Linking water column perturbations to soft-bottom biological element descriptors: the response of macroinvertebrates

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Coastal lagoon ecosystems

Mediterranean lagoons, including harbors, are transitional/coastal “paralic” ecosystems exposed to natural and anthropogenic disturbances. In particular environmental conditions, hypoxia is a frequent phenomena causes dystrophic events affecting both abiotic and biotic ecosystems components.

These events determine disequilibrium conditions along temporal and spatial scales, which affect ecosystem functions, life cycle and community structure of biotic components.

Resistance and resilience are ecosystem properties and important ecological tools to analyses the response of ecosystems to dystrophic events.

Resistance & Resilience

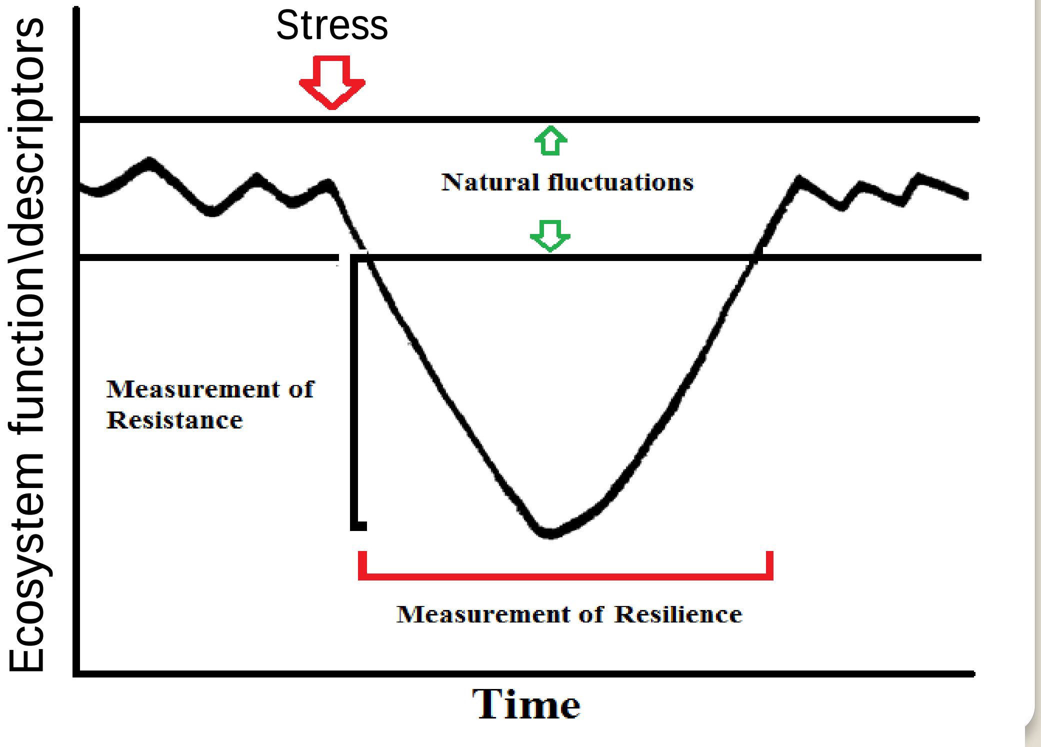
Disturbances (pulse, press and ramp) constitute a major driving force influencing the structure and functions of populations, communities and ecosystems. The capacity to weather a disturbance without losses and/or modifications is defined as resistance, whereas resilience is the capacity to recover from a disturbance after incurring losses or changes, which may be considerable.

Resilience

..is an ecosystem property;

..measures ecosystem stability;

