Responses of diatoms to river habitat alterations

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DBios

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Summary

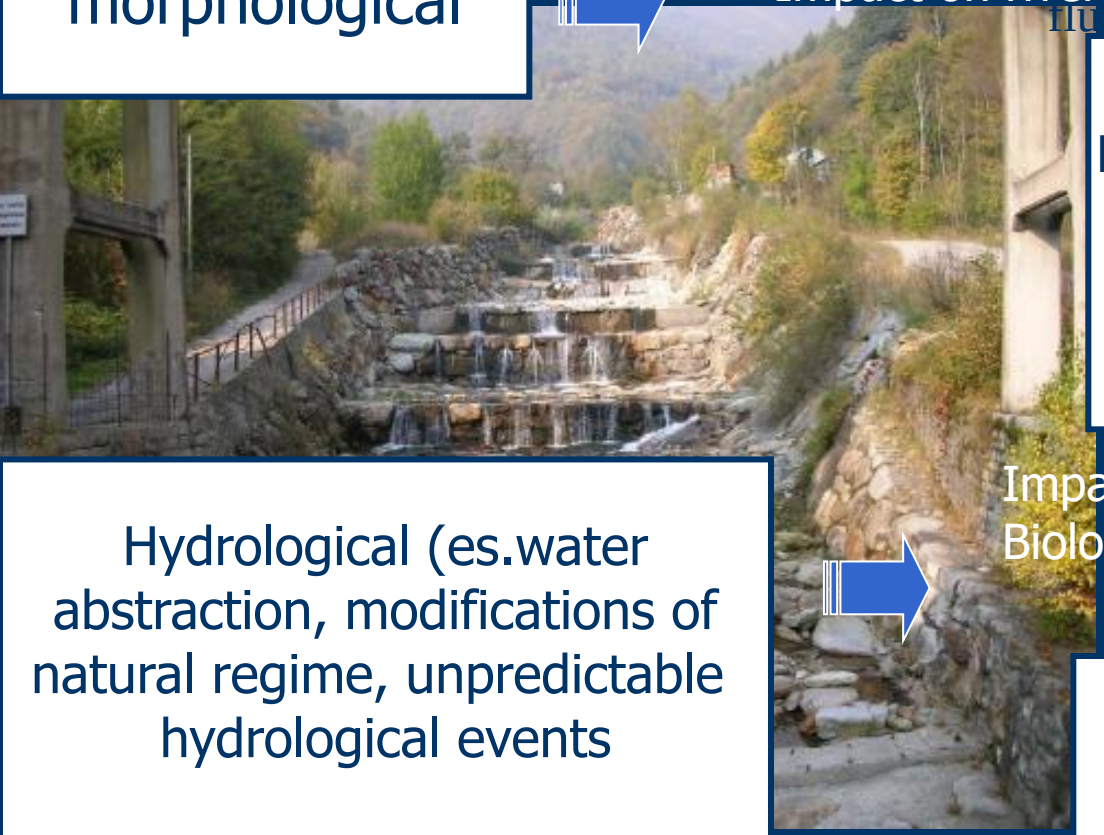
- Main physical alterations of rivers and streams
- Hydrological alterations; temporary Mediterranean rivers. A variety of hydrological and diatom metrics.
- Functional traits: life forms ecological guilds,biovolume. Preliminary applications to Arpa Liguria data set
- Hydromorphological alterations: QNNS, dredging, shear stress from ice melting, siltation from quarry activities
- Discussion and future perspectives…

Physical alterations of rivers and streams

morphological

Impact on river habitat

Decrease in bed stability and heterogeneity, reduced habitat availability, reduction in riparian organisms
Increased turbidity

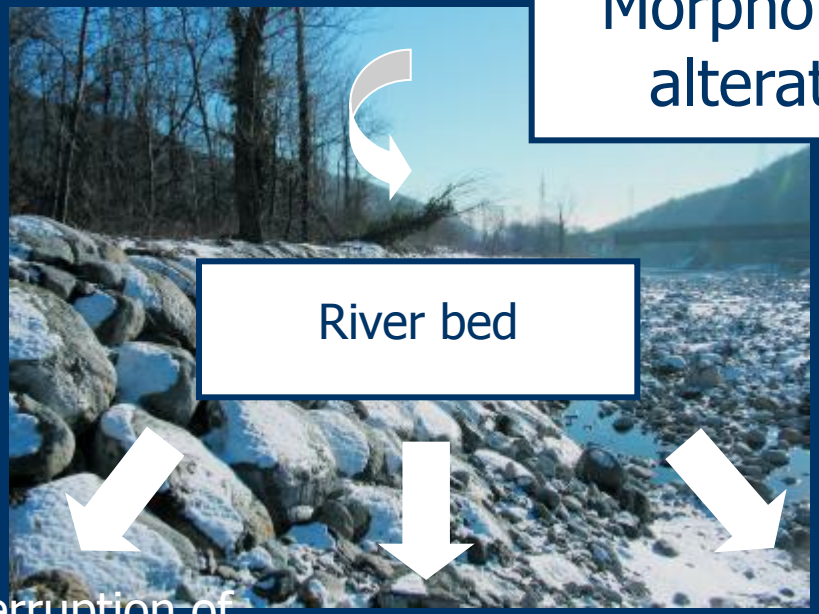


Hydrological (es.water abstraction, modifications of natural regime, unpredictable hydrological events

Impacts on chemical, physical and Biological water parameters

Decrease in dilution factor of wastewater , decreased hydraulic diversity in microhabitats

Morphological alterations



River bed

River banks

Interruption of longitudinal and vertical connectivity

Habitat Decrease/ alteration

Increased water speed

Interruption of trasversal connectivity

Alteration of riparian vegetation

Alteration of ecosystem structure and functioning

Too much water…

- Floods are on of the key-factor in the organization of water bodies. River communities can dramatically decrease but the recovery is generally fast.

Main effects: shear stress with sediment resuspension, and new pattern of bottom materials, abrasion on river bed, removal of primary producers and detritus

Not enough water…

Multiple effects:

- Reduced available habitat
- New pools
- Accumulation of pollutants
- Longitudinal fragmentation
- Increased temperature
- hypossia
- Biotic interactions intensify
- Algal bloom
- river bed colonization by terrestrial organisms
- An importanti ssue is to distinguish between natural and human induced intermittent rivers.

Hydrological alterations

Autori	Rif biblio	Titolo	Parole chiave	Area di studio	Endpoints
Boix et al.	Journal of Hydrology 383 (2010) 135–146	Response of community structure to sustained drought in Mediterranean rivers	Water scarcity, diatoms, macroinvertebrates, fish, hydrology, regualted rivers	Nord Est Spagna	Ricchezza, diversità Tax Distinctness
Tornes & Ruhi	Freshwater Biology (2013) 58, 2555–2566	Flow intermittency decreases nestedness and specialisation of diatom communities in Mediterranean rivers	intermittent streams, nestedness, niche breadth, species–environment relationships, unicellular organisms	Nord Est Spagna	parametri comunità (OMI, nestedness, α e ß diversity
Ros et al	Marine and Freshwater Research, 2009, 60, 14–24	Biodiversity of diatom assemblages in a Mediterranean semiarid stream: implications for conservation	dynamics, south-eastern Spain, conservation	Sud est Spagna	diversità, pigmenti

Boix et al. 2010 (1)

