IASON WP6
A Science plan for the region.

Deliverable D6.2:
Report on the design of a future coupled physical ecosystem model.

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Basic Considerations:

Ocean physical dynamics:

Temporal and spatial scales of variability above and below the conventional "seasonal" and "large" scales.

The large spatial and temporal variability of the physical system is deeply influencing and significantly driving the biogeochemical and ecological dynamics.

Ocean ecosystem dynamics:

Wide range of trophic structures with large spatial and temporal variability (shifts) in response to the seasonal to interannual variability of the physical and biogeochemical forcing functions.

The Southern European Seas, SES (Mediterranean and Black Sea)

Remarkably different biogeochemical/ecological characteristics with large variability of the ecosystem structure and functioning.

Strong anthropogenic pressure and exploitation in the coastal zone

Therefore the basic objectives to be pursued in designing a coupled physical ecological model of the SES should be:

Resolve the physical biological coupling of the system at the relevant spatial and temporal physical scales.

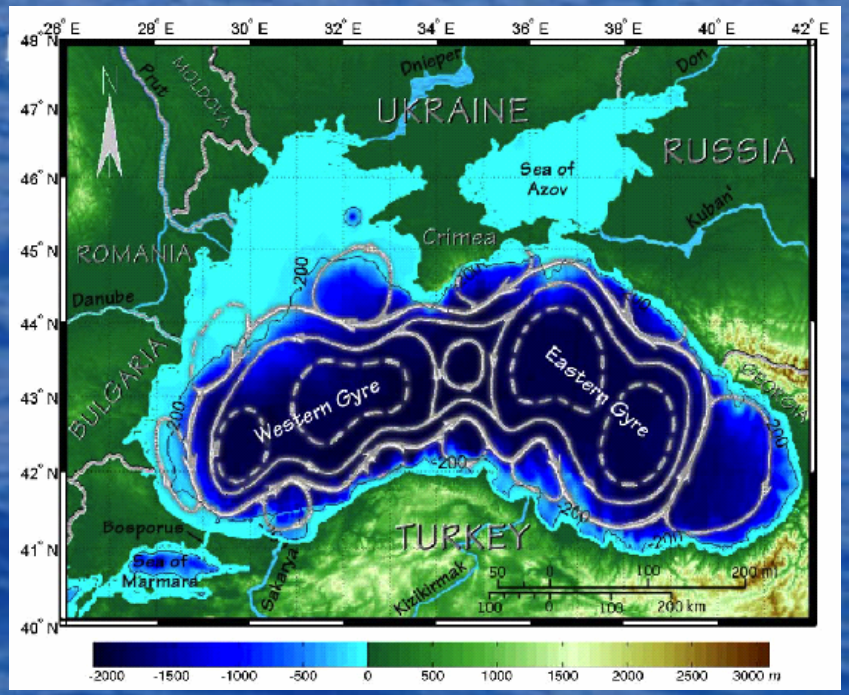
Envisage a marine ecosystem description allowing for spatial and temporal trophic structure shift in dependence of the variability of the forcing functions acting on the system.

Provide adequate description of the coastal zone ecosystem dynamics.

Provide relevant information for environmental management amd planning focusing on the integrated coastal zone management.

Coastal and open sea physical processes

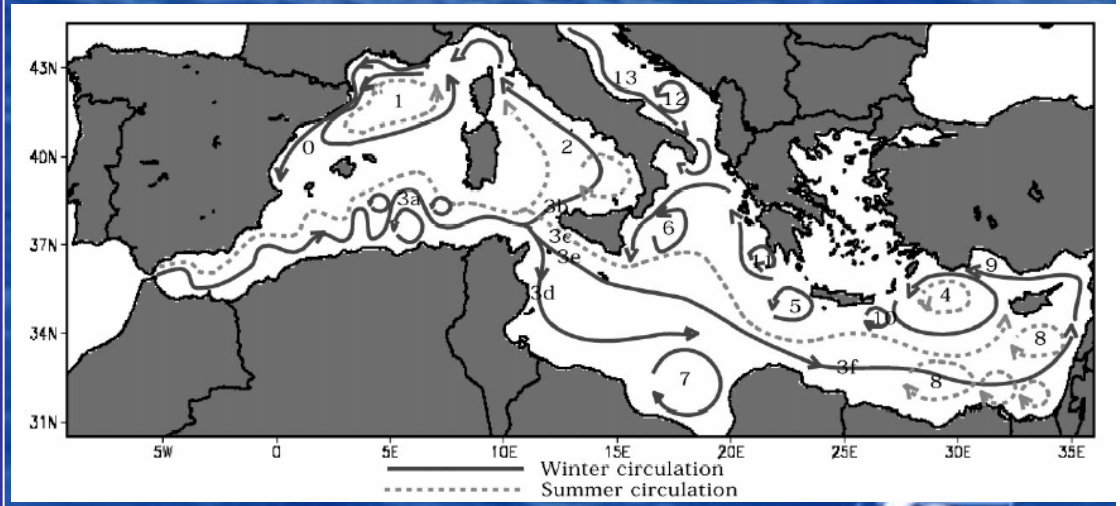
In the SES:
General circulation composed by features directly impinging on the coastal domain
e.g.:
Mediterranean: Liguro-Provençal and Algerian Currents.
Black Sea: The “Rim” current.



