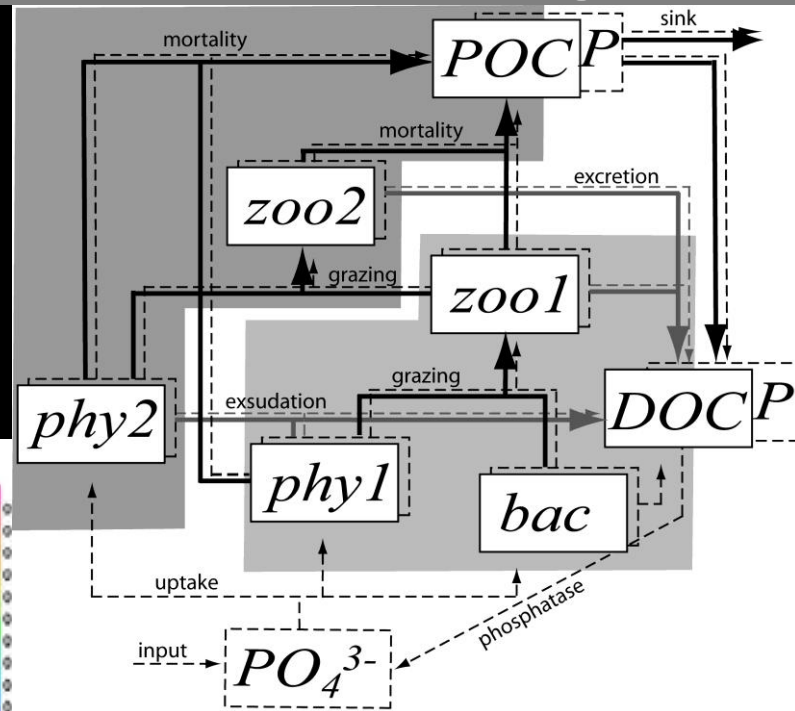
Forced by surface winds (hi res local meteo model)

Forced by river load (automatic probe)

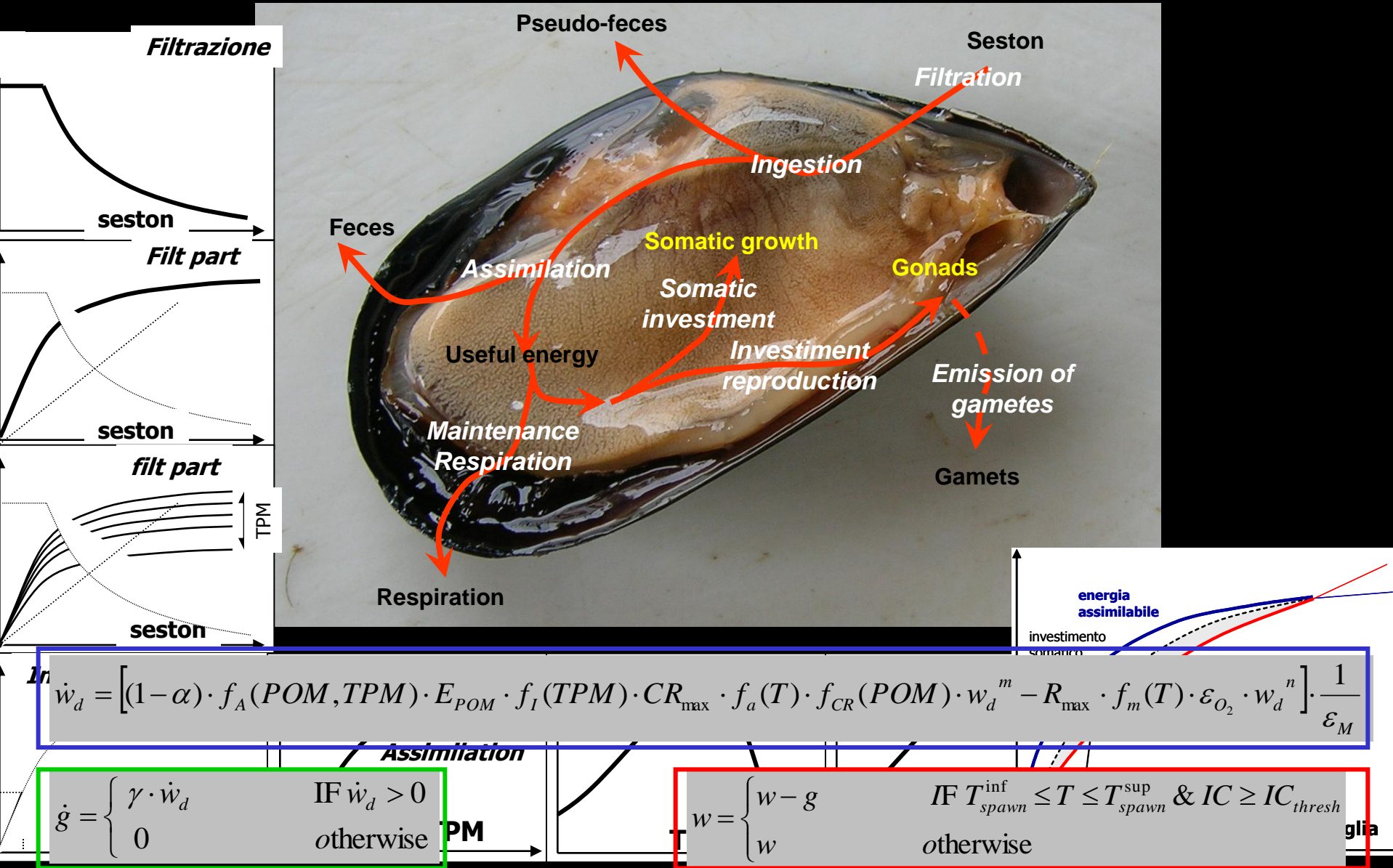
Nested in larger model (BC at open boundary)