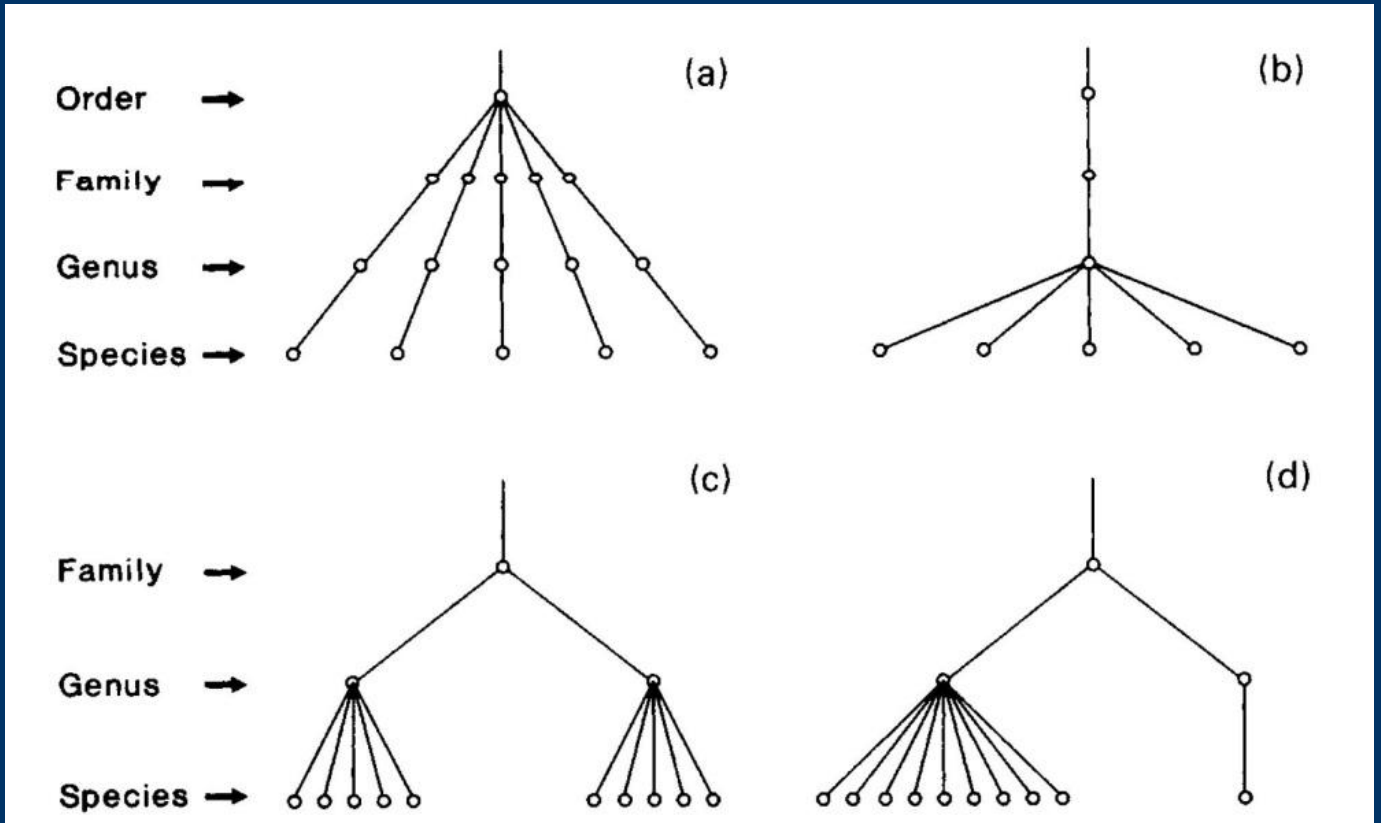
- They analyse the recovery of biological communities (also diatoms) after an exceptional long drought in NE Spain; all sites never dried,some were donwstream of reservoirs.
- **Abiotic variables:** a) hydrology (drought ratio, abstraction rate, monthly discharge); b) spatial (catchment, river order, distance from source, reservoir upstream/downstream c)14 environmental variables (water quality, vegetation,substrate…
- **Biological variables** (diatoms):richness, diversity, taxonomic distinctness + 2 biological matrices, one with species and the other with functional groups (trophic indicator index di Van Dam)

Boix et al. 2010 (2)

- Only Tax distinctness is significantly related to pure effects of hydrology,while environmental and spatial variables were more clearly related to other diatom variables and matrices
- Diatoms are sensitive to frequency and timing of disturbance. Gradual drying allows much higher desiccation resistence
- Reservoirs significantly alter habitat morphology and many water parameters, with direct and indirect effects on biota

TAXONOMIC DISTINCTNESS INDICES

These indices were firstly proposed by Clarke & Warwick (1998) to measure the interspecies phylogenetic distance in a given community and relate it to human impact.



TAXONOMIC DISTINCTNESS: la lunghezza del percorso filogenetico tra due individui scelti a random nel campione purché siano di specie differenti.

$$\Delta^* = \frac{\sum\sum_i \omega_{ij} x_i x_j}{\sum\sum_i x_i x_j}$$

Dove ω_{ij} è la distanza filogenetica tra la specie i e la specie j, mentre x_i e x_j sono le abbondanze relative rispettivamente della specie i e della specie j.

AVERAGE TAXONOMIC DISTINCTNESS: adattamento dell'indice precedente per dati di presenza/assenza.

$$\Delta^+ = \frac{\sum\sum_i \omega_{ij}}{s(s-1)/2}$$

Dove s è il numero di specie presenti nel campione.

Tornes and Ruhl, 2013 (1)

Study on 3 different river types:

1) *Highly stables*

2) *moderately stables*

3) *intermittent*

Hypothesis to test:

- *Hydrological stability increases the diatom communities nestedness*
- *ß-diversity is higher in unstable sites*

2 matrices:

1) presence/absence (419 species x 122 stations)

2) Environmental data (e.g. water quality, temperature, altitude,river width, canopy cover, stability

Tornes and Ruhl, 2013 (2)

- Hydrological stability is the main driver of nestedness

3 taxa groups:

a) "Nested taxa" , exclusively found in highly stable sites

b)at the other extreme, idiosyncratic taxa , most of them found in all 3 typologies (e.g. *Sellaphora seminulum, Fistulifera saprophila, Hannaea arcus)*;

c) few "nested taxa with very high occurences" *(Nitzschia palea, N. dissipata, Navicula cryptotenella, Cocconeis placentula, Amphora pediculus and Achnanthidium minutissimum*)

In highly stable sites there is a higher proportion of specialist taxa while in intermittent streams taxa tend to be more generalist

Ros et al 2009

- They assess annual changes in the structure and species richness od diatom communities in runs and pools of a semiarid stream in SE Spain and their relationship with nutirents and hydrology.

- Species richness and diversity were correlated with hydrology, whereas biomass (Chl a) was associated with variations in temperature, conductivity and ammonium.

- Species richness is high and strongly dependent on microhabitat and substrate

To sum up….

HYDROLOGICAL VARIABLES
discharges (annual,monthly, drought ratio),water depth, velocity, river stability.

RESPONSE VARIABLES
Richness, diversity, tax distinctness, trophic functional groups, nestedness, indicator taxa

ECOLOGICAL GUILDS

Groups of taxa belonging to a functional group which rely on the same resources and live in the same environment

They can be identified according to their potential to use resource and avoid disturbance

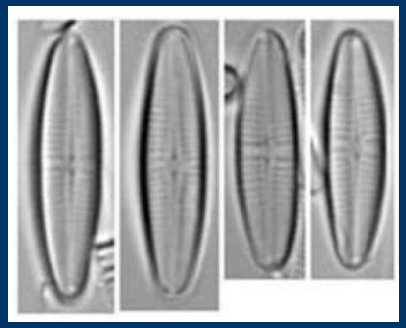
NUTRIENT CONCENTRATION

DISTURBANCE (PHYSICAL +GRAZERS)

Rimet & Bouchez, 2012. Life-forms, cell-sizes and ecological guilds of diatoms in European rivers. *Knowledge and Management of Aquatic Ecosystems,* 406: 1-14.
Passy 2007 Aquatic Botany 86 (2007): 171-178