Oguz et al. 1993

Significant two ways exchanges between the coastal and the open Sea domains.

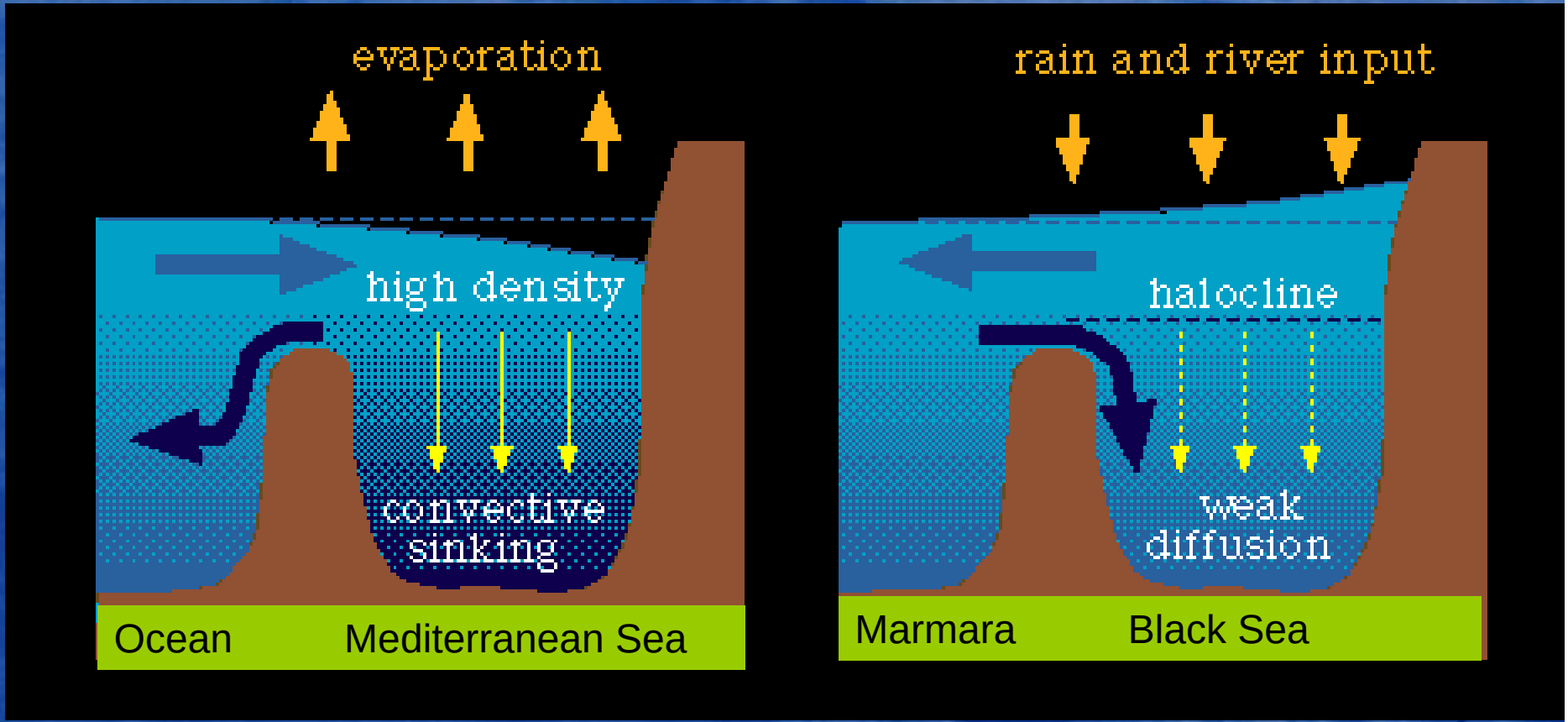
Therefore:
The open sea circulation should be explicitly considered for a consistent physical and ecological modelling of the of the coastal domain.