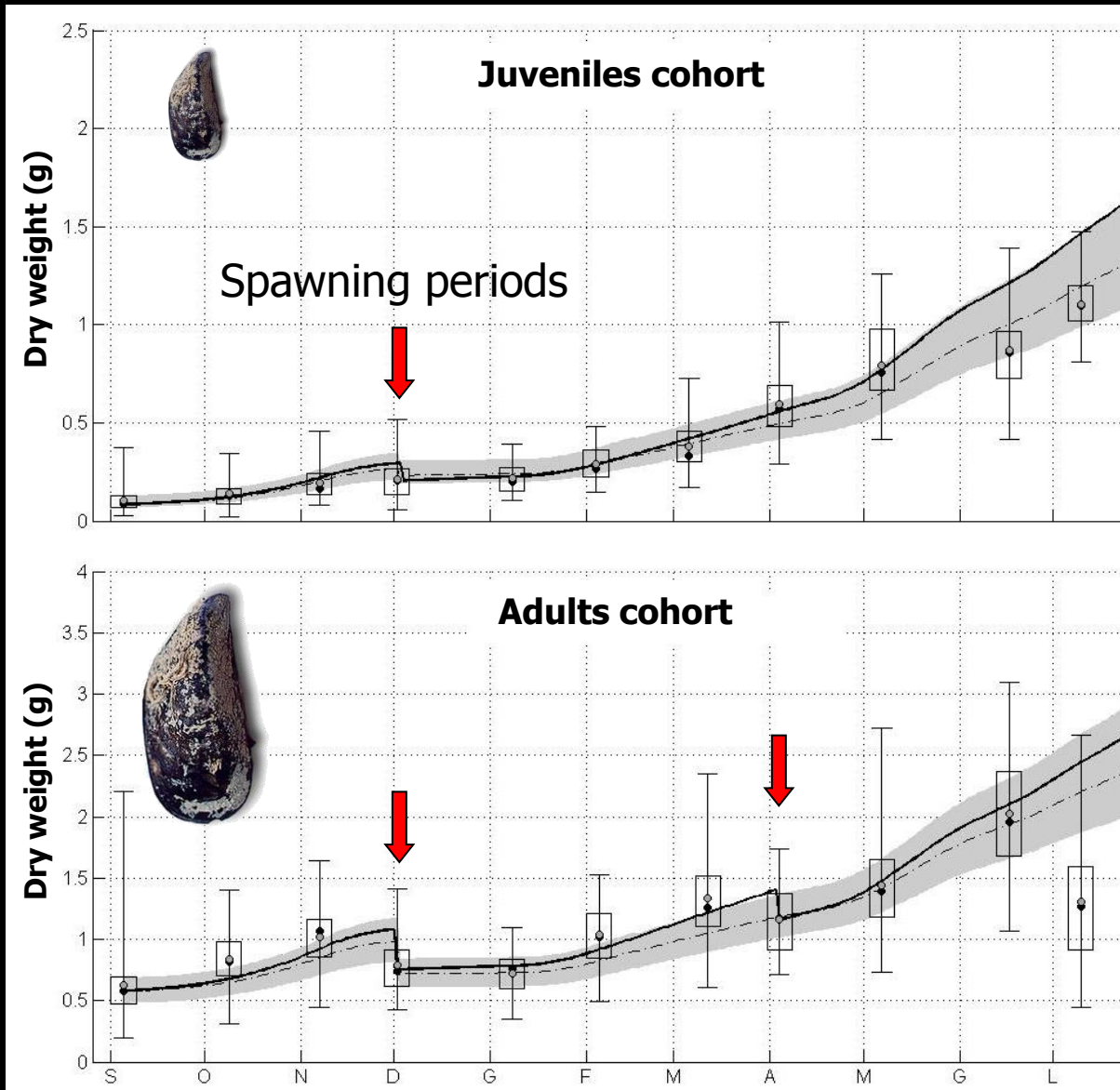
Bgc model (coupled to mitgcm) fields of bgc properties in no mussel condition



bioenergetic model of individual mussel



Population (many individuals with different parameters)

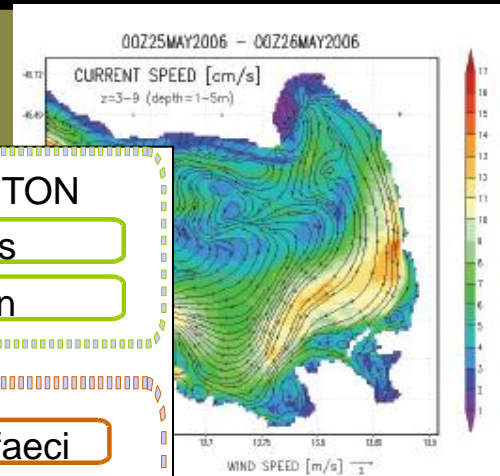
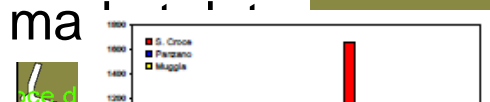
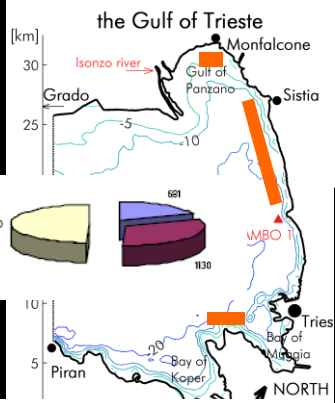