..is measured as a process rate • recovery rate



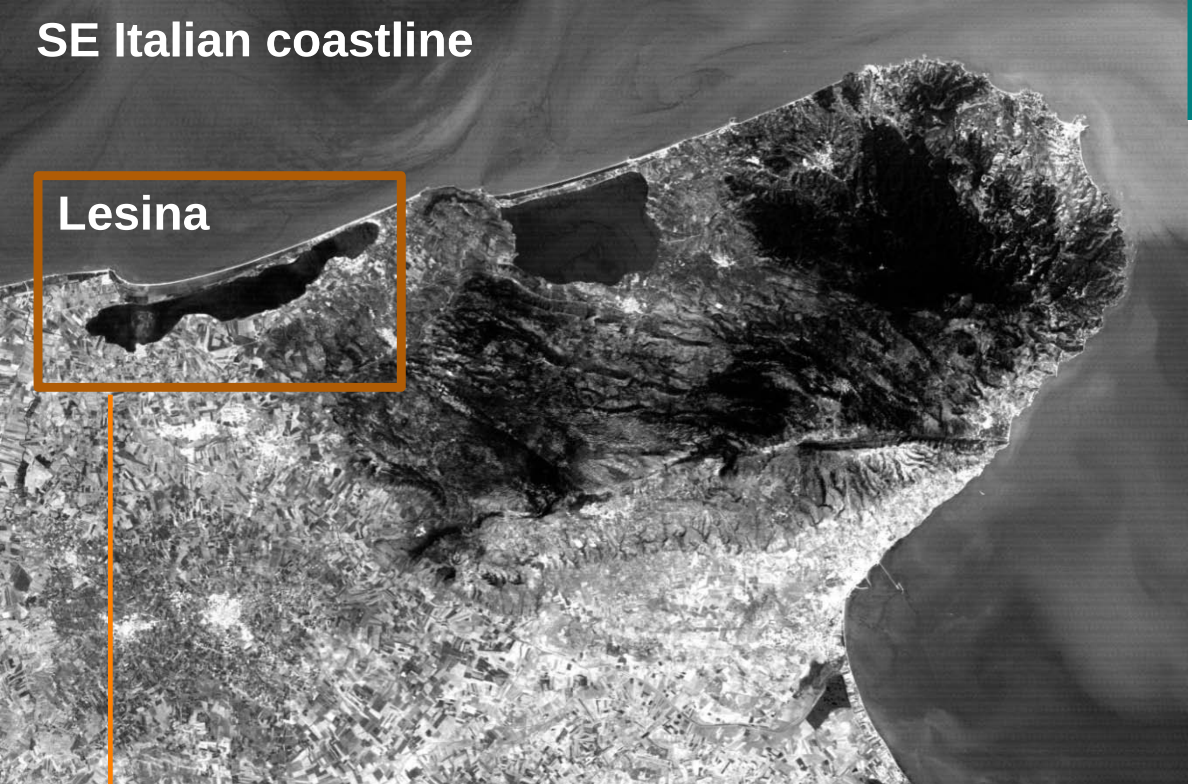
Aim of this study

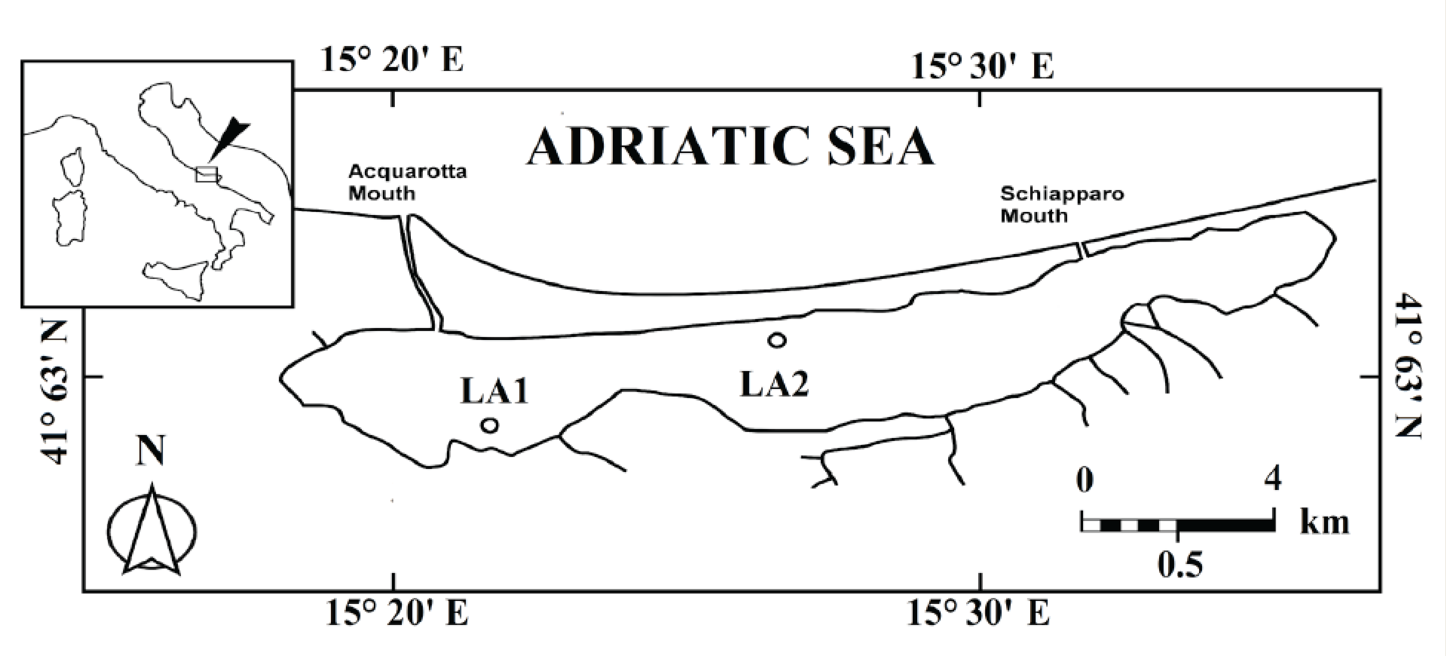
The aim of the study was to analyze the pathways of ecosystem responses to dystrophic stress, searching for the characteristic scales for each ecosystem compartment to resistance and resilience properties, in a coastal lagoon (Lesina, Italy).

A field study of the temporal dynamics of abiotic and biotic ecosystem descriptors was performed to analyze perturbed/unperturbed conditions of ecosystem descriptors respect to a dystrophic event.

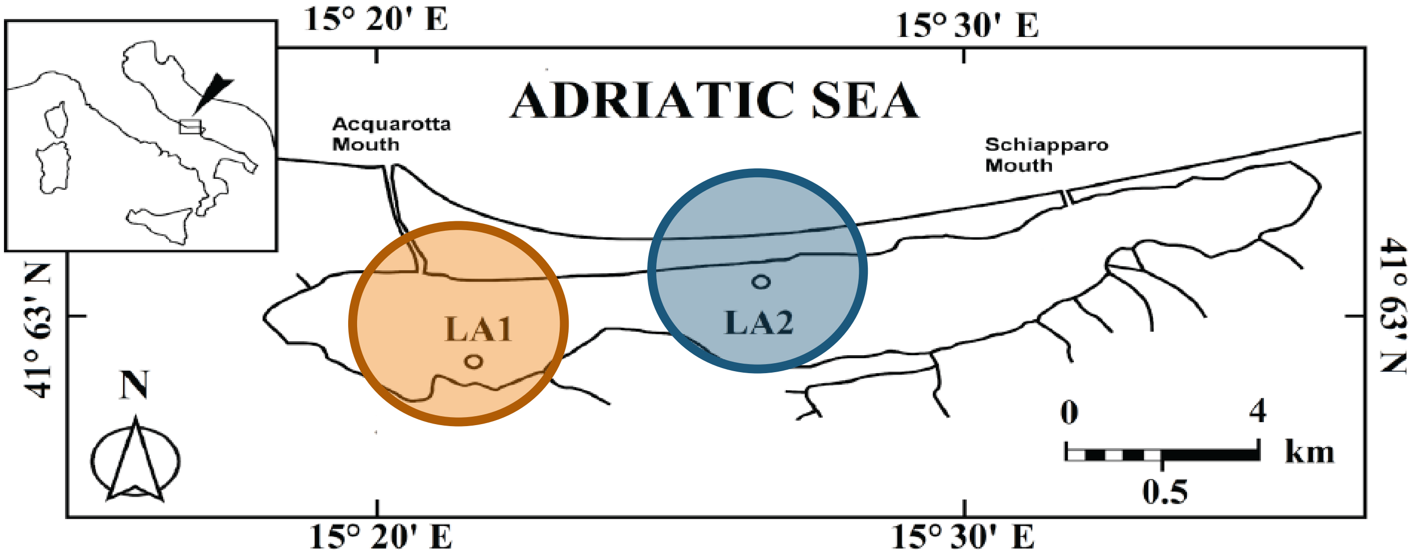
Study area

In summer 2008, a severe and geographically localized dystrophic crisis affected the 8% of the total Lesina lagoon surface.