Pinardi et al. 1997

Mediterranean: Antiestuarine thermohaline circulation, oligotrophic conditions.

Black Sea: Estuarine thermohaline circulation, meso to eutrophic conditions,



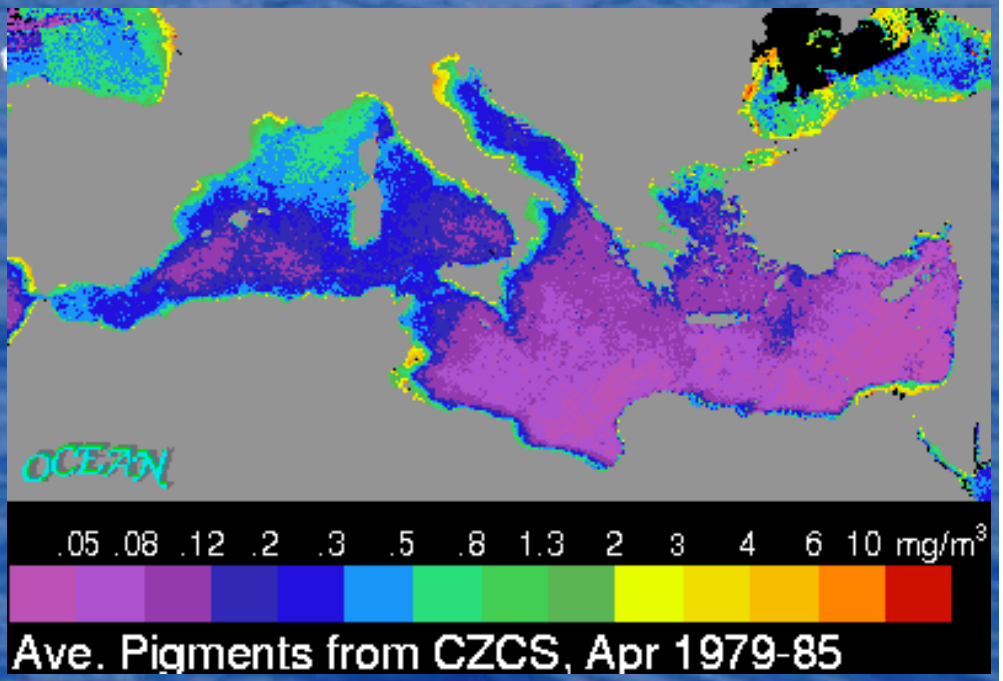
Ecosystem functioning: General

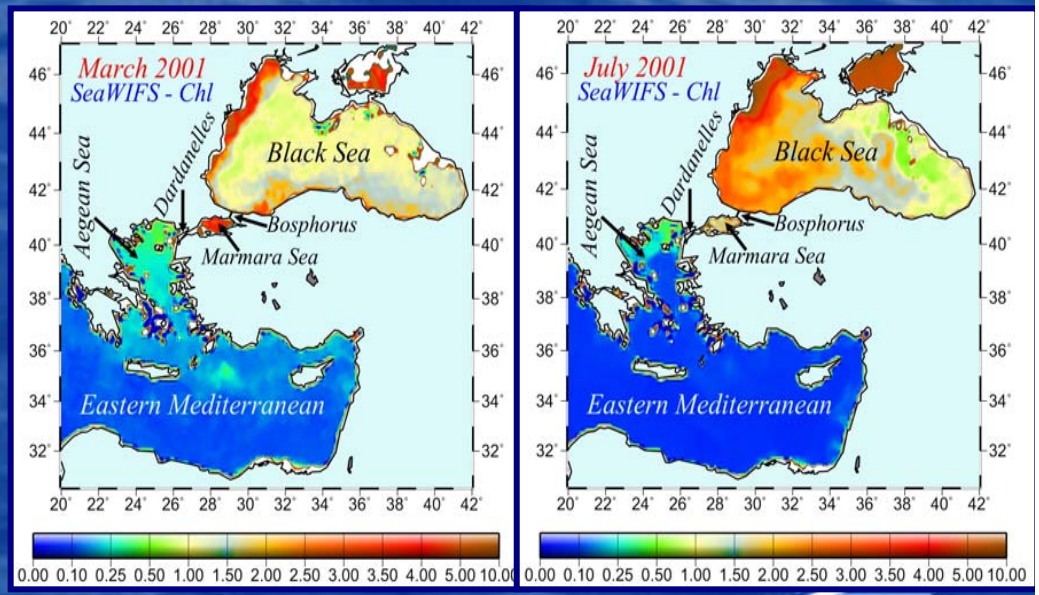
In both basins: Coastal areas with significant river runoff and meso to eutrophic
characteristics enhanced by strong anthropogenic nutrient load.
e.g.:

