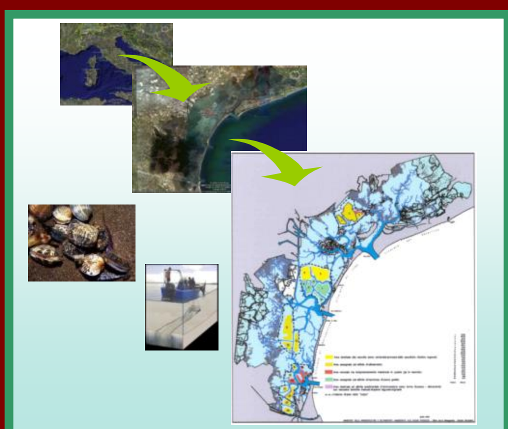
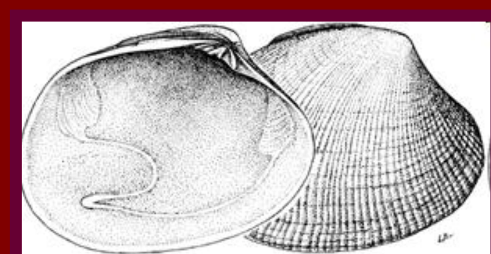
SSA15 *Lagoon of Venice*
Design and scenarios to explore system dynamics

D. Melaku Canu[1]; P. Campostrini[2]; S. Dalla Riva[2]; R. Pastres[4]; L. Pizzo[3] L. Rossetto[3]; C. Solidoro[1].

1. *OGS Istituto Nazionale Oceanografia e Geofisica Sperimentale. Trieste. Italy*
2. *CORILA Venezia. Itay*
3. *TESAF University of Padua. Italy*
4. *Dipartimento Chimica Fisica University of Venezia. Italy*





SPICOSA CONFERENCE -MALTA 2010

SSA15 Design

SPICOSA

Sustainable management of the clam *Tapes philippinarum* in the Lagoon of Venice

History

•**1983**: *Tapes philippinarum* introduction

•**1983-1990** clam colonisation

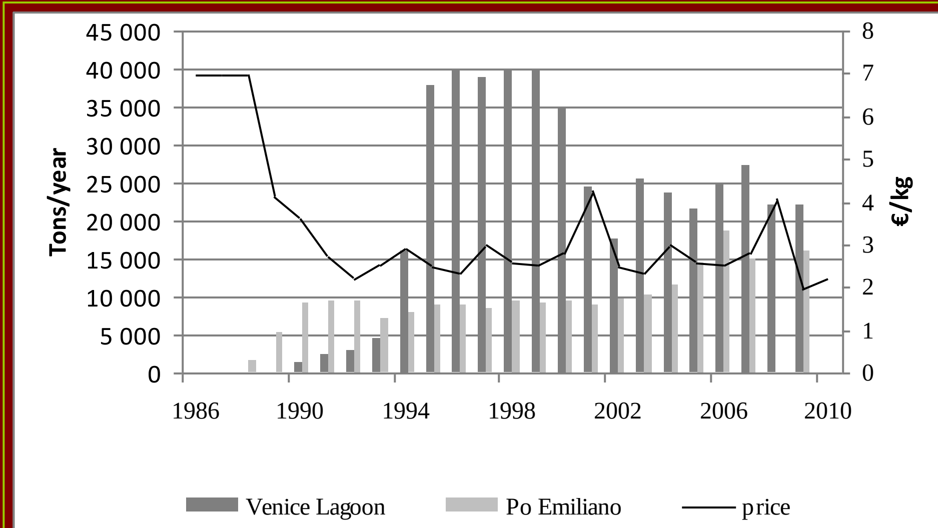
•**From1990**: fishermen started to fish in **open access regime/ social tensions/poor quality** (fished also in prohibited area)

•**1999**: catches decline

•**2001**: allocation of aquaculture concessions

•**2005**: extension of aquaculture concessions

•**2009**: revision of aquaculture concessions



SPICOSA

SSA15 *Design*

SWOT ANALYSIS CLAM FARMING IN VENICE LAGOON	
STRENGHTS	**WEAKNESSESS**
High Lagoon suitability to clam growth High productivity Nursery areas producing natural seeds Good scientific knowledge of the environmental system and of the clam's biology	Low education Low traditional knowledge Low trust of local consumers Illegal market Illegal fishing in polluted areas Low efficiency of governance network Sediment composition alteration
THREATS	**OPPORTUNITIES**
Over fishing Loss of nurseries and clam farming suitable area for other uses Climate change **SAF to address….**	Promoting education Promoting co-management Developing technology (hatcheries) Diversification Product Traceability and Certification Integrated management following a systemic approach Common Fisheries Policy: FLAG Farnet strategy based on territorial approach

Design: Stakeholder meetings

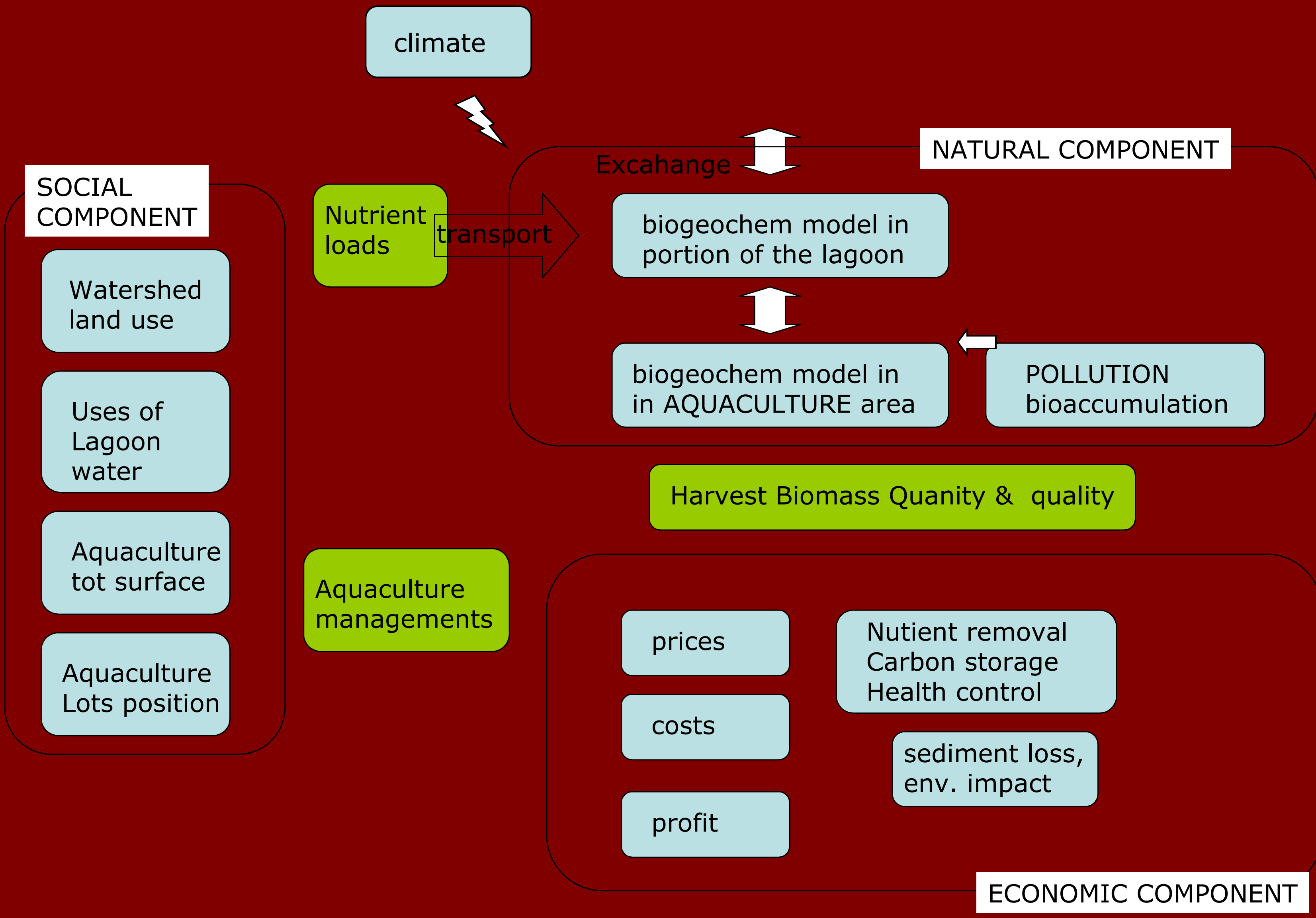
Design: Stakeholder meetings

Stakeholder type	***Stakeholder name***	***Functions***
Economic	Fishermen, market, etc.	Harvest, culture, cleaning, etc.
Institutions with management tasks	Province of Venice	Fisheries/aquaculture plan in Venice Lagoon
	Regione Veneto	sanitary legislation application
	Comune di Venezia	Lagoon protection,
	Osservatorio Laguna	Natura2000, Habitat Directive implementation
	MAV-CVN	Lagoon area allocation Lagoon protection,
Middle level management institution	GRAL, Veneto Agricoltura	Implementation of Tapes philippinarum management plans.
Institutions without management tasks		
Other associations	Consumer association: Confconsumatori Recreational association:, Vela al terzo	Citizens associations

SSA 15 General Objectives -Design (win-win management actions)

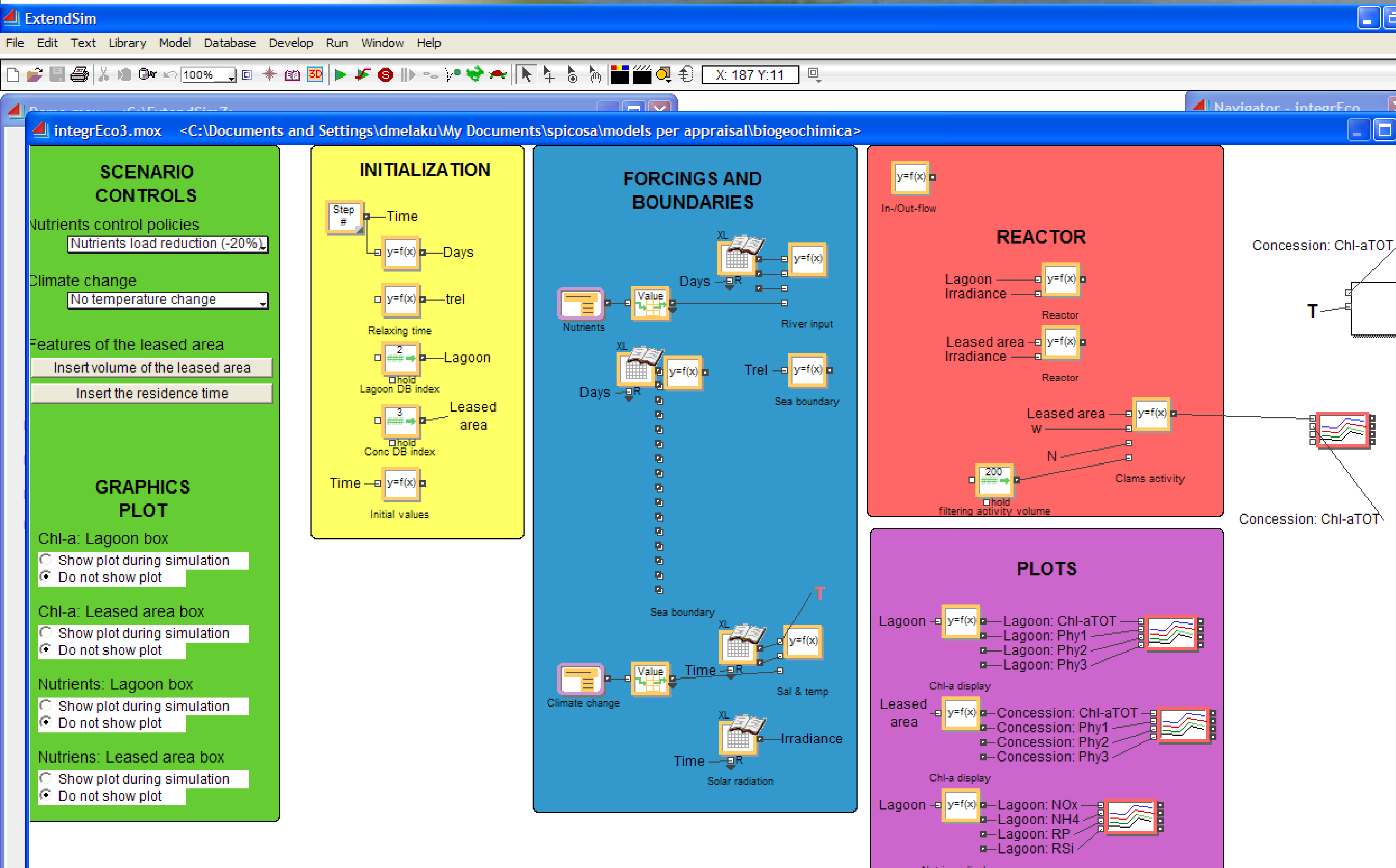
- Physical carrying capacity
- Ecological carrying capacity
- Social carrying capacity
- Sensitivity to changes