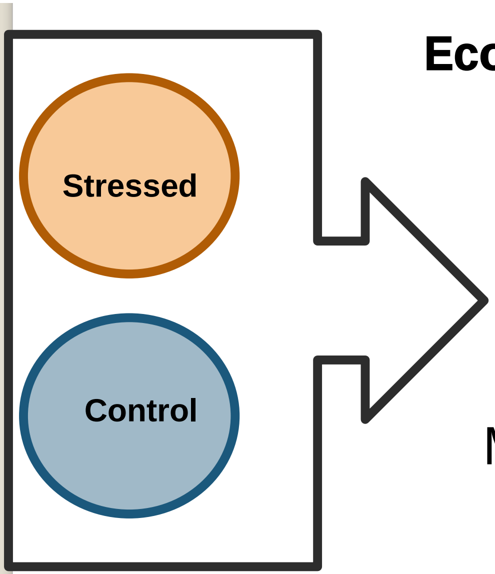




Materials & Methods



Samplings were performed weekly/monthly before and in the five months after the dystrophic event



Ecosystem components

Water
Sediment

Abiotic

Phytoplankton
Macrozoobenthos

Biotic

Component descriptors

Water
S, T, Cond., O_2, pH, Eh, TP, TN, NH_4^+, NO_2^-, NO_3^-, SRP, tot. Chl-*a*

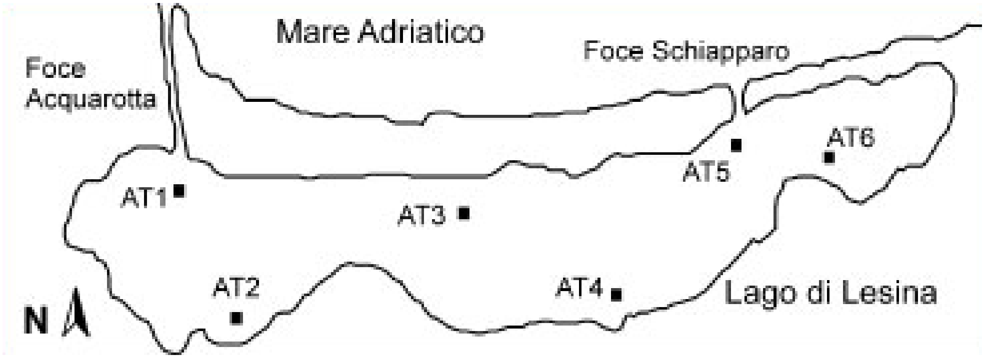
Sediment
Eh, pH, TOC, TN, TP, Fe

Phytoplankton
Av. Cell. density, Cell.size, micro-, nano-, pico- Chl-*a*, richness

Macrozoobenthos
Density, Tax. Richness, Shannon Index, Distinctness, Biomass

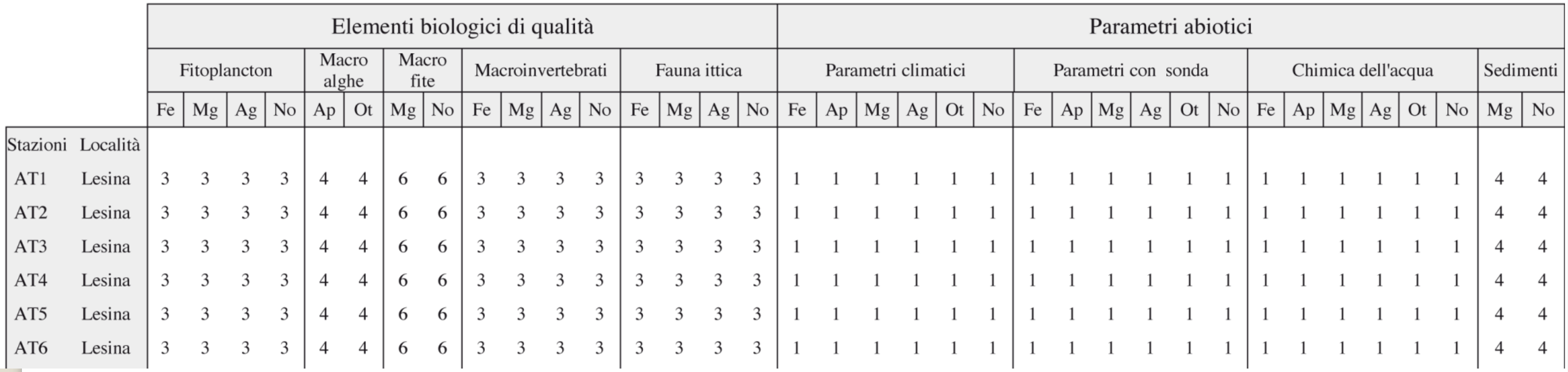
Sampling dates

Since 2006, Lesina lagoon was monitored, in the framework of the Apulia Region Monitoring Program of aquatic ecosystem health. Samplings were performed every 1 or 2 months, depending on the considered parameter (see table), in six stations situated along the major axis of lagoon.



AT2 = **LA1**

AT3 = **LA2**

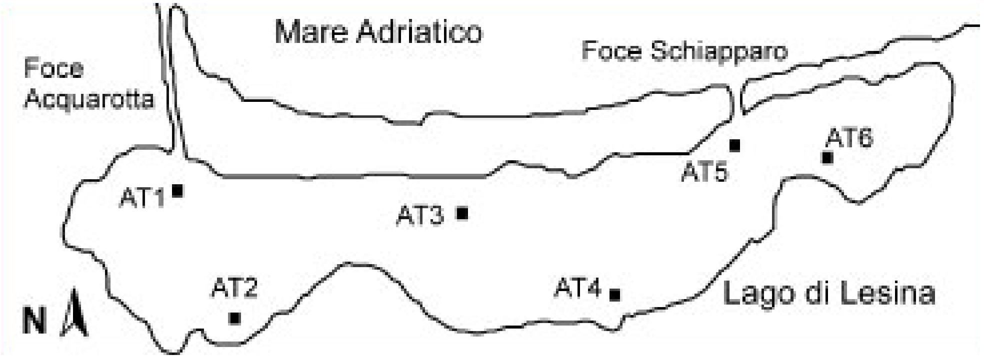


		Elementi biologici di qualità																Parametri abiotici																			
		Fitoplancton				Macro alghe		Macro fite		Macroinvertebrati				Fauna ittica				Parametri climatici						Parametri con sonda						Chimica dell'acqua						Sedimenti	
		Fe	Mg	Ag	No	Ap	Ot	Mg	No	Fe	Mg	Ag	No	Fe	Mg	Ag	No	Fe	Ap	Mg	Ag	Ot	No	Fe	Ap	Mg	Ag	Ot	No	Fe	Ap	Mg	Ag	Ot	No	Mg	No
Stazioni	Località																																				
AT1	Lesina	3	3	3	3	4	4	6	6	3	3	3	3	3	3	3	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	4
AT2	Lesina	3	3	3	3	4	4	6	6	3	3	3	3	3	3	3	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	4
AT3	Lesina	3	3	3	3	4	4	6	6	3	3	3	3	3	3	3	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	4
AT4	Lesina	3	3	3	3	4	4	6	6	3	3	3	3	3	3	3	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	4
AT5	Lesina	3	3	3	3	4	4	6	6	3	3	3	3	3	3	3	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	4
AT6	Lesina	3	3	3	3	4	4	6	6	3	3	3	3	3	3	3	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	4

