MODELLING REPORT
Coastal lagoon modelling: An integrated approach

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Joint Research Centre

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MODELLING REPORT
Coastal lagoon modelling : An integrated approach

Deliverables D12 – D13 – D14

DITTY PROJECT (Development of an information technology tool for the management of Southern European lagoons under the influence of river-basin runoff)

(European Commission FP5 EESD Project EVK3-CT-2002-00084)

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CONTENTS

1. Introduction

The objectives of the DITTY project are to develop scientific bases for sustainable development of Southern European lagoons taking into account all the activities that affect the aquatic environment. Five sites have been identified ranging from the Ria Formosa (Portugal) at the entry to the Mediterranean Sea in the west, to the Gulf of Gera (Greece) in the Aegean archipelago in the east and between these, Mar Menor in Spain, Thau lagoon in France and Sacca di Goro on the Adriatic coast of Italy. These sites with their associated catchment areas and coastal zones are all economically very important (aquaculture-shell fishing) and exhibit a range of anthropogenic pressures (agriculture, industry and tourism). Meteorologically, they are influenced by a very varied range of conditions (rainfall events, temperature) which could be influenced by long-term climatic factors.

The final objective of the DITTY project is to develop a prototype of a Decision Support System (Work Package 8) for the management of coastal lagoons, but besides this objective and linked to it, the DITTY project proposes the development of various tools as data collecting and data base (WP1-2), GIS tool (WP3), Numerical Models (WP4), Indicators and Benchmarking (WP5) and Economic tools (WP7).

Workpackage 4 provides a general modelling framework with implementation of different modelling modules able to describe the system components, i.e. lagoon, river basin and coastal waters, as well as the ecosystem functioning and the hydrodynamics. These models have been developed and implemented at each test site according to their specific characteristics, data availability and defined end-users scenario analysis and case studies. The approach have consisted of using already developed parts, when available, and developing/implementing a shared modelling approach for the non existing models. Each model, watershed, hydrodynamic or biogeochemical has been calibrated separately. Finally, the coupling between watershed model and lagoon model (hydrodynamic and biogeochemical parts) provides an integrated representation of the entire watershed-coastal lagoon ecosystem and allows scenarios simulations. The model outputs are then used to compare site responses and calculate water quality indicators and, linked to the economic indicators, become the inputs for the Decision Support System.

In practice, the modelling activity started in august 2003 and lasted 18 months. Six meetings and regular mail exchanges have allowed to share modelling development.

4. Integrated modelling framework			**Aug. 03**					**Jan. 05**				
4.1. Watershed modelling												
4.2. Coastal lagoon/waters modelling												
4.3.Coupling watershed + lagoon models, SA												
4.4. Integration of socio-economic data												

Table 1 : WP 4 Modelling framework lasting 18 months from August 2004 to January 2005.

This report (assembling the 3 deliverables D12 to D14) presents in a synthetic way the main results for all sites. More detail can be find in the publications and site specific reports which are joined. Model intercomparison in terms of structure, input and output is done in the deliverable D15 and benchmarking exercises are presented in D16 . Both deliverables are under preparation.

Re = Report; **Pr** = Prototype; **Si** = Simulation;

D12	Report Watershed modelling	21 (oct 04)	Re/Pr	PU
D13	Report lagoon modelling	21 (oct-04)	Re/Si	PU
D14	Report model coupling	24 (jan 05)	Re/Si	PU

Table 2 : Deliverables due to the Modelling workpackage

2. General framework for modelling activity

Models have been developed for each site following a common quality assurance procedure as it is recommended in the HarmoniQua project (http://harmoniqua.wau.nl/) described by Scholten *et al.* (2004) for the modelling of catchment and river basin modelling and here extended for lagoon and adjacent sea. It offers a computer-based guidance for all water management domains, different types of users, different types of modelling purposes (planning, design and operational management) and different levels of modelling complexity. It allows to keep track of all steps and modelling work and facilitates communication and cooperation within modelling groups Applied to DITTY project, tasks have been listed and followed all along the workpackage lasted, using a modelling survey sheet (figure 1). We can notice six steps, each one including several tasks that have been more or less followed in this workpackage.

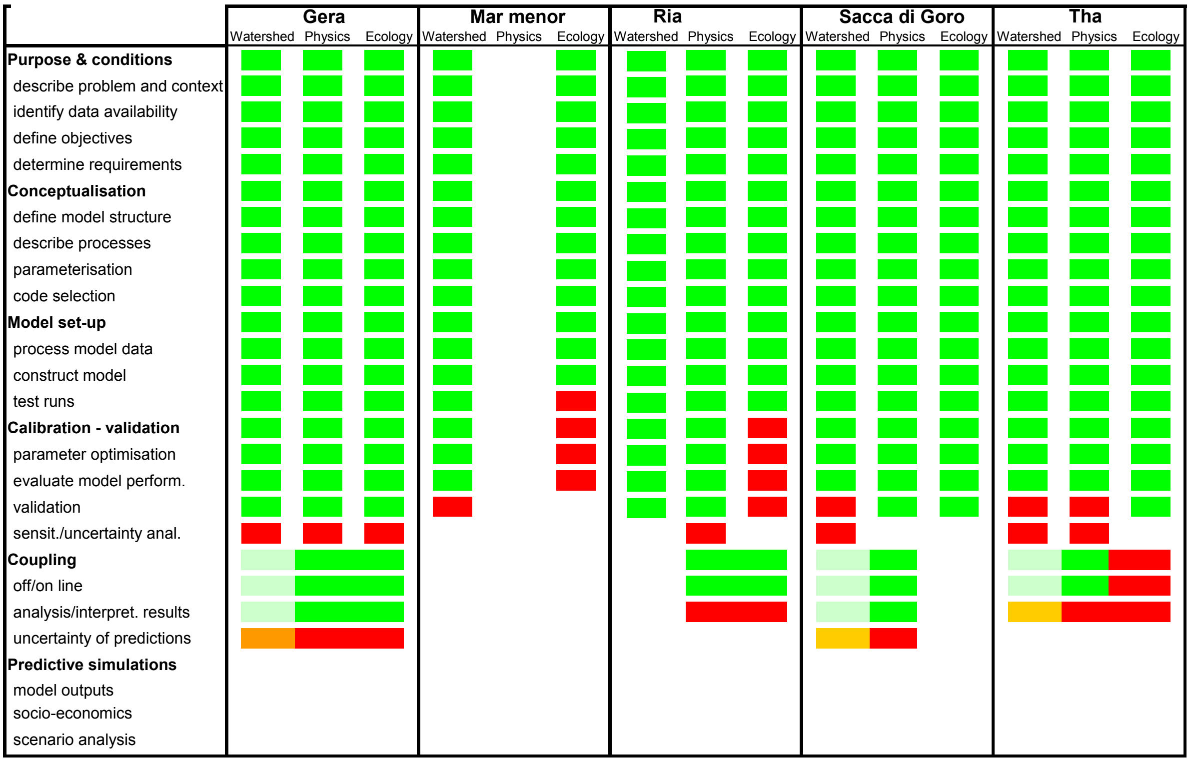


Figure 1 : An exemple of the model sheet to date with the modelling procedure for all the sites provided during the modelling activity (task achived, task in work, task to be done)

For each model an id-card has been filled in order to resume the description and type of application of the model. All id-cards are presented in Annex A.

3. Watershed modelling

For all sites, watershed models have been developed simulating river flow, transport and nutrient cycles in relation to climate, soil properties, land-use and management practices. Concerning space scale, watershed can be considered either as a lumped basin or divided into sub-basins (semi distributed model) or meshed by a regular grid (distributed model).

SWAT model (http://www.brc.tamus.edu/swat/), acronym for **S**oil **W**ater **A**ssessment **T**ool is a basin scale, spatially distributed watershed model that simulates on a daily time step, sediment erosion, surface runoff and subsurface flow, nutrient loads, crop growth and agricultural management. Point sources are also taken into

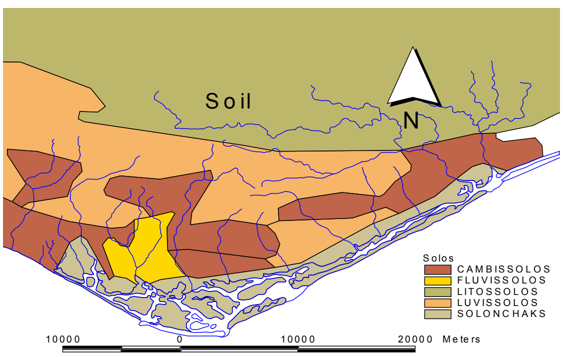
account, and can be inserted in the model as constant or varying inputs. It has been used for Thau (Plus *et al.*, 2003), Sacca di Goro (Galbiati *et al.*, 2005) and Ria Formosa (Gueirrero and Martins, 2005).
For Sacca di Goro, it was coupled to the groundwater model Modflow (3D finite difference) and the in-stream water quality model Qual2E (Galbiati *et al.*, 2005) model to simulate the river quality.

To describe more precisely flood events in the context of non permanent rivers with high loadings when intensive rainfall events occurred, which is characteristic of Mediterranean climate, two other models have been developed, based on flood events, the POL model (Tournoud, 2003) applied for Thau and the model of Mar Menor watershed (Martinez *et al*, 2005). The Mar Menor hydrological model is 2D and runs on an hourly basis. It is coupled to the integrated model, following an input-output approach and focussing on the estimation of discharges and nutrient loadings into the lagoon.

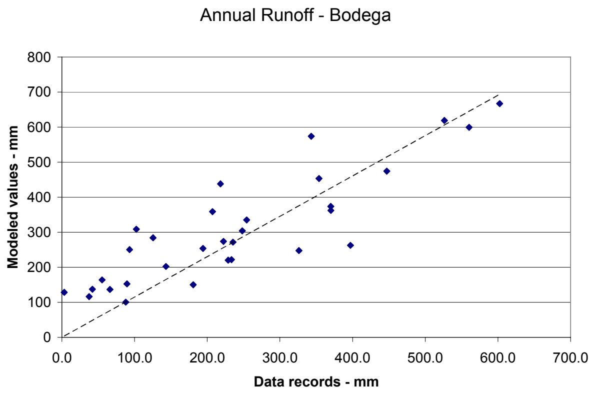
More detail on each model can be find in the site specified report, see references table 3 and a comparative analysis in the reports is being developed in D15.