VE ESE system, Conceptual model -Design

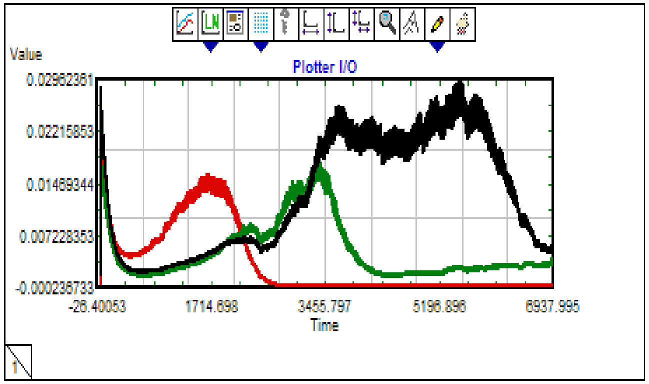


SPICOSA

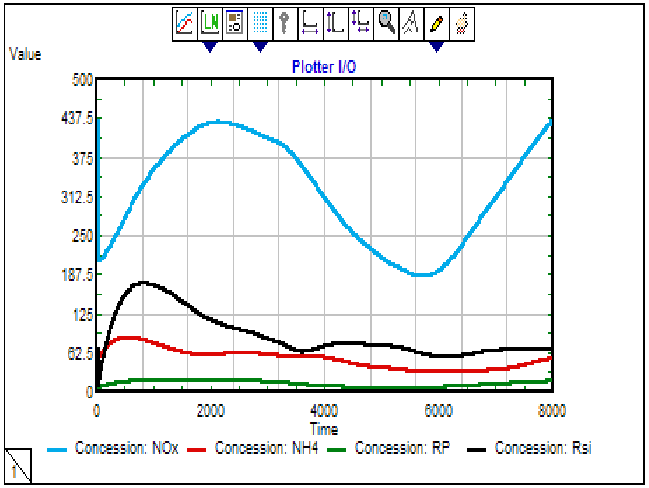
Biogeochemical Model -Design



Biogeochemical Model -Design



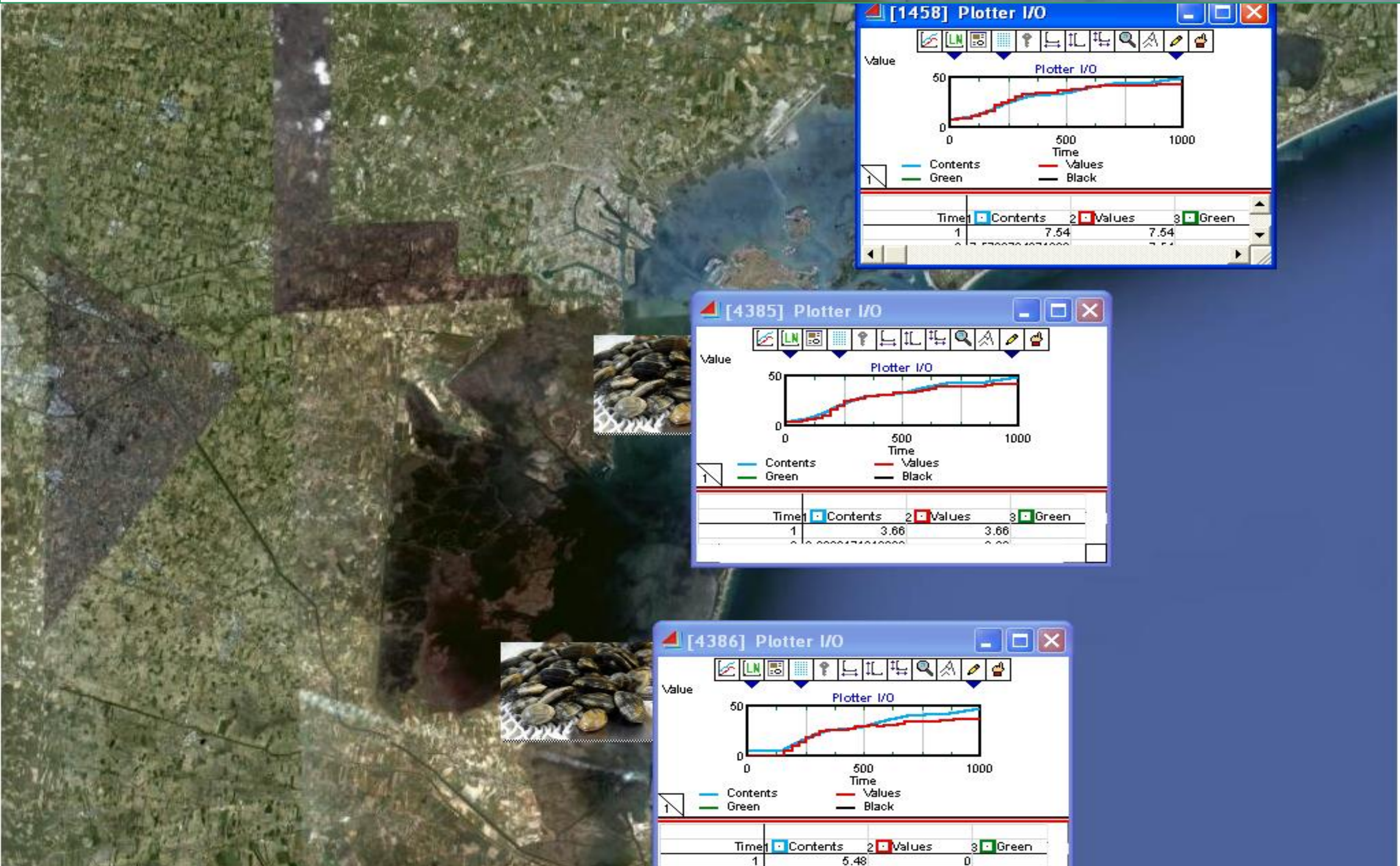
Chl a leased area



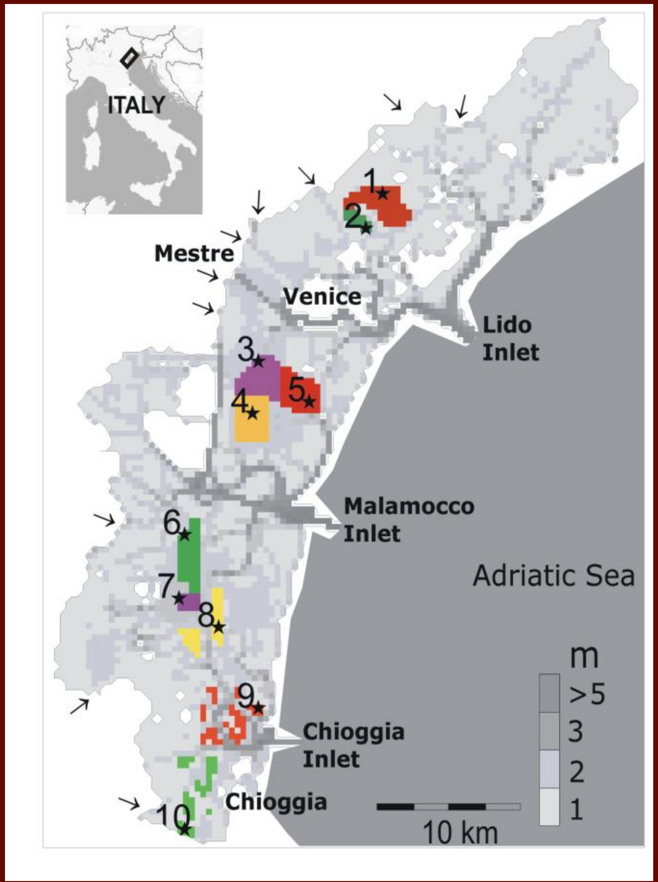
Nutrient leased area

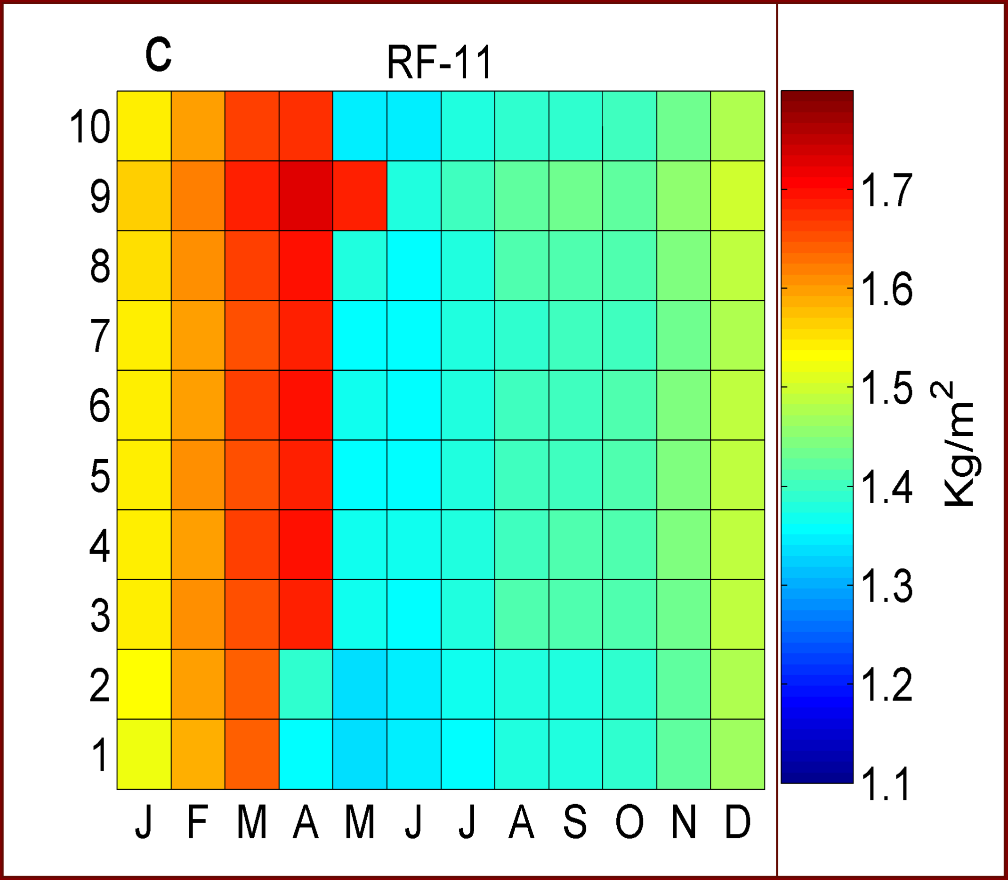
SPICOSA

Clam growth and Population dynamic model design

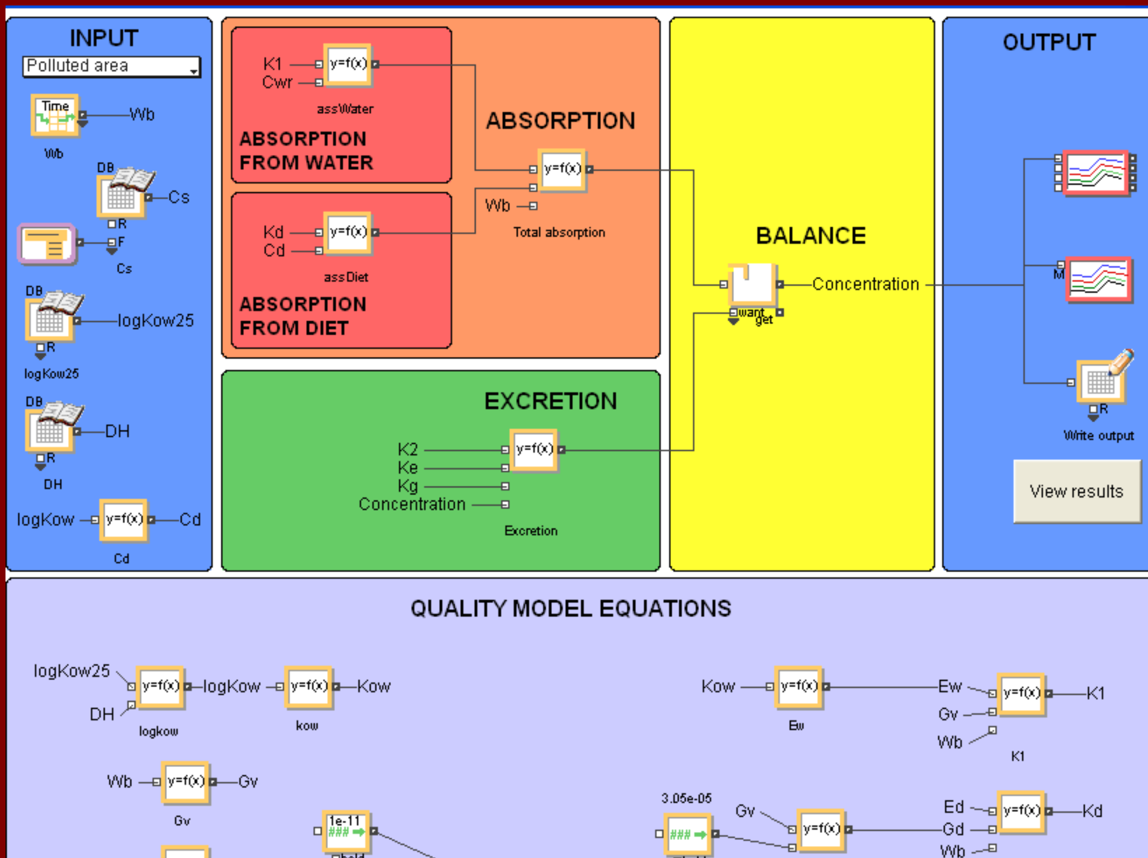


Biomass variability: kg/mq





Bioaccumulation model -design

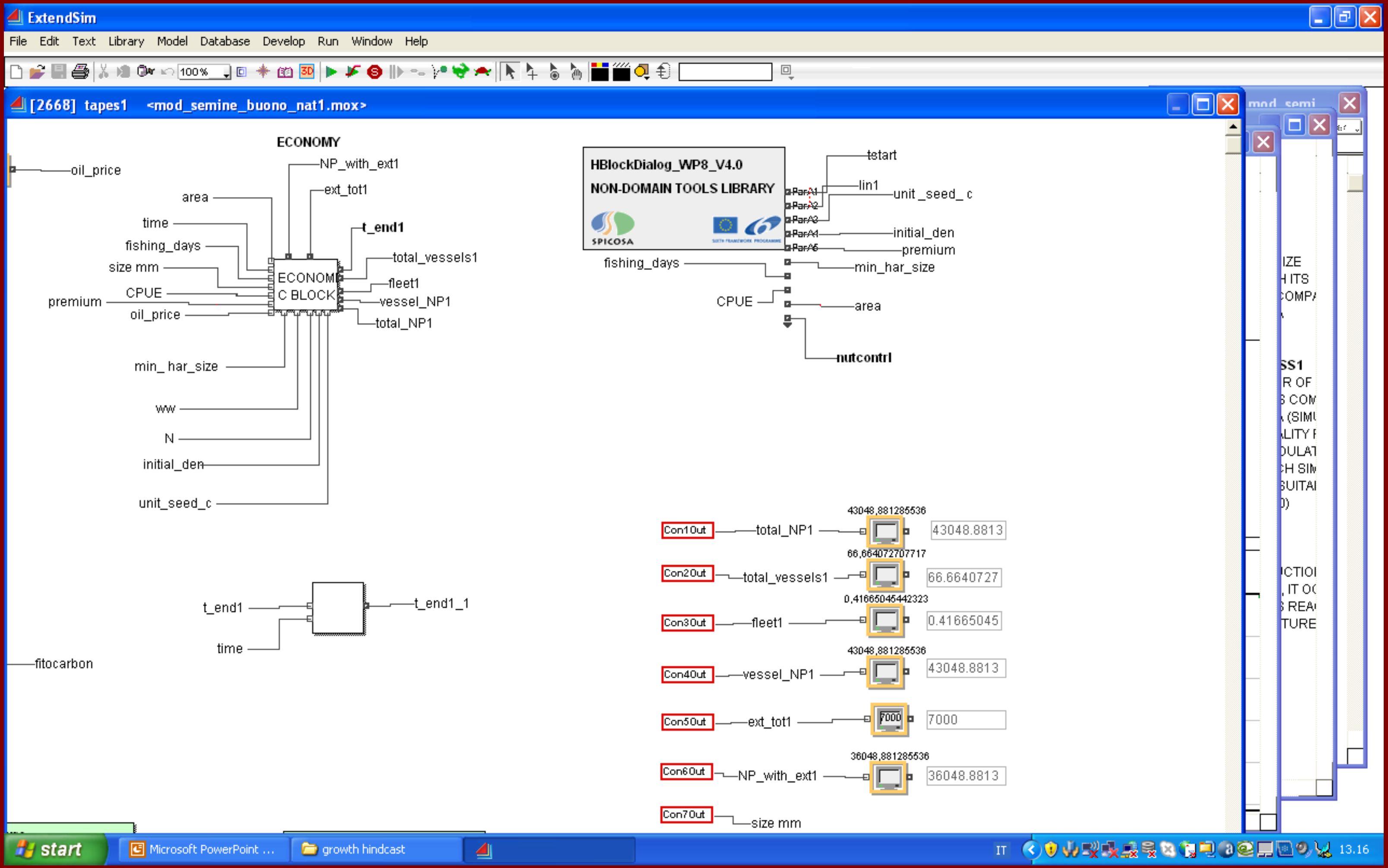


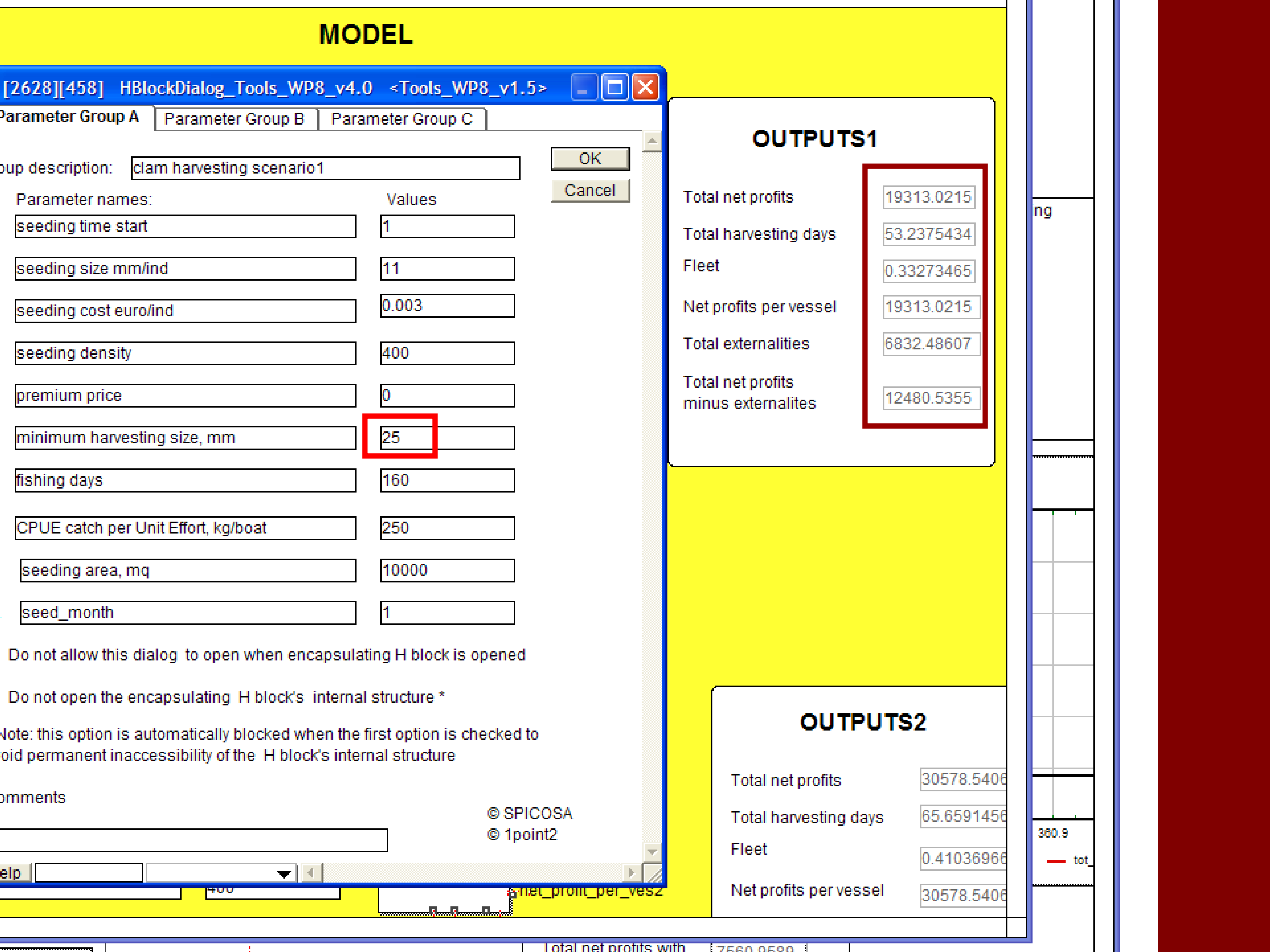
Chemical	Field data: leased areas	Model output: leased areas	Model output: illegal fishing grounds
PCB 105	1.45×10^{-7}	3.29×10^{-7}	2.76×10^{-6}
PCB 118	5.43×10^{-7}	3.56×10^{-6}	3.65×10^{-5}
PCB 180	4.49×10^{-7}	4.06×10^{-7}	7.19×10^{-6}

Consumer survey

- Preferences and habits
- Satisfaction
- Knowledge regarding clam issue (environmental, quality, social)

Bio-economic model -deisign




MODEL
[2628][458] HBlockDialog_Tools_WP8_v4.0 <Tools_WP8_v1.5>
Parameter Group A
Parameter Group B
Parameter Group C
oup description:
clam harvesting scenario1
OK
Cancel
Parameter names:
Values
seeding time start
1
seeding size mm/ind
11
seeding cost euro/ind
0.003
seeding density
400
premium price
0
minimum harvesting size, mm
25
fishing days
160
CPUE catch per Unit Effort, kg/boat
250
seeding area, mq
10000
seed_month
1
Do not allow this dialog to open when encapsulating H block is opened