Fe:February; Ap:April; Mg:May; Ag: August; Ot:October; No:November

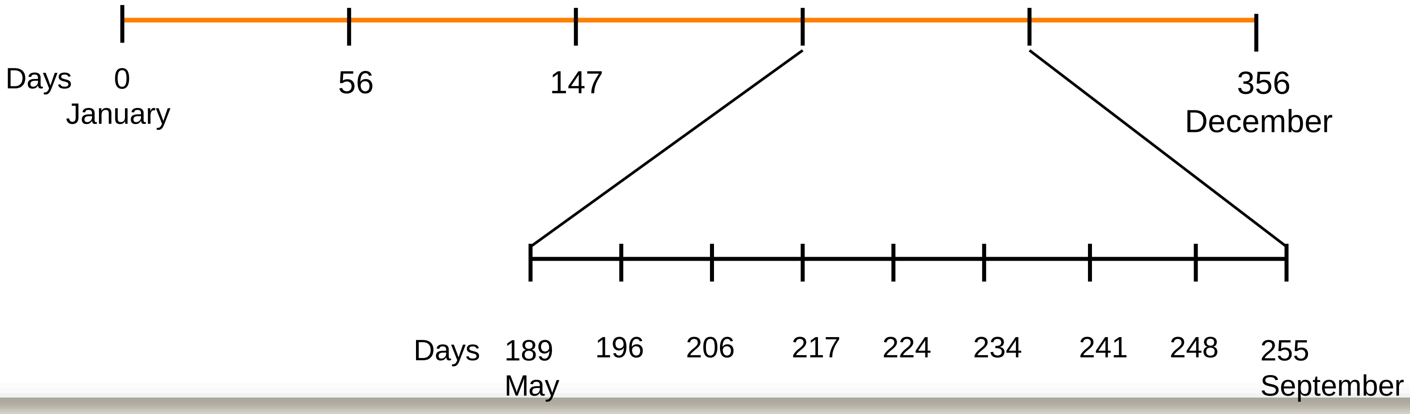
Sampling dates

In summer 2008, during these routine sampling an expected dystrophic crisis occurred in the Western part of lagoon, caused by favourable environmental conditions (high temperatures, low rains, absence of wind, temporary closing of mouth). The first early warning was provided by the reduction of phytoplankton cell size sampled in May. From that moment the temporal scale of sampling was modified to a weekly scale (from 9.00 am to 12.00 am) in two sampling site: AT2 and AT3 for a period ranging from the end of May to September.



AT2 = **LA1**

AT3 = **LA2**



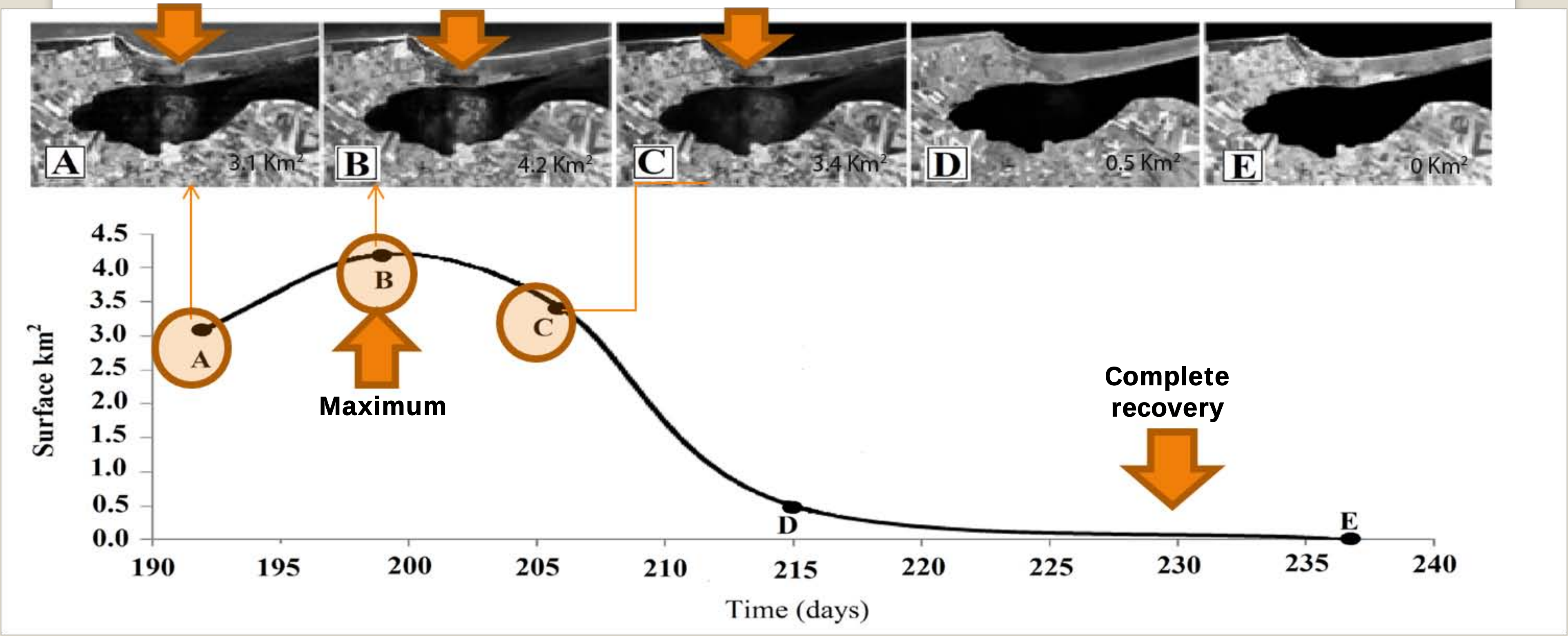
Results

Optical evidences of dystrophic crisis

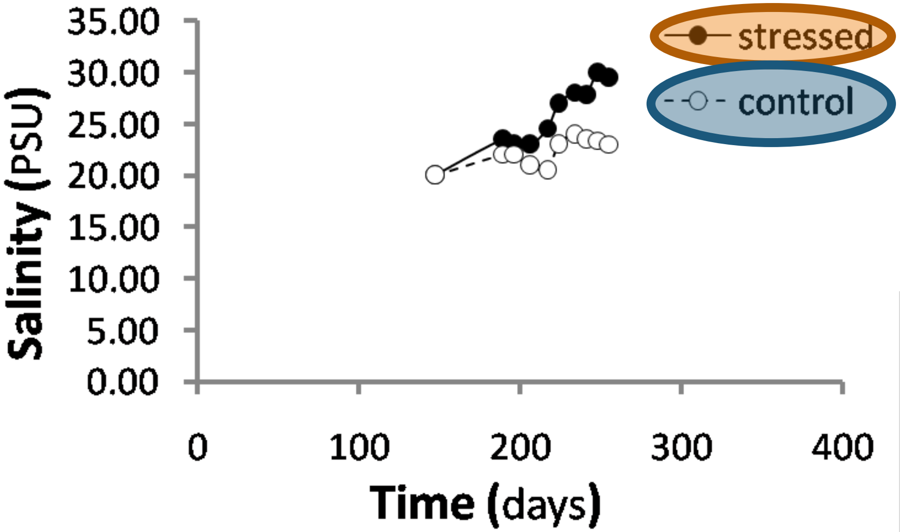
Increase of temperature, complete absence of wind and surface waters white colored were observed in LA1 compared to LA2.