Ria Formosa	Gueirrero M., Martins C., Calibration of SWAT Model Ria Formosa Basin (South coast of Portugal). 2005, 44 pp.
Mar Menor	J. Martínez, F. Alonso, F. Carreño, M.T. Pardo, J. Miñano and M.A. Esteve. Report on watershed modelling in Mar Menor site. 2005, 50 pp.
Thau lagoon	Plus M., Bouraoui, Zaldivar, Murray, Lajeunesse. 2003. Modelling the Thau lagoon watershed (south mediterranean coast of France). EU report EV43CT. 2002-0084. Ditty program, 95 pp.
Sacca di Goro	Galbiati, L., Bouraoui, F., Elorza, F. J., Bidoglio, G., 2005. Integrated modelling in coastal lagoons: Part A. Watershed Model. Sacca di Goro case study. EUR report n 21558/1. EC. JRC. pp 68.
Gulf of Gera	Tamvaki N., G.Tsirtsis. 2005. Integrated modelling in coastal lagoons. Watershed modelling. Gulf of Gera case study, 24Pp.

Table 3 : Watershed model References

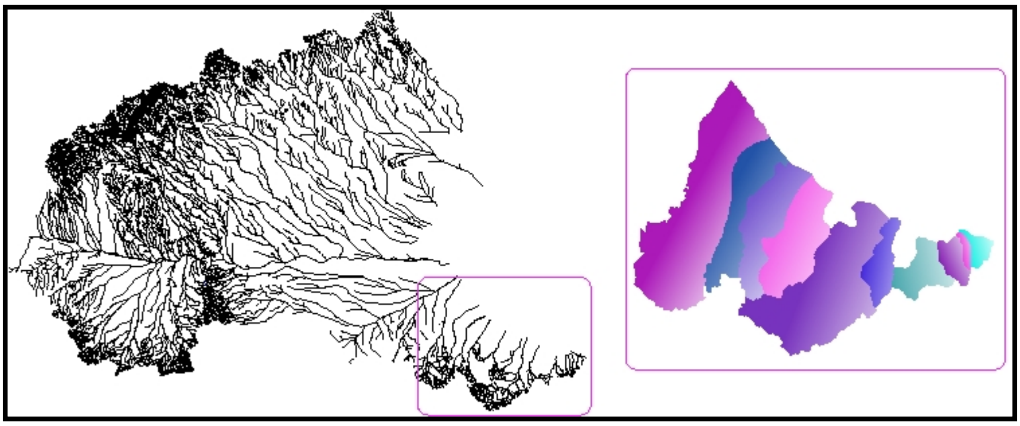


Soil types in Ria Formosa basin

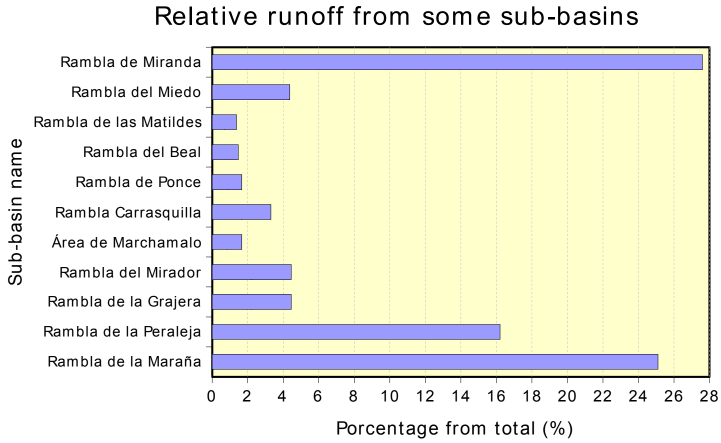


Annual flow modelled and data records

Figure 2 : Ria Formosa watershed model

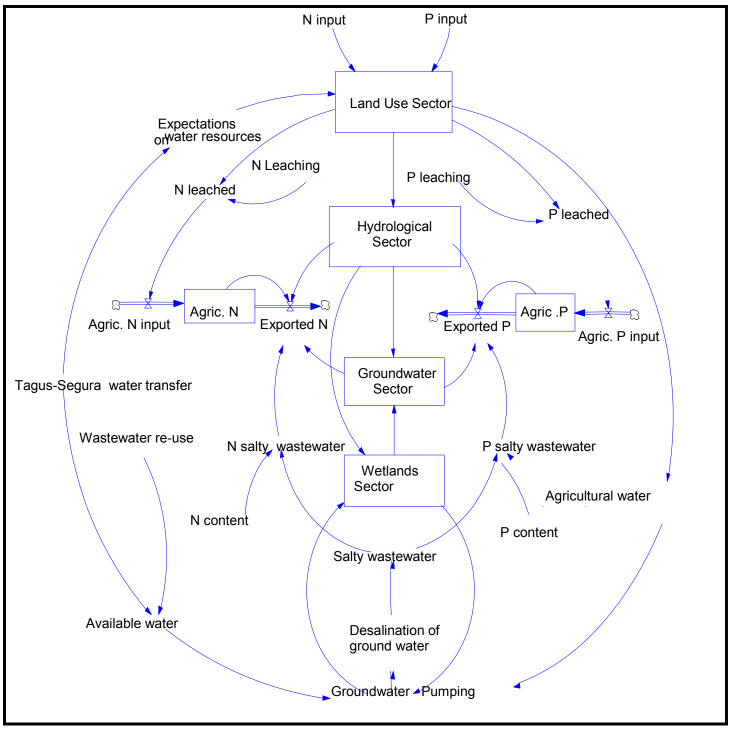


Drainage channels in the Mar Menor watershed and generation of the sub-basins



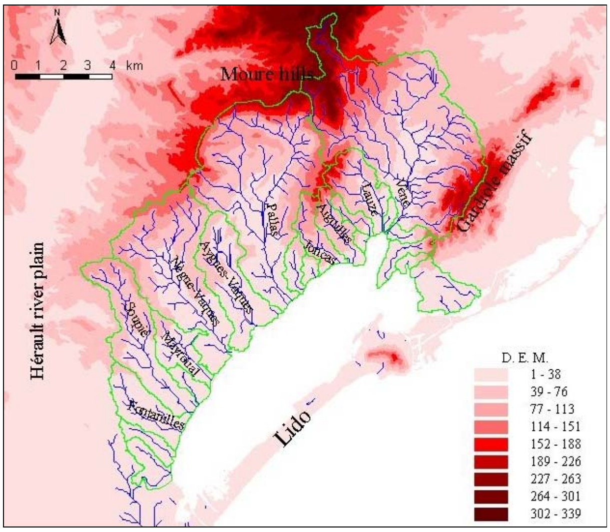
Relative contribution of main sub-basins to total runoff in the Mar Menor watershed

Figure 3 : Mar Menor hydrological model model

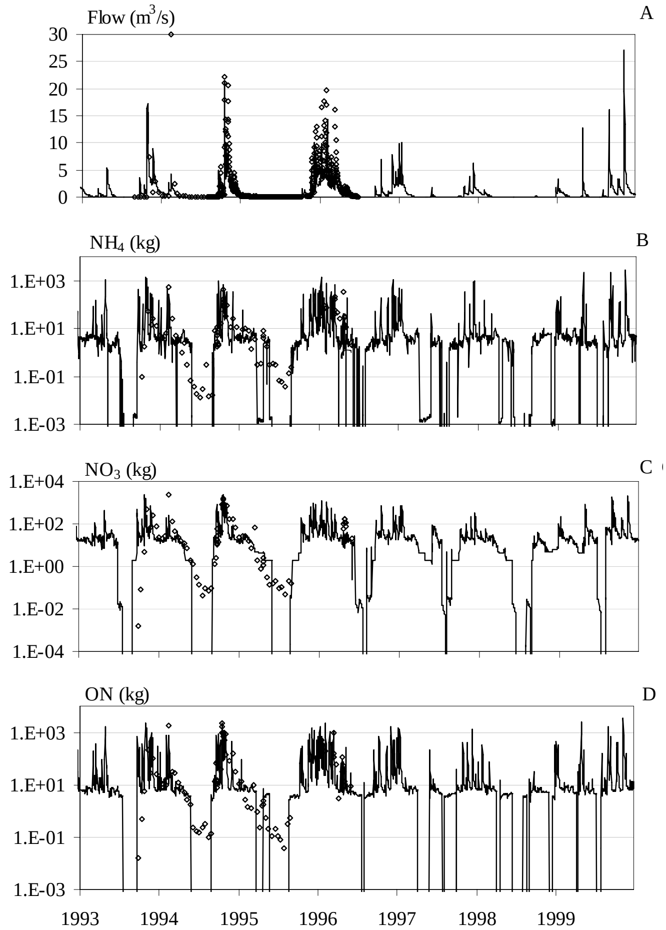


Parameter	Average
pH	7,8
Conductivity (µS/cm)	6963
Suspended material (mg/l)	157
DQO (mg O_2/l)	376
DBO_5(mg O_2/l)	190
Kjeldahl nitrogen (mg N/l)	50,5
Phosphorous (mg P/l)	4,74

Figure 4 : Linkages between the main sectors of the integrated watershed model and average value for the main parameters characterising the gross wastewater in the Mar menor watershed

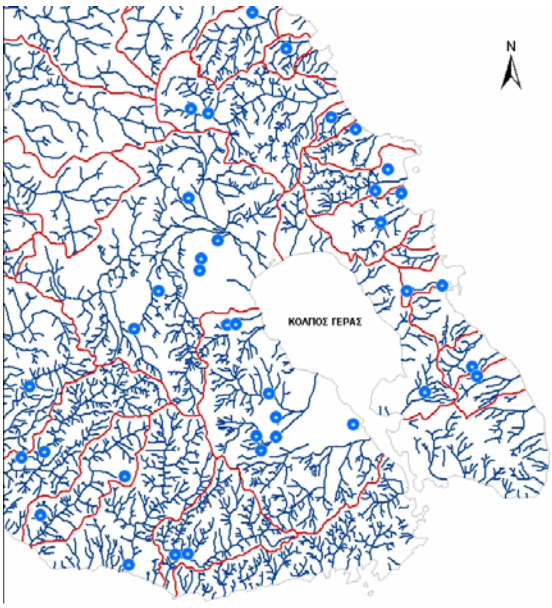


General map of the Thau lagoon and its watershed: digital elevation model (D.E.M., 50 m grid, values expressed in m), and river network. Names of rivers are reported as well as their catchment area (expressed as a % of total watershed surface).



Long term simulation for Vène river water flow (A), ammonia (B), nitrates (C) and organic nitrogen (D) daily loads. B, C and D are in log scale, line breaks are due to extremely low values.

