

Northern Adriatic sea (Italy, Slovenia, Croatia)

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Introduction

The Northern Adriatic sea is located between Italy and former Yugoslavia countries. The modeled area (see figure below) spans from the gulf of Trieste (lat. 45° 38' 10", long. 13° 48' 15", Italy) in the north to the imaginary line joining the Italian city of Ancona (lat. 43° 35' 56", long. 13° 30' 39") to Pago island (44° 26' 42", long. 15° 3' 27", Croatia).

The model surface is 32000 km² and the mean depth is 29 m. This shallow basin is characterized by strong primary production and eutrophication problems caused by the anthropogenic nutrient input loads due to the Po river, which has a very high and quite variable inflow (mean basin residence time is about 18 months).

Modeled Ecosim period spans from 1992 to 2004. Calibration time series are fish biomasses (acoustic survey-derived) and CPUEs, and the model is driven forcing effort. The Ecosim automatic calibration routine to calculate primary production anomalies in order to fit data was also used, and we compared the results to PP data based on satellite measurements. We are also thinking about using temperature as a forcing factor for small pelagics.

3. Objectives

The main goals in constructing a Northern Adriatic sea model are

1. analyzing the optimal siting and sizing of MPAs in the area (to date, only a small MPA exists and the area appears to be quite exploited)
2. testing the hypothesis that Croatian rocky coasts function as a *refugium* for many exploited fish species
3. testing the hypothesis that some small rocky spots in front of Venice (called *tegnue*) can protect demersal species from the heavy fishing that is going on in the sand and

mud bottoms all around. The biggest of these spots (the only one big enough to be represented in the model) is also an MPA.

4. analyzing relationships between spatial distribution of species

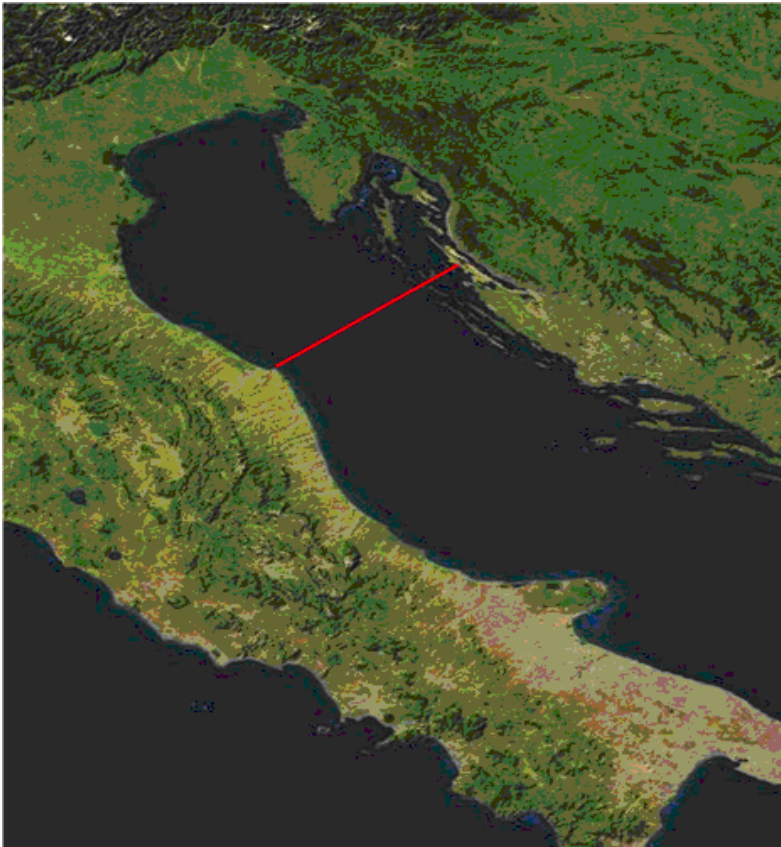


Fig.1. Modeled area (Northern Adriatic sea).

4. Groups

The model is made up of 26 groups:

- 2 detritus groups (detritus, discard)
- 2 primary producers groups (phytoplankton, macroalgae and phanerogams)
- 3 other planktonic groups (bacteria, zooplankton, jellyfish). Bacteria are included to account for microbial loop, which is known to be quite important in Adriatic.