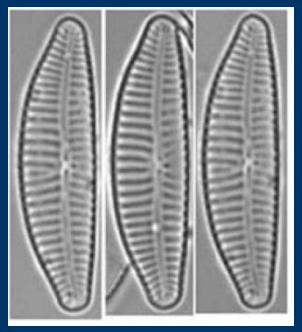
LOW PROFILE

Small species, mostly adnate or erected, highly resistant to high velocity but low tolerant to high nutrient concentration

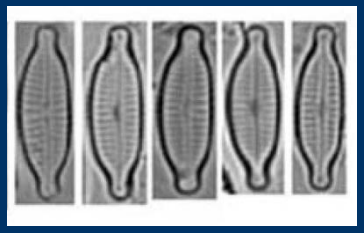


Genere *Achnanthidium*

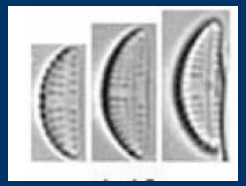
Genere *Cocconeis*



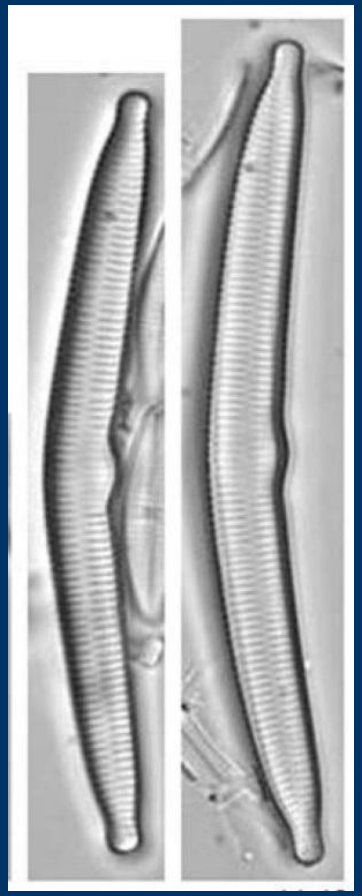
Genere *Cymbella*



Genere *Encyonopsis*



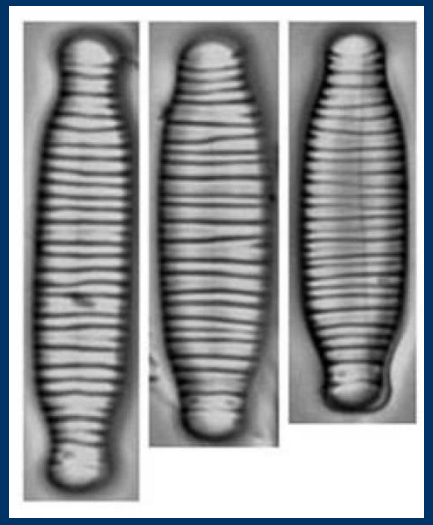
Genere *Amphora*



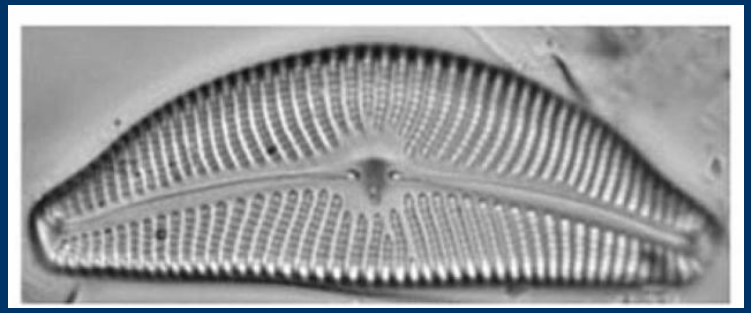
Fragilaria arcus

HIGH PROFILE

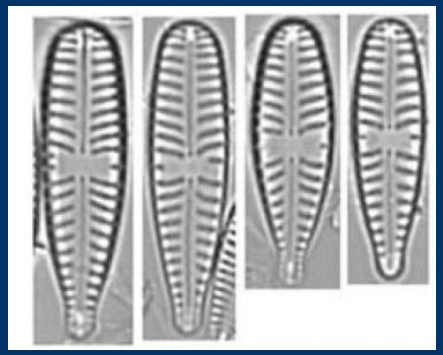
Large species, frequently colony- forming, low resistant to high current but tolerant to high trophic level.



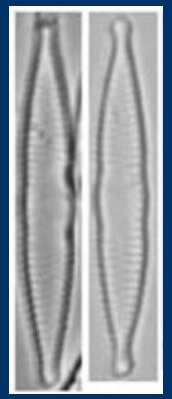
Genere *Diatoma*



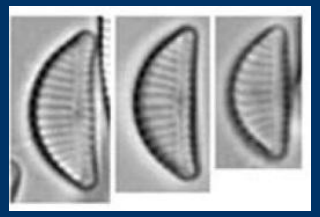
Cymbella tumida



Genere *Gomphonema*



Genere *Fragilaria*

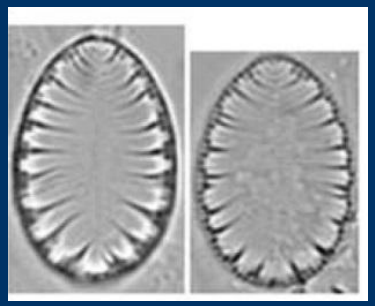


Genere *Encyonema*

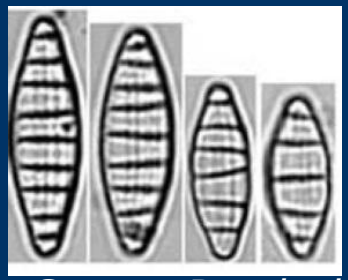
Melosira varians

MOTILE

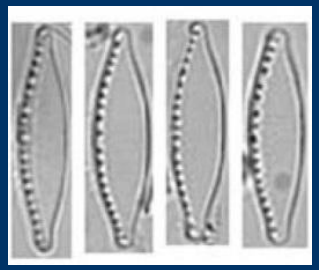
Relatively fast moving species, resistant to physical disturbance and to high nutrient concentration



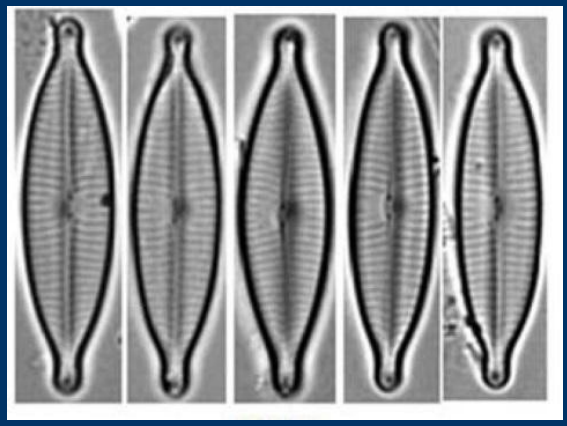
Genere *Surirella*



Genere *Denticula*



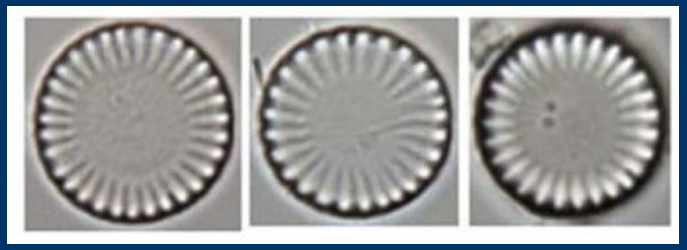
Genere *Nitzschia*



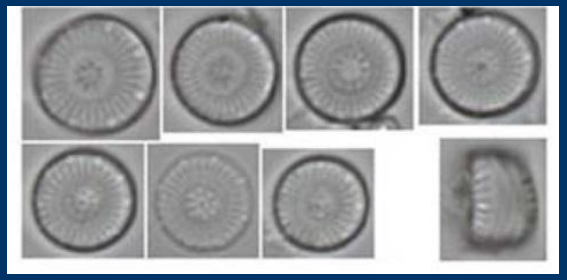
Genere *Navicula*

PLANKTIC

Solitary taxa, unable to resist to high velocity, as they live suspended in the water column