- Mediterranean: The northern Adriatic
- Black Sea: The western coastal areas

- Mediterranean: convection
- Lesepsian species

- Both: Invasive species

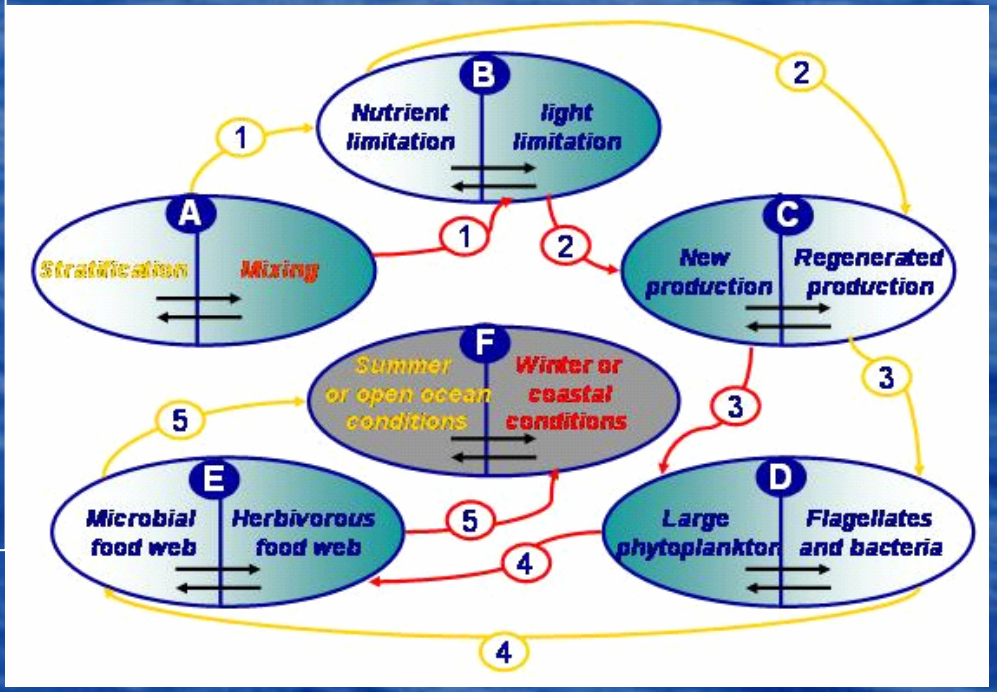




Ecosystem functioning: the pelagic trophic structure.

- The SES hosts a wide range of trophic structures with temporal and spatial variations ranging from the “herbivorous” to the “microbial” food web.

- Transitions along this trophic continuum in response to the physical dynamics and the boundary conditions determines the observed spatial and temporal variability of the SES ecosystem.



Legendre and Rassoulsadegan, 1995

Ecosystem functioning: The benthic pelagic coupling

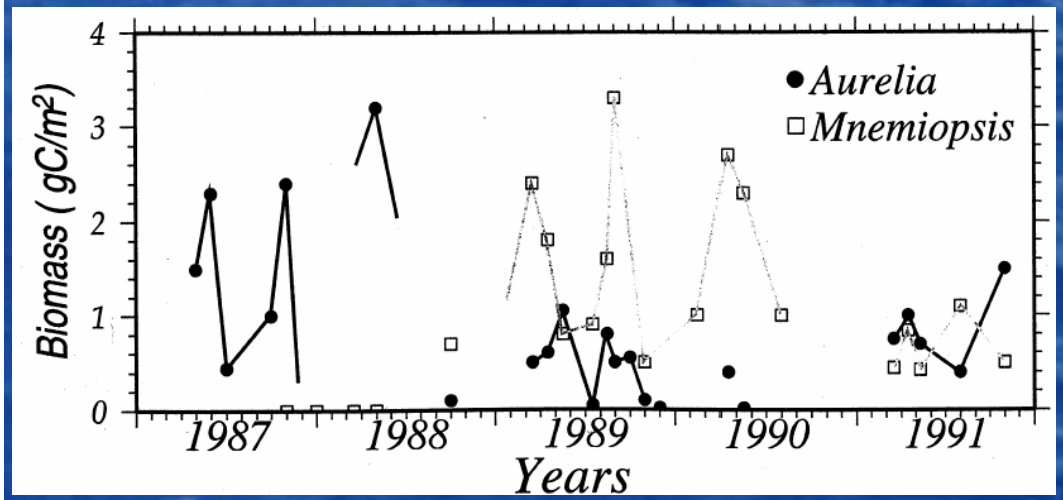
Extremely important in the coastal domain.

e.g.