- 8 invertebrate groups (all benthos except for cephalopods). Decapods seem to be quite an important group (in trophic sense).
- 10 fish groups.
- 1 seabird group

One group of dolphins is being added, as there are new data available.

The system appears to be a mix of bottom up control (phytoplankton) and wasp-waist control (small pelagics).

5. Fleets

There are 6 fleets. The first five are Italian fleets.

- Hydraulic dredge
- Mid water trawling
- Bottom trawling
- Beam trawling
- Other fisheries
- Croatian – Slovenian fleet (aggregation due to scarce availability of data)

6. Habitats

The five defined habitats, defined according to bottom type and depth, are reported. Relative model area fraction is reported too.

1. Rock	0.111
2. Sand	0.467
3. Mud > 20 m	0.293
4. Mud 0 - 20 m	0.127
5. Tegnue	0.002

We are considering to introduce a new habitat (Posidonia), as soon as we will get data about its spatial distribution (hopefully in a short time).

6. Map of habitats

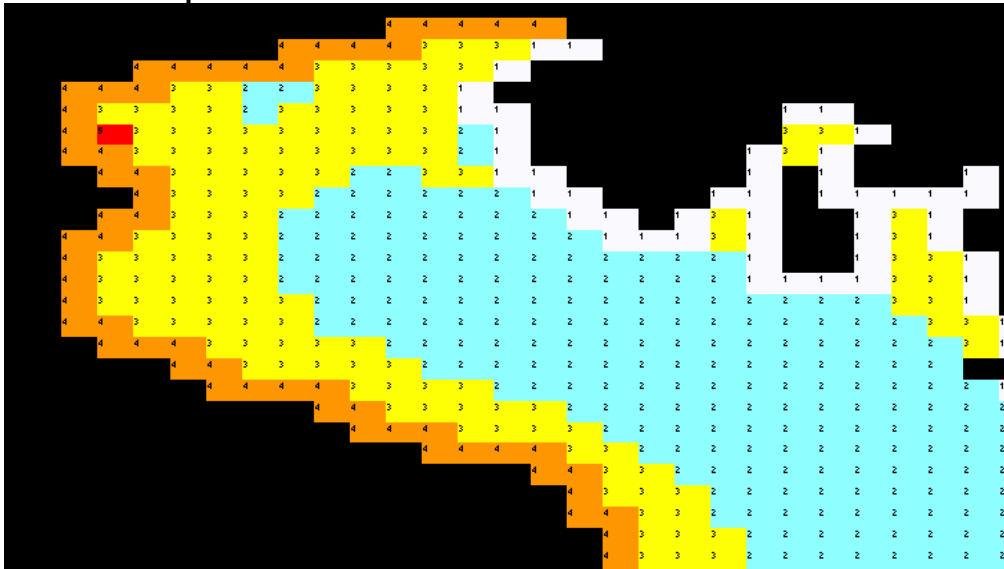


Fig. 2. Habitats. Red one is *Tegnet*

Tab. 1. Habitat preference.

Group \ Habitat #	All habitats	Rock	Sand	Mud > 20 m	Mud 0 - 20 m	Tegnet	Ecospace area
Sea-birds	+						1
Sharks			+	+	+	+	0.89
Rays		+	+	+		+	0.87
European hake			+	+			0.76
Zoobenthivorous fish 1	+						1
Zoobenthivorous fish 2	+						1
Pelagic piscivorous fish			+	+		+	0.76
Zooplanktivorous fish			+	+		+	0.76
Omnivorous fish		+			+	+	0.24
Benthic piscivorous fish	+						1
Flatfishes			+	+	+		0.89
Cephalopods	+						1
Crustacea 1	+						1
Crustacea 2	+						1
Gastropods	+						1
Bivalves	+						1
Filter feeding	+						1

10. Regions

Only one region is defined, in order to minimize SS (by biomass and CPUE fitting). By doing this we are trying to catch the overall time (Ecosim) trends in the modeled area (even if we do not use spatially distributed data).

We are also defining more regions in order to fit spatially data which we are obtaining from MEDITS trawl surveys. We are setting up as many regions as are the locations surveyed during MEDITS (the number varies as it depends on the species being analyzed).