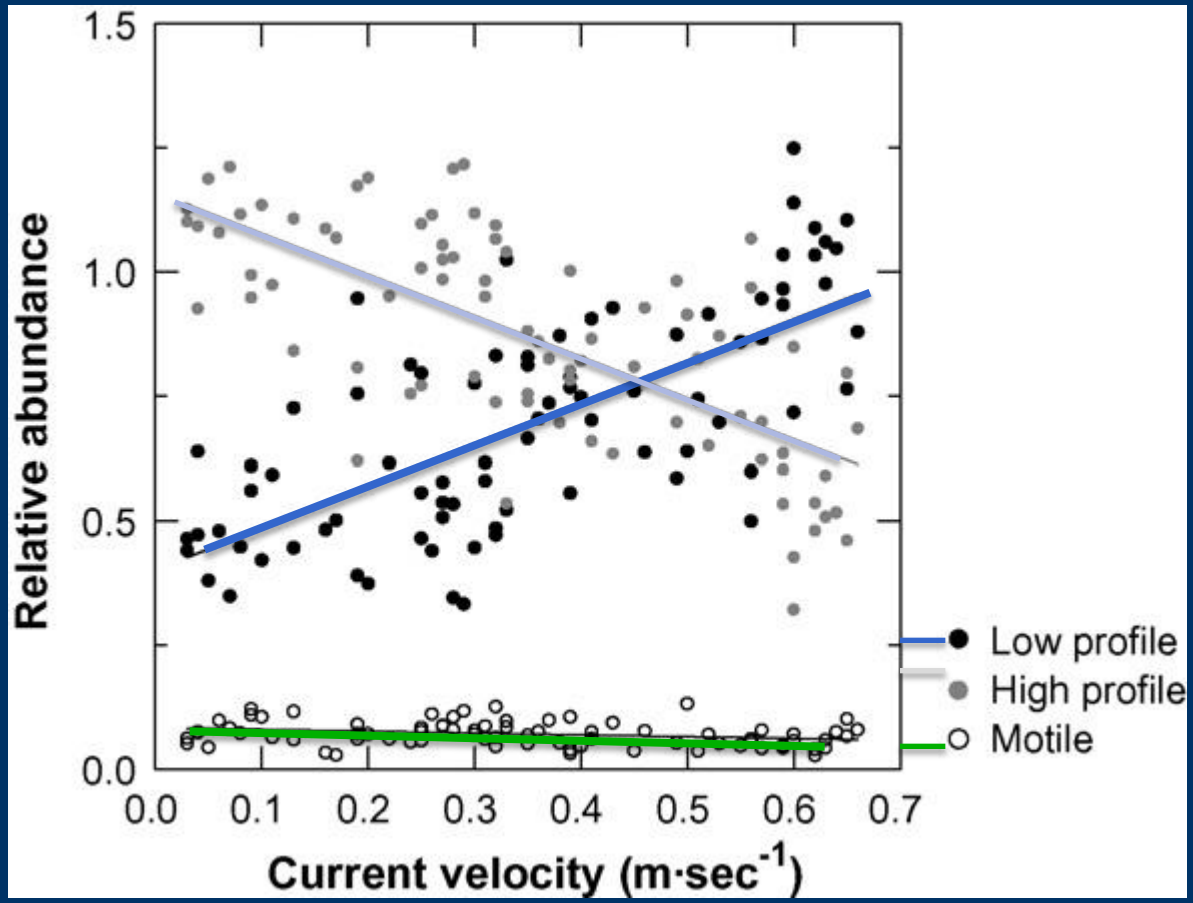


Genere *Cyclotella*



Discostella pseudostelligera

Passy, 2007 Ecological guilds and current velocity



GROWTH FORMS

ECOLOGICAL GUILDS

A MEASURE OF SUCCESSIONAL STAGE OF PERIFITON

Strongly influenced by the hydromorphological disturbance

Include a measure of perifiton successional stage as a response to habitat alteration

BIOVOLUME

Space occupied by individuals

BIOVOLUME = lenght * width * thickness * correction factor

- Diatoms of Europe
- Iconographia Diatomologica
- Bibliotheca Diatomologica
- Süßwasserflora von Mitteleuropa

- Expert evalution
- OMNIDIA

Shape

Mean biovolume value

Why use biovolume?

1)It is a measure of the room actually occupied by cells of a given species

2) Decrease in intraspecific biovolume and community mean biovolume in altered sites

3) Increase in individual size in eutrophic sites

- From our collaboration with Arpa Liguria, from 2008 to 2013 240 samples collected ≈300 taxa

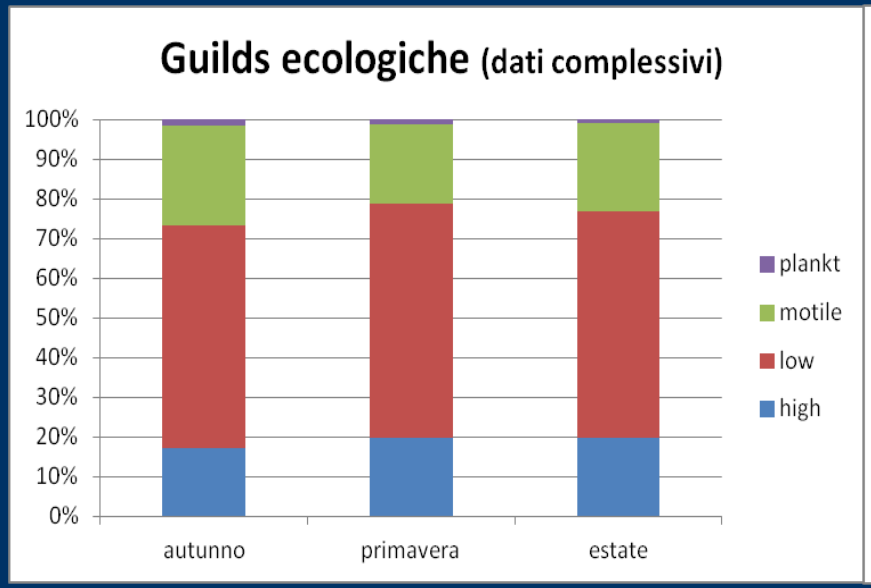
Rapporti ISTISAN 09/19

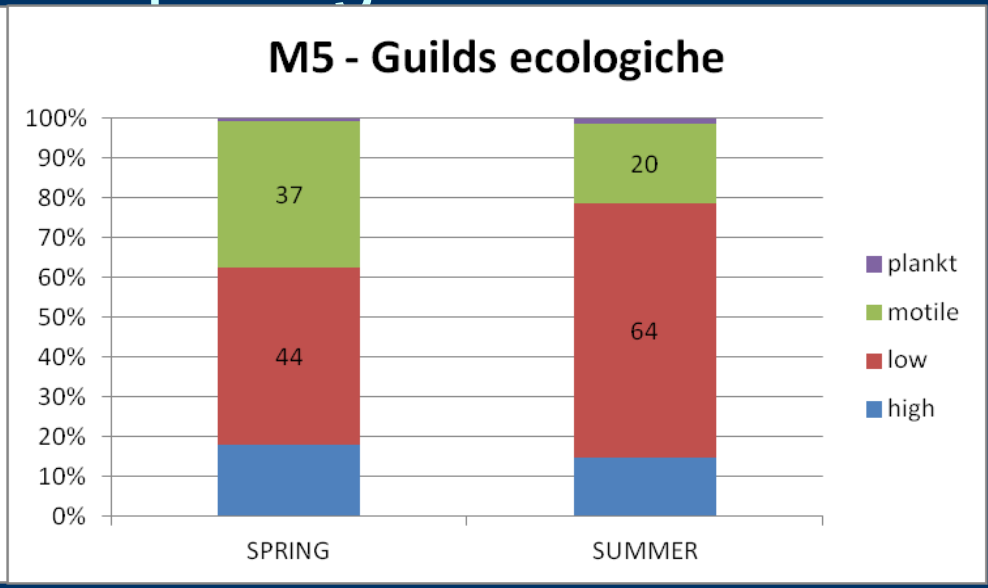
Tabella 3. Tipologie fluviali dell'area geografica Mediterranea