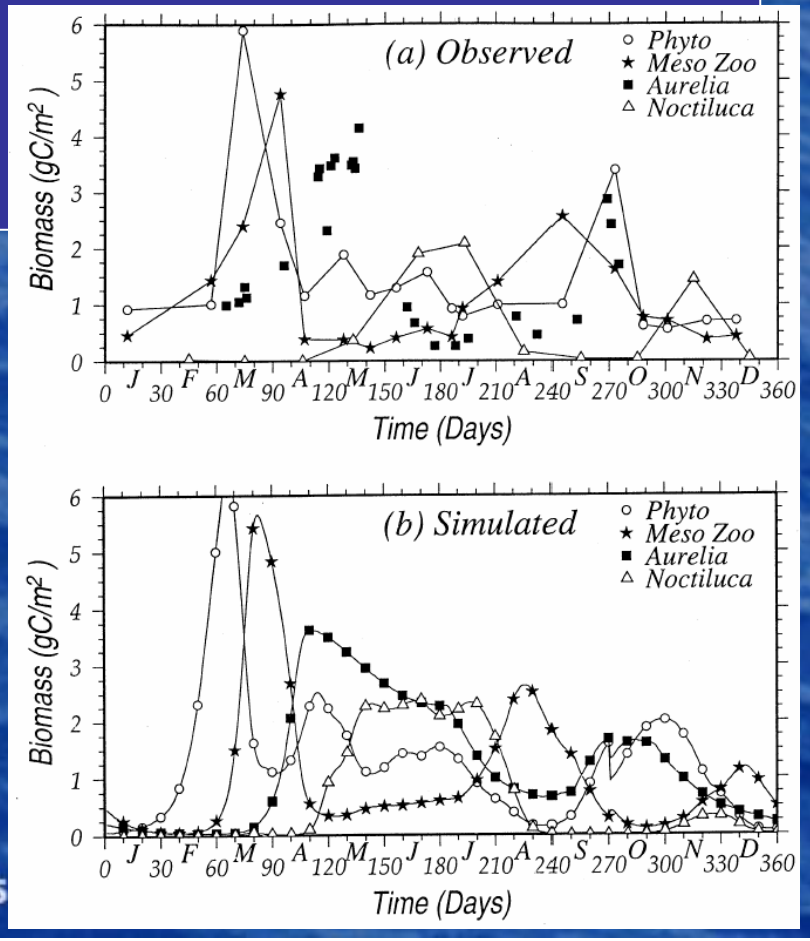
Benthic phosphate and silicate cycling in the north western Black Sea estimated to be respectively 50 and 35% of the Danube river load (Friedrich et al. 2002)

Ecosystem functioning: Gelatinous zooplankton

- Gelatinous zooplankton blooms (*Aurelia Aurita and Mnemiopsis leidy*) heavily affected the Black Sea in the past two decades.
- Strong reshaping of the trophic web structure.
- Modelling efforts already undertaken
- Episodic jelly fish bloms in the Mediterranean.



Oguz et al. 2001



Ecosystem functioning: Anoxia (relevant to Environmental management)

Black Sea: One of the largest stably anoxic basins in the world.
Mediterranean: Well ventilated. Episodic anoxic phenomena in coastal waters related to eutrophication processes.

•Modelling anoxia and the transition from oxic to anoxic conditions requires explicit consideration of anaerobic bacteria and sulfides.

•Episodic onset of anoxia in coastal waters and processes of limited ventilation of the Black Sea calls once more for a detailed representation of the physical biogeochemical coupling

Ecosystem functioning: Harmful Algal Blooms (relevant to environmental management)

•HAB's occur naturally but anthropogenic forcing is recognised as a possible factor

•Strong impact on the environmental sustainability of coastal areas.

•HAB's modelling implies the inclusion of a specific functional group with:

Allelopathic characteristics
Reduced grazing pressure from phytoplankton feeders

Structure: A nested physical model hierarchy

The need for:

- The explicit simulation of the large scale open sea physical dynamics,
- The accurate representation of the coastal dynamics at the relevant spatial and temporal scales,

Calls for:

- The implementation of a modelling system constituted by a hierarchy of numerical models having different spatial resolution (from coarse to fine resolution).
- The use of “nesting” techniques to provide connection between models and to downscale the information from the “coarse” to the “fine” resolution model.