forcing

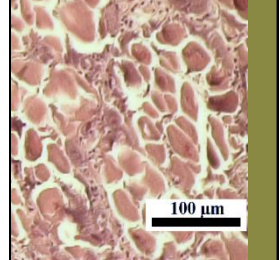
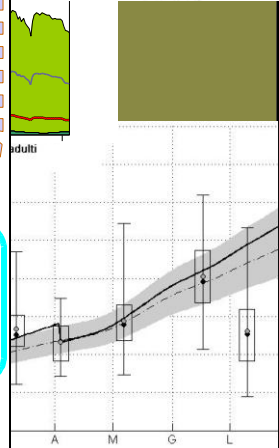
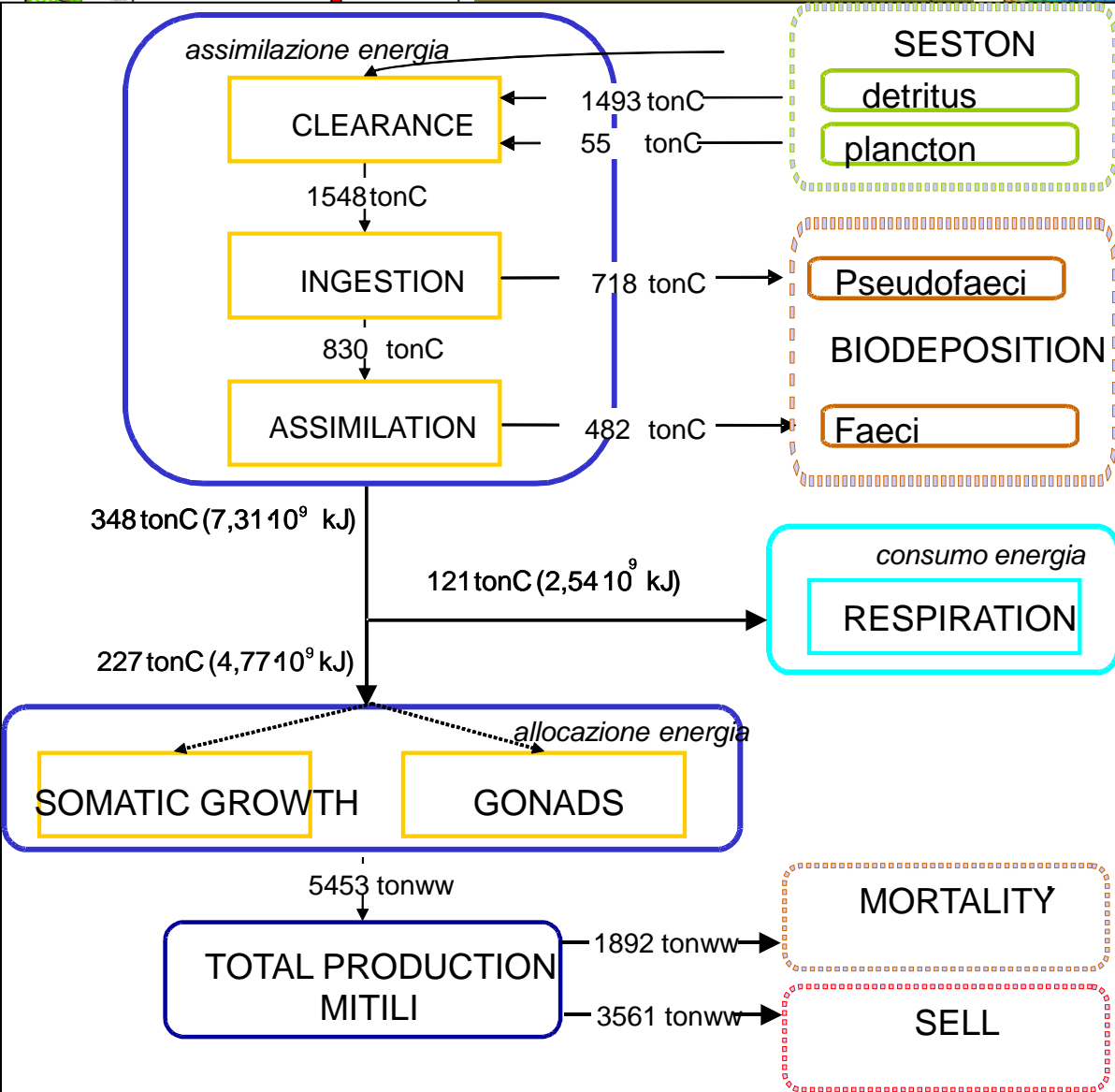
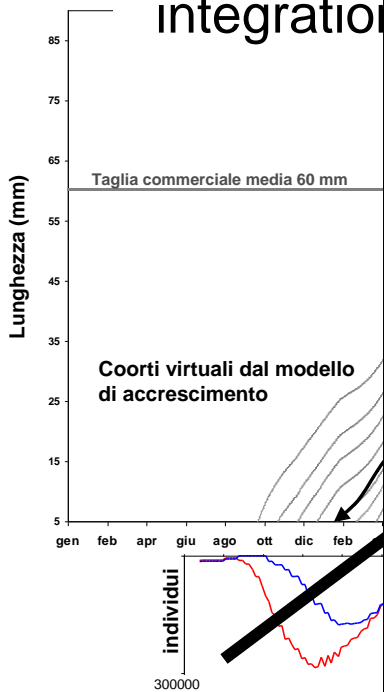
TSM
POM
Clorofilla
Temperatura
 (data interpolati)

Bootstrap for **(C_{max}, γ)**.

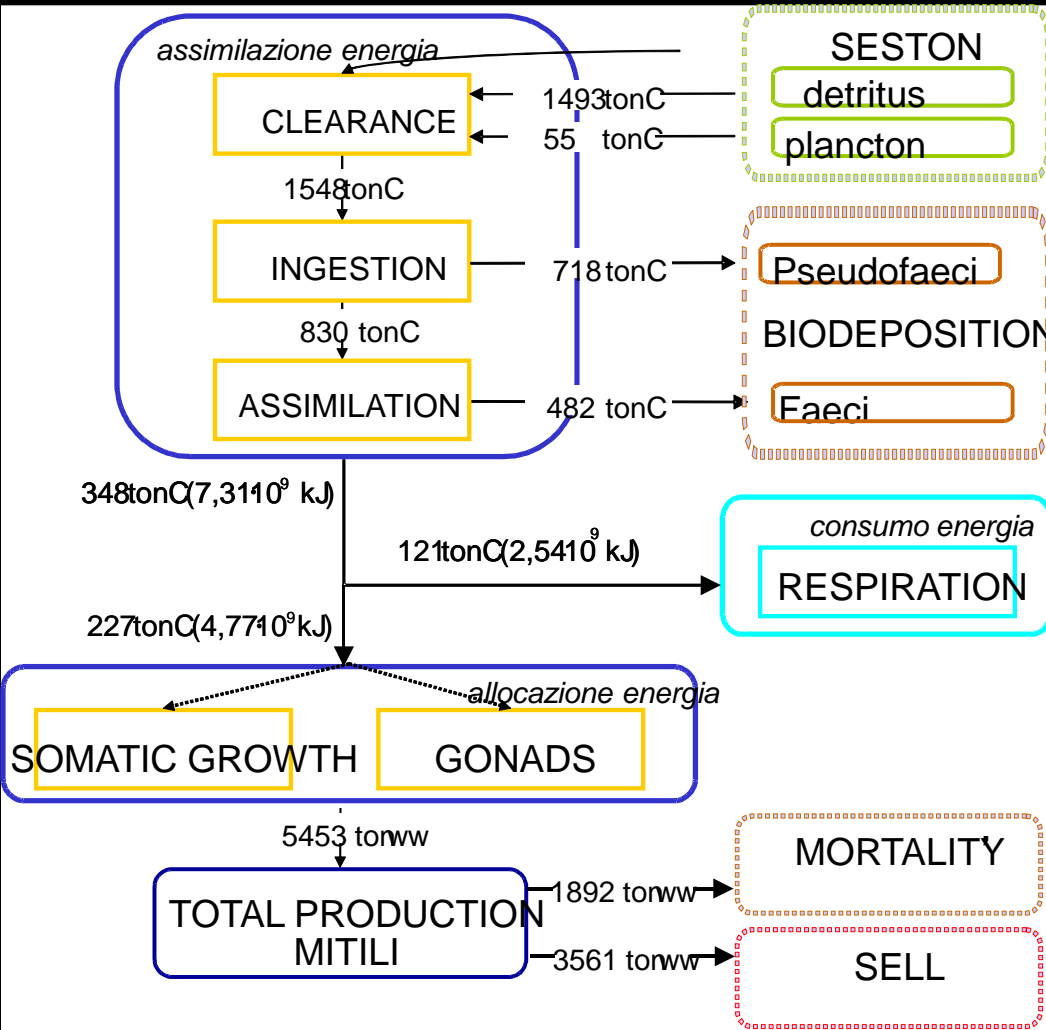
integration



market da
backward
integration



Fluxes associated to musselculture [tonn C/y]



Mussels filter 12000 ton /y of organic matter, equivalent to 600 ton C/y

= plankton primary prod of 30 km² (if all pom were plankton use 30 km²..)