11. Fleet allocation

Fleets have been allocated in three main ports for Croatian/Slovenian fleet, and in four main ports for Italian fleets, in order to calculate sailing costs as a function of distance from the ports. Italian fleets cannot fish in Croatian waters, and Croatian fleet cannot fish in Italian waters

Tab. 2. Allocation of fleets.

Fleet \ Habitat use:	Rock	Sand	Mud > 20 m	Mud 0 - 20 m	Tegnue-habitat	Tegnue MPA	Italian waters	Cro-Slo waters
SLO-CRO fleet	+	+	+	+				+
Hydraulic dredge		+	+	+			+	
Other fisheries	+	+	+	+	+		+	
Beam trawling (rapido)		+	+	+			+	
Bottom trawling (coccia)		+	+	+			+	
Mid-water trawl (volante)	+	+	+	+	+		+	

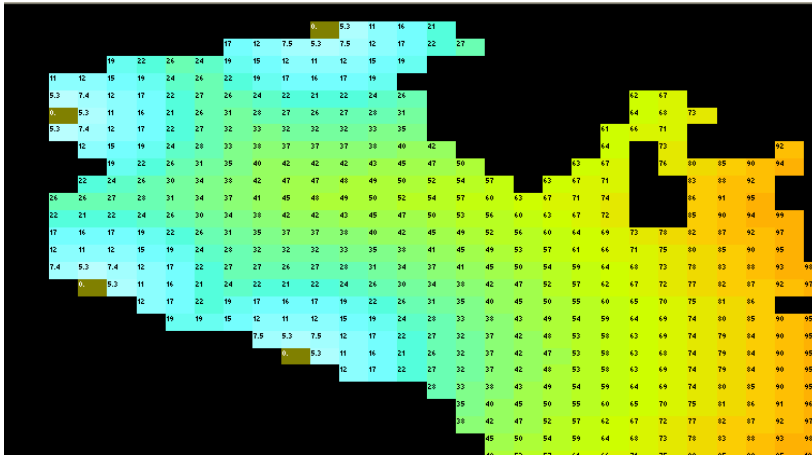


Fig. 4. Italian ports (brown).

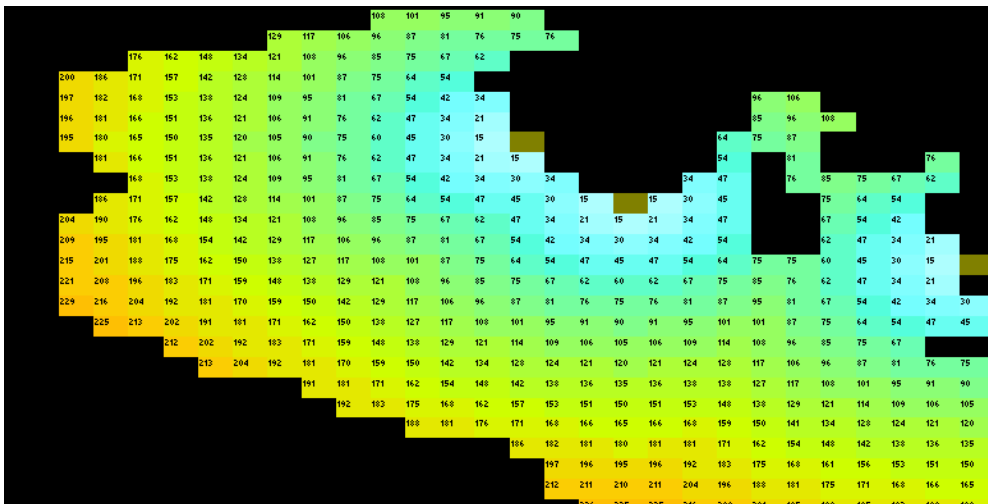


Fig. 5. Croatian ports (brown).