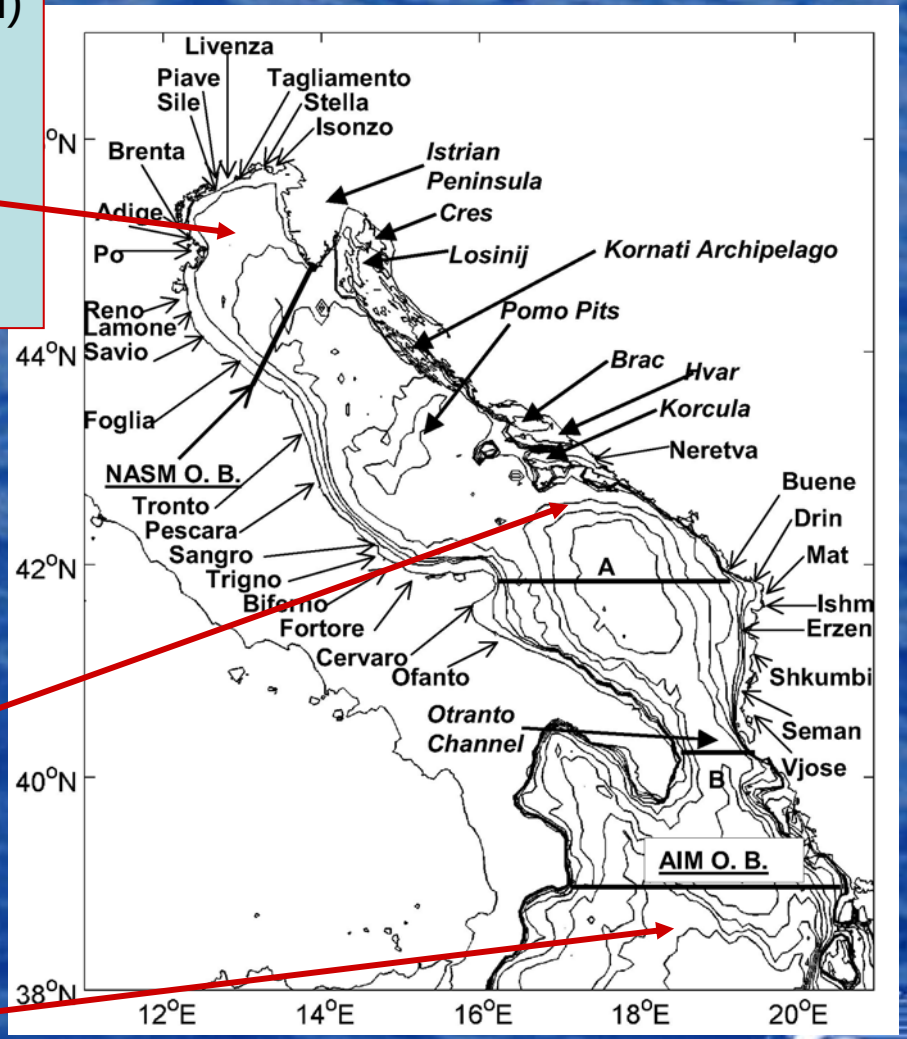
Nesting: A numerical technique aimed to simulate (with fine resolution) a limited area domain embedded in a larger (and coarsely resolved) model domain.

The Adriatic modelling system
Based on the Princeton Ocean Model (POM)
And the Modular Ocean Model (MOM)