Actually plankton used is about 100 tC/ equivalent area used about 3 km²

Considering transport + presence other species 10 km²

75% ingested matter recycled in very short time

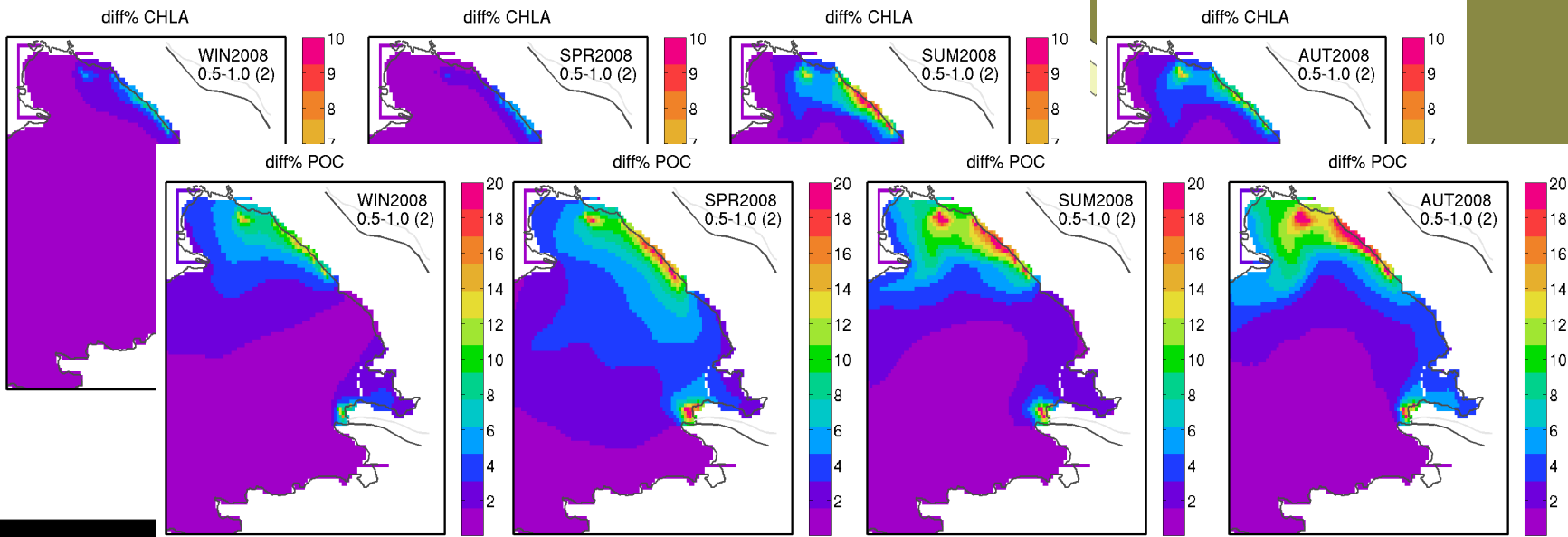
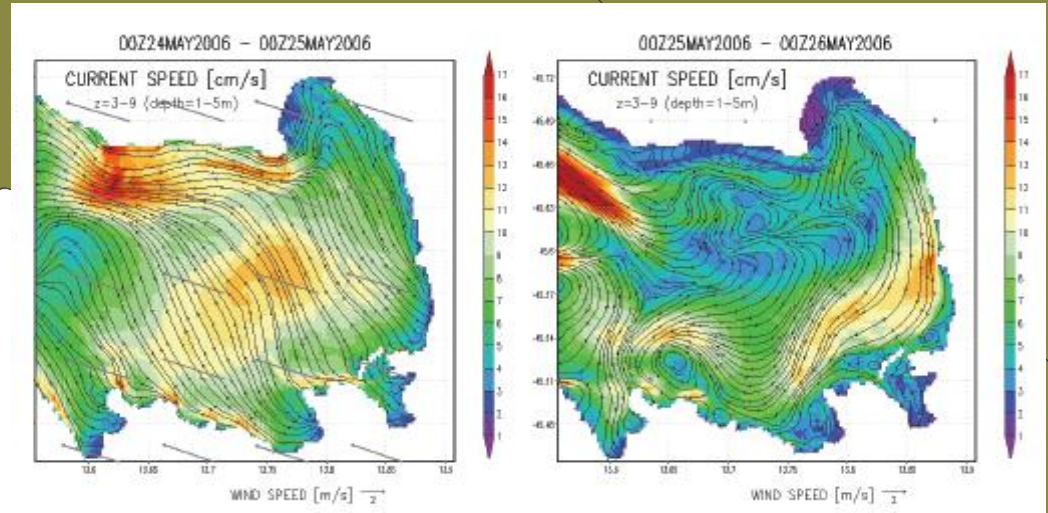
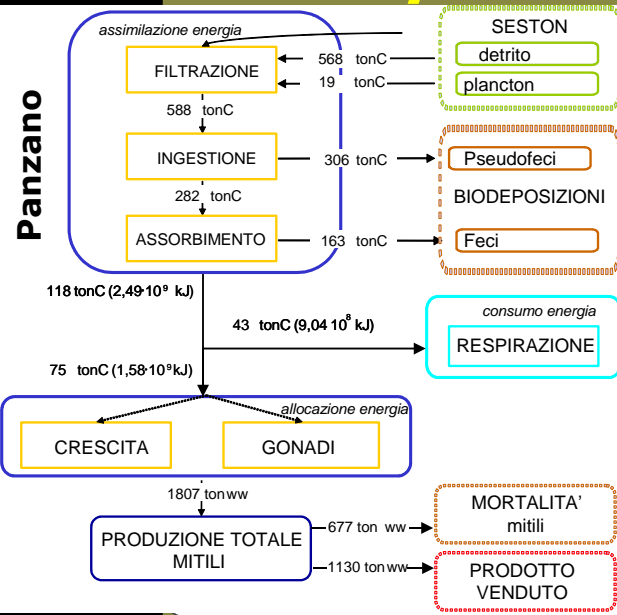
about 3km²

PLANKTON PP GoT: 42-53 gC m⁻² year⁻¹
(Fonda Umani et al., 1992)