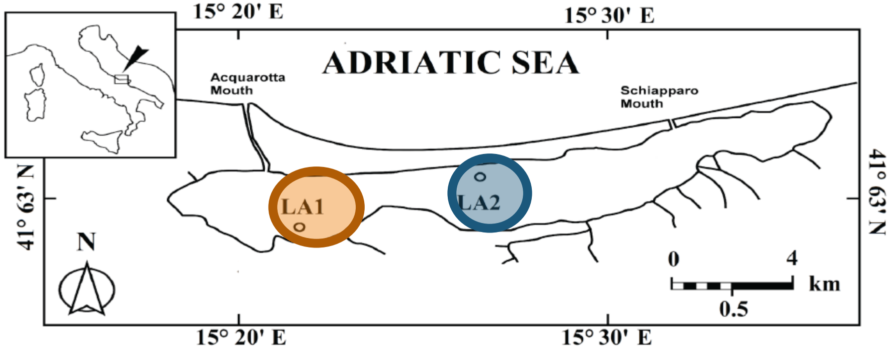
Photo by dott. Breber

The analysis of satellite images evidenced that the interested area reached the maximum surface extension in July (day 198) while disappeared completely in August (day 230).

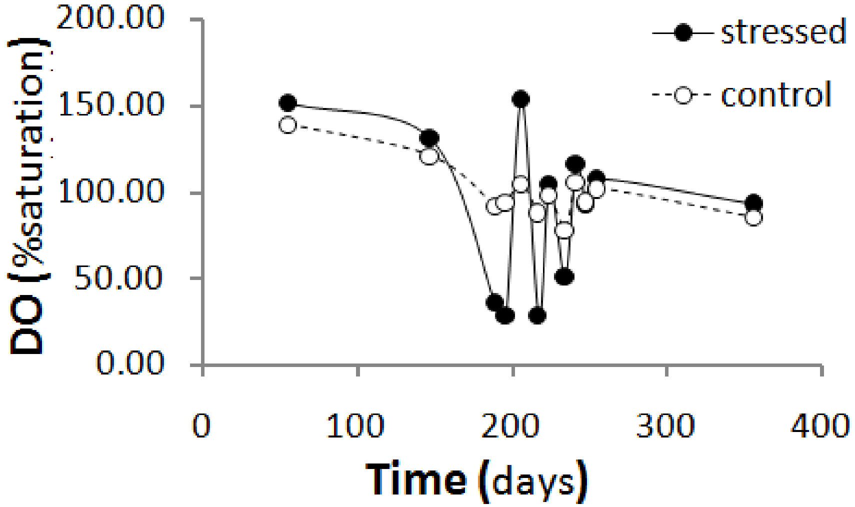


Results – Water descriptors

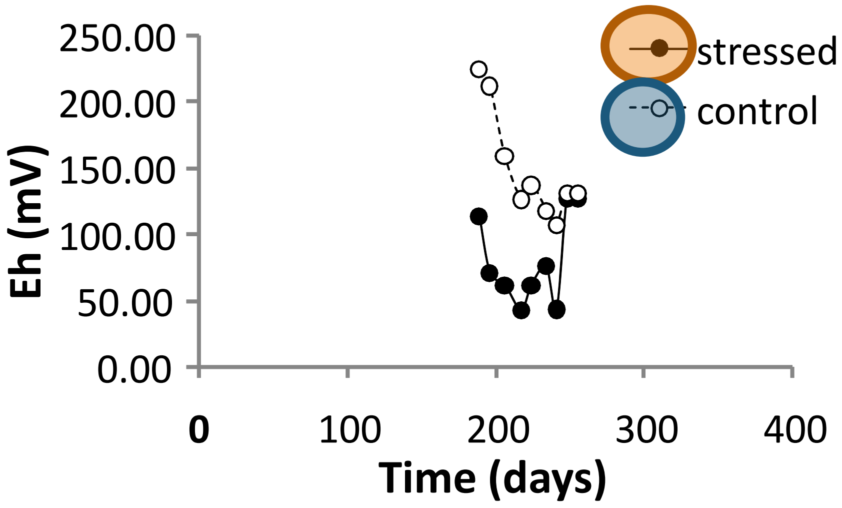


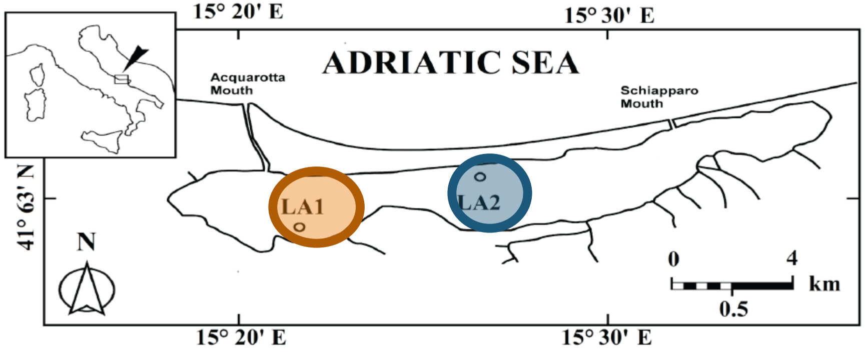


Temporary evolution of descriptors evidencing a significant difference in considered stations during the stressor event are here reported