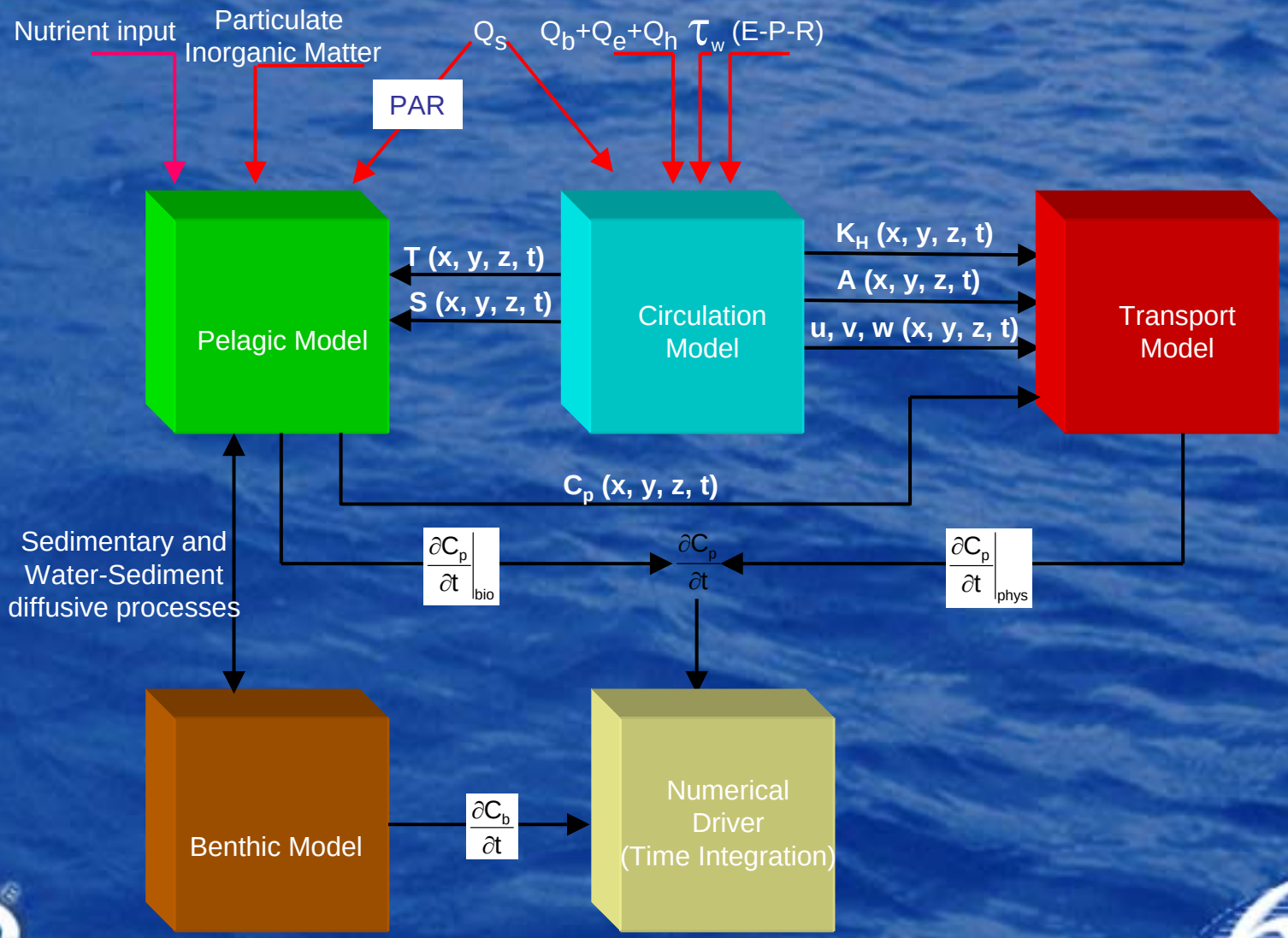
NASM (Northern Adriatic Shelf Model)
POM
Northern Adriatic only
1.5 km horizontal resolution
11 Sigma layers
Nested with AIM

AIM (Adriatic Intermediate Model)
POM
Whole Adriatic Sea.
5 km horizontal resolution,
21 sigma layers
Nested with the Mediterranean Sea General Circulation Model

Mediterranean Sea OGCM (MOM)
1/8° Horizontal resolution
31 levels



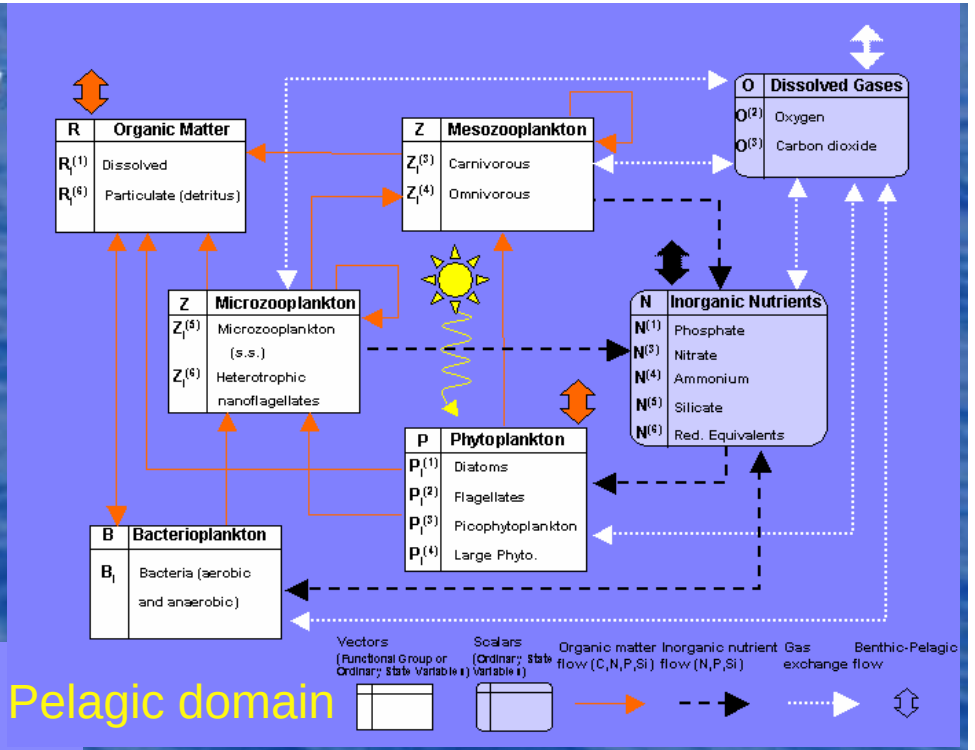
Structure: The Physical biological coupling (on- or off-line)