Castello di Miramare

Spatial distributions *DIRECT* impacts

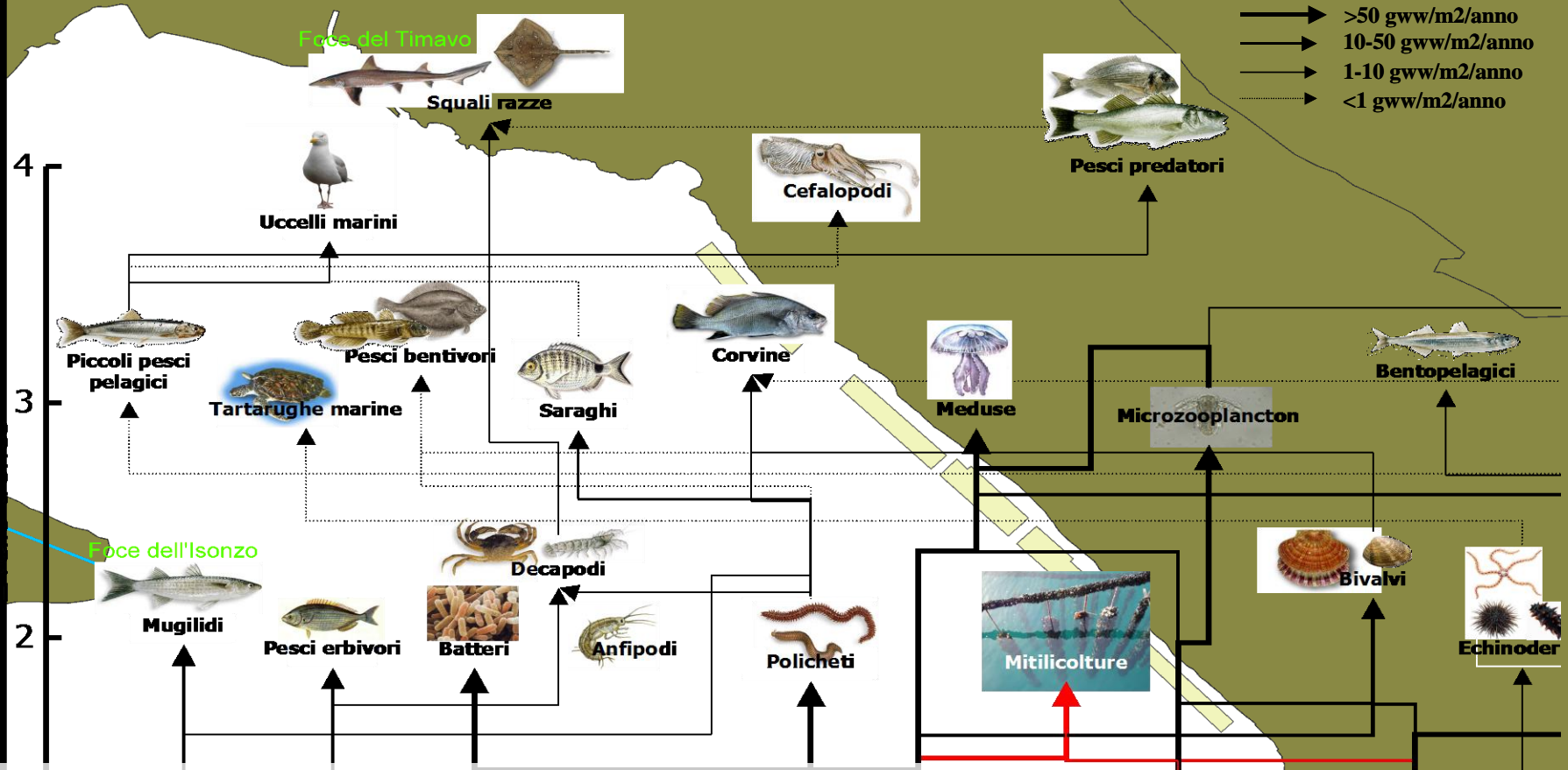
Panzano



<20%
<5km

HYDRO+BCG+ mussel

INDIRECT (CASCADING) EFFECTS: FOOD WEB + MUSSELS

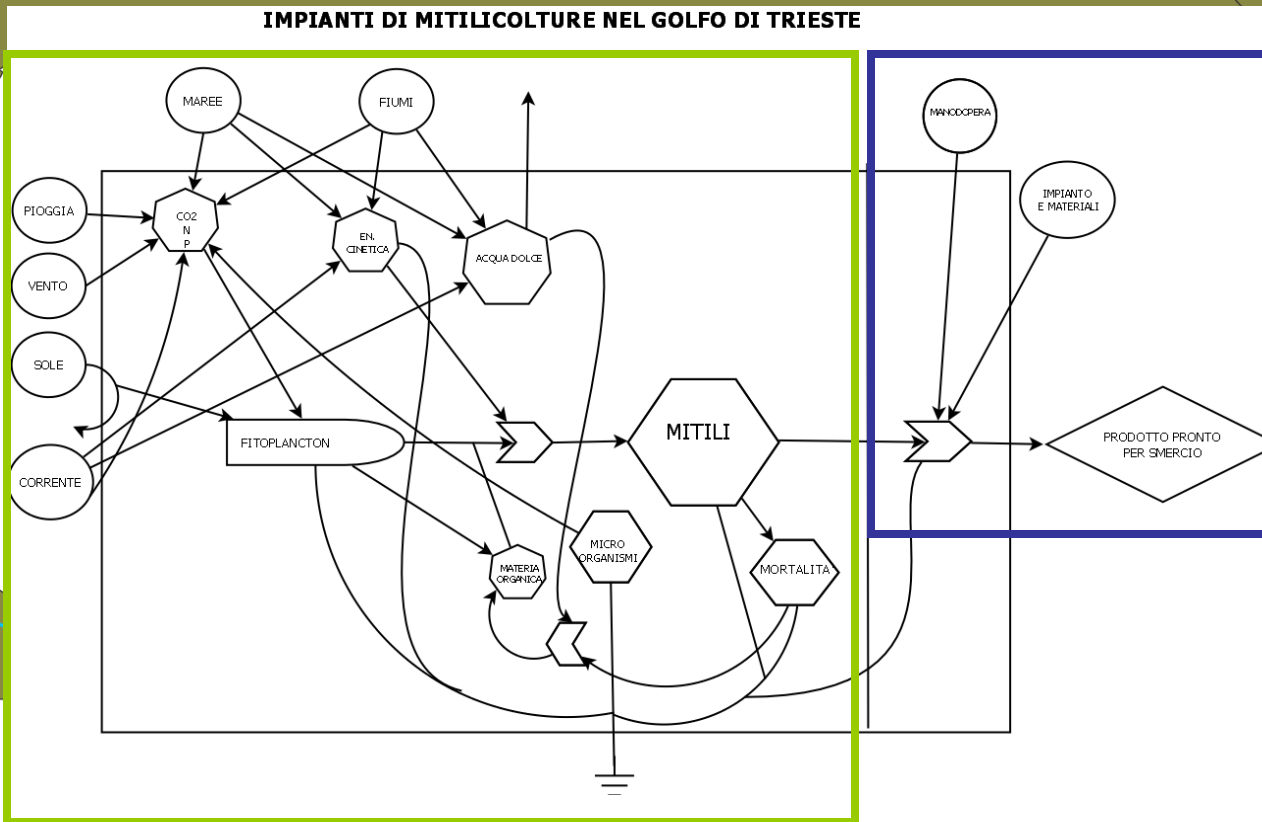


- >50 gww/m2/anno
- 10-50 gww/m2/anno
- 1-10 gww/m2/anno
- <1 gww/m2/anno

MUSSEL FARMS :
 filter 10% of phyto totally filtered in the food web
 Filter 65% of POM totally filtered by foodweb
 produce 45% of POM totally produced by FW
 High biomass (10% FB)
 Low relevant cascading effects