Results – Sediment descriptors





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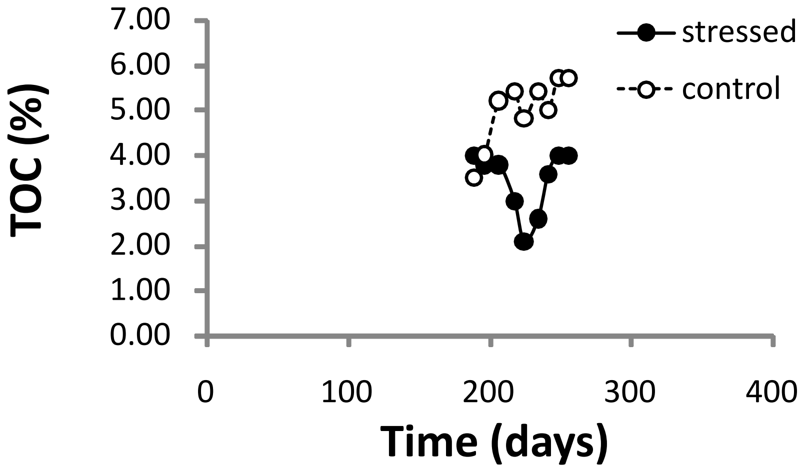
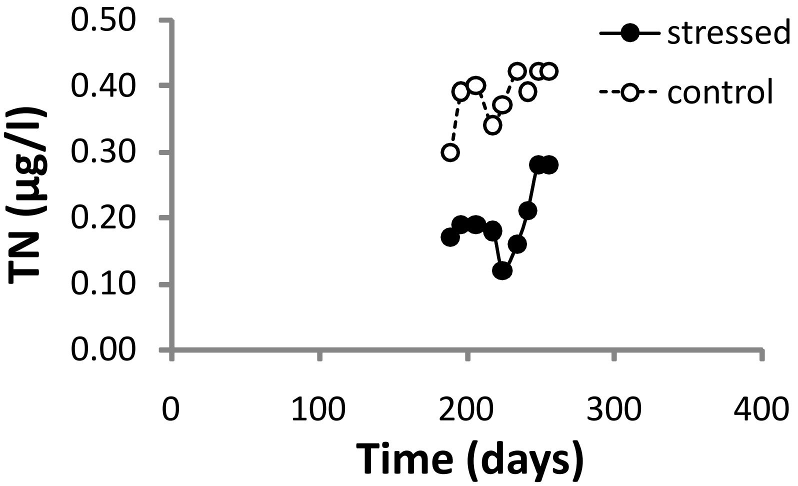
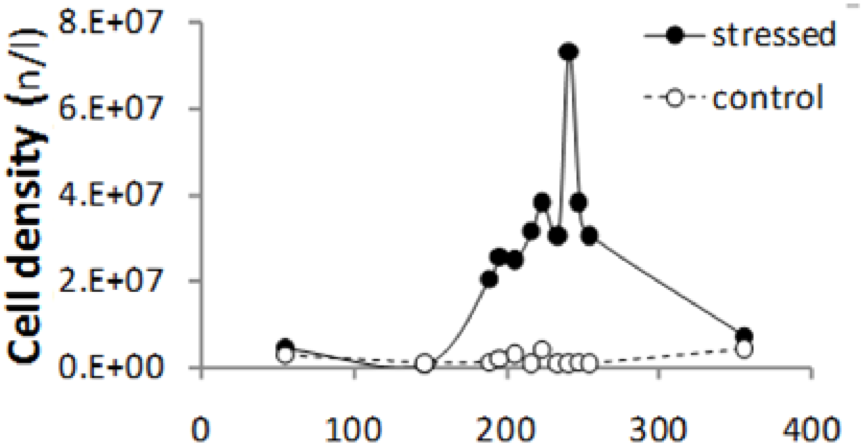
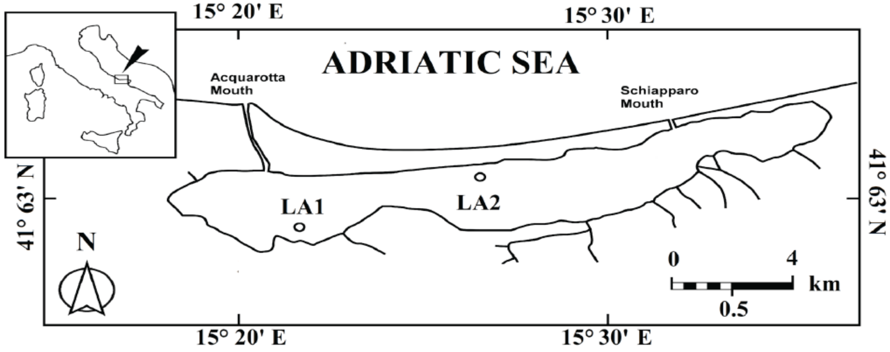