Tipologia	Caratterizzazione del fiume	Bacino	Altitudine (m) Geomorfologia	Geologia del bacino	Regime di portata
M-1	Piccolo, media altitudine	10-100 km^2	200-800 m	Misto	Altamente stagionale
M-2	Medio, pianura	100-1000 km^2	< 600 m	Misto	Altamente stagionale
M-3	Grande, pianura	1000-10000 km^2	< 600 m	Misto	Altamente stagionale
M-4	Piccolo medio Montagne mediterranee	10-1000 km^2	400-1500 m	Misto non siliceo	Stagionale con elevato trasporto di sedimenti
M-5	Piccolo Mediterraneo, Temporaneo	10-100 km^2	< 300 m	Misto	Temporaneo

138
4
49
45

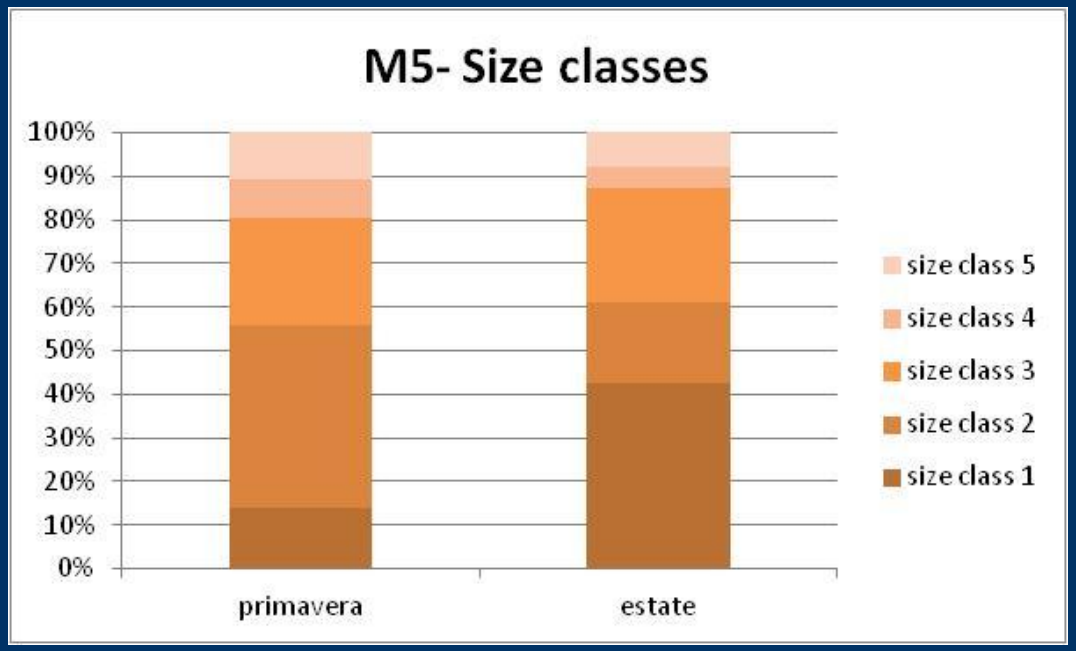
Data from Arpa Liguria





- Only in M5 strong seasonal differences with a significant decrease of motile guild in favor of LP going from spring to summer

Dati Arpa Liguria



In summer a high increase of class I and decrease of class II , IV and V.

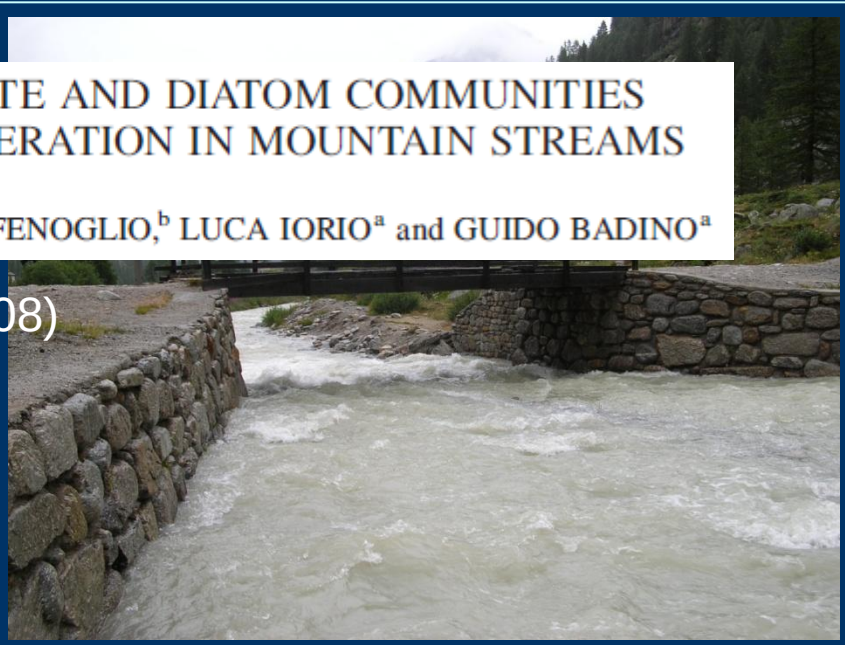
QNNS An Index of physical disturbance (Battegazzore et al., 2004; Gallo et al.,2013)

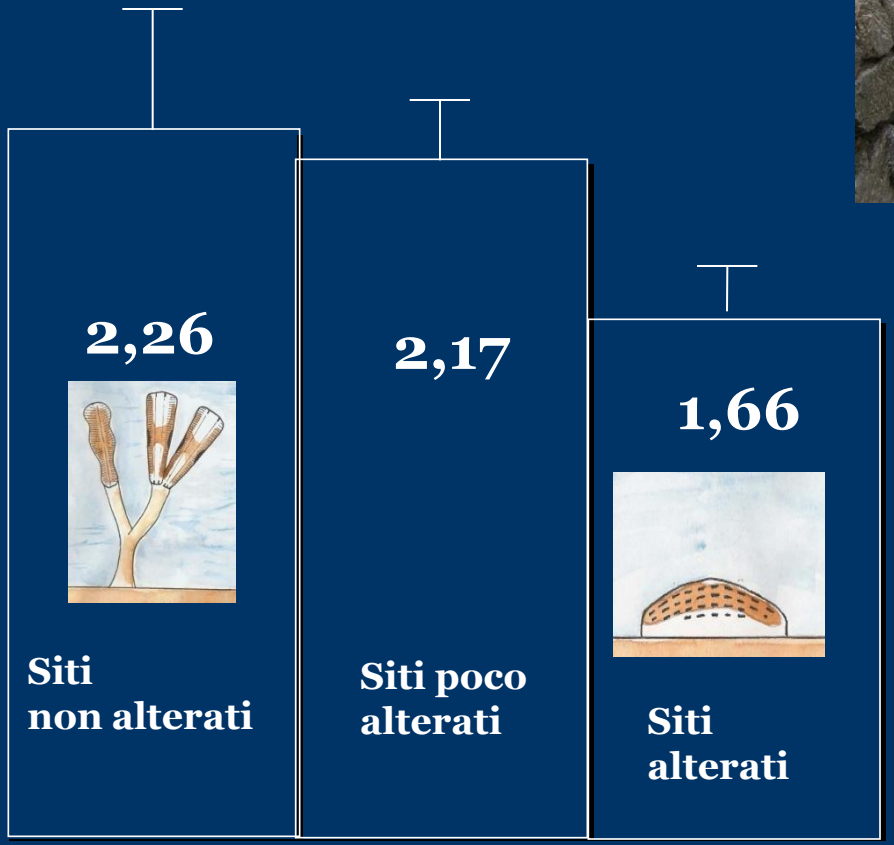
- Study on 8 stations on a regulated Mediterranean river
- QNNS :% individual belonging to the following genera: *Navicula* sensu lato, *Nitzschia* and *Surirella*
- Found a significant correlation between SS and QNNS