Do not open the encapsulating H block's internal structure *
Note: this option is automatically blocked when the first option is checked to
oid permanent inaccessibility of the H block's internal structure
omments
© SPICOSA
© 1point2
elp
OUTPUTS1
Total net profits
19313.0215
Total harvesting days
53.2375434
Fleet
0.33273465
Net profits per vessel
19313.0215
Total externalities
6832.48607
Total net profits minus externalites
12480.5355
OUTPUTS2
Total net profits
30578.5406
Total harvesting days
65.6591456
Fleet
0.41036966
Net profits per vessel
30578.5406
360.9
tot_
ng
net_profit_per_ves2
Total net profits with
7560.9589

Scenarios

- climate change
- exploring ecological and social carrying capacity

Scenarios

1.

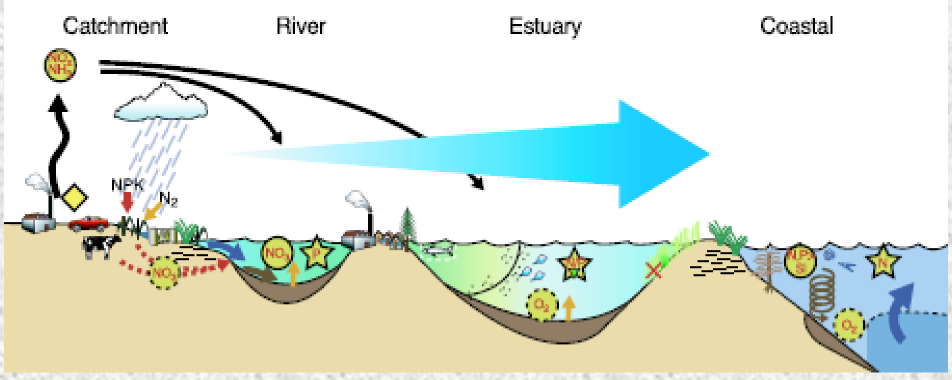
Climate Change effects and adaptive approach

Effects of changes in precipitation patterns Scenarios

Climate changes projections for 21st century are expected to cause a number of potential impacts (IPCC 2007).

While changes in sea level appears the most obvious threat to costal areas, **changes in precipitation patterns** and therefore in **timing** and **volume** of **freshwater** and **nutrient delivery** to coastal wetlands will also be critical

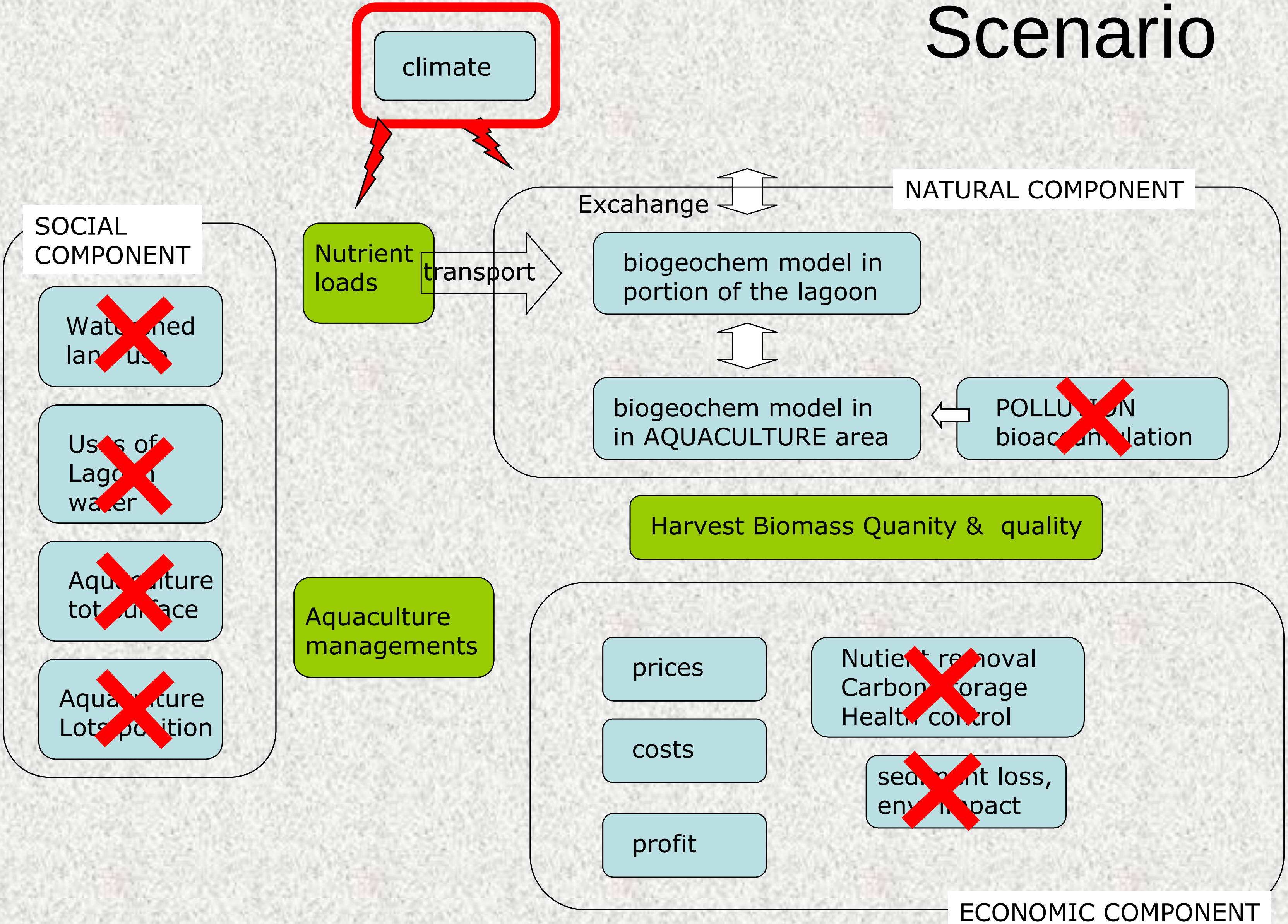
Scavia et al., 2003



<u>Aim</u>: assessing the potential impact of changes on **seasonal precipitation patterns** on the biogeochemistry and – in turn- on clam aquaculture in the lagoon of Venice