Results – Biota - Phytoplankton





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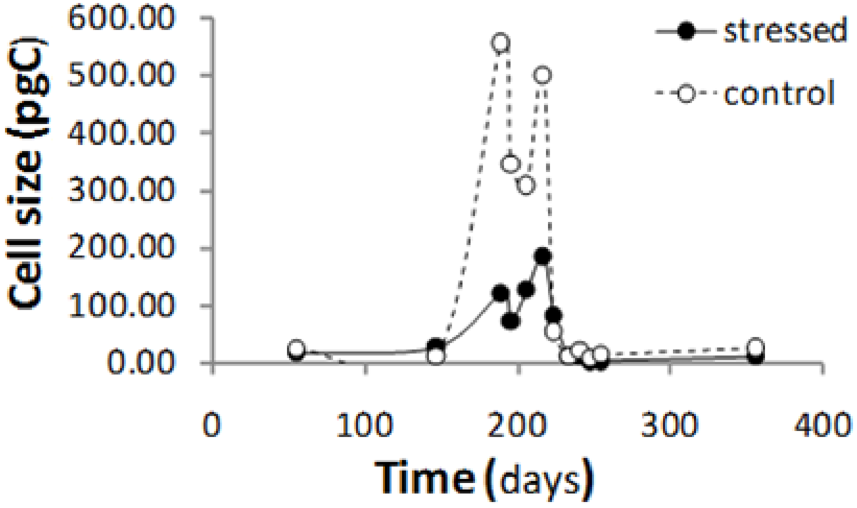
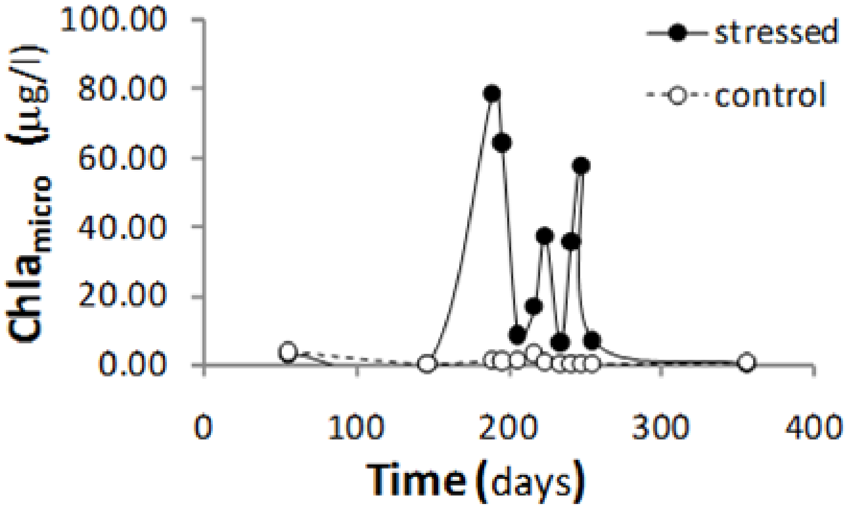
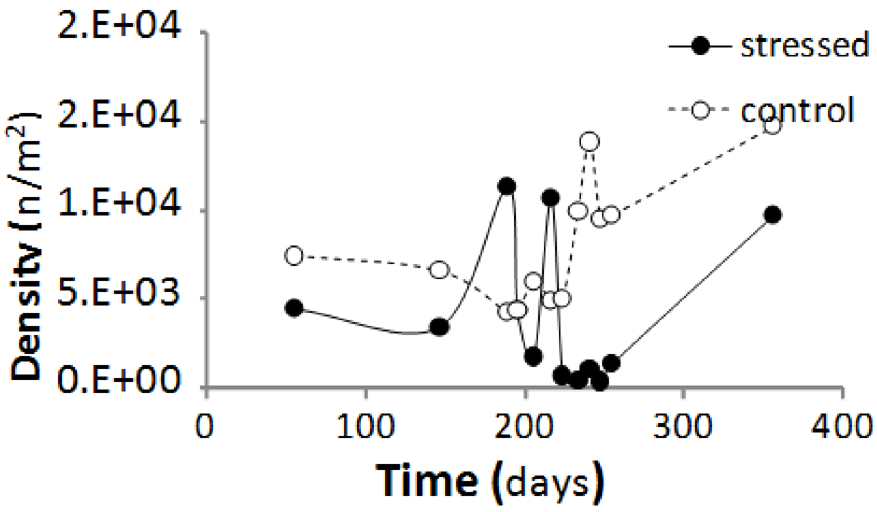
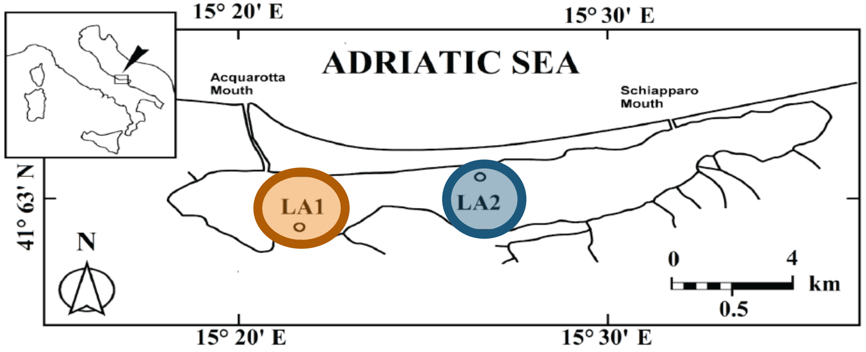




Results – Biota - Macrozoobenthos





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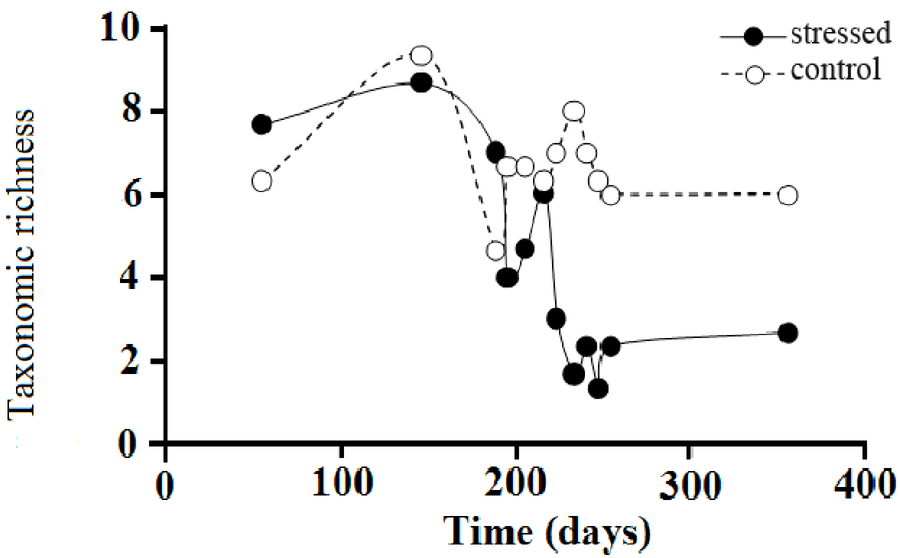
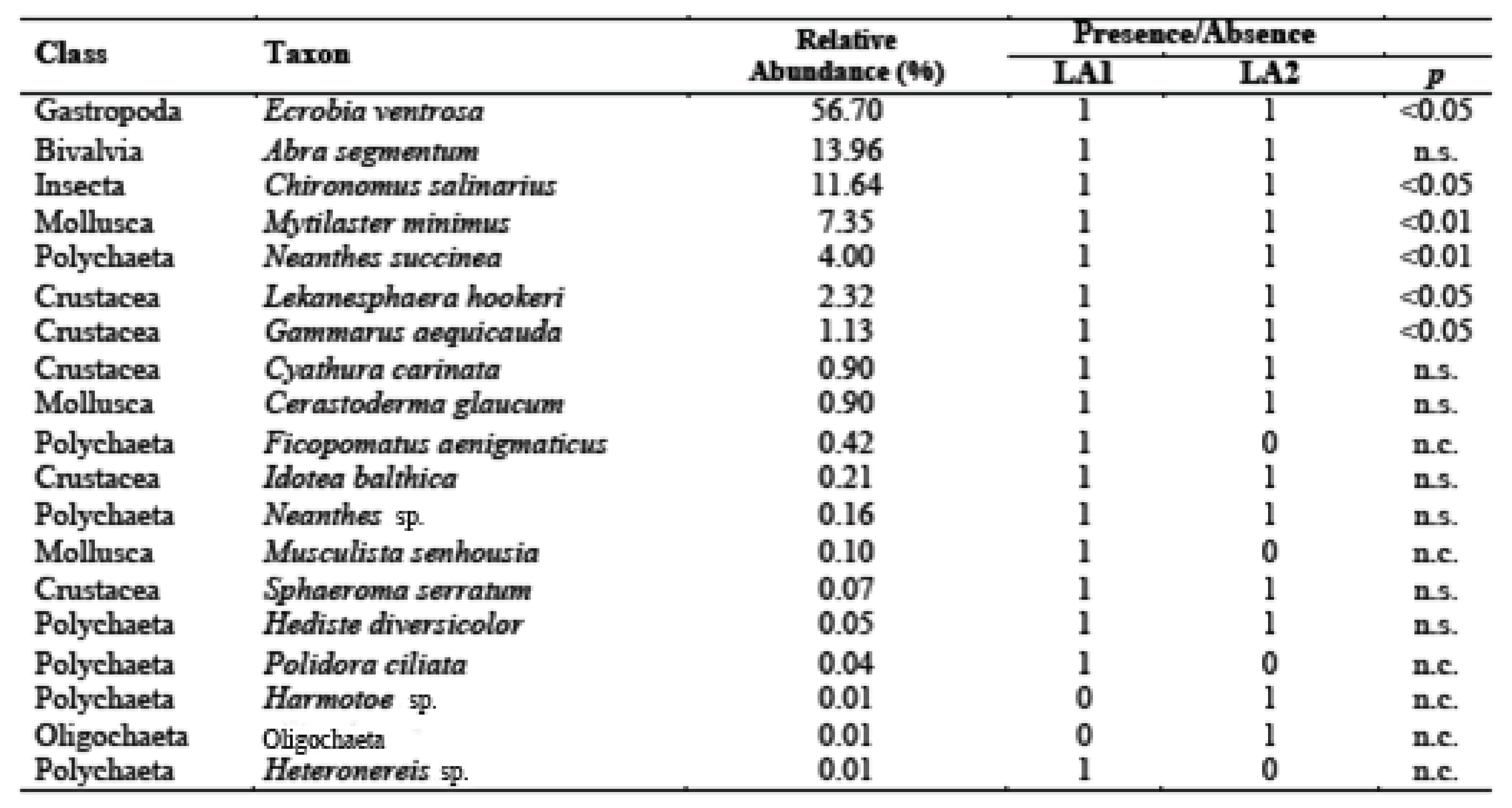