Figure 5 : Swat Watershed model of Thau lagoon



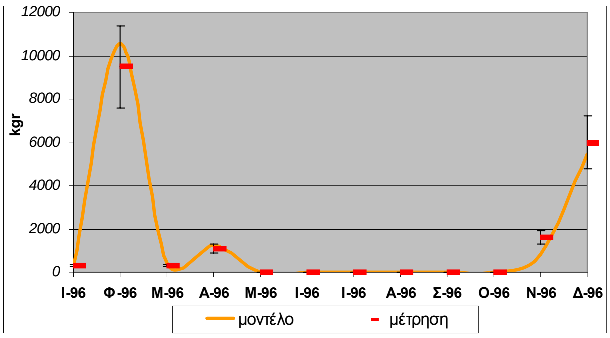
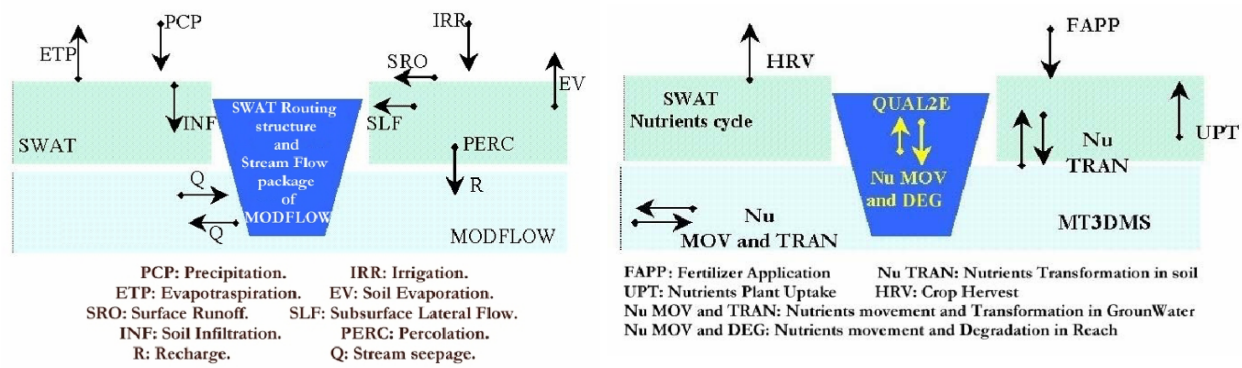
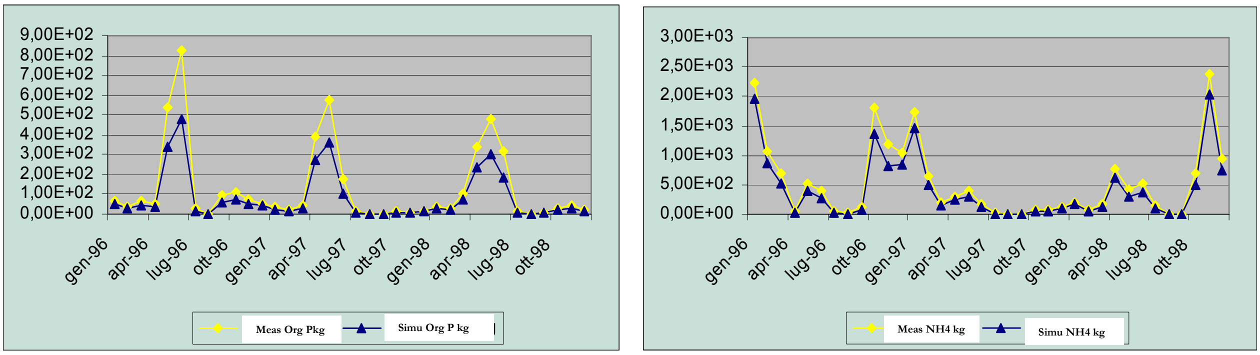


Figure 6 : Gera watershed model

a) hydrographic network ; b) runoff of NH4, monthly basis – simulations and data



Water quantity and quality conceptual models for the watershed



P and NH4 river Po di Volano content , data and simulations

Figure 7 : Sacca di Goro watershed model

To take into account the characteristics of the Burana-Po di Volano watershed a model named ISSM (Integrated Surface and Subsurface model) was developed. The model is composed by the hydrological model SWAT, the groundwater models MODFLOW and MT3DMS and the in-stream water quality model QUAL2E

4. Lagoon modelling

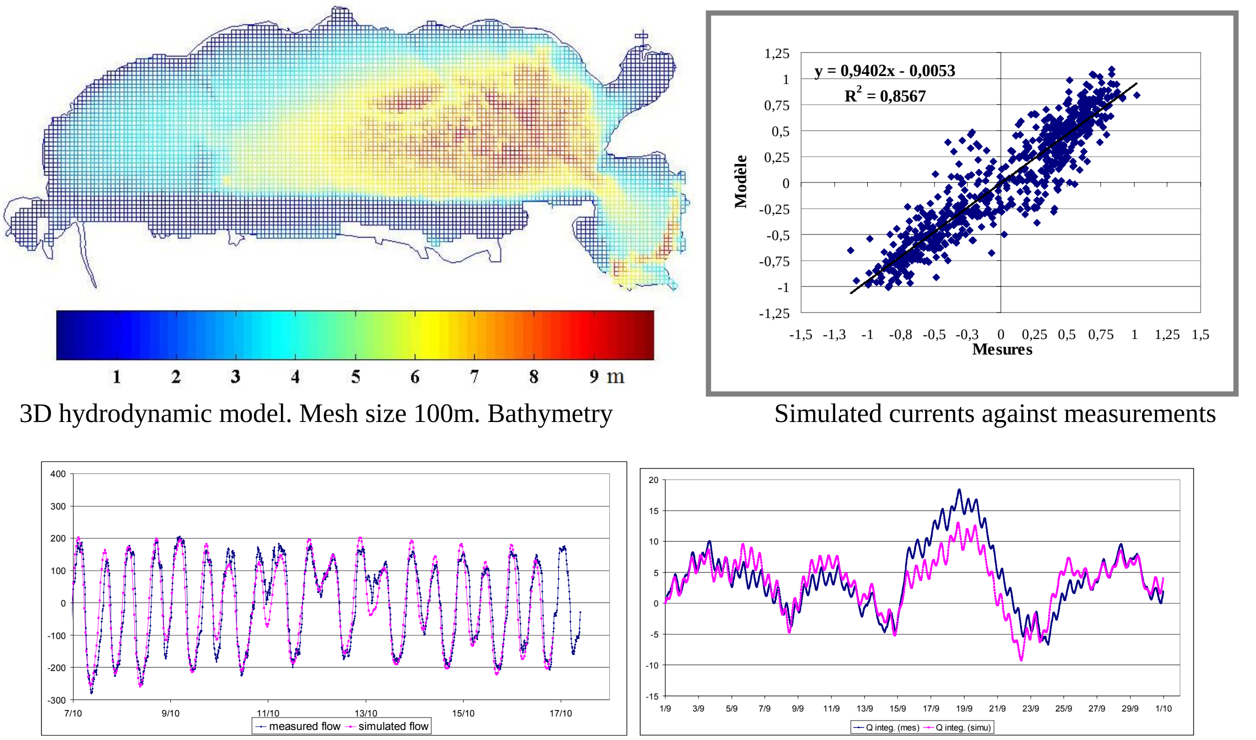
Lagoon modelling has been splitted in hydrodynamic modelling and ecological modelling which is specific of the test site since it addresses specific site problems that the end-users are aiming to tackle.

4.1 Hydrodynamic modelling

For Gera, Sacca di Goro and Thau 3D hydrodynamic models, based on finite differences, have been developped using the code of Coherences for Sacca di Goro (Luytens, 1999 ; Marinov *et al*, 2004 & 2005a) , POM for Gera (Mellor and Yamada, 1982 ; Kolovoyiannis et al. 2005) and Mars for Thau (Lazure, 1992 ; Fiandrino *et al*. 2003). More details can be found in the site specific reports (see table 4). Technical comparison is adressed in report D15.

Ria Formosa	P. Duarte, B. Azevedo and A. Pereira. 2005. Hydrodynamic Modelling of Ria Formosa (South Coast of Portugal) with EcoDynamo . xxpp.
Thau lagoon	Anonymous, Ifremer LER/LR. 2004. Study of the spatio-temporal heterogeneity of Thau lagoon water mass under the constraints of bacteriological and HAB contamination
Sacca di Goro	Marinov, D., Zaldivar, J. M. and Norro, A., 2004. Hydrodynamic investigation of Sacca di Goro coastal lagoon (Po river delta, Italian Adriatic Sea shoreline). EUR Report n° 21178 EN. EC, JRC
Gulf of Gera	Kolovoyiannis, V., Sampatakaki, A. and Tsirtsis, G. 2005b. Modeling of the hydrodynamic circulation and the physical properties distributions in the gulf of Gera, Greece. DITTY Project, Technical Report. Dept of Marine Sciences, University of the Aegean.

Table 4 : Hydrodynamic model reports references



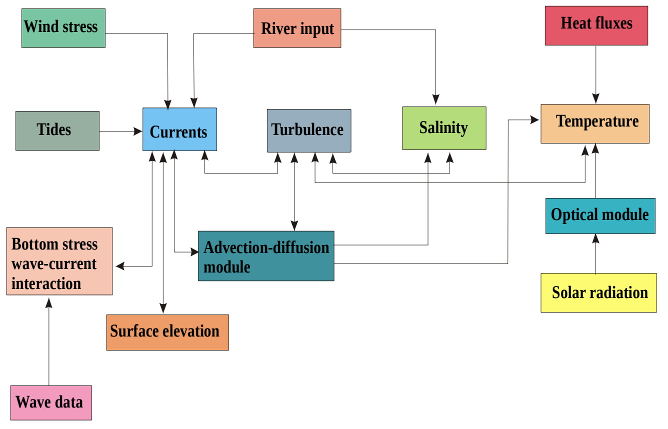
3D hydrodynamic model. Mesh size 100m. Bathymetry

Simulated currents against measurements

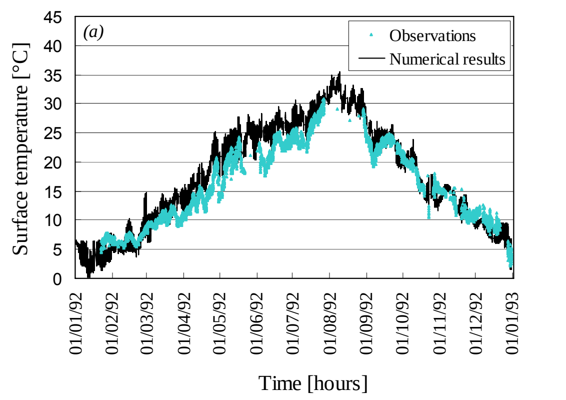
instantaneous flow/current speed (-1m -4m)

flow (instantaneaous and integrated)