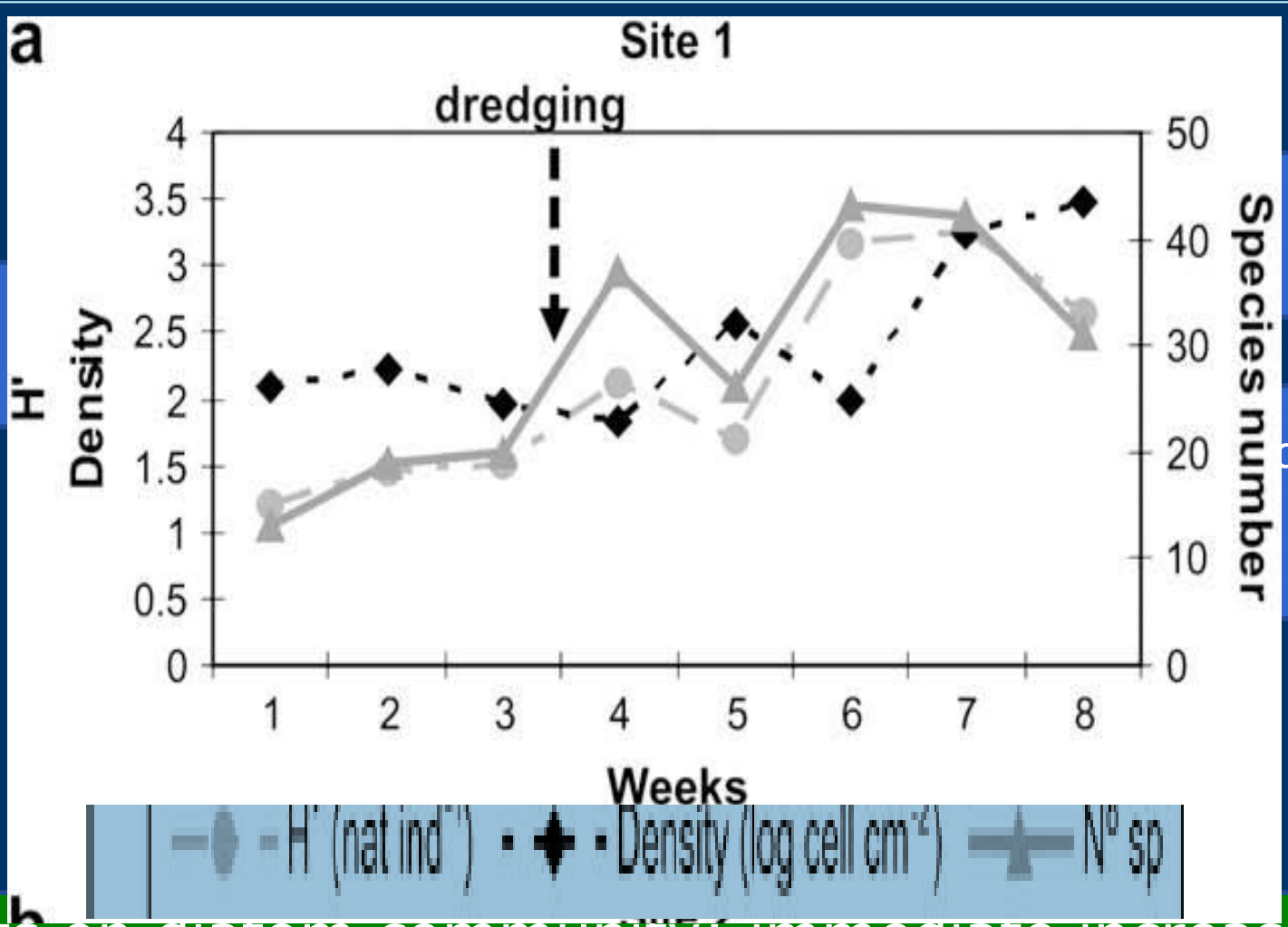
RESPONSE OF MACROINVERTEBRATE AND DIATOM COMMUNITIES TO HUMAN-INDUCED PHYSICAL ALTERATION IN MOUNTAIN STREAMS

FRANCESCA BONA,[a]* ELISA FALASCO,[a] STEFANO FENOGLIO,[b] LUCA IORIO[a] and GUIDO BADINO[a]

River. Res. Applic. 24: 1068–1081 (2008)







Effects on diatom community: immediate increase of diversity and richness with a decrease at the end of the study

Licursi &Gomez, 2009 (2)

- The trend in density and richness can be a consequence of the increase availability of nutrients in the water column after dredging. This response is coincident with those occuring in the first successional stages characterized by empty niches.
- Dredging takes to species substitution by favouring more tolerant species
- Also the former dominant species (*Rhoicosphenia abbreviata)* has been taken over by *Nitzschia amphibia*

Hydromorphological alterations

River Res. Applic. **28**: 1289–1298 (2012)

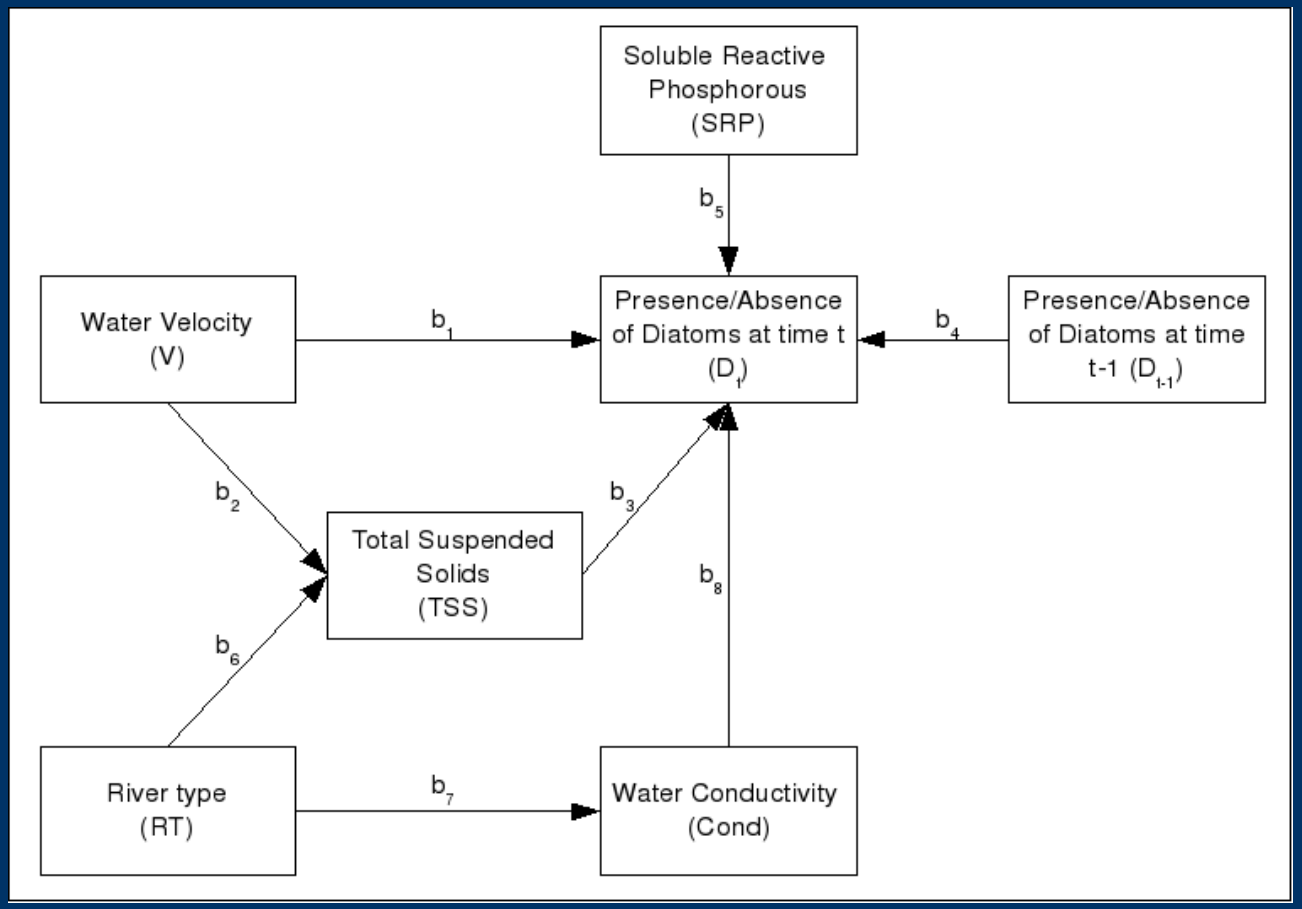
Published online 14 April 2011 in Wiley Online Library
(wileyonlinelibrary.com) DOI: 10.1002/rra.1517