30 km2

eMergy Balance and Ecological Footprint

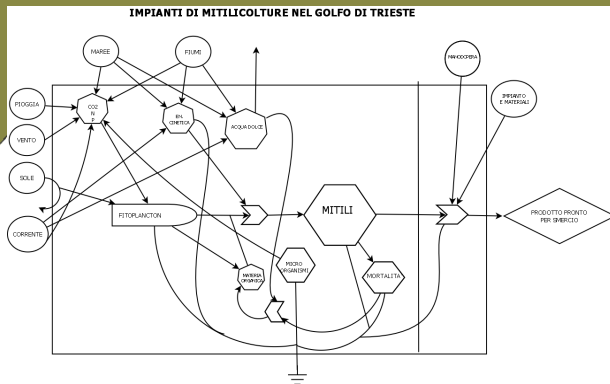


eMergy = total energy (natural and anthropogenic, converted in solar energy) used to sustain a process

Enable to compare 'environmental load' of different resources

Castello di Miramare

eMergy Balance

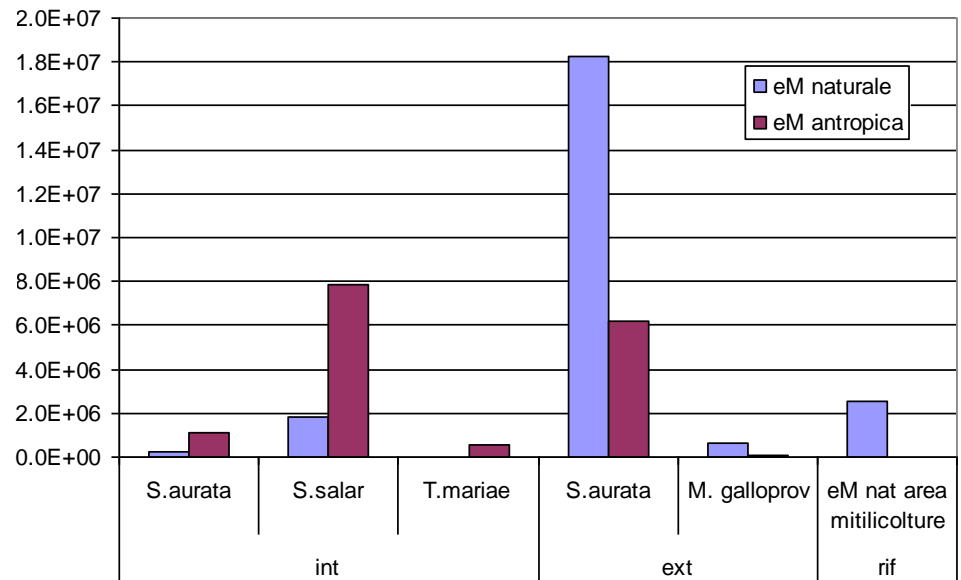
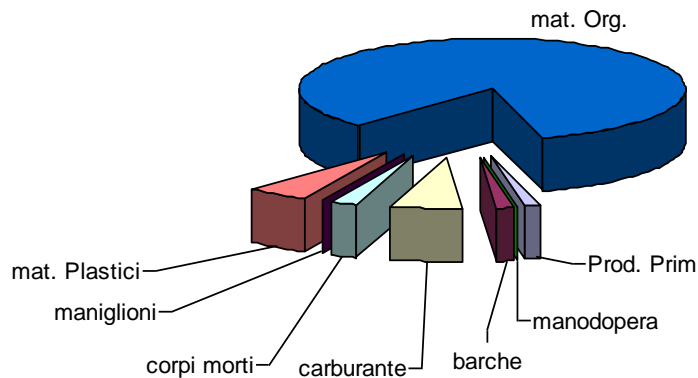


Natural Resources 5x anthropogenic ones (plastic, gasoline)

Use of Anthropogenic resources moderate in respect to other activities)

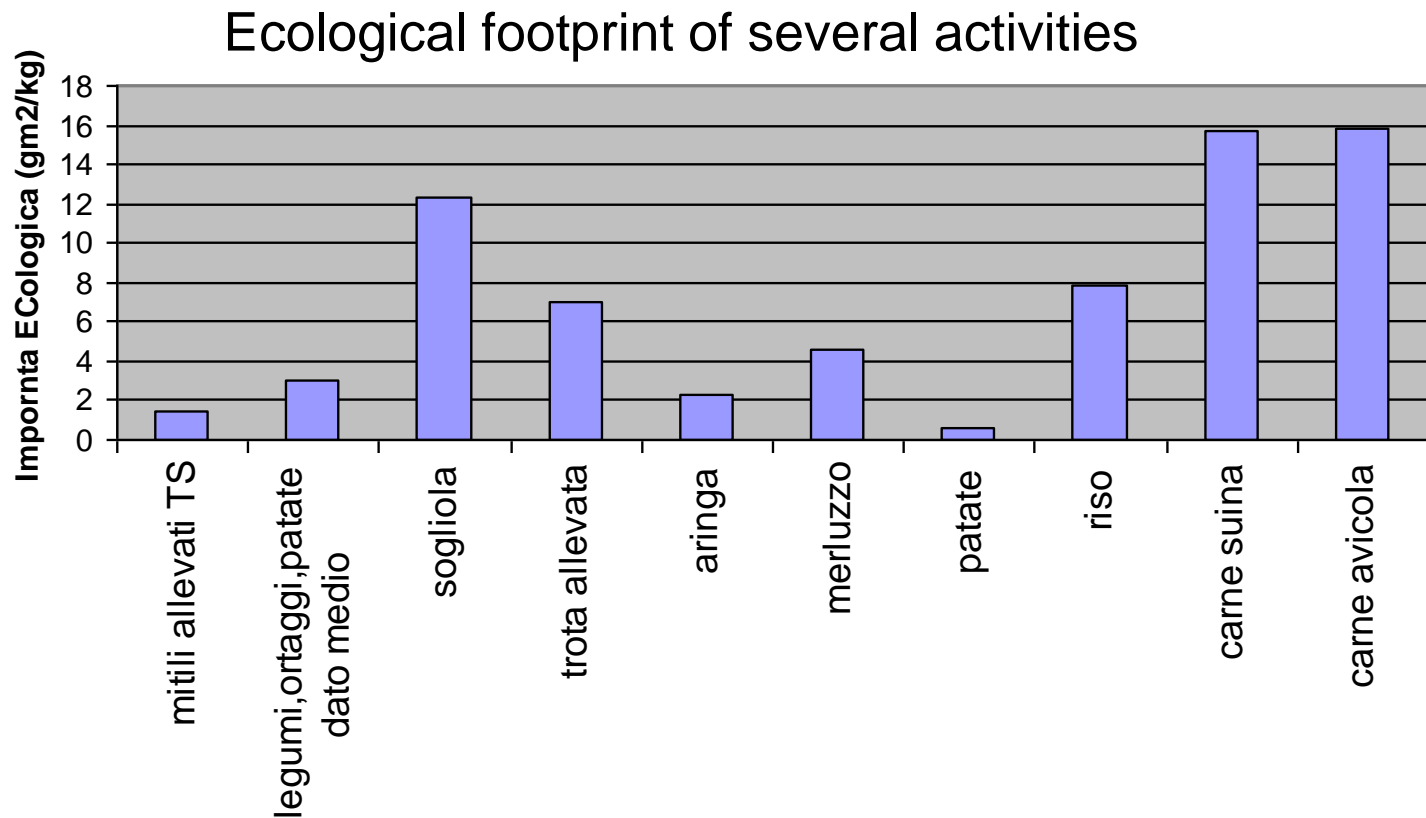
Use of natural resources moderate in respect to other activities and in respect to availability