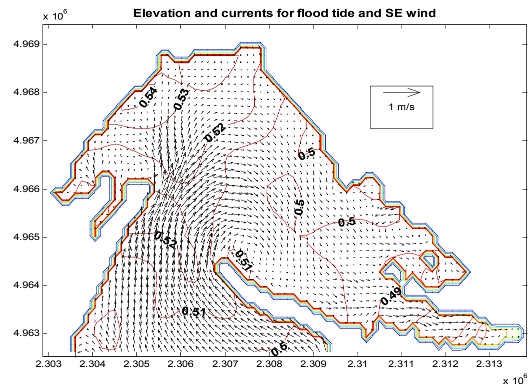
Figure 8: Mars 3D hydrodynamic model of Thau lagoon

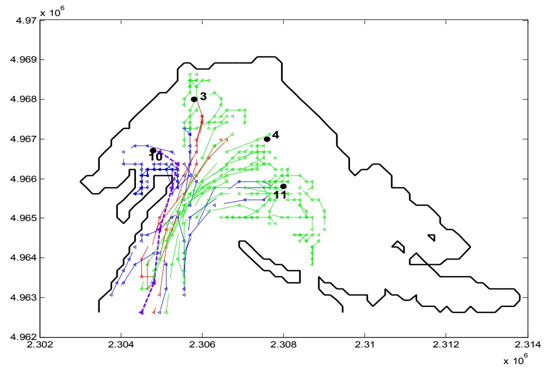


COHERENS model



Comparison of numerical results for the surface temperature and salinity

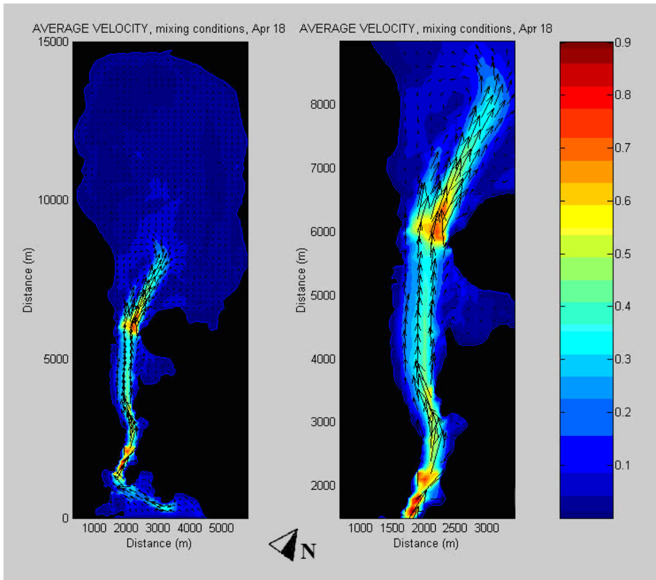




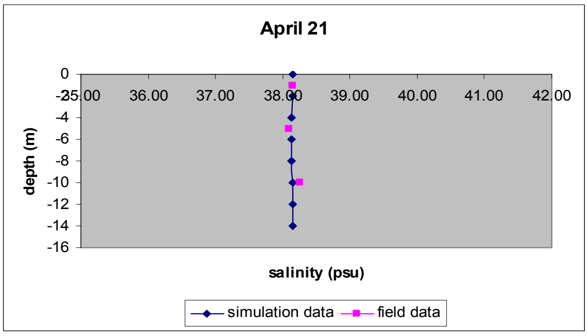
Flow patterns, water surface elevation and particle trajectories taking into account the effects of the new artificial connection with Adriatic Sea

Figure 9 : Hydrodynamic model of Sacca di Goro

The opening of new connection with open sea in August 1992 resulted in formation of additional streams inside of the lagoon which reduced the current speed in the main strait and enlarge the eddy circulation in the central and eastern parts of Sacca di Goro.



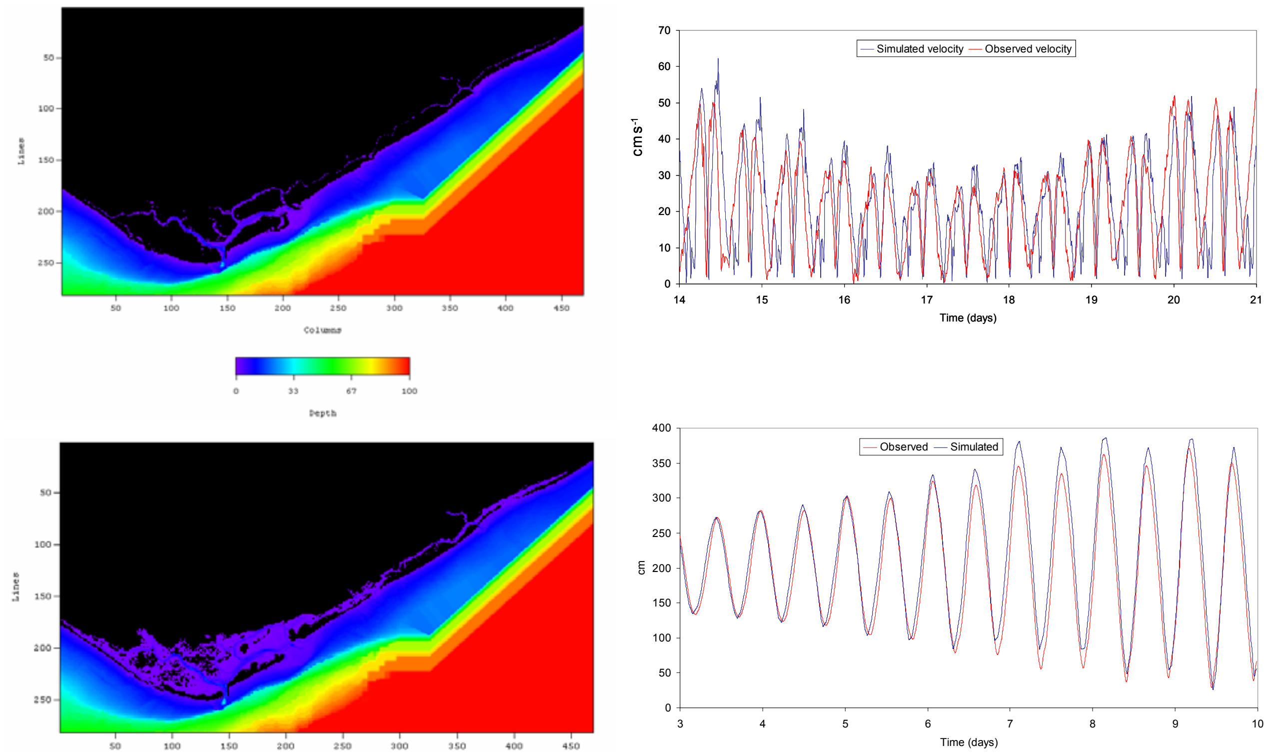
Hydrodynamic circulation (depth-averaged values) during the high tide at 18th April 1997 under a WNW wind of 2.4 m/sec.



Vertical profiles of salinity

Figure 10 : Hydrodynamic model of Gera

Ria Formosa hydrodynamic model is a two-dimensional vertically integrated hydrodynamic model, based on a finite differences grid with a 100 m spatial step and a semi-implicit resolution scheme (Perreira and Duarte, 2005). It is forced by tide level changes at the sea boundary and river flows at the land boundary. The model includes a wet-drying scheme to account for the dynamics of the large intertidal areas.



Bathymetry reported to the hydrographic zero (a) and during a flood (b).

Predicted and measured velocities and water levels at Olhão

Figure 11 : Hydrodynamic model of Ria Formosa

For Mar Menor, as the modelling was inexistent at the beginning of Ditty, the choice to develop the watershed model has be taken instead of the lagoon hydrodynamic as the major problem in Mar Menor are linked to the inputs from the watershed.

4.2 Ecological modelling

The task of ecological modelling has been to develop ecological and geochemical models taking into account the different parts of the ecosystem and according the scenarios chosen with end-users.

So, different models have been developped according the relevant characteristics of each coastal lagoons, i.e. fish and/or shellfish farming, macroalgae blooms, dynamics of bacteria of sanitary concern and shellfish contamination.

For modelling the impact of nutrient inputs from the watershed, nutrients (N and P), phytoplankton, zooplankton and organic matter have been described for all lagoons (Plus et al., 2003 ; Zaldivar et al.,2003a).

Dynamic of shellfish culture is also implemented, clams for Sacca di Goro (Zaldivar et al., 2003b; Zaldivar et al., 2003c, Marinov et al., 2005b) and Ria Formosa (Duarte *et al*, in prep), oysters and mussels for Thau (Gangnery *et al.*, 2004a ; Gangnery *et al.*, 2004b).

Modelling the anoxia crisis lead to a special model for Thau (Chapelle *et al*, 2001) and is linked to Ulva model for Sacca di Goro.

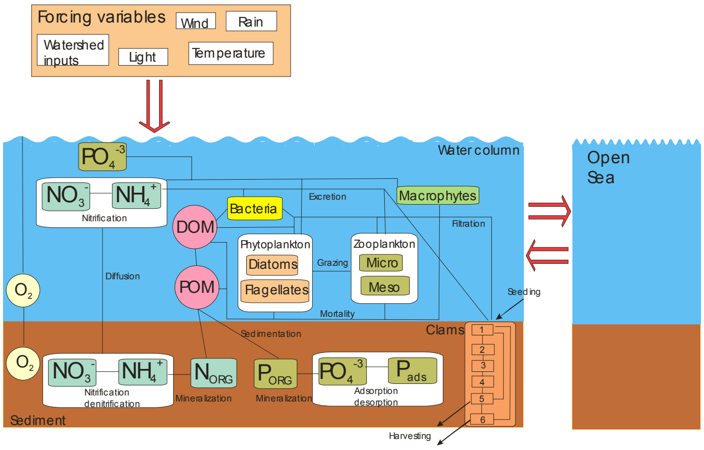


Figure 12 : Conceptual model for Sacca di Goro

Impact of bacteria of sanitary concern is also simulated for Thau (Fiandrino et al, 2003).

To study the link beween eutrophication and jellyfish blooms in Mar menor, a jellyfish model describing the different processes of jellyfish nutrition and decay has been developped for 3 species.

More detail can be found in the site –specific reports that are joined, see table 5 for references.