PREDICTING RIVER DIATOM REMOVAL AFTER SHEAR STRESS INDUCED BY ICE MELTING

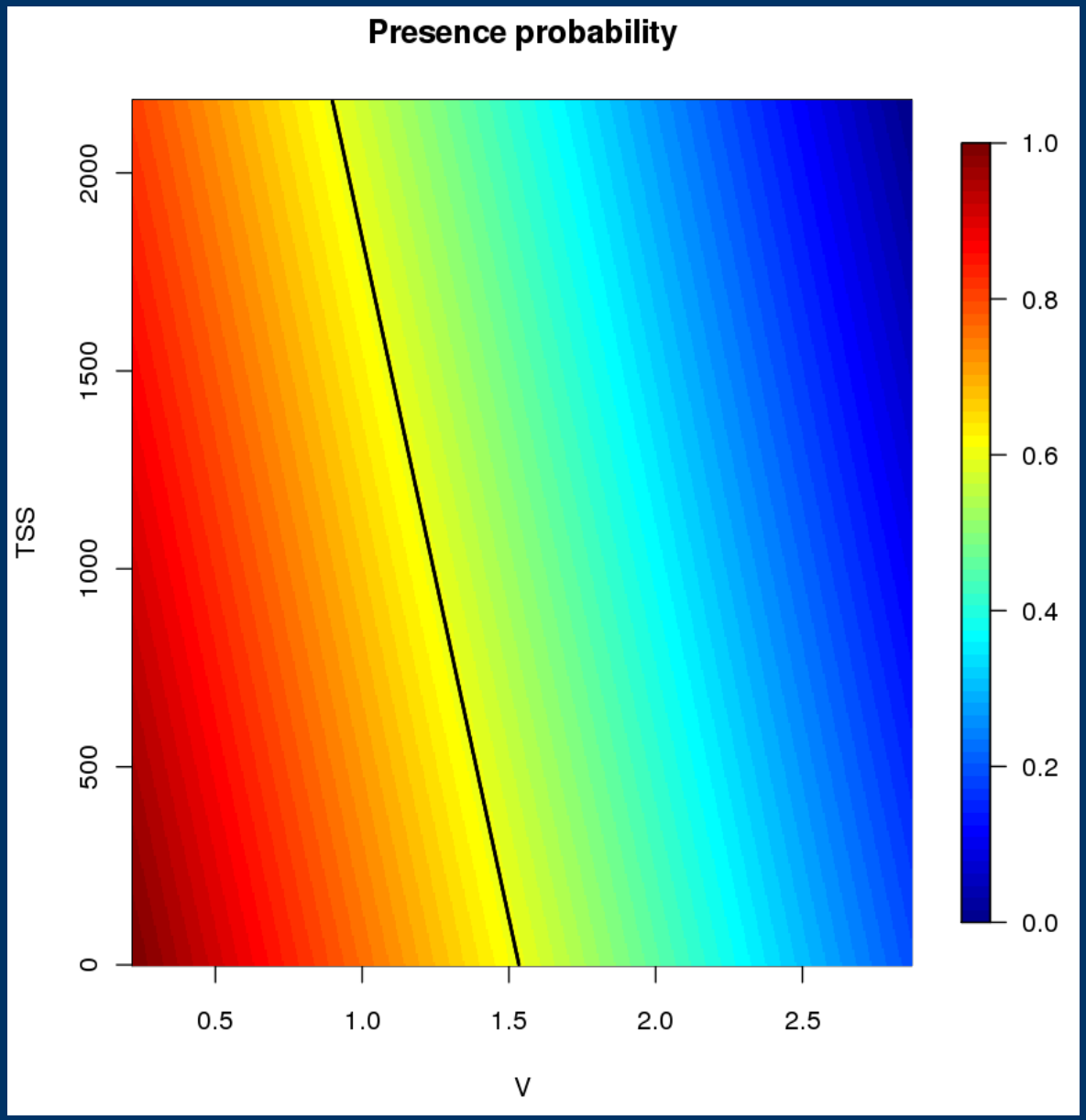
F. BONA,* V. LA MORGIA and E. FALASCO

Aim of the study: to relate the removal of diatoms to changes in environmental variables during high flows in alpine streams (effect of SS and current velocity)

Path Analysis- Causal graph expressing the hypothesized causal model for the presence/absence of diatoms



Hydromorphological alterations



Main findings

SS had the major effect in terms of direct action, followed by water velocity but the latter had the highest total effect (direct and indirect). Water quality parameters did not affect the presence of diatoms.

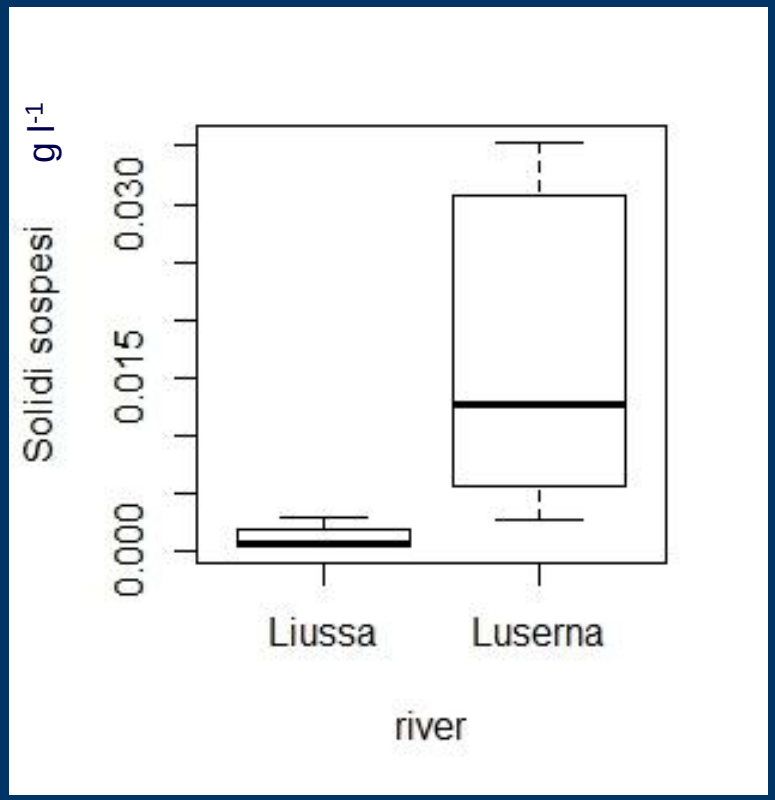
Diatom community composition: the accrual phase was characterized by low-profile taxa.