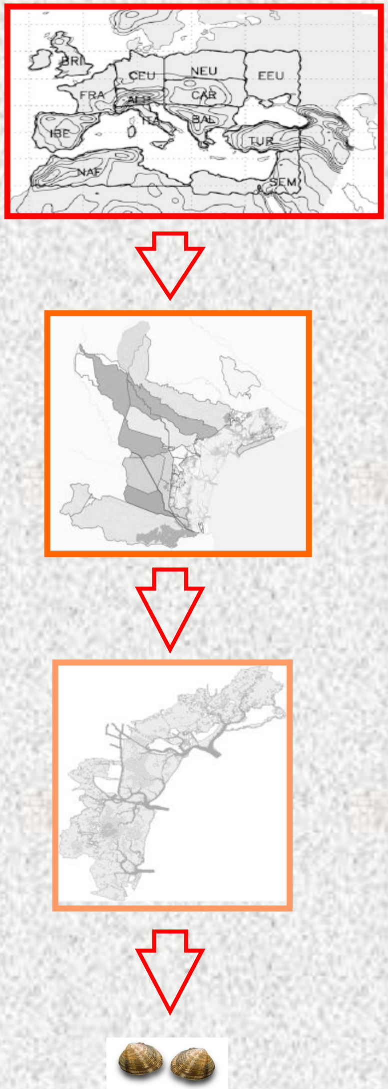
In shallow water litte mixing

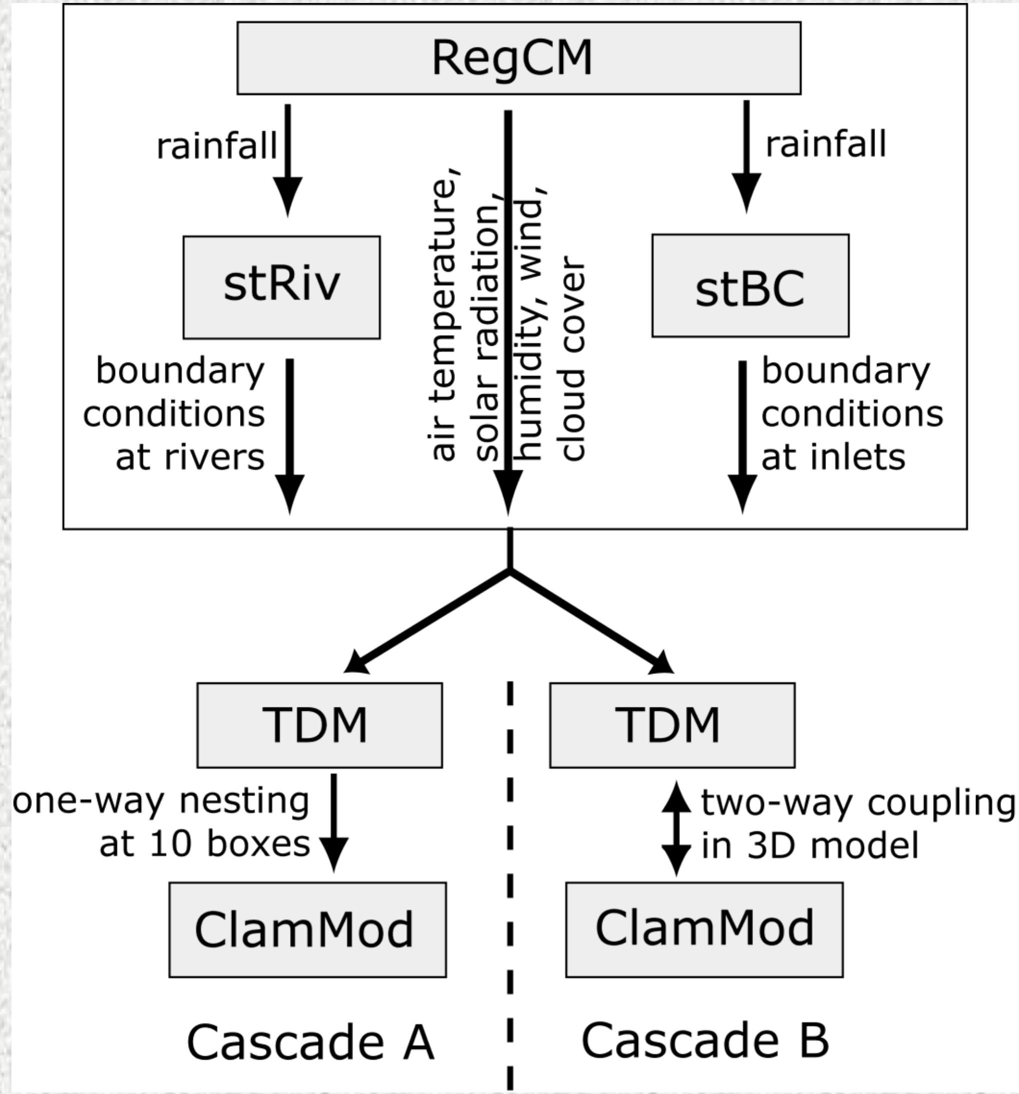
Tapes philippinarum VE



Downscaling GLOBAL effect to LOCAL scale

Scenario



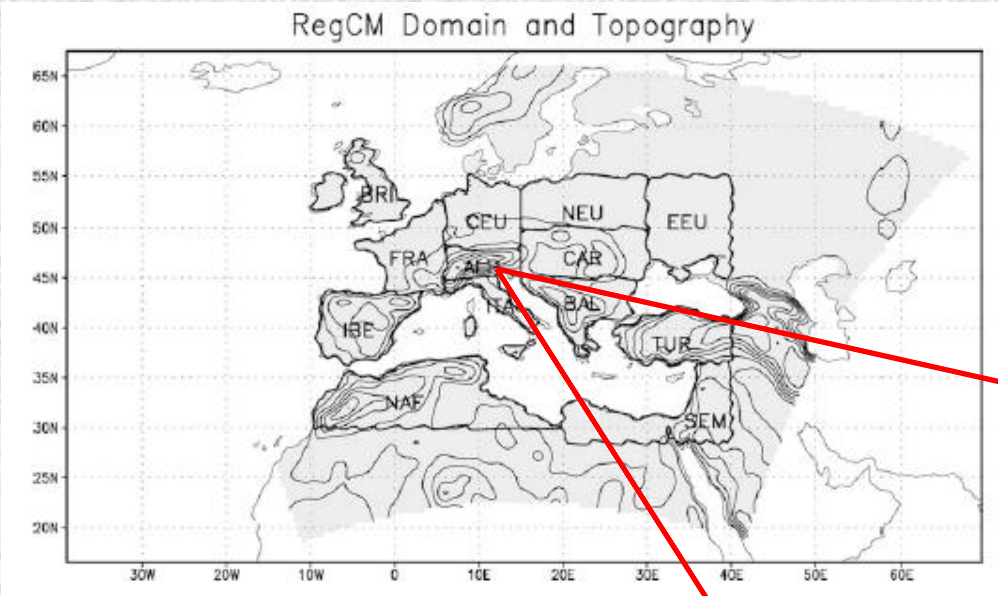


(SPICOSA like screening)

(detail)

Salon et al . 2008 Clim Res
Cossarini et al. 2008 Clim Res
Solidoro et al 2010 Prog Ocean
Melaku Canu et al. 2010 Clim Res

(1) High resolution Regional Climate Model (RegCM)



State of the art regional climate model, one way nested in Global Climate Model HadAM3H, resolution 20km

Giorgi et al. 2004a,b
Gao et al. 2006
ICTP (Trieste, ITALY)

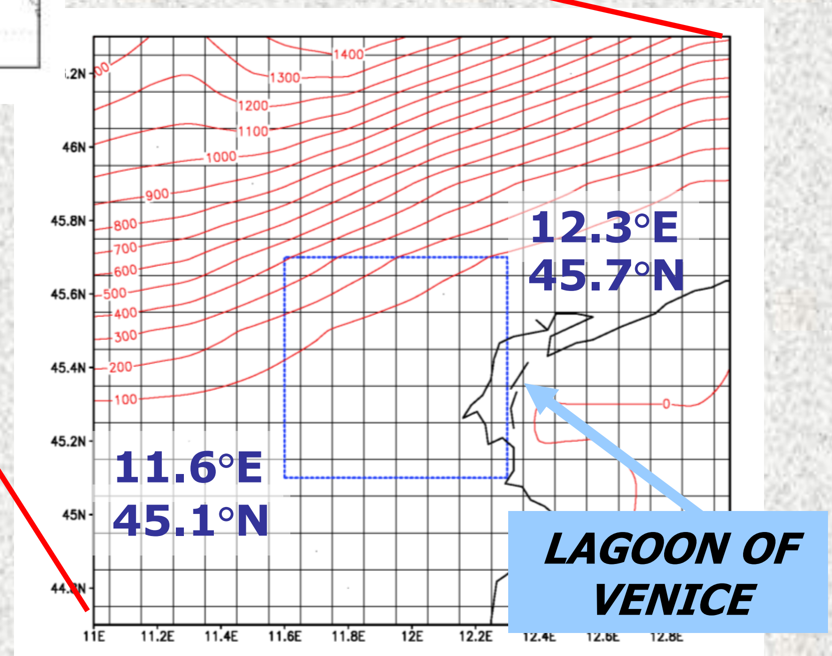
We use results of rain, T, wind, humidity and pressure fields for the drainage basin

3 runs:

RF – reference condition 1961-1990

A2 - simulation of future condition 2071-2100 based on IPCC A2 scenario [*CO_2 ~800ppm*]

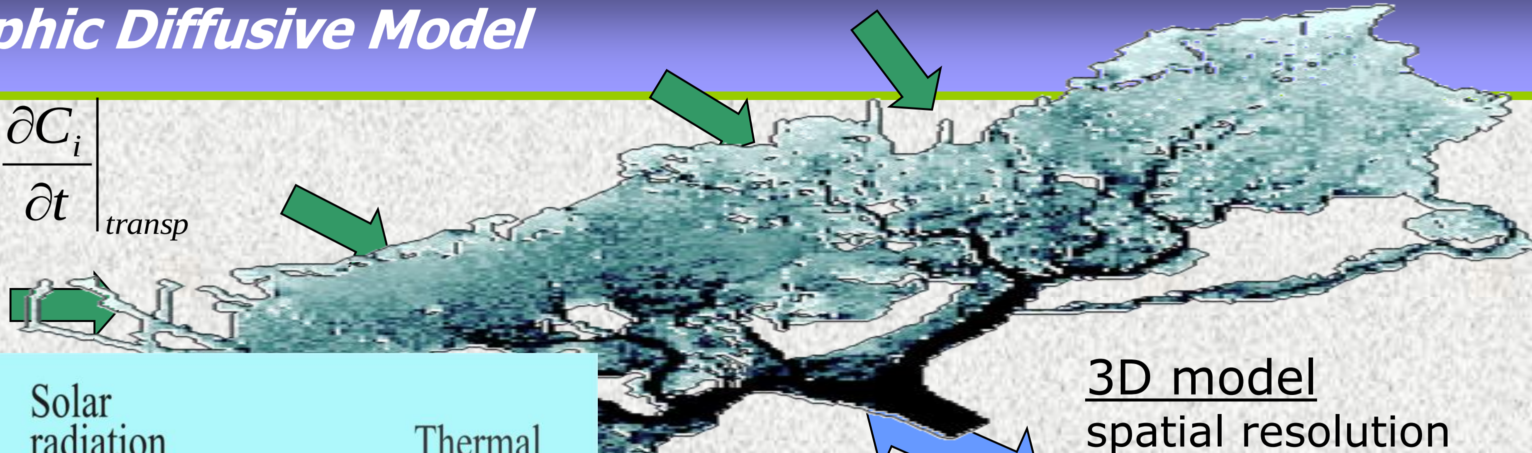
B2 - simulation of future condition 2071-2100 based on IPCC B2 scenario [*CO_2 ~600ppm*]