Ria Formosa	In preparation
Mar Menor	S. Rodríguez, J. Martínez, F. Carreño, M.T. Pardo, J. Miñano and M.A. Esteve. 2005. Report on lagoon modelling in Mar Menor site, 27 pp.
Thau lagoon	Plus M., Chapelle A., Lazure P., Auby I., Levavasseur G., Verlaque M., Belsher T., Deslous-Paoli J.-M., Zaldívar J. M., Murray C. N. 2003. Modelling of oxygen and nitrogen cycling as a function of macrophyte community in the Thau lagoon. Continental Shelf Research 23: 1877-1898 Gangnery A., Chabirand J-M., Lagarde F., Le Gall P., Oheix J., Bacher C., Buestel D. 2003. Growth model of the Pacific oyster, *Crassostrea gigas*, cultured in Thau lagoon (Mediterranea, France). Aquaculture 215, 267-290. Gangnery A., Bacher C., Buestel D., 2004. Application of a population dynamics model to the Mediterranean mussel, Mytilus galloprovincialis, reared in Thau lagoon (France). Aquaculture, 229, 289-313. Gangnery A., Bacher C., Buestel D., 2004. Modelling oyster population dynamics in a Mediterranean coastal lagoou (Thau, France): sensitivity of marketable production to environmental conditions. Aquaculture, 230, 323-347.
Sacca di Goro	D. Marinov, J.M. Zaldivar, A. Norro, G. Giordani, P. Viaroli. 2005. Integrated modelling in coastal lagoons. Part B : Lagoon model, Sacca di Goro case study (Italian Adriatic Sea shoreline), 89pp.
Gulf of Gera	V. Kolovoyiannis, A. Sampatakaki, G. Tsirsis, 2005. Integrated modelling in coastal lagoons. Coupled hydrodynamic-ecological modelling. Gulf of Gera case study, 32 pp.

Table 5 : Ecological modelling references

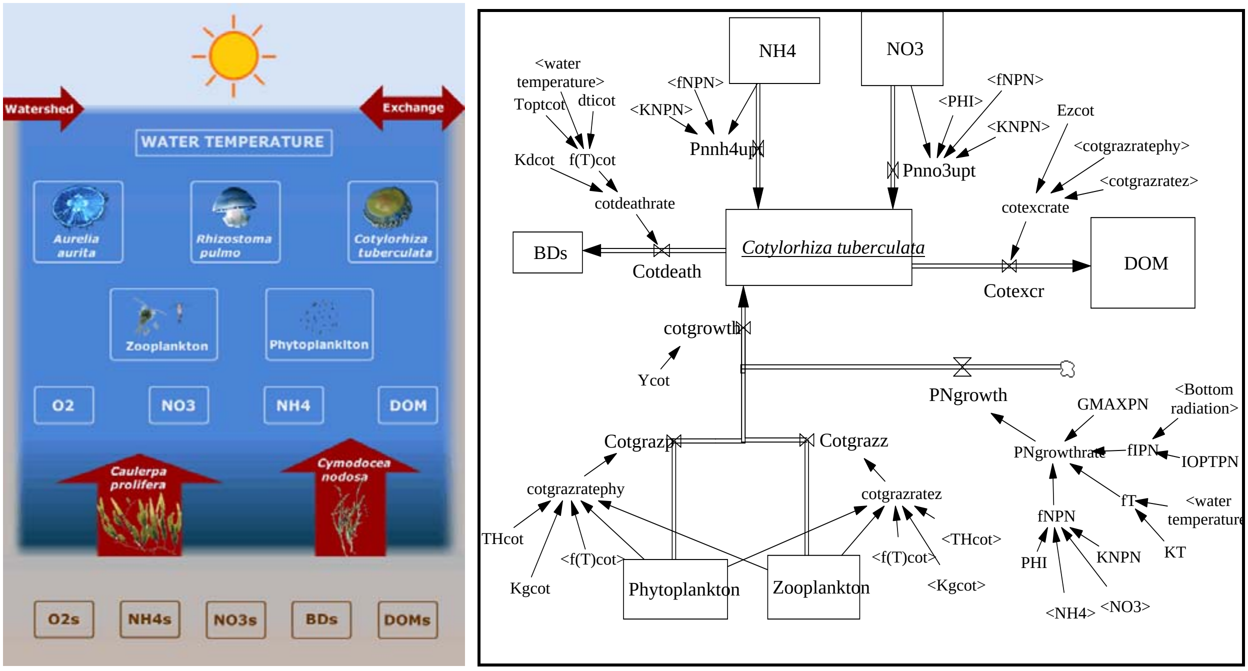


Figure 13. Schematic diagram of the Mar Menor lagoon model.

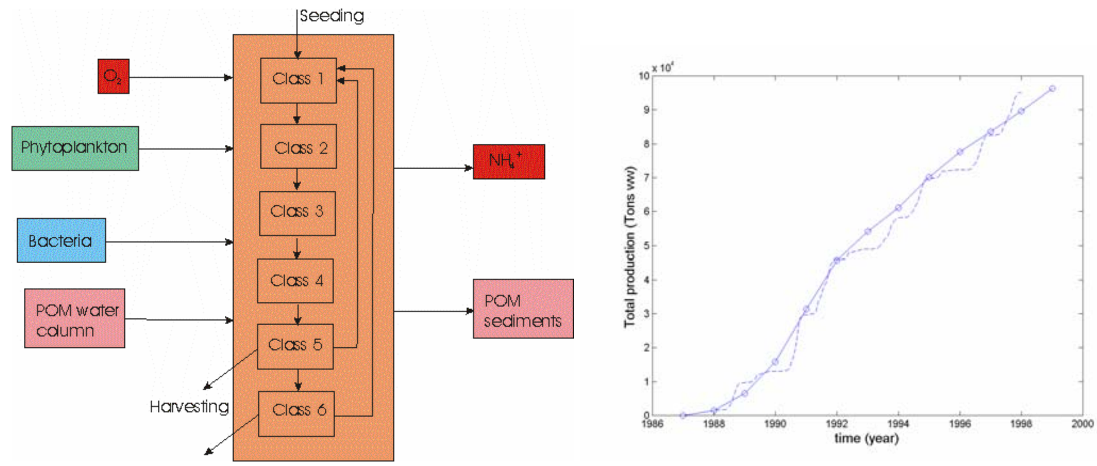


Figure 14 : Discrete Stage based model for clams in Sacca di Goro model. Simulations and data

A discrete stage-based model for the growth of *Tapes philippinarum* was coupled with the continuous biogeochemical model of the Sacca di Goro ecosystem. The model is able to reproduce the biomass production. Finally, the model has allowed studying and assessing the impact of the clams in the biogeochemical cycles.

In Ria Formosa nutrient exchanges between water and sediment are also modelled taking into account the incursion of the tide.

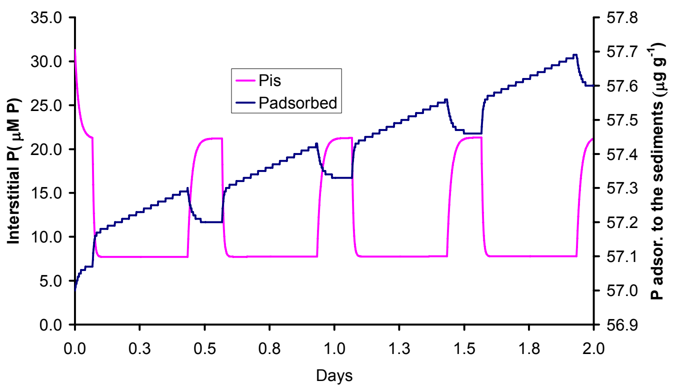


Figure 15 :Simulation of P sediment content during flood and ebb in Ria Formosa

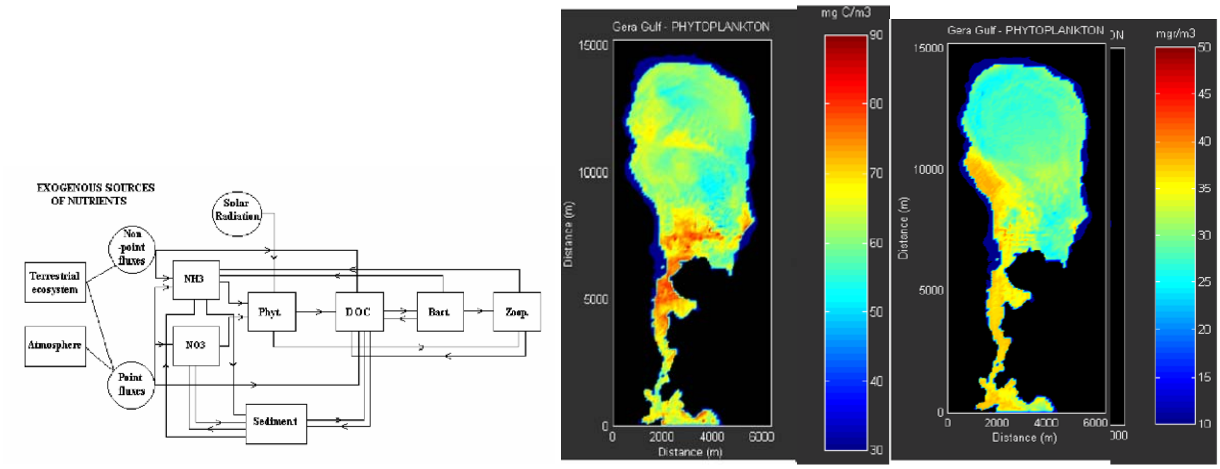


Figure 16 : Gera ecological model and simulated phytoplanktonic carbon in subsurface in january and august

5. Coupling watershed-Lagoon modelling

This means the use of watershed model outputs as inputs of the lagoon model in order to test in a predictive way the impact of modification of watershed uses on the lagoon ecosytem (eutrophication, shellfish production, dystrophic crisis, bacteria contaminations…) instead of using watershed data as lagoon model inputs. This is the last task when both watershed and lagoon model have benn calibrated and validated.

Simulations have been performed for each site for testing the impact of nutrient inputs from watershed, more deatil are given in the reports, table 6.

Ria Formosa	In preparation
Mar Menor	S. Rodríguez, J. Martínez, F. Carreño, M.T. Pardo, J. Miñano and M.A. Esteve. 2005. Report on lagoon modelling in Mar Menor site, 27 pp.
Thau lagoon	Plus, M. I. Lajeunesse, F. Bouraoui, J Zaldivar, A. Chapelle, P. Lazure. Modelling water discharge and nitrogen input into a Mediterranean lagoon. Impact on the primary production *Continental shelf research* .
Sacca di Goro	D. Marinov, J.M. Zaldivar, L.Galbiati, F. Bouraoui, F. Sena, F.J. Elorza, A. Norro, G. Giordani, P. Viaroli. 2005. Integrated modelling in coastal lagoons. Part C : Coupling watershed - Lagoon model, Sacca di Goro case study, 80pp.
Gulf of Gera	V. Kolovoyiannis, A. Sampatakaki, G. Tsirsis, 2005b. Integrated modelling in coastal lagoons. Coupled hydrodynamic-ecological modelling. Gulf of Gera case study, 32 pp.