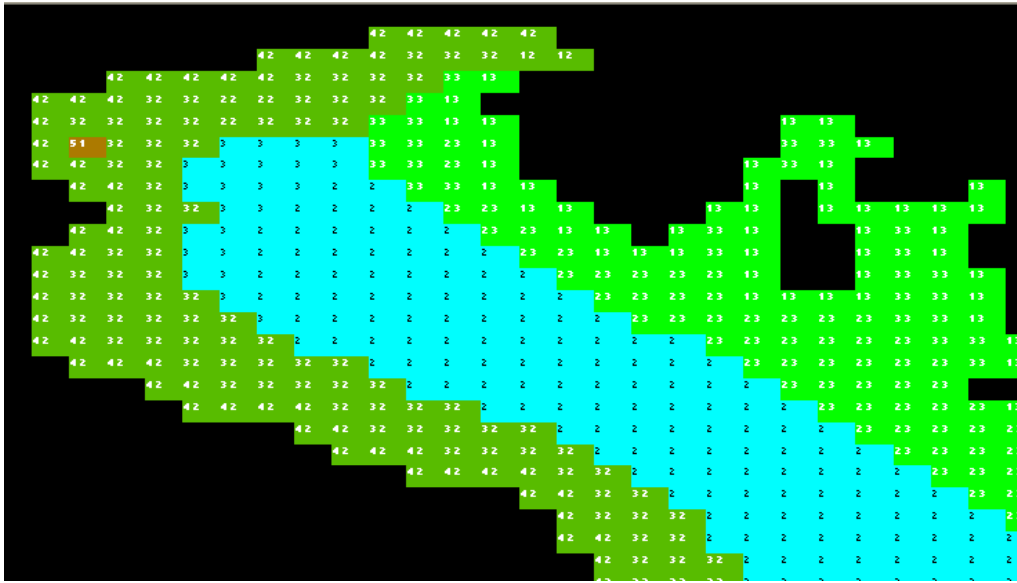


Fig. 6. Territorial waters (Italian on the left, Croatian on the right).

12. Advection field, migration and other relevant information

As a first simple approach, a qualitative advection field has been hand-sketched from various models that can be found in literature (e.g. Oddo et al, 2005, A numerical study of the interannual variability of the Adriatic Sea (2000-2002), *Sci. Total Environ.*).

Given the importance of river inflow and currents in driving transport of nutrients controlling phytoplankton growth, which in cascade shape the entire ecosystem, which appears to be bottom up controlled), this field is being refined by using POM model forced with climatological input data, in order to obtain an average advection field of the simulated time-span. It was not possible to obtain from POM an advection field which is time-varying across the whole simulated period (1992-2004), and this is surely a weak point in our model, as the current field in Northern Adriatic can be really different from the average one.

No migration was implemented in Ecospace.

As it is not possible yet to import from Ecosim to Ecospace time-varying primary production forcing, we simulated PP dynamics creating a fake group having a mediation effect on phytoplankton. This fake group is fished by a fake fleet (Ecospace can import effort) and so phytoplankton is driven this way in the spatial model. Primary production spatial distribution was taken from SeaWiifs database by using the automatic Ecospace routine.

There are four advected groups (phytoplankton, zooplankton, bacteria and jellyfish).

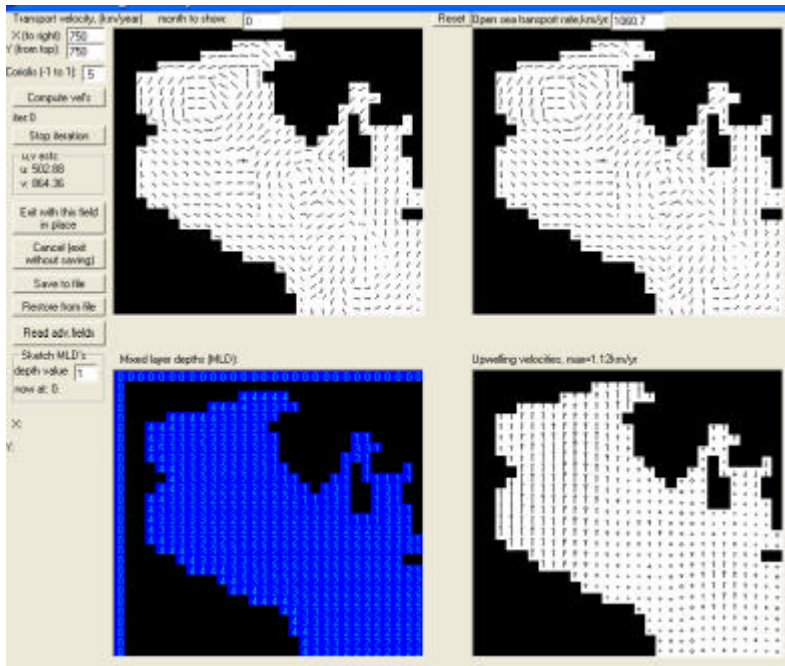


Fig. 7. Advection field (sketched).