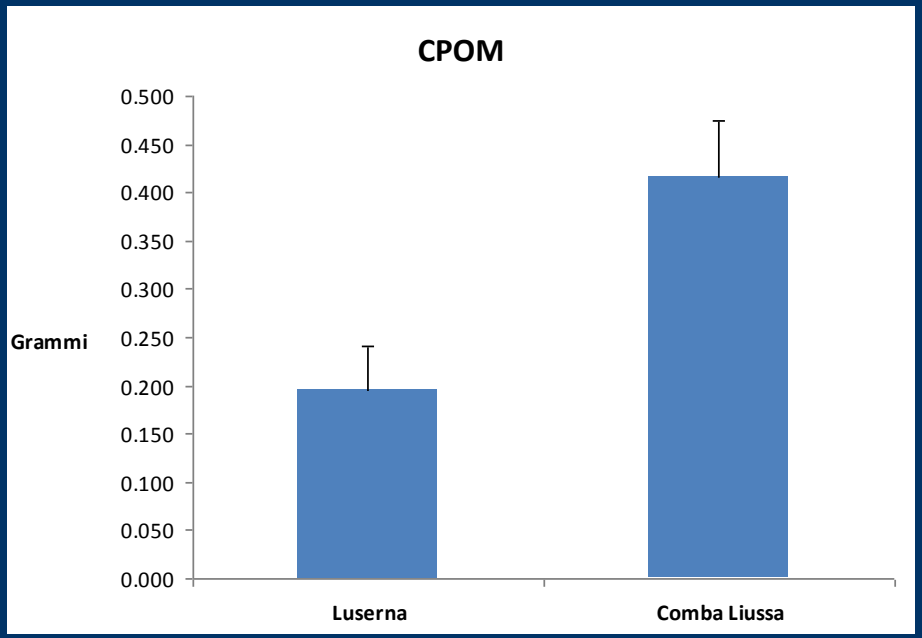
Potential application: improvement of biomonitoring experimental design for these fluvial systems;

Effect thresholds for works that can increase SS concentration in the Environmental Impact Assessment.

Hydromorphological alterations

Study on the impct of siltation due to quarry activities (Cave Pietra di Luserna)
Master Thesis A. Doretto – in collaboration with S. Fenoglio UNIPMN





Study on the impct of siltation due to quarry activities (Cave Pietra di Luserna)
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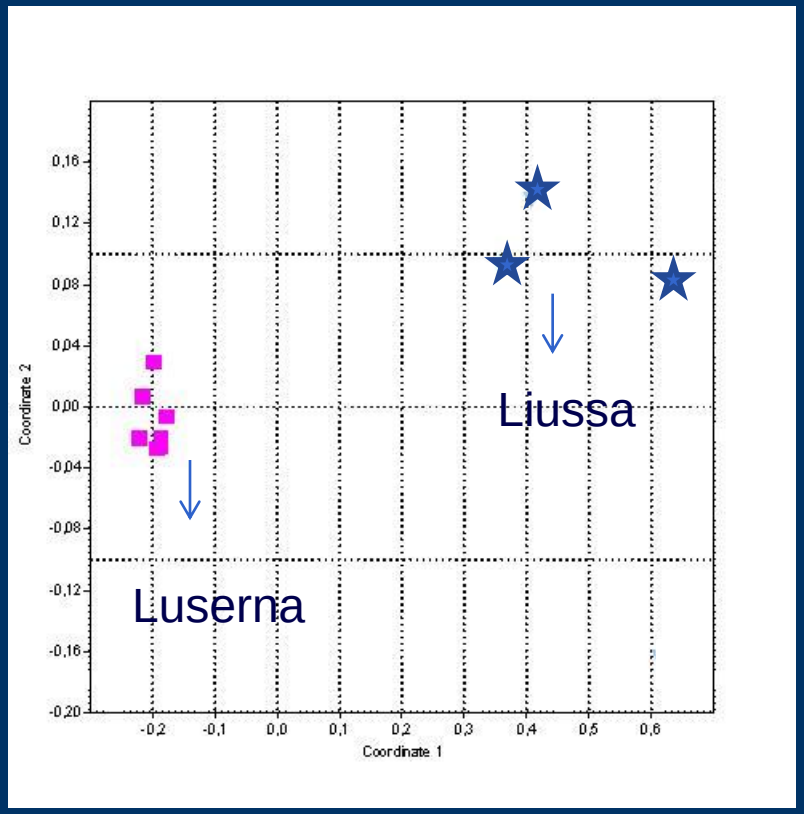
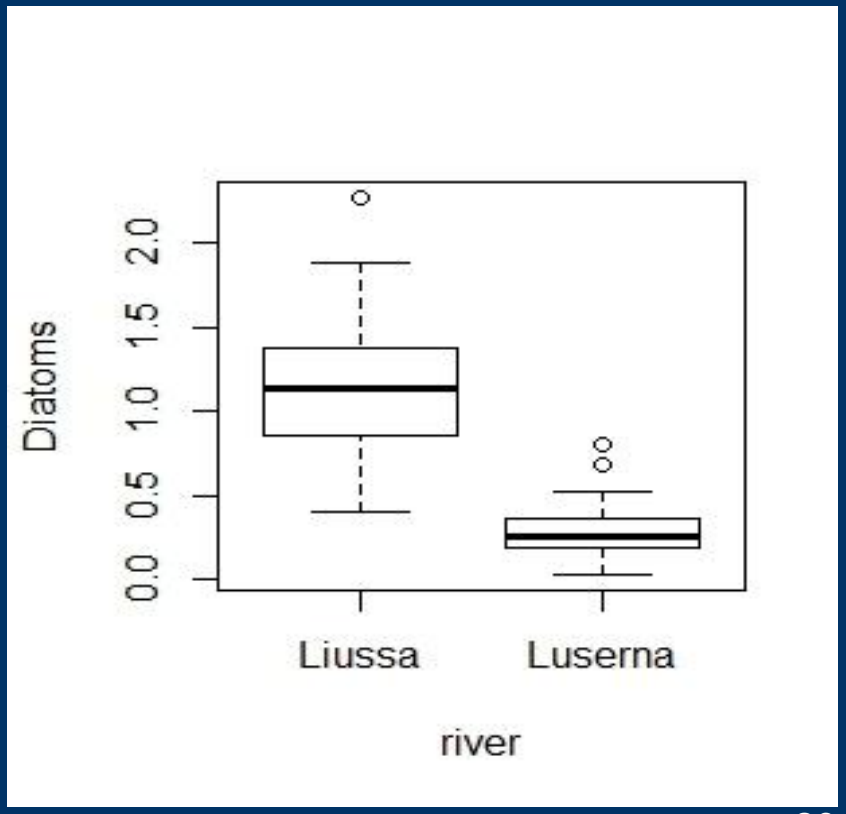
Diatom communities



Diatom biomass (ug/cm^2 Chl a)



Future perspectives

In terms of diatom indices, highly alterated streams can be classified as high ecological status

- Ad hoc sampling strategies : to sample a variety od substrates, possibly quantitative samplings (measures of diatom density through pigments or cell enumeration)
- Testing of functional metrics :guilds, growth forms, biovolume, successional stage
- Analysis of taxa composition; community structure (nestedness, taxonomic distinctness)
- To include in diatom indices a coefficient of sensitivity to physical disturbance?
- How to measure and quantify the physical alteration?