Table 6 : Site-specific integrated model references

Simulations have been performed for each site for testing the impact of nutrient inputs from watershed. These allows to test in the scenario analysis the evolution of the lagoon status (eutrophication, shellfish production) against the evolution of land-use or the climatic evolution.

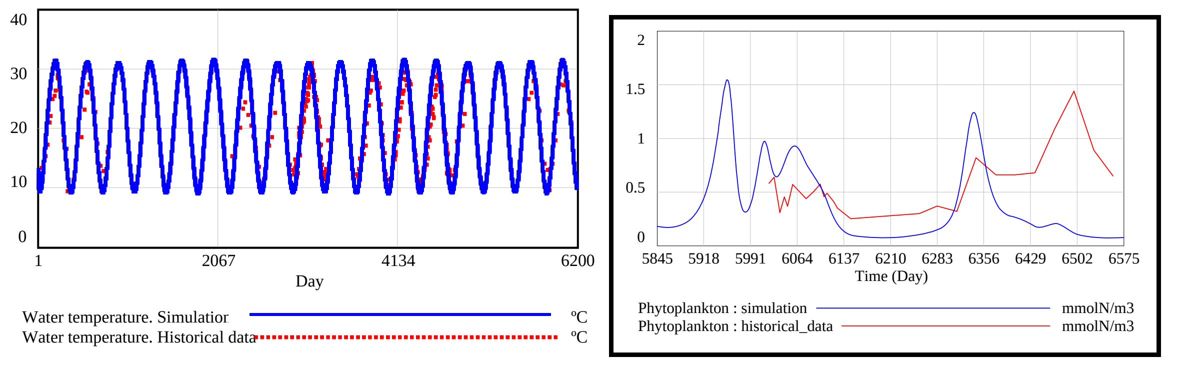


Figure 17 : Simulation of Mar Menor temperature and phytoplankton in the 0D model in response to nutrient inputs from watersed model.

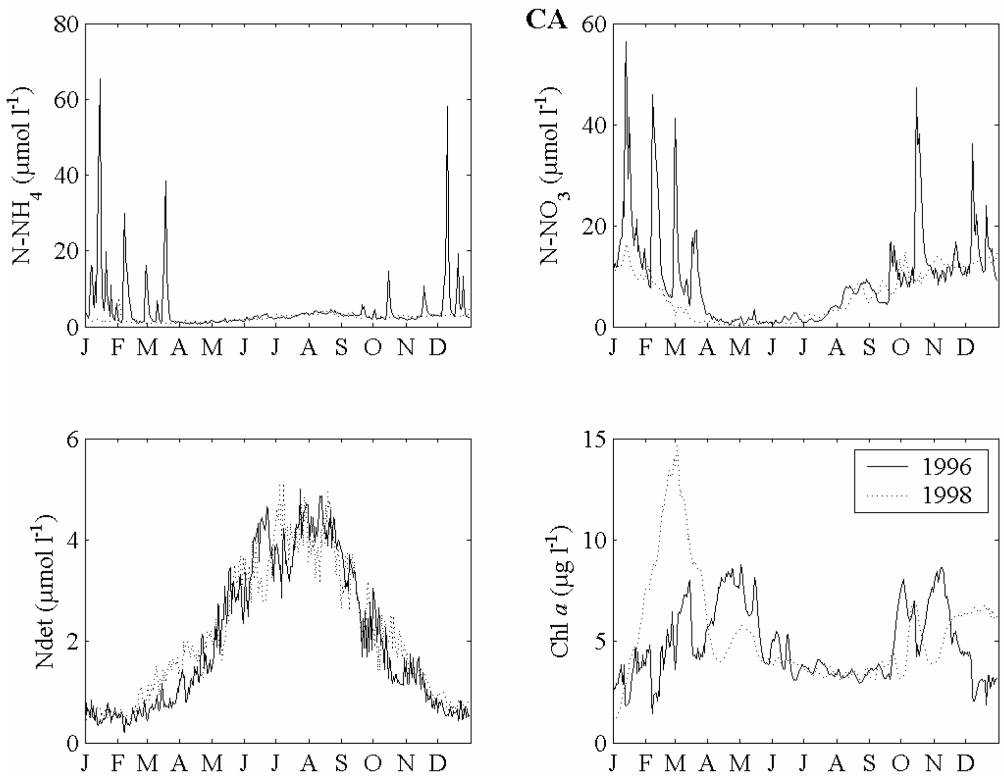


Figure 18 : Simulated nutrient (NH_4 and NO_3), detrital nitrogen (Ndet) and chlorophyll *a* (Chl *a*) concentrations in Thau lagoon in response to nutrient inputs simulated from watershed model.

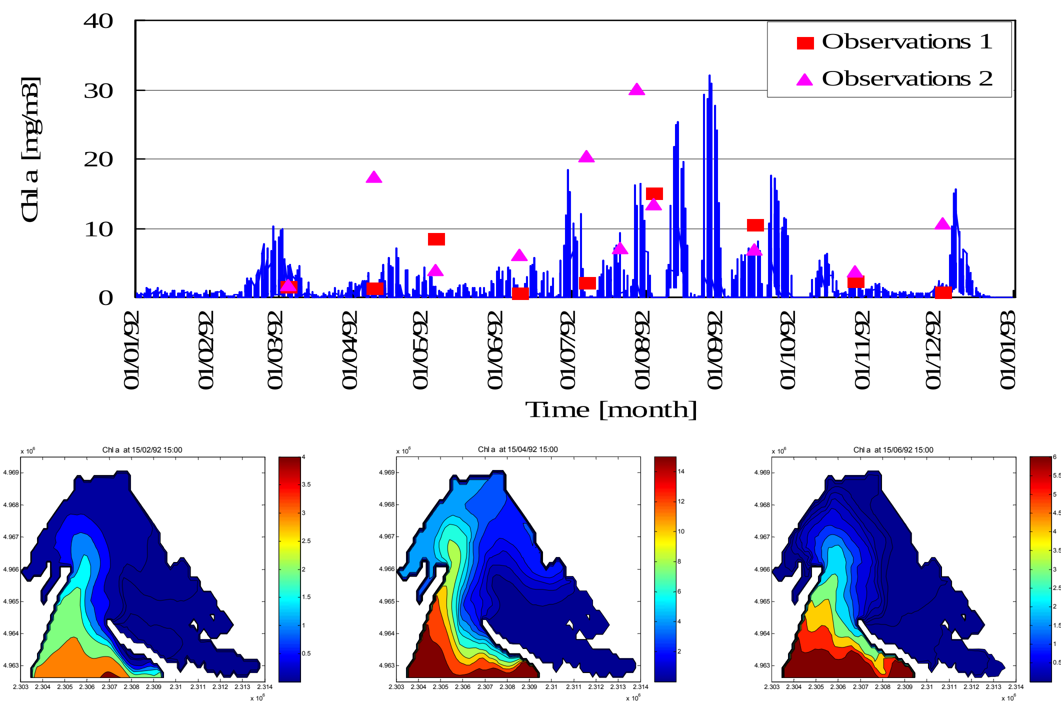


Figure 19 : Phytoplankton simulation in Sacca di Goro in response to nutrient inputs from watershed model.

For Thau lagoon, the impact of bacteria fluxes from watershed has been chosen as priority one for the scenario analysis, and simulated (Fiandrino *et al*, 2005).

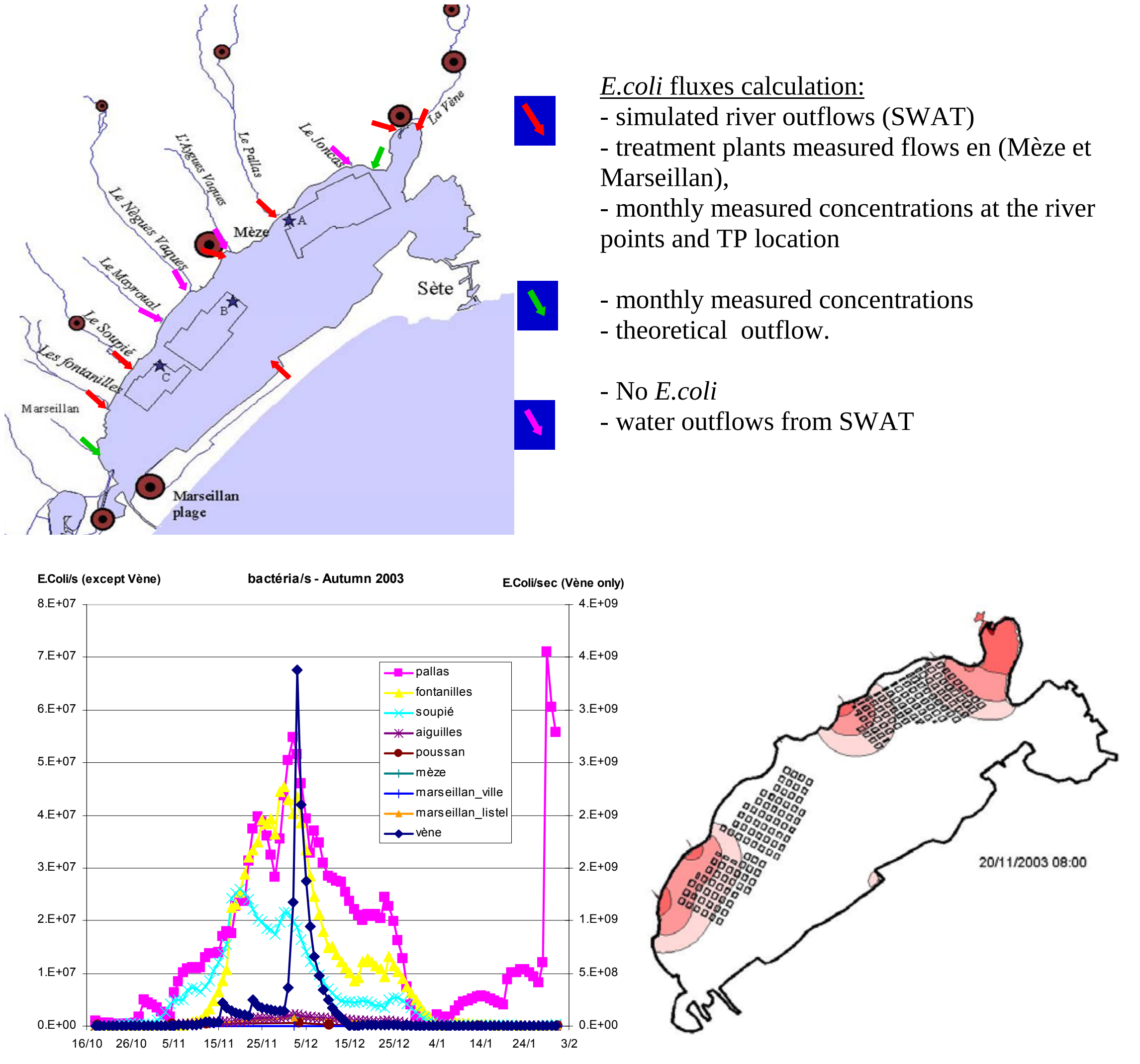
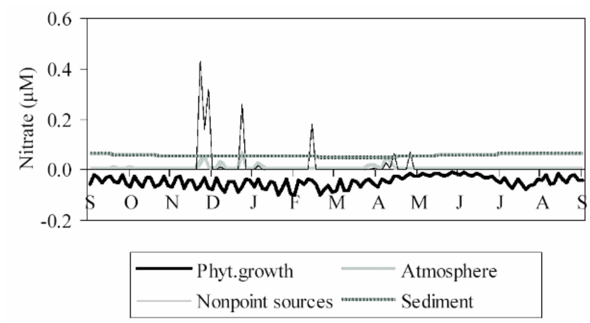