13. Outputs

We are expecting to achieve much more precise results as soon as we calibrate the model on spatially distributed data taken from MEDITS trawl surveys (ongoing). At this point we have taken dispersal rates from literature and tested model sensibility to them. Also, parameters like relative vulnerabilities, feeding rates and dispersal rates in bad habitat were varied to achieve results which qualitatively follow spatial distribution of groups that can be inferred from literature (e.g. polychaete biomass higher near Po river delta; hake biomass higher in the east part of the area) or which appears to be reasonable (no sharp gradients of biomass on large spatial scales)

The choice of advecting or not advecting detritus can be quite important, because there are strong currents and the network energy fluxes are mainly based on detritus. We have chooses not to do it, because the bigger quantity of detritus can be found in the sediment and because advection leads to quite strangely patched benthos distribution).

The presence of the *tegnue* MPA seems not to change sensitively fish spatial patterns, except for omnivorous group. Instead, benthos biomass is higher in the *tegnue* MPA, but it is difficult to decouple the MPA influence from the river plume effects (the MPA is very close to the river delta).

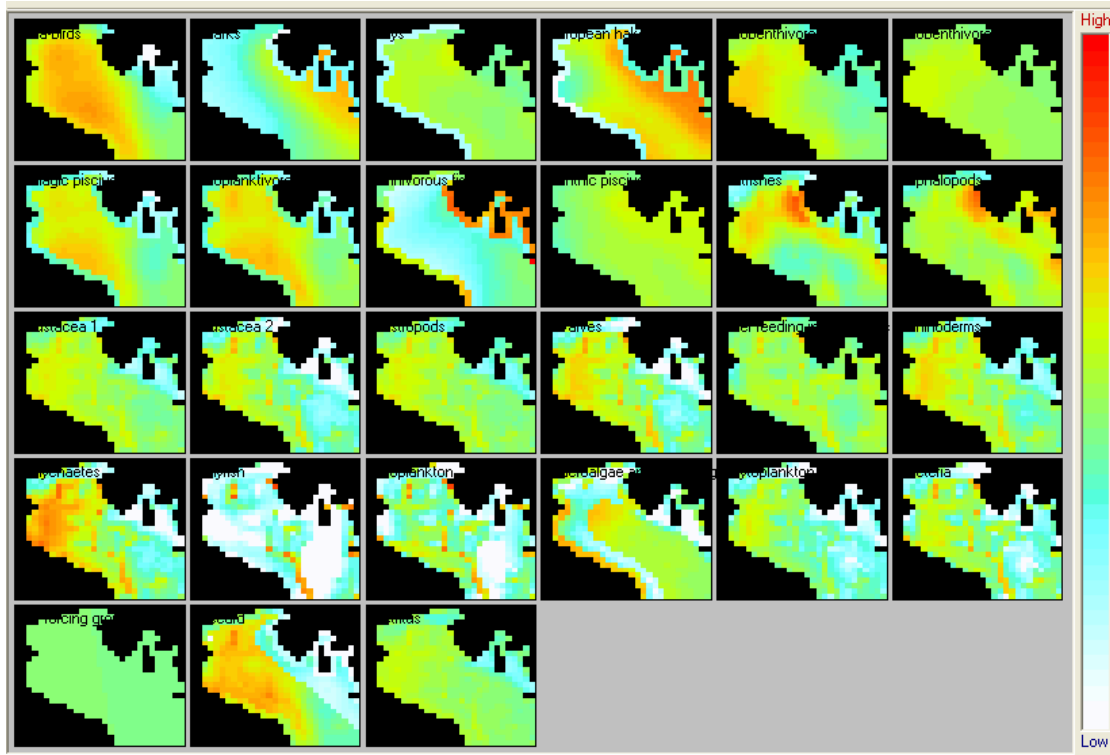


Fig. 8. Spatial distribution maps.