Results – Biota - Macrozoobenthos



Class	Taxon	Relative Abundance (%)	Presence/Absence		
			LA1	LA2	*p*
Gastropoda	*Ecrobia ventrosa*	56.70	1	1	<0.05
Bivalvia	*Abra segmentum*	13.96	1	1	n.s.
Insecta	*Chironomus salinarius*	11.64	1	1	<0.05
Mollusca	*Mytilaster minimus*	7.35	1	1	<0.01
Polychaeta	*Neanthes succinea*	4.00	1	1	<0.01
Crustacea	*Lekanesphaera hookeri*	2.32	1	1	<0.05
Crustacea	*Gammarus aequicauda*	1.13	1	1	<0.05
Crustacea	*Cyathura carinata*	0.90	1	1	n.s.
Mollusca	*Cerastoderma glaucum*	0.90	1	1	n.s.
Polychaeta	*Ficopomatus aenigmaticus*	0.42	1	0	n.c.
Crustacea	*Idotea balthica*	0.21	1	1	n.s.
Polychaeta	*Neanthes* sp.	0.16	1	1	n.s.
Mollusca	*Musculista senhousia*	0.10	1	0	n.c.
Crustacea	*Sphaeroma serratum*	0.07	1	1	n.s.
Polychaeta	*Hediste diversicolor*	0.05	1	1	n.s.
Polychaeta	*Polidora ciliata*	0.04	1	0	n.c.
Polychaeta	*Harmotoe* sp.	0.01	0	1	n.c.
Oligochaeta	Oligochaeta	0.01	0	1	n.c.
Polychaeta	*Heteronereis* sp.	0.01	1	0	n.c.

Relative abundance (%) of benthic macroinvertebrate taxa and significant differences between stressed and control stations are reported.

The presence of taxon in the stations LA1 and/or LA2 is reported as 1, the absence as 0. Significant difference between stations of taxon abundance is reported for $p<0.05$; not significant difference is reported as n.s.; n.c. indicates that the comparison was not made.

Scaling responses:
Resistance & Resilience patterns

… Significant differences of abiotic and biotic descriptors between LA1 and LA2…

All the descriptors considered are able to significantly discriminate stressed by non-stressed stations. Some among considered water, sediment and phytoplankton descriptors showed a fast response to the stress as well as a fast recovery time after the occurrence.
Most of the benthic descriptors considered identify the occurrence after long times from the beginning of critical period, highlighted higher resistance than other descriptors and a long time of recovery after the occurrence of the dystrophic event such as high resilience.

	Water					**Sediment**				**Phytoplankton**			**Benthic macroinvertebrates**				
Day	S	TP	Chl-***a***	O_2	NH_4^+	Eh	TOC	TN	Fe	Density	Cell size	Chl-*a* *micro*	Density	Taxon. richness	Shannon Index	Dist.	Biom.
56	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
147											$p<0.01$						
189			$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$		$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$				$p<0.01$	
196		$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$		$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$				$p<0.01$	
206		$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	n.s.			$p<0.01$	$p<0.01$	
217	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$			$p<0.01$	$p<0.01$	
224	$p<0.01$	$p<0.01$	$p<0.01$	↑	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$
234	$p<0.01$	↑	$p<0.01$		↑	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	↑	n.s.	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$
241	$p<0.01$		$p<0.01$			$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$		$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$
248	$p<0.01$		$p<0.01$			↑	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$		$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$
255	$p<0.01$		$p<0.01$				$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$		$p<0.01$	$p<0.01$	$p<0.01$	↑	$p<0.01$	$p<0.01$
356	↑		↑				↑	↑	↑	↑		↑	$p<0.01$	$p<0.01$		↑	$p<0.01$

Resistance ↓

Resilience ↑

Conclusions

- The characteristic time-scale of abiotic and biotic component time responses varied from days, for the selected markers of the water column, to year, for the benthic ones.
- Short-term biotic and abiotic responses in the water column were strongly coupled while biotic and abiotic responses at the sediment level were remarkably un-coupled.
- Dynamics and recovery time of water column and benthic components do not match in Lesina following the dystrophic crisis, highlighting an intrinsic individualistic behavior within the lagoon community driving ecosystem processes and ecosystem level responses.
- The emphasized differences in the stability components, i.e., resistance and resilience, of water column and sediment abiotic and biotic characteristics as well as of taxonomic and non-taxonomic descriptors has key implication in planning monitoring strategies and programs for transitional waters in the Mediterranean EcoRegion.

Perspectives

We are running on:

I. to test the resistance and resilience of taxonomic and not taxonomic ecological indicators (Ambi, M-Ambi, Bentix, Bits, ISS) to dystrophic crisis using the same comparative approach described in this study for the perturbed/unperturbed stations;

II. to perform a before/after analysis to compare the responses of abiotic and biotic descriptors used in this study and the ecological indicators, before and after the dystrophic crisis.

Thank you for attention

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