Figure 20 : Exemple of coupling bacteria watershed inputs to the lagoon from different ways for Thau lagoon



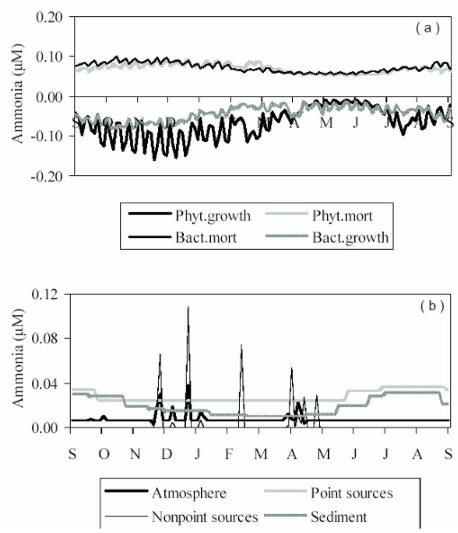


Figure 21 : Annual variability of nitrates and ammonia sources and sinks in the Gulf of Gera

6. Conclusions

The modelling activity, that finished with the second year of DITTY, will continue, with other emphasis, through other workpackages. Mainly, WP5 (Intercomparison) and WP6 (Scenario Analysis) and then results will be incorporated into the DSS prototypes (WP8)

Models outputs are going to be prepared for visualization using the GIS developed in WP3. This will give the possibility to visualize maps of model results for each site and compare to data maps (see www.dittyproject.org)

In the WP5, models are going to be compared and a benchmarking analysis is in progress. This concerns 3D hydrodynamic models, Swat and AGWFL models for watershed, POL and Ria Rormosa flood events models. Comparison between ecological models is more difficult since they are more site specific but some case studies are under development.
The scenario analysis workpackage (WP6) will use the models to simulate the scenarios chosen for each lagoon.

For Sacca di Goro clam farming is one of the most critical issues. For this reason a bioeconomic analysis comparing the benefits and related costs of collecting Ulva with the increase of shellfish productivity has been carried out (Zaldivar *et al*., 2005).

Finally model outputs will be used for inputs for the Decision Support System, directly or more probably with aggregation methods (calculation of indicators, statistical interpretations, results from scenario analysis).

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Annex A : Model Identity cards

Model name :
MMW

Short description :
Integrated watershed model for the Mar Menor river basin

General description

Type :	Dynamic System Model
Dimension :	Semi-Distributed (Sub-basin units)
Time step :	Daily (Computing time step = 1/5 day)
Mesh size *(horizontal plan)*	No mesh. Divided in 10 sub-basins (semi-distributed structure)
Number of meshes :	
Integration :	
Programming language / software :	Vensim

Variable description

Nb of state variables : 23

List of state variables :

LAND USE	NITROGEN	PHOSPHOROUS	OTHERS		
tree area -	NH_4 -	Phumus active -	water in Quaternary	...	...
open area -	N livmat -	Pinorg active -	N Quaternary	...	...
dry area -	N resid -	Pinorg stable -	P Quaternary	...	...
nat area -	Nhumus active -	Presid -	Resident population	...	...
green area -	Nhumus stable -	Psolution -	Seasonal population	...	...
N solution -	N solution	Plivmat		...	...

Nb of forcing variables : 7

List of forcing variables :

Water flow inside rambla	Tagus water transfer	...	...	...
Overland flow	Purification index	...	...	...
deep percolation	Re-use for irrigation inde	...	...	...
	drainage index			

Development

Calibration process :	Partial (only for variables with enough data)	***Method :***	Visual adjusting
Sensitivity analysis :	Not yet		
Validation process :	Not yet.	***Method :***	
Coupled ?	Yes	***...to model(s) :***	Mar Menor hydrological (MMH); Mar Menor lagoon (MM_lagoon)
Published ?	Not yet		

Scenarii to test in WP6

Scenario 1 : MM-BAU — Continuation of current trends of increase in urban-tourist development

Model to test this scenario: COUPLED MMH-MMW-MM_lagoon

Scenario 2 : MM-PT1 — Groundwater desalination and re-use of agricultural drainage

Model to test this scenario: COUPLED MMH-MMW-MM_lagoon

Scenario 3 : MM-PT2 — Optimisation of wetlands for nutrients removal

Model to test this scenario: COUPLED MMH-MMW-MM_lagoon

REMARKS

Annex A : Model Identity cards

Model name :	MMH
Short description :	Continuous and distributed hydrological model for the Mar Menor river basin

General description

Type :	watershed
Dimension :	2D
Time step :	daily and hourly (rainfall events) inputs; daily outputs
Mesh size *(horizontal plan)*	25 meters
Number of meshes :	4000000
Integration :	with GIS
Programming language / software :	R language integrated with GRASS, PostgreSQL and RPgSQL, under Linux

Variable description

Nb of state variables :	1					
List of state variables :	Soil moisture				...	...
					...	...
Nb of output variables :	3				...	...
					...	...
List of output variables :	Daily water flow inside ramblas per sub-basin				...	...
	Daily overland flow per sub-basin				...	...
	Daily deep percolation per sub-basin					
Nb of forcing variables :	8					
List of forcing variables :	Precipitation	Humidity	DEM		...	...
	Temperature	Soil	Irrigation practices		...	...
	Radiation	Land use			...	...

Development

Calibration process :	Not yet (not enough data)	***Method :***	
Sensitivity analysis :	Not yet		
Validation process :	Not yet.	***Method :***	
Coupled ?	yes	***...to model(s) :***	Mar Menor watershed model (MMW)
Published ?	Not yet		

Remarks /other infos

Annex A : Model Identity cards

Model name : MM_lagoon

Short description : A 0D-simulation model for the Mar Menor lagoon. It is based on nitrogen cycling. and includes 16 state variables

General description

Type :	Dynamic ecological model
Dimension :	OD, aggregated model
Time step :	dayly (Computing time step = 1/5 day)
Mesh size *(horizontal plan)*	
Number of meshes :	
Integration :	
Programming language / software :	Vensim modelling software

Variable description

Nb of state variables : 15

List of state variables :

Water temperature	Zooplankton density	Dissolved oxygen in sediments
NH4 water column	Rhyzostoma pulmo biomass	Dissolved organic matter in sedir
NO3-NO2 water column	Cothylorhiza tuberculata biomass	Biodeposits
Dissolved oxygen	Aurelia aurita biomass	
Dissolved organic matter	NH4 in sediments	
Phytoplankton density	NO3-NO2 in sediments	

Nb of forcing variables : 5

List of forcing variables :

N input from the watershed	Caulerpa prolifera biomass
N input from the open sea	Cymodocea nodosa biomass
N output to the open sea	

Development

Calibration process :	Yes(Provisional)	***Method :***	Visual adjusting
Sensitivity analysis :	Not yet		
Validation process :	Not yet	***Method :***	
Coupled ?	Yes	***...to model(s) :***	Mar Menor hydrological (MMH); Mar Menor lagoon (MM_lagoon)
Published ?	Not yet		

Scenarii to test in WP6: THE SAME AS SPECIFIED IN THE MMW IDENTITY CARD

Remarks / other infos

Annex A : Model Identity cards

Model name :	ECODYN Formosa

Short description :	Coupled physical-ecological model for the Ria Formosa

General description

Type :	ecological
Dimension :	2D
Time step :	3 s
Mesh size *(horizontal plan)*	100 m
Number of meshes :	>100 000
Integration :	not integrated
Programming language / software :	C++

Variable description

Nb of state variables : 15

List of state variables :

Current velocity		NH4	Total particulate matter	
Water elevation		ON	Particulate OM	
Water density		OP	Clam biomass	
Water temperature		Inorganic phosphorus		
Submarine light intensity		Dissolved O2		
NO3 + NO2		Phytoplankon cc		

Nb of forcing variables : 8

List of forcing variables :

Air temp.	Light intensity		Riverine nutrient cc	
Nutrient cc at sea boundaries			Phytoplankton cc at sea boundaries	
River flows	Nutrient cc from WWTP		Water elevation at sea boundary	

Development

Calibration process :	done	***Method :***	*visual fitness*	Only for hydrodynamics
Sensitivity analysis :	undone			
Validation process :	done	***Method :***	*visual fitness*	Only for hydrodynamics
Coupled ?	no			
Published ?	no			

Remarks / other infos

Annex A : Model Identity cards

Model name :	SWAT-THAU

Short description :	Continuous and distributed model of the Thau lagoon watershed

General description

Type :	watershed	
Dimension :	2D	(distributed)
Time step :	1 day	
Mesh size *(horizontal plan)*	variable (hydrologic response units)	
Number of meshes :		
Integration :	with GIS	
Programming language / software :	Fortran / Swat	

Variable description

Nb of state variables : 10

List of state variables :

water flow	DIP	…	…	…	…
susp. matter	org. P	…	…	…	…
NO_3	O_2	…	…	…	…
NH_4	contamin.	…	…	…	…
NO_2	…	…	…	…	…
org. N	…	…	…	…	…

Nb of forcing variables : 9

List of forcing variables :

precipitations	air humidity	land use	…	…	…
solar rad.	wind speed	soils	…	…	…
air temp.	point sources	dem	…	…	…

Development

Calibration process :	done	***Method :***	*visual fitness*
Sensitivity analysis :	undone		
Validation process :	done	***Method :***	*visual fitness*
Coupled ?	yes	***…to model(s) :***	*Thau lagoon model (hydrodynamical + ecological)*
Published ?	submitted		*(Ecological Modelling): Modelling water discharges and nutrient inputs into a Mediterranean lagoon. Impact on the primary production.*

Remarks / other infos

Annex A : Model Identity cards

Model name :	MARS 3D

Short description : Mars 3D is a three-dimensional numerical model that solve primitive equations using finite difference method and dedicated to coastal and shelf

General description

Type :	hydrodynamical
Dimension :	3D
Time step :	20 s
Mesh size *(horizontal plan)*	100 x 100
Number of meshes :	10 000-100 000
Integration :	not integrated
Programming language / software :	Fortran 90

Variable description

Nb of state variables : 6

List of state variables :

Longitudinal velocity					
Transverse velocity					
Vertical velocity					
Surface elevation					
Temperature					
Salinity					

Nb of forcing variables : 9

List of forcing variables :

Wind	air temp.	river discharge		
Atmospheric press.	air humidity	fresh water temperature and salinity		
Tide	clouds covering	open sea temp. & sal.		