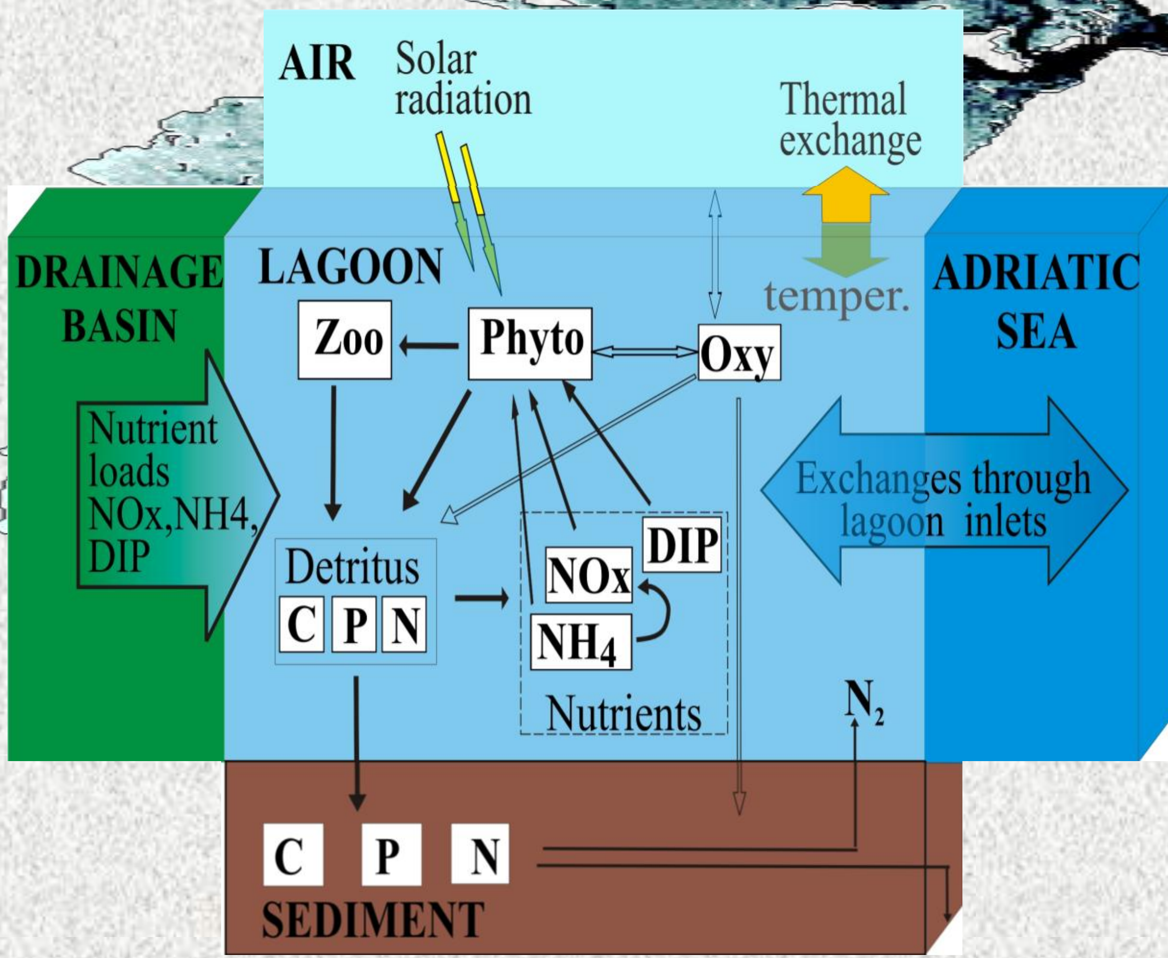


(Salon et al., *Clim. Res.*,08)

[3] TDM Trophic Diffusive Model

$$\frac{\partial C_i}{\partial t} = \left.\frac{\partial C_i}{\partial t}\right|_{biol} + \left.\frac{\partial C_i}{\partial t}\right|_{transp}$$





3D model
spatial resolution
300x300x1m
time step 1h

Transport model
turbulent diffusion formulation parametrises the tidal mixing (inhomogeneous and anisotropic eddy tensors)

Biogeochemical model
12 state variables
28 parameters

Boundaries:
Air-water interface
Heat fluxes
Exchanges through lagoon inlets
Nutrients loads

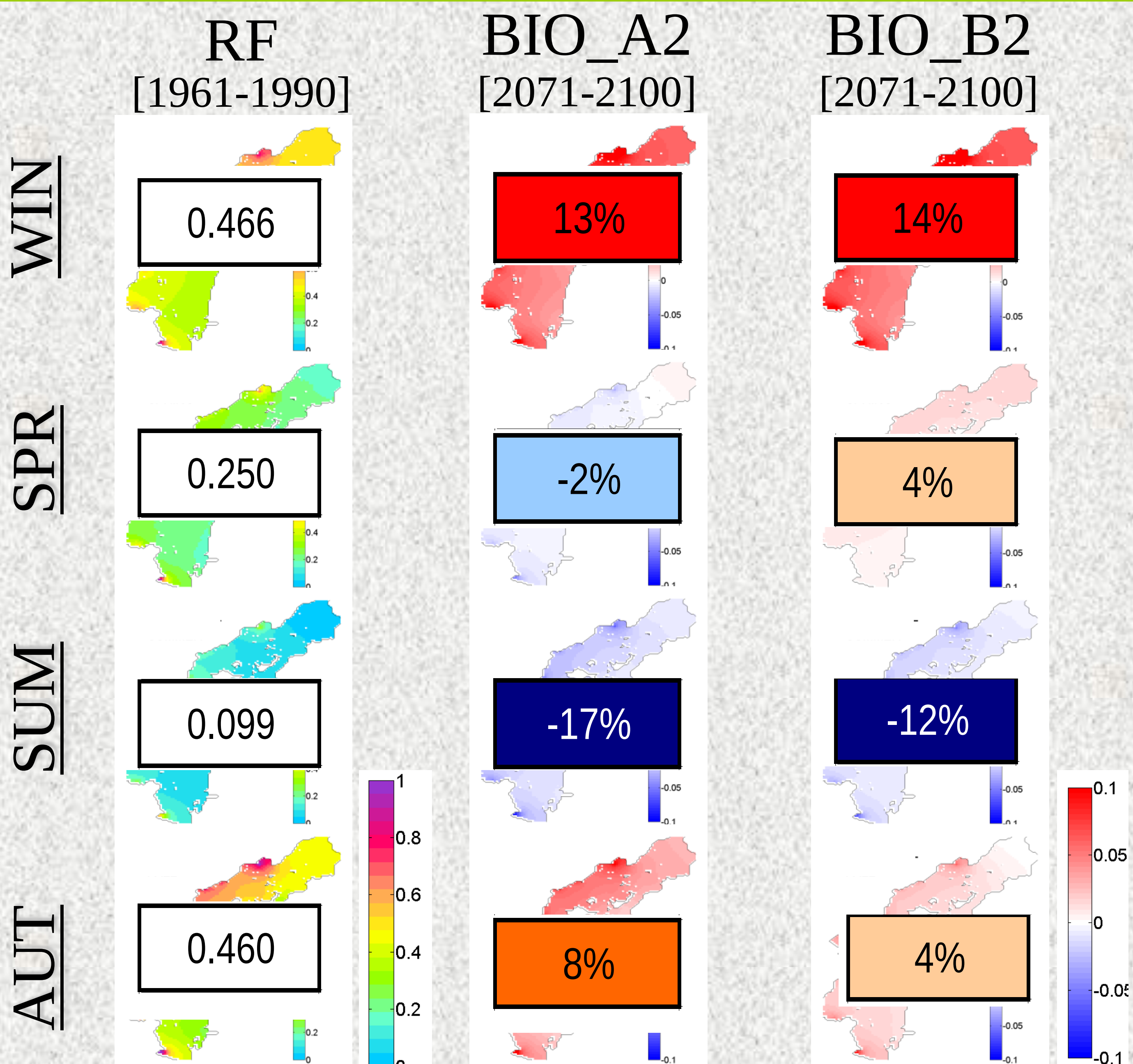
Dejak et al.,1998; .. Solidoro et al., 2005 EcolMod

EFFECT ON BIOGEOCHEMISTRY

Scenarios of the Venice Lagoon biogeochemical processes

Seasonal averages (over 30 years)

DIN
[mg/l]



Scenarios of the Venice Lagoon biogeochemical processes

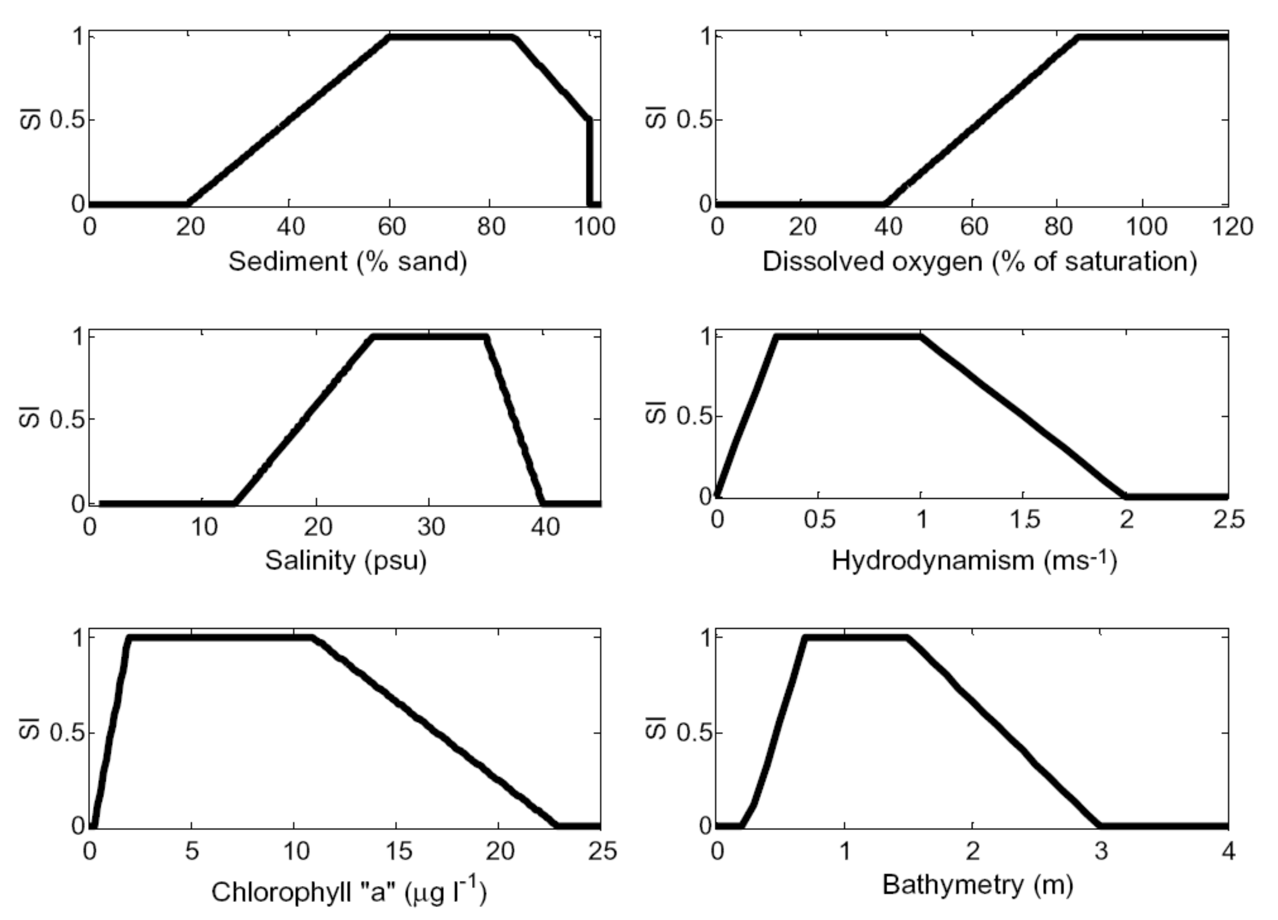
Seasonal averages & anomalies for state variables and fluxes

Scenario	Season	INPUT N [tN/y]	DIN [mg/l]	P. PRI. [tN/y]	P. SEC. [tN/y]	PHYTO [mg/l]	ZOO [mg/l]	EXPORT TO THE SEA [tN/y]
BIO_RF	win	1304	0.466	1352	499	0.290	0.259	-988
	spr	1629	0.250	4412	1295	0.702	0.459	-1119
	sum	1290	0.099	4712	1135	0.924	0.348	-806
	aut	1710	0.460	1507	509	0.292	0.269	-1325
BIO_A2	win	12%	13%	-2%	0%	-2%	0%	13%
	spr	-4%	-2%	0%	1%	-1%	2%	1%
	sum	-9%	-17%	-6%	-13%	-3%	-13%	-11%
	aut	8%	8%	2%	3%	1%	2%	7%
BIO_B2	win	15%	14%	0%	2%	0%	3%	14%
	spr	-1%	4%	3%	5%	0%	6%	7%
	sum	-6%	-12%	-3%	-10%	0%	-11%	-5%
	aut	6%	4%	1%	2%	0%	2%	0%

<-10%	-10%<x<-5%	-5%<x<-1%	-1%<x<1%	1%<x<5%	5%<x<10%	x>10%

EFFECT ON CLAM 2
HABITAT SUITABILITY MODEL
(STATISTICAL APPROACH)
2D (static)