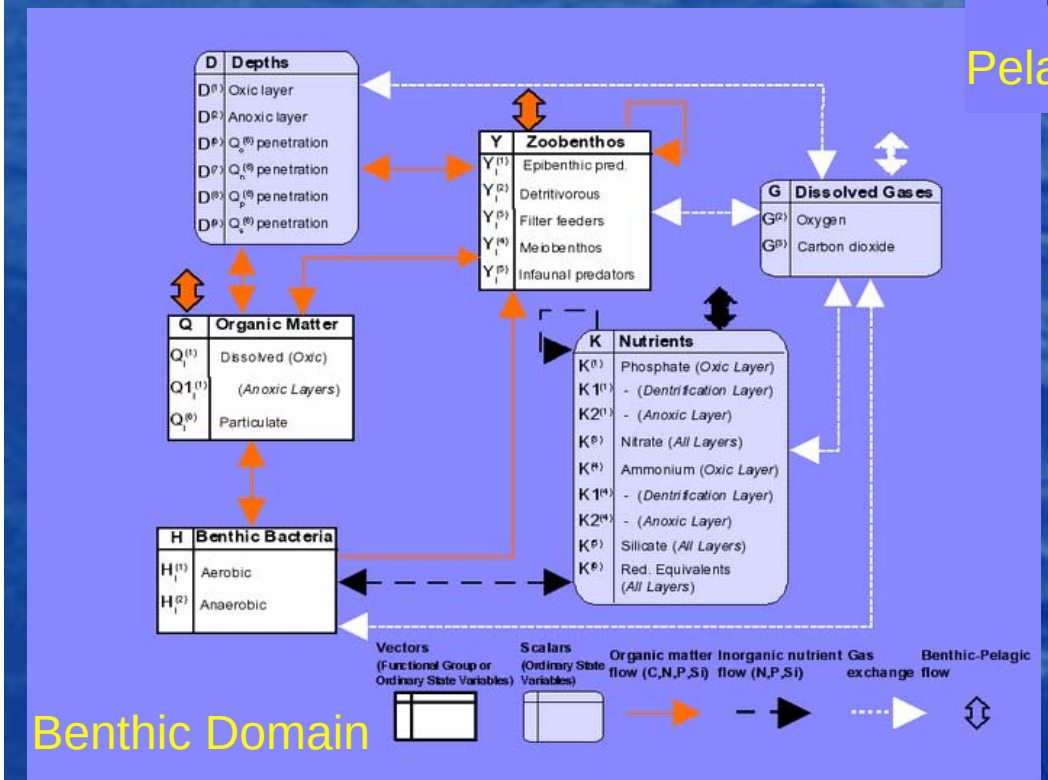
Structure: The ecological model

Ecological models currently in use to simulate the SES ecosystem dynamics are biomass based and use the functional group approach

Functional group dynamics is described by population and physiological Processes.



Pelagic domain



Benthic Domain

Biota is generally divided into three Main functional group types: Producers decomposers and Consumers.
Functional groups should account for the representation of two main trophic chains.
Full set of inorganic nutrients suited for Coastal and open sea domains as well as for modelling basins with Contrasting characteristics.

Technical Recommendations

- Coastal system coupled with the large scale (models hierarchy).
- Nesting between models complying with the volume and mass conservation constraints.
- Coupling in the off- or on-line mode. Off-line coupling requires careful evaluation of the update frequency of the physical fields.
- Ecological model explicitly accounting for the variability of the trophic web structure.
- Ecological model should be multi –nutrient.
- Modelling anoxia and HAB's important for environmental management issues.