contributi energetici al totale mitilicoltura

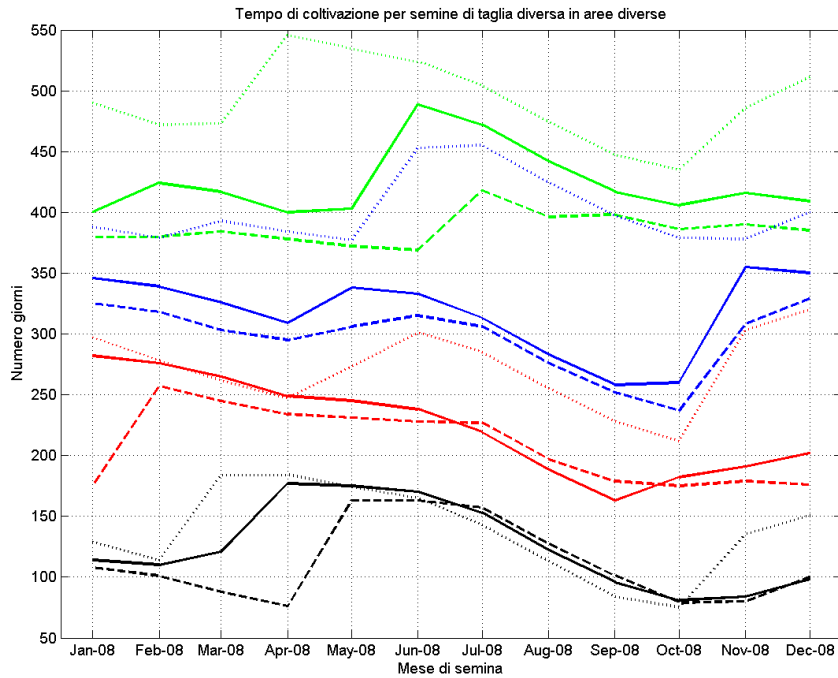


Ecological footprint

EF= 600 gha, similar to vegetable,
Balanced by 6 km² of local coastal area



SCENARIOS

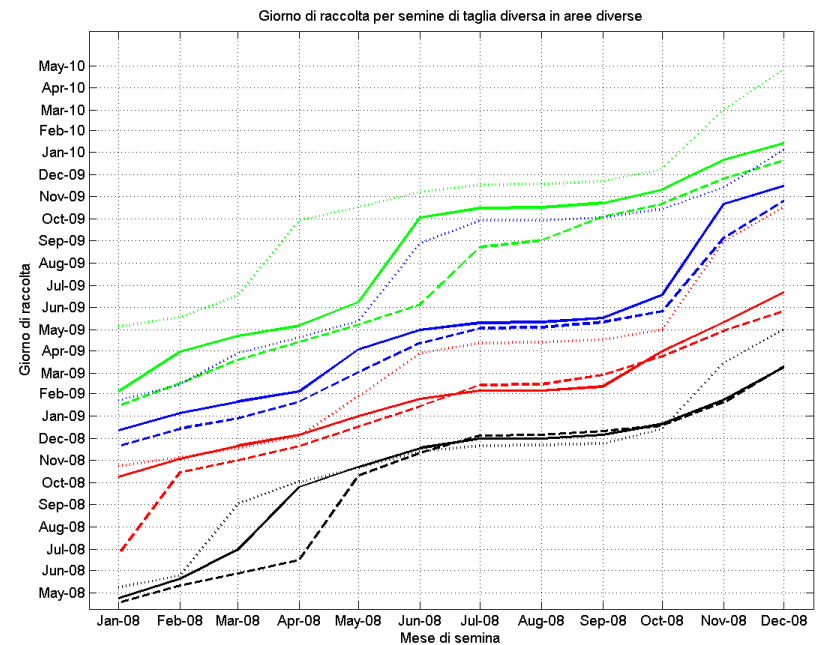


management

Time to harvest

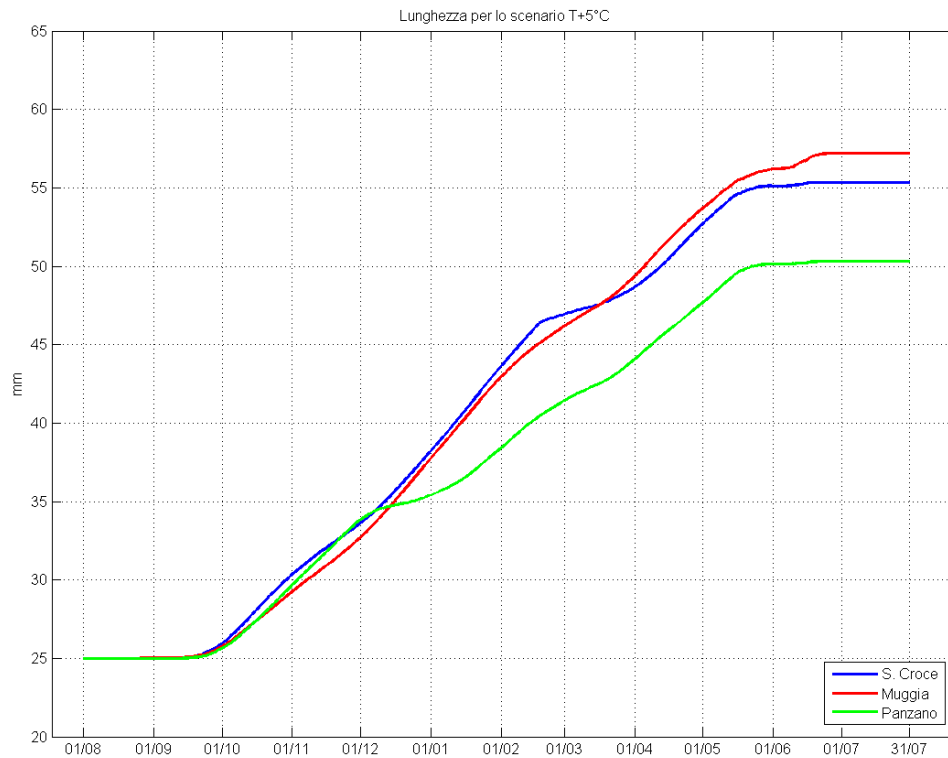
Harvest day

As a function of seeding months, size and area



SCENARIOS

CLIMATE



**SLOWER GROWTH
IN ALL SITES**

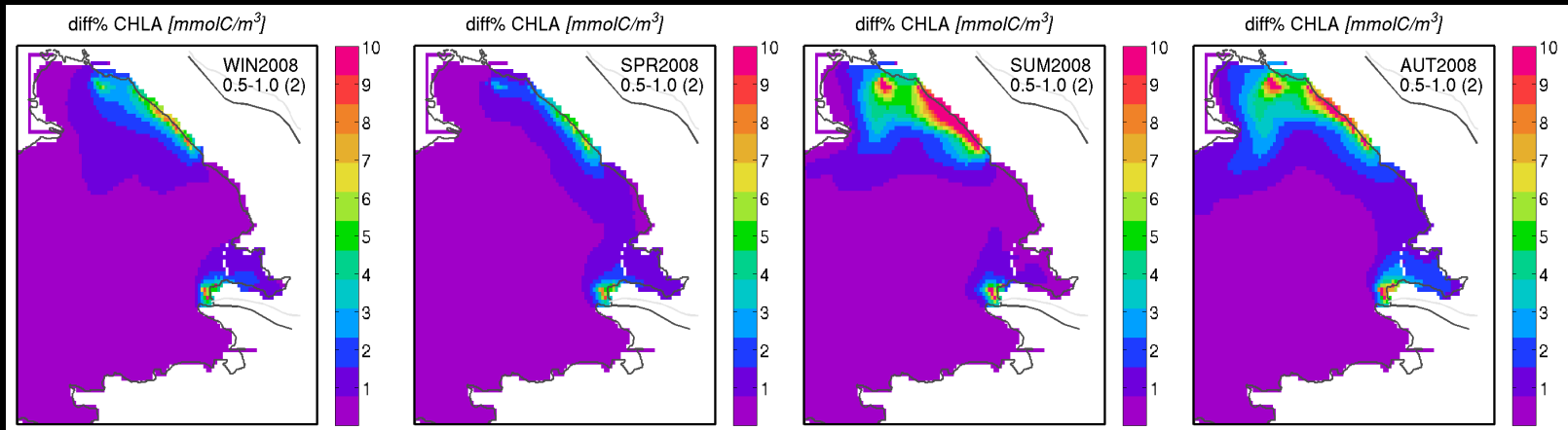
Panzano 50 (-4)

SCroce 55 (-4.5)

Muggia 57 (-6)

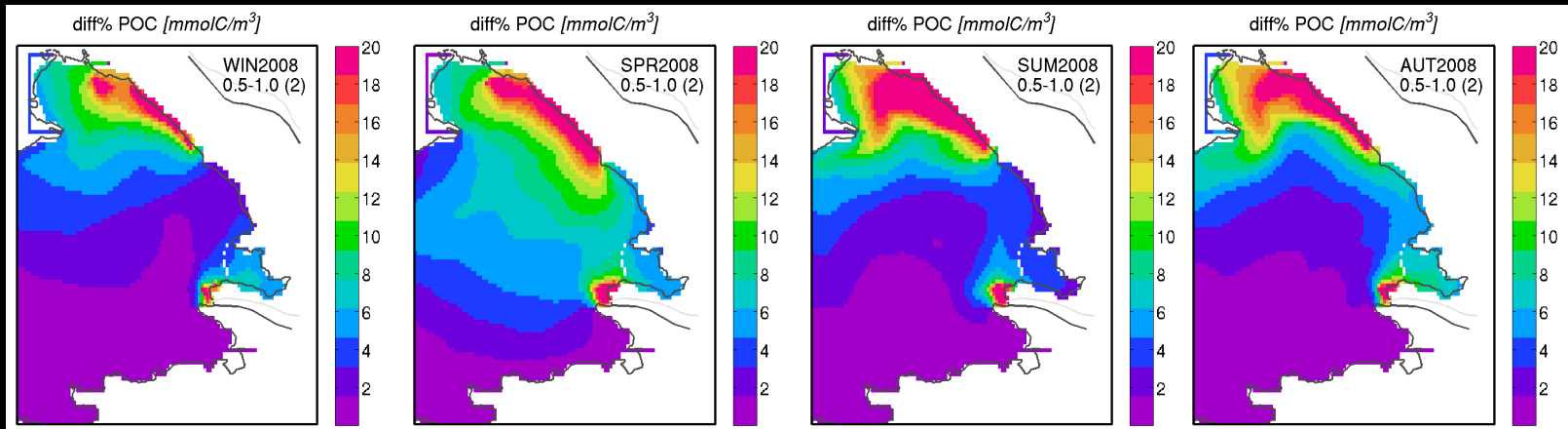
SUMMER TOO HOT

**SPAWNING LIMITED IN
TIME**

SCENARIOS**MORE FARMING X2**

>10%

1 ->6 KM2



>20%

2->20 KM2

INDIRECT effects: negativ on PPP, planctivors e bentos,
Balanced by increament in OM

exercise shows as (a suite of) models
are precious tool for:

- 1 upscale effects/impacts of mussel
from individual to ecosystem
- 2 compute/compare direct effects
- 3 compute/compare indirect effects
- 4 provide information needed for
computation of sustainability
indicators (eM or EF)
- 5 provide info needed for MSP
- 6 scenario analysis
- 7 assess sustainability of an
activity based on exploitation of
natural resources**



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