"RULES" for Suitability Indexes



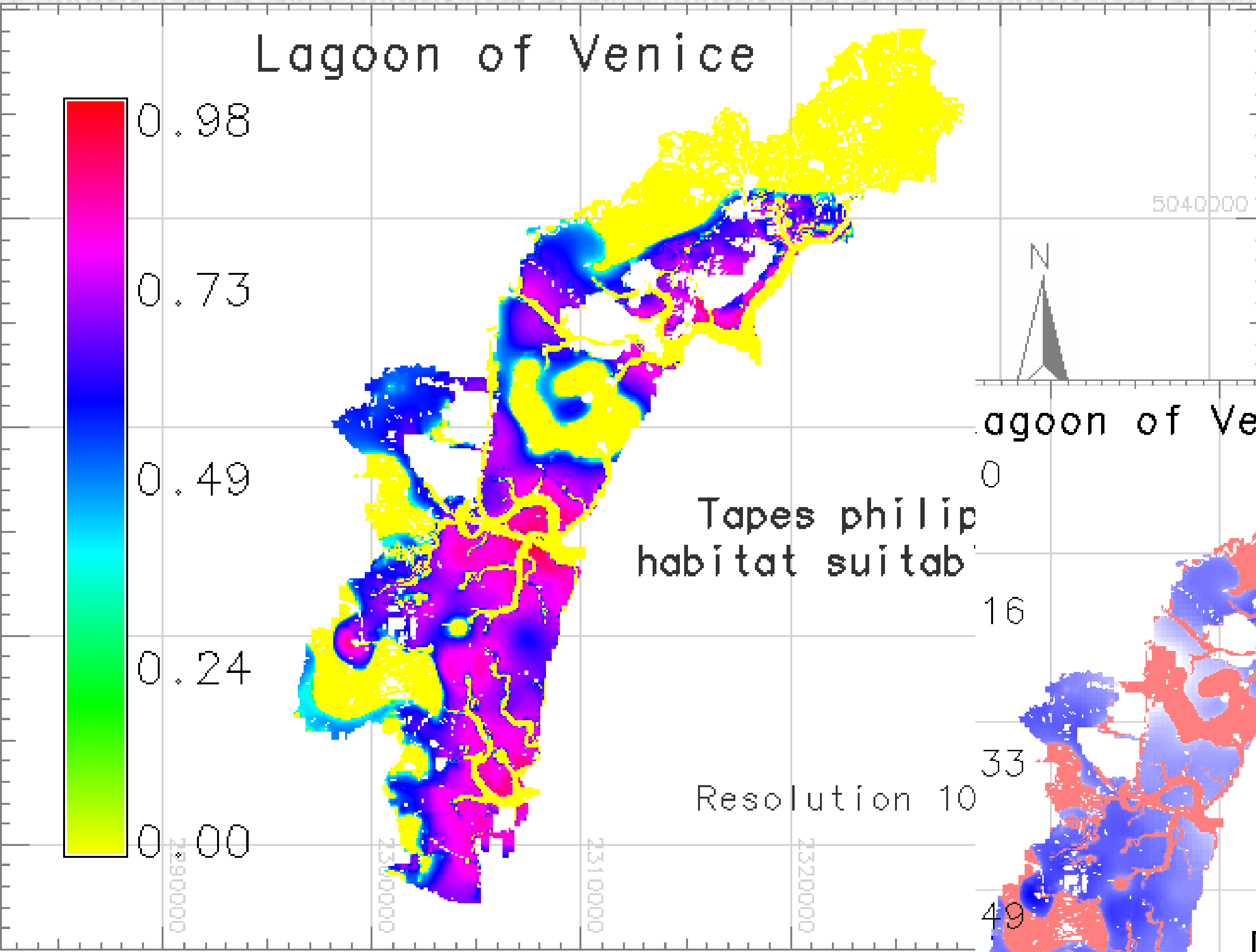
HSMod uses 7 parameters:

- TEMP,
- SAL,
- OXYSAT,
- CHLA,
- BAT,
- SAND,
- HYDRODYNAMISM

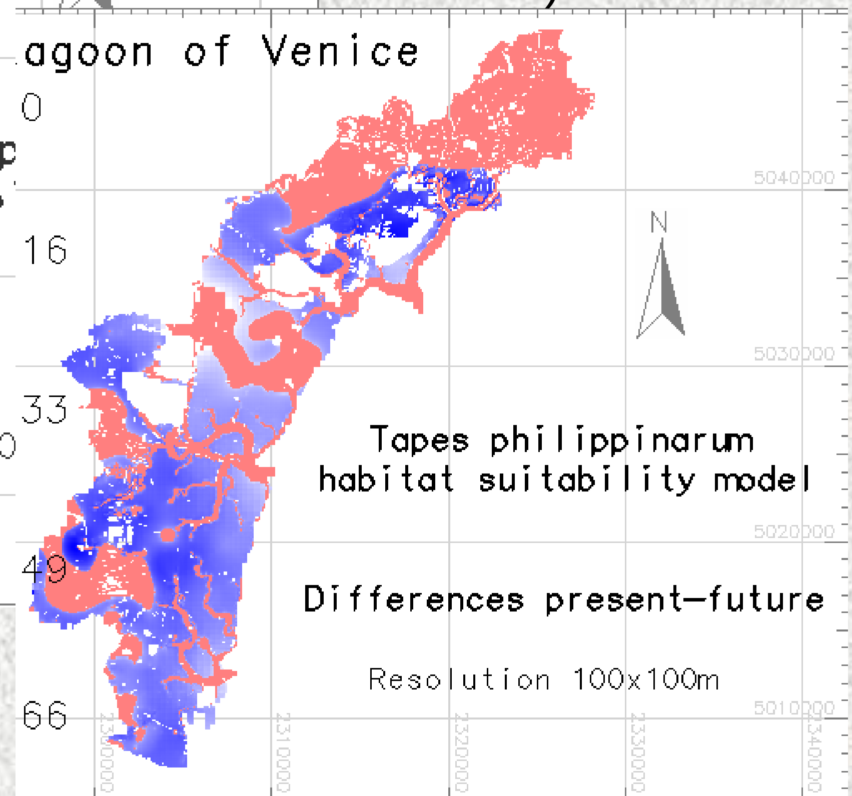
functional forms from specificic literature

Vincenzi et al 2006a, Vincenzi et al 2006b, Vincenzi et al 2007,

Suitabilty will decrease ..



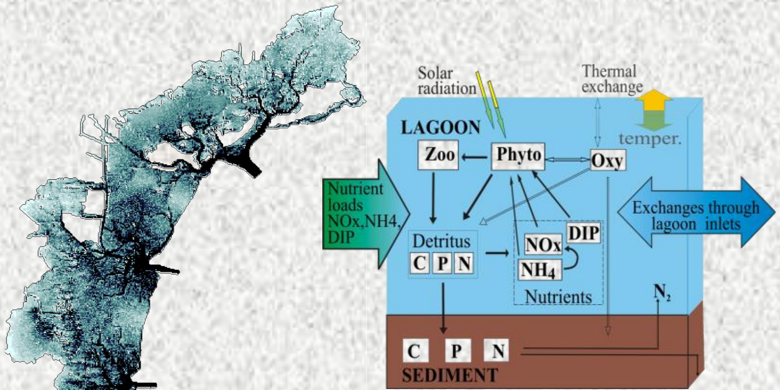
PRESENT DAY CONDITIONS (high suitability in the flats of the southern lagoon, near the main channels)



FUTURE CONDITIONS

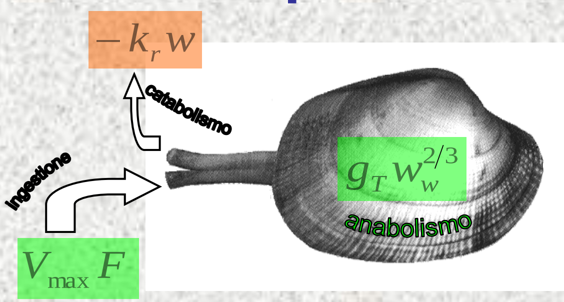
EFFECT ON CLAM 3
integrated bioenergetic model
(dynamic 2D and 0D)

Focus on Manila clam for its economic importance



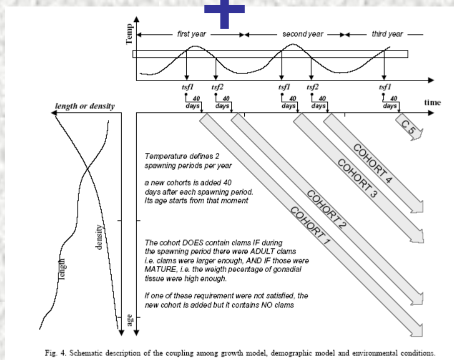
Biogeochemical model (TDM)

+

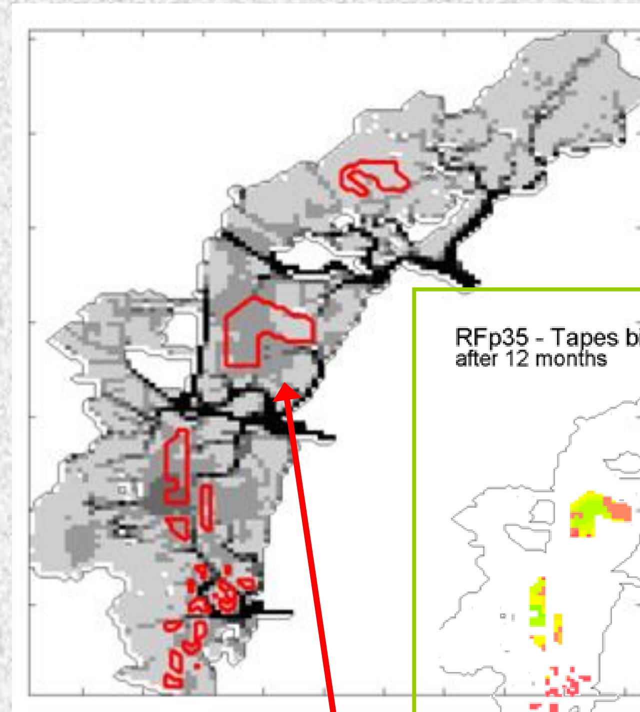


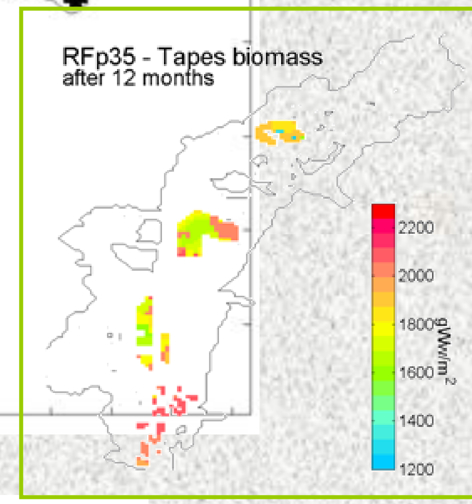
Bioenergetic clam model

+



Demographic clam model





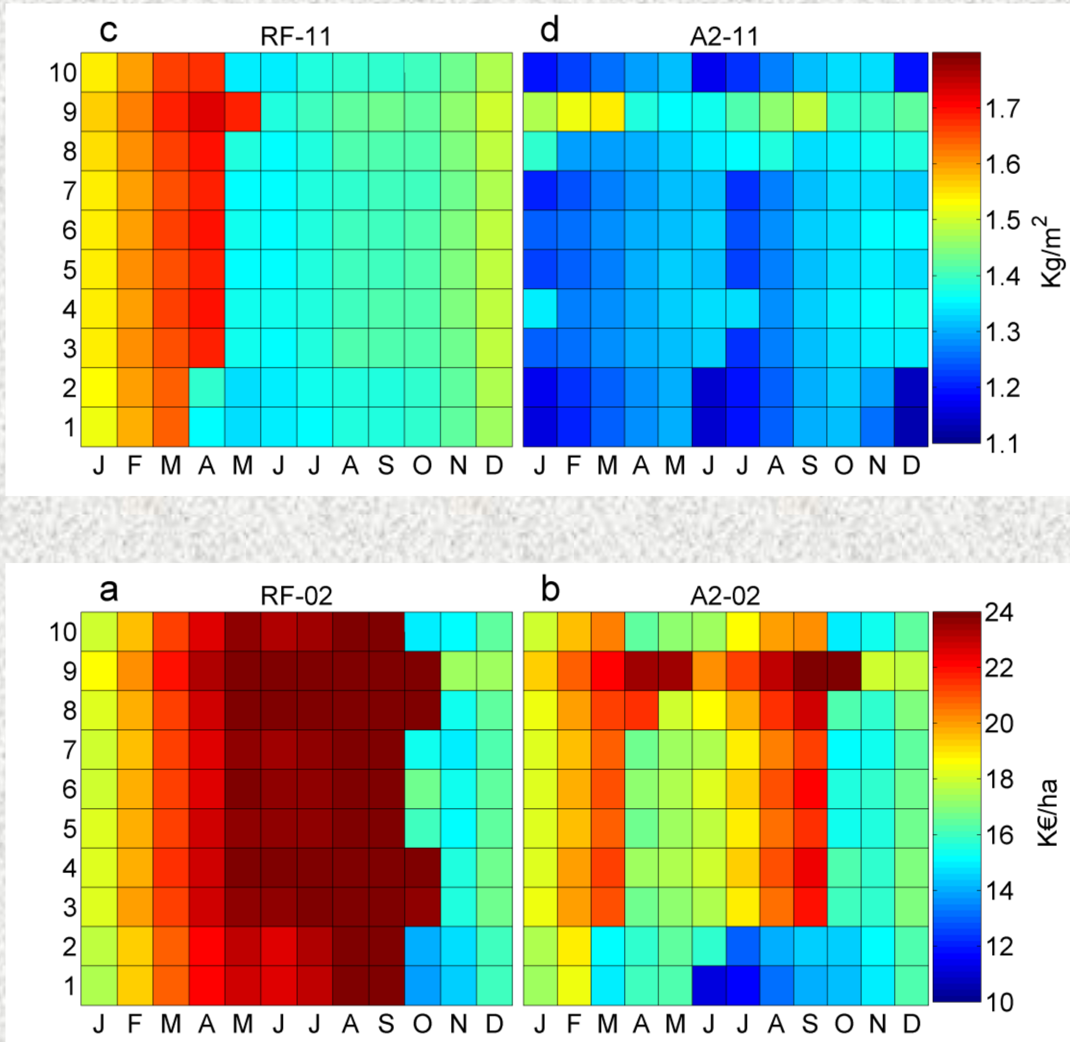
seeding specimen in controlled areas (areas defined for extensive clam aquaculture)