Development

Calibration process :	done	***Method :***	*visual fitness*	
Sensitivity analysis :	done	***Method :***		***Param./var. :***
Validation process :	undone	***In progress***	*visual fitness*	*Exchange with sea ; Currents in the lagoon*
Coupled ?	yes	***…to model(s) :***	*Biogeochemical model (N,P) ; Macrophytes model ; Anoxia model ; Bacteria model ;*	
Published ?	no	***In progress***		

Remarks / other infos

Annex A : Model Identity cards

Model name :	Thau- ecosystem

Short description : Model that simulates nutrient cycling in Thau lagoon and sediment, phytoplankton (2 types: micro and pico-nanaoplankton), zooplankton (2 types :

General description

Type :	ecological
Dimension :	3D
Time step :	20 s
Mesh size *(horizontal plan)*	400 x 400
Number of meshes :	1 000-10 000
Integration :	with database
Programming language / software :	Fortran 90

Variable description

Nb of state variables : 12

List of state variables :

NO3 water column	NH4 water colu	Org. N in water	O2 water column
NO3 interst. Water	NH4 interst. Wa	Org. N in sediment	O2 interst. water
Picophytoplankton	Microphytoplankton		
Microzooplankton	Mesozooplankton		

…

Nb of forcing variables : 11

List of forcing variables :

Temperature	Wind	Solar radiation		
NO3 rivers	NH4 rivers	Org. N rivers	O2 rivers	
Macroalgae biomass	N in Macroalgae		Oysters	Epiphytes

Development

Calibration process :	done	***Method :***	*visual fitness*
Sensitivity analysis :	done	***Method :***	***Param./var. :***
Validation process :	undone	***In progress***	*visual fitness*
Coupled ?	yes	***...to model(s) :***	*Biogeochemical model (N andP) ; to couple to the Anoxia model*
Published ?	yes	***In progress***	*Plus M., Chapelle A., Lazure P., Auby I., Levavasseur G., Verlaque M., Belsher T., Deslous-Paoli J.-M., Zaldivar J. M., Murray C. N. 2003. Modelling of oxygen and nitrogen cycling as a function of macrophyte community in the Thau lagoon. Continental Shelf Research 23: 1877-1898*

Annex A : Model Identity cards

Model name :	shellfish production

Short description :	model of oyster and mussel productions as a function of rearing strategies and environmental conditions

General description

Type :	other :	Popul. Dyn.
Dimension :	OD	
Time step :	1 day	
Mesh size *(horizontal plan)*		
Number of meshes :		
Integration :	not integrated	
Programming language / software :	MATLAB	

Variable description

Nb of state variables : 1

List of state variables :

nb of individuals	…	…	…	…	…
…	…	…	…	…	…
…	…	…	…	…	…
…	…	…	…	…	…
…	…	…	…	…	…
…	…	…	…	…	…

Nb of forcing variables : 4

List of forcing variables :

temperature	seeding	…	…	…	…
POM	…	…	…	…	…
chlorophyll	…	…	…	…	…

Development

Calibration process :	done	***Method :***	*optimization algorithm*		
Sensitivity analysis :	done	***Method :***	*Monte Carlo*	***Param./var. :***	*all/fixed*
Validation process :	done	***Method :***	*optimization algorithm*		
Coupled ?	no				
Published ?	yes	***References :***			

References :

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Remarks / other infos

the model is 0D (in space) but solves a 1D partial differential equation of the population dynamics

Annex A : Model Identity cards

Model name :	Sacca di Goro - 3D Physics

Short description : Based on COHERENS model (version 8.4/1999), simulates physical processes as water circulation, surface elevation, temp. & sal.

General description

Type :	hydrodynamical	
Dimension :	3D	
Time step :	6 seconds	
Mesh size (horizontal plan)	150x150 m	
Number of meshes :	1 000-10 000	3358 (73x46)
Integration :	not integrated	
Programming language / software :	Fortran 77	

Variable description

Nb of state variables : 6

List of state variables :

longitudinal velocity		…	…	…	…
transverse velocity		…	…	…	…
vertical velocity		…	…	…	…
surface elevation		…	…	…	…
temperatute	…	…	…	…	…
salinity	…	…	…	…	…

Nb of forcing variables : 11

List of forcing variables :

wind	clouds cover	waves	fresh water temp. & sal.	…
air temp.	precipitation	bottom stress	open sea temp. and sal.	…
air humidity	tides	river discharge	…	…

Development

Calibration process :	done	**Method :**	other :	Same method as validation
Sensitivity analysis :	done	**Method :**	other :	Ruddick K.G., Deleersnijder E., Luyten P.J. and Ozer J., 1995. Haline stratification in the Rhine-Meuse freshwater plume: a 3D model sensitivity analysis. Cont. Shelf Res. 15: 1597-1630
Validation process :	done	**Method :**	other :	Quantification of divergence between calculations and observations : absolute mean deviation (AMD), normalised absolute mean deviation (NAMD, normalisation is done by dividing the deviations to the observation values), and root mean square deviation (RMSD)
Coupled ?	no			
Published ?	submitted		Marinov D., Norro A., Zaldívar J.-M., 2004, Application of COHERENS model for hydrodynamic investigation of Sacca di Goro coastal lagoon (Italian Adriatic Sea shore), Ecological Modelling	

Remarks / other infos

Dimitar has prepared the 3D version that we hope will be coupled with the biology part quite soon (in fact, it seems that Alain has already coded the 0D model into COHERENS), but at the moment they are separated parts.
Josema

Annex A : Model Identity cards

Model name :	Goro-Biology

Short description : Nutrient cycling in Sacca di Goro lagoon, phytopkt (flagellates and diatoms), zoopk (2 types), bact. loop, Ulva and clams (discrete stage based)

General description

Type :	ecological
Dimension :	OD
Time step :	variable
Mesh size *(horizontal plan)*	None
Number of meshes :	<100
Integration :	not integrated
Programming language / software :	Fortran

Variable description

Nb of state variables : 44

List of state variables :

NO3 wat. col.	NH4 wat. col.	SRP wat. col.	Silica wat. col.	O2 wat. col.	NH4 interst. wat.
NO3 interst. wat.	P interst. wat.	Innorg. P in sed.	O2 interst. wat.	Org. P in sed.	Org. N in sed.
Ulva biomass	N in Ulva tissue	Monom. OM-C	Monom. OM-N	Diss. Polym1 OM-C	Diss. Polym.1 OM-N
Dis. Polym.1 OM-P	Diss. Polym2 OM-C	Diss. Polym.2 OM-N	Diss. Polym.2 OM-P	Part. OM 1 C	Part. OM 1 N
Part. OM 1 N	Part. OM 2 C	Part. OM 2 N	Part. OM 2 P	Detrital Si	Bact. biomass
Microzoopk	Mesozoopk	Diatoms (3 state var.)	Flagellates (3 var.)	Clams (6 classes)	…

Nb of forcing variables : 18

List of forcing variables :

SG Temp.	SG Salinity	SG Wind	Rain intens.	Solar rad.	Rivers flow
NO3 rivers	NH4 rivers	SRP rivers	O rivers	Ptot rivers	Si rivers
Adriatic flow	NO3 Adriatic	NH4 Adriatic	SRP Adriatic	Ptot Adriatic	Ntot Adriatic

Development

Calibration process :	done	***Method :***	*visual fitness*		
Sensitivity analysis :	done	***Method :***	*sensitivity index*	***Param./var. :***	*all/stochastic*
Validation process :	undone				
Coupled ?	no				
Published ?	yes	***Reference :***			

Zaldívar, J. M., Cattaneo, E., Plus, M., Murray, C. N., Giordani. G. and Viaroli, P., 2003, Long-term simulation of main biogeochemical events in a coastal lagoon: Sacca di Goro(Northern Adriatic Coast, Italy). Continental Shelf Research 23, 1847-1876. Zaldívar, J. M., Plus, M., Giordani, G. and Viaroli, P., 2003, Modelling the impact of clams in the biogeochemical cycles of a Mediterranean lagoon. Proceedings of the Sixth International Conference on the Mediterranean Coastal Environment. MEDCOAST 03, E. Ozhan (Editor), 7-11 October 2003, Ravenna, Italy. pp 1291-1302.G9

Remarks / other infos

We have started to prepare the cards for the 3D Goro-COHERENS, the 0D-Goro and the Goro watershed. This is the 0D biogeochemical model + clams that we are now coupling with the 3D so it will become only one identity card in few months, but at the moment we are on the process. Next will arrive soon.

Annex A : Model Identity cards

Annex A : Model Identity cards

Model name :	Gera watershed model
Short description :	2-d medium resolution watershed model

General description

Type :	watershed
Dimension :	2D
Time step :	1 day
Mesh size *(horizontal plan)*	1 Km
Number of meshes :	500-1 000
Integration :	not integrated
Programming language / software :	FORTRAN

Variable description

Nb of state variables : 8

List of state variables :

Diss P	Diss.NO3	Diss. NH4	DON		
Part. P	Part. NO3	Part. NH4	PON		

Nb of forcing variables : 2

List of forcing variables :

Rainfall	Evapotransp.				

Development

Calibration process :	done	***Method :***	
Sensitivity analysis :	undone		
Validation process :	done	***Method :***	
Coupled ?	yes	***...to model(s) :***	*Hydrodynamic, Ecological submodels*
Published ?	yes	***Reference :***	Arhonditsis G., Tsirtsis G., Karydis M., 2002. The effects of episodic rainfall events to the dynamics of coastal marine ecosystems: Applications to a semi-enclosed gulf in the Mediterranean Sea, J. Mar. Syst. 35, 183-205 Arhonditsis G., Karydis M., Tsirtsis, G., 2002. Integration of mathematical modeling and multicriteria methods in assessing environmental change in developing areas: A case-study of a coastal system, J. Coast. Res. 18, 698-711

Remarks / other infos

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