Anyway, the lack of effects on fish groups is surely not to be taken as a conclusion, since it is sensitive to dispersal rate values. A sensitively better result is going to be obtained by more precisely calibrating dispersal rate on MEDITS data. It is worth noticing that large-scale spatial patterns of distribution of many groups seem to be quite independent on the choice of dispersal rate and relative vulnerability and feeding rate in bad habitats, but this is not the case for smaller areas like *tegnue*, which are believed to be quite important also in sustaining biodiversity, even if on small scales. In fact, the high aggregation degree of the model (26 groups) probably overshadows the *refugium* effects this area has on some very rare species, which are integrated into a bigger box comprising more species. We are testing this hypothesis splitting some groups in more parts by using MEDITS data.

The rocky coasts of Croatia seem to be protecting some demersal groups (omnivorous fish, hake, benthic piscivorous, cephalopods), but the degree of protection is quite sensitive to dispersal rate too. Also, it is worth analyzing if higher biomasses there are due to lower Croatian fishing effort or to habitats and trophic conditions too. Decoupling the two effects is not very simple, but a combination of both factors seems to be the answer, as it can be seen by.

Distribution of benthos seems to be related with advection field and river plume, and this is in agreement with existing literature.

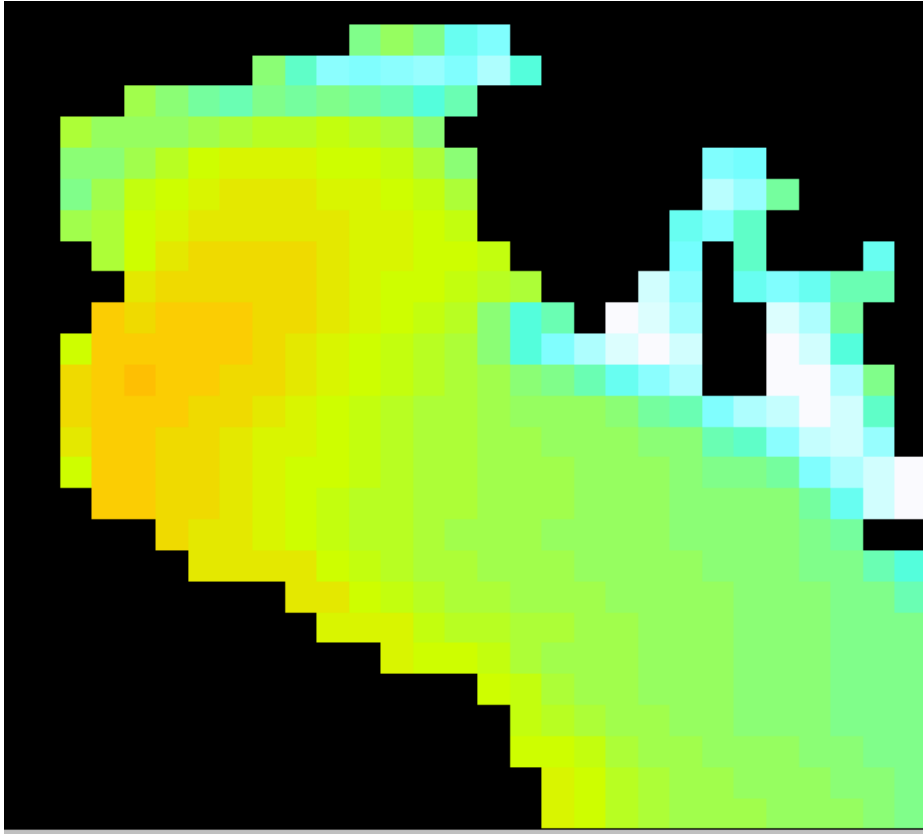


Fig. 9 Polychaete distribution seems to be related with Po river inflow.

14. Aspects of Ecospace to be improved

The main thing to be improved is surely the absence of forcing functions in Ecospace. In an heavily bottom up controlled ecosystem like this, it is very important to force primary production (which is very strongly time varying) to have realistic simulations. We have done it by using a fake mediating group and a fake fleet, but this way you can force phytoplankton biomass (not primary production) and anyway it is really difficult, rough and time consuming to reproduce available production time series or external forcing effects (like temperature or river inflows). It could be good also to make time-varying the spatial distribution of primary production. Also, spatial fitting interface by region should be improved and made more user-friendly.