Solidoro et al 2000, 2003 Pastres et al 2001 reference

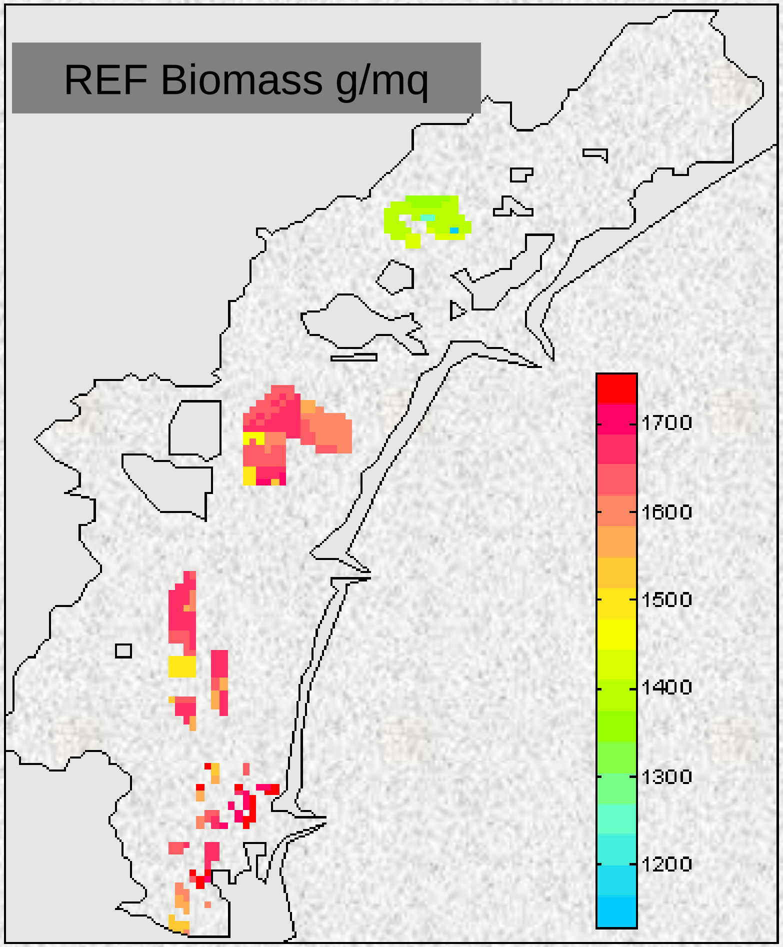
A2

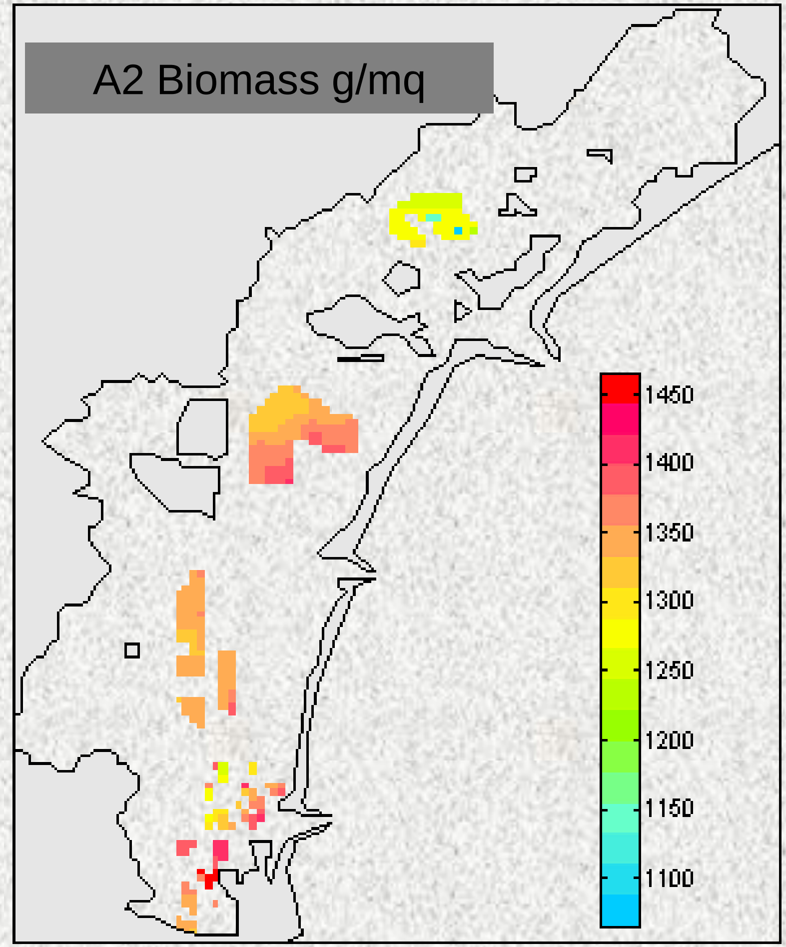
biomass

revenue



Comparison REF /A2 scenarios



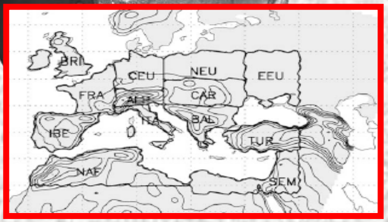


Tapes philippinarum annual production

BIOMASS
-20%

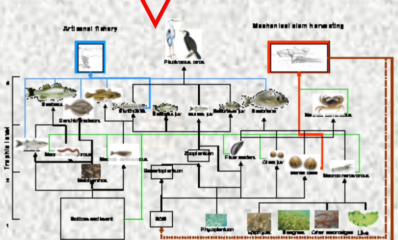
models indicate a reduced suitability for clam under future scenarios

Conclusions



Future climate projections: summer & spring more dry and winter & autumn more rainy

A multi models analysis indicates a lower suitability for clams in the future.
The implementation of adaptive managemet policies might mitigate such effects

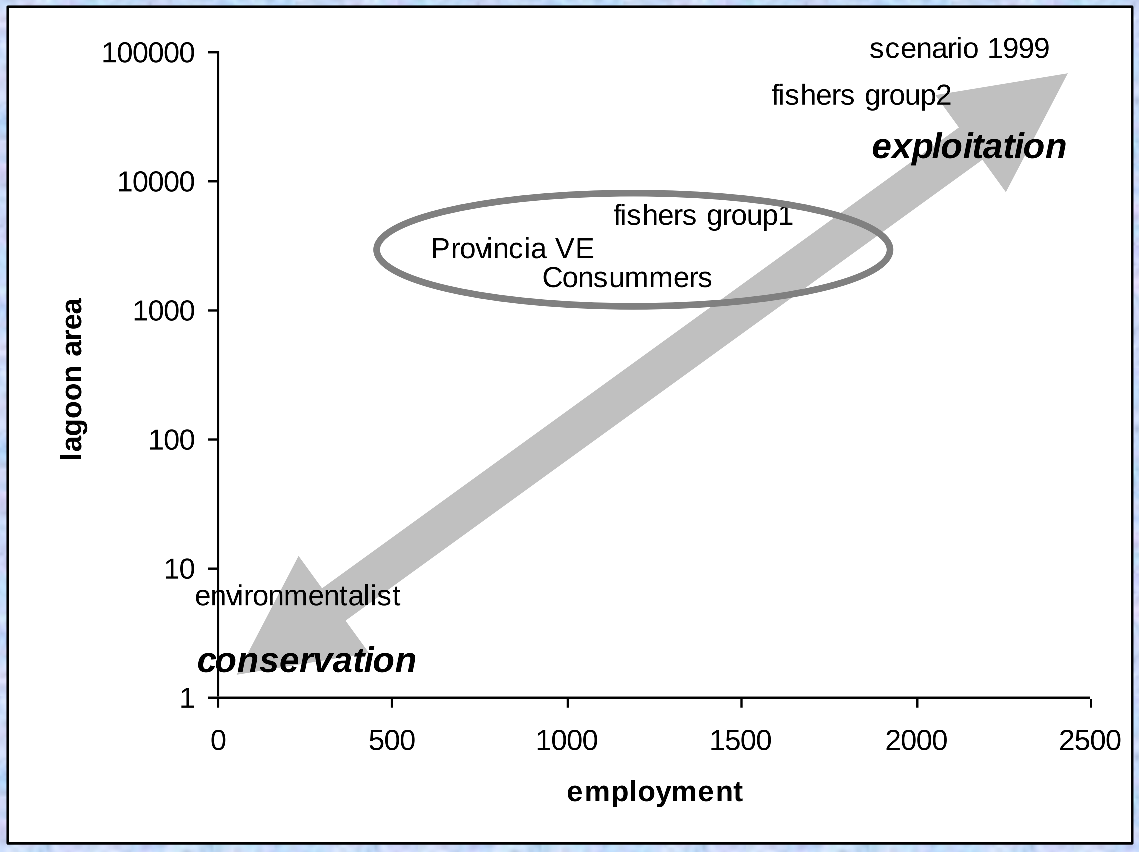


Melaku Canu D, Solidoro C, Cossarini G, Giorgi F. 2010 Effect of global change on bivalve rearing activity and the need for adaptive management. Climate Research 2010, Vol42:13-26.

2.

Exploring ecological and social carrying capacity

Scenario analysis

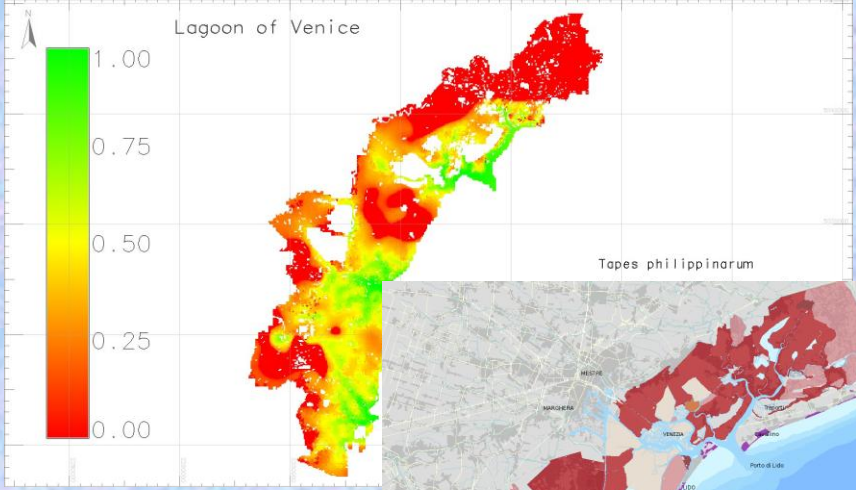


Grey arrow: alternative scenario of exploitation and stakeholders views.

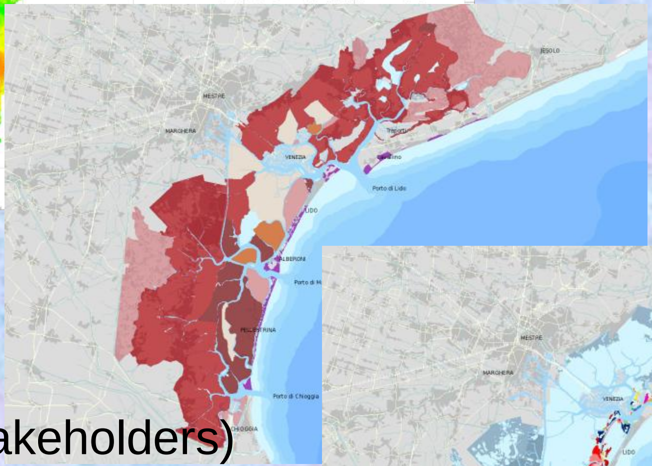
Simulations setup

- Physical constrains
- Seeding constrains

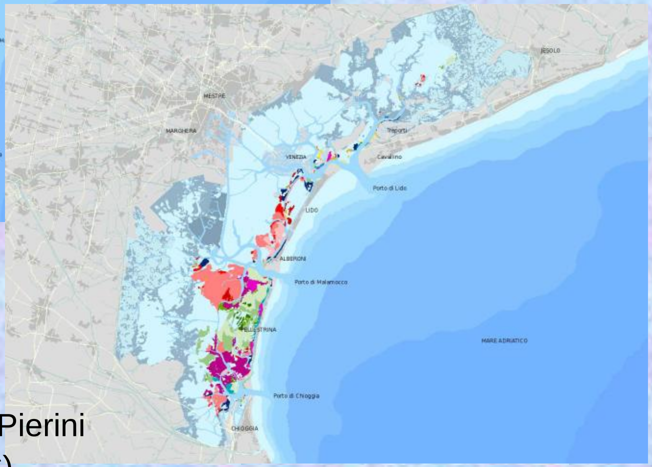
- Harvesting scenarios



1 suitability



2 Use conflits (stakeholders)

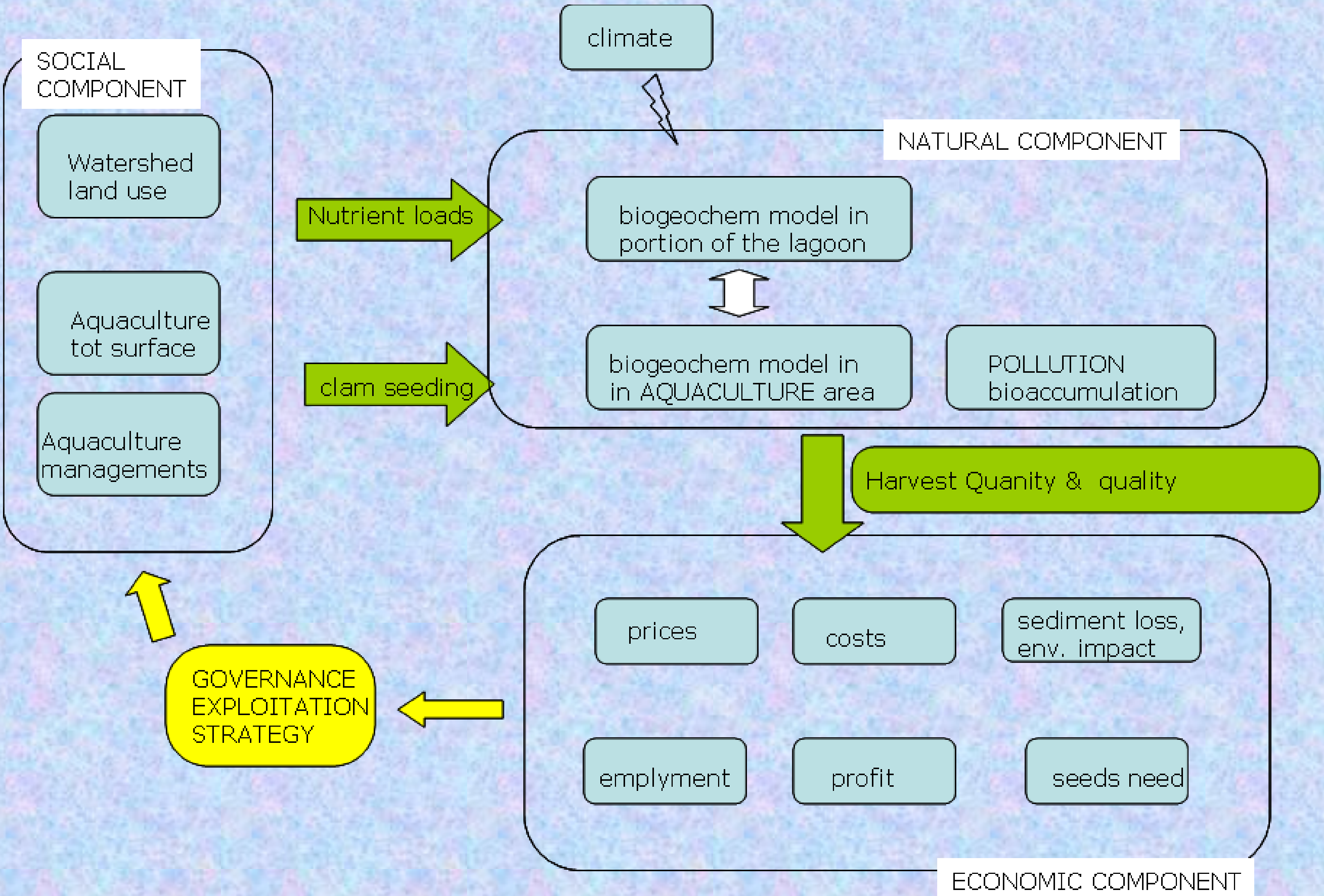


3 Habitat

In Atlante della Laguna, D. Mion, A. Pierini
D. Curiel, A. Rismondo (CVN - SELC)

In agreement with Province of VE plan, GRAL plan

Physical and Ecological carrying capacity


climate
SOCIAL COMPONENT
Watershed land use
Aquaculture tot surface
Aquaculture managements
Nutrient loads
clam seeding
NATURAL COMPONENT
biogeochem model in portion of the lagoon
biogeochem model in in AQUACULTURE area
POLLUTION bioaccumulation
Harvest Quanity & quality
prices
costs
sediment loss, env. impact
emplyment
profit
seeds need
ECONOMIC COMPONENT
GOVERNANCE EXPLOITATION STRATEGY

SCENARIOS

seeding type	*seeding month*	*seeding size*	*seeding density*	*harvesting size*	*area type*
natural	Jan to Dec	11, 14 mm	300 - 400 ind/mq	25, 27 30 mm	1-2-3-4
hatchery	Jan to Dec	11, 14 mm	300 - 400 ind/mq	25, 27 30 mm	1-2-3-4
Internal hatchery	Jan to Dec	14 mm	300 - 300 ind/mq	25, 27 30 mm	1-2-3-4

600 simulation scenarios

SCENARIO RESULTS, excluding not feasible ones

seed size	source	are a	harv size	profits	externalities (harvest+nat seed harvest)	harvest	productivit y	max employment (lagoon)	seeding needs (lagoon)
[illegible]	[illegible]	[illegible]	[illegible]	*euro/ha/year*	*euro/ha/year*	*kg/ha*	*kg/mq*	[illegible]	*ton/year*
11	Nat	4	30	34502	381	13192	1.32	1932	2326
11	Nat	2	30	34063	381	13149	1.31	1908	2326
11	Nat	1	30	33855	381	12497	1.25	1896	2326
11	Nat	3	30	33227	381	12747	1.27	1861	2326
11	Nat	3	27	31816	483	11784	1.18	1782	2713
11	Nat	1	27	30533	483	11613	1.16	1710	2713
11	Hatch	1	30	25628	180	12458	1.25	1435	2326
11	Hatch	4	30	24959	180	13168	1.32	1398	2326
11	Hatch	2	30	24551	180	12983	1.30	1375	2326
11	Hatch	3	30	23800	180	12698	1.27	1333	2326
11	Hatch	2	27	22940	240	13700	1.37	1285	3101
11	Hatch	1	27	21437	240	13317	1.33	1200	3101
11	Hatch	4	27	20328	240	13542	1.35	1138	3101
11	Hatch	3	27	20084	240	13251	1.33	1125	3101
11	Hatch	4	25	15260	300	14295	1.43	855	3876
11	Hatch	2	25	14699	300	14251	1.43	823	3876
11	Hatch	3	25	14223	300	13918	1.39	796	3876
11	Hatch	1	25	13434	300	13650	1.36	752	3876

Maximum

Selected reference scenario results. Columns 1-4: scenario setup, columns 5-10 results.

Precautionary approach

SCENARIO RESULTS, price decreased by 75%

seed size	*source*	*area*	*harv size*	*profits*	*externalities cum*	*harvest*	*productivity*	*employment (lagoon)*	*seeding needs (lagoon)*
Mm	***Code***	***type***	***mm***	***euro/ha/year***	***euro/ha/year***	***kg/ha***	***kg/mq***	***number***	***ton/year***
11	Nat	1	**27**	9554	483	11613	1.16	535	2713
11	Nat	3	**27**	10500	483	11784	1.18	588	2713
11	Nat	1	**30**	11399	381	12497	1.25	638	2326
11	Nat	2	**30**	10316	381	13149	1.31	578	2326
11	Nat	3	**30**	10212	381	12747	1.27	572	2326
11	Nat	4	**30**	10669	381	13192	1.32	597	2326
11	Hatch	1	**25**	-11162	300	13650	1.36	-	3876
11	Hatch	2	**25**	-10961	300	14251	1.43	-	3876
11	Hatch	3	**25**	-10865	300	13918	1.39	-	3876
11	Hatch	4	**25**	-10512	300	14295	1.43	-	3876
11	Hatch	1	**27**	-2520	240	13317	1.33	-	3101
11	Hatch	2	**27**	-1888	240	13700	1.37	-	3101
11	Hatch	3	**27**	-3850	240	13251	1.33	-	3101
11	Hatch	4	**27**	-4260	240	13542	1.35	-	3101
11	Hatch	1	**30**	3113	180	12458	1.25	174	2326
11	Hatch	2	**30**	1048	180	12983	1.30	59	2326
11	Hatch	3	**30**	804	180	12698	1.27	45	2326
11	Hatch	4	**30**	1113	180	13168	1.32	62	2326

Unsustainable scenariosc

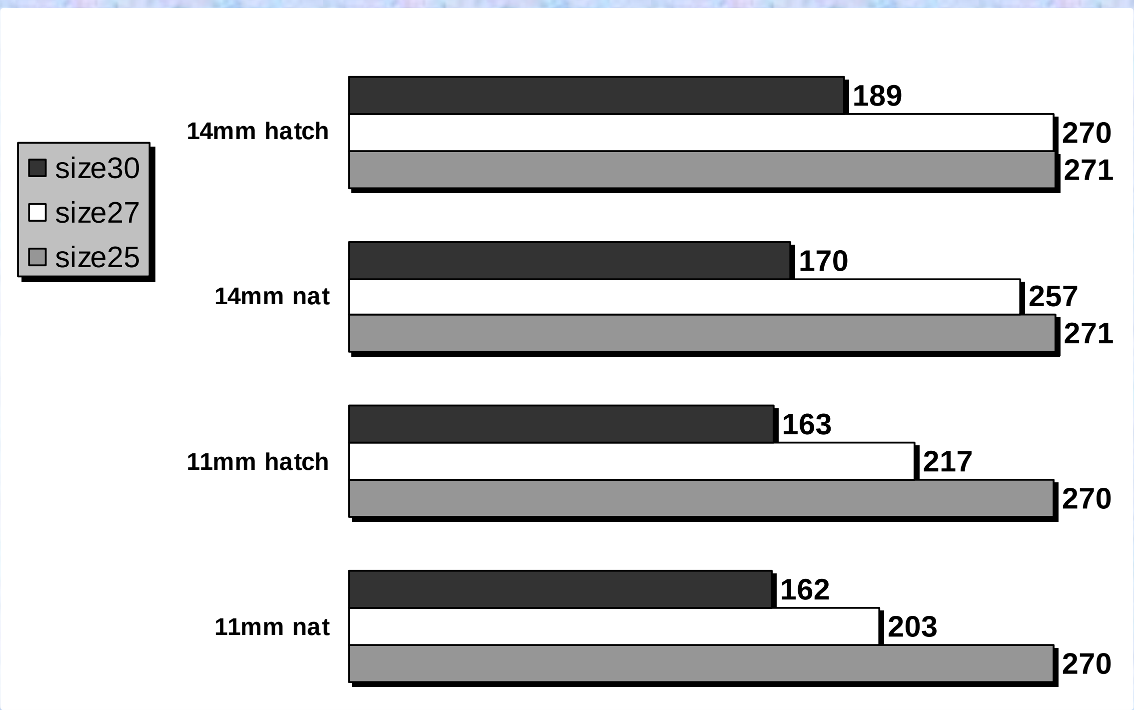
Selected scenario results with lowest pricee. Columns 1-4: scenario setup, columns 5-10 results.

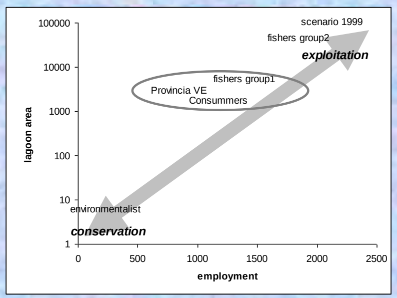
sensitivity

- Sensitivity to **seeding month is very high (38%)** confirming model sensitivity to environmental conditions.
- Average **sensitivity to harvesting size is 27%.**
- Average **sensitivity to area type is 12%.**
- **Sensitivity to price is very high**: simulating a decrease of 1 euro and 2 euro (average -54% and -70% respectively over 60 simulations) gives an average decrease of **59% and 117%** in profits.
- increase in natural mortality parameter by 20% caused a reduction of productivity of about 10%

- This suggests that the **productivity is less sensitive to trophic variability than to management choices** and economic constrains.

Externalities [euro/concession/year] computed varying seeding and harvesting size





- 3) Externalities and relative advantages due to local (inside the concession) recruitment have been taken into account in scenario analysis, even if not internalised in the profits.

Confronting with the open access (1999 like) in terms of production, externalities, natural ecruitment

parameters/scenarios	***1999***	***Scen Mix***	***Scen Nat***	**Scen Mix2**	**Conserv**
boats	1400	400	400		0
workers	2500*	1402**	1288**	1667	0
seeding tons (N natural, H hatchery)	0	1200N, 2400H	1200N	2400N 1200H	0
global surface fished/year [ha]	40500	2160	2760	2160	0
sediment loss (from Orel et al., 2000) [mc]	405000	21600	27600	21600	0
externalities (1999 value) [million euro]	12.15	1.07	1.10	1.36	0
production [tons/year]	40000	30921	37266	31021	0
*profits**(20% premium price quality) [million euro]*	64	70	64	83	0
% externalities	**19%**	**1.5%**	**1.7%**	**1.6%**	**0**

Conclusions 2.

- 1) The integrated model confirms the feasibility of the developed management plan.
- 2) Productivity inefficiencies are more related to management choices and seed scarcity than to environmental constraints.
- 4) Models show a high range of uncertainty which depends in part on the model parameterisation but also on the randomness of natural/biological processes -mainly predation and mortality- and to economic factors -price, consumer preferences-. This suggests to use a precautionary approach when addressing the social carrying capacity.
- 5) We stress the need for the inclusion of clam farmers in the management process since our results indicate that the most sustainable management strategy is also the one with the longest harvesting cycles and the highest uncertainty.
- 6) Based on stakeholder meetings and other studies we underline the need of diversification (such as traceability, transformation, ittio-tourism and hatchering) as strategies to reduce risk.