

Evidence for wastewater influence in a low impacted area throughout stable isotope analyses of the limpet *Patella caerulea* and epilithic biofilms

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Introduction

Carbon and nitrogen stable isotope ratios : a tool to detect and trace biological availability of sewage-derived matter and its pathways throughout food webs (2,4,5).

Potential eutrophication indicators : limpet *Patella caerulea* and one of its food sources (3,6) = low trophic level gastropod & epilithic biofilms.

Measurements were performed at several spatial & temporal scales in the low impacted area of the Calvi Bay (North Corsica) and in the Marseilles harbor (fig. 1).

Isotopic data were analyzed as follow :

- Seasonal and site comparisons,
- Small scale horizontal variations,
- Depth-related variations,

Material & Methods

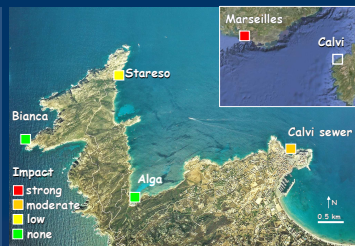


Figure 1 : Satellite view of the Calvi Bay (Google earth™, CNES/SPOT 2009), gradual colors match with the exposure of sites to sewage discharge.

	Mean TKN discharge (tonnes · day ⁻¹)	
	Min	Max
Marseilles	10.3	13.2
Calvi	0.05	0.5
Stareso	Local from septic tank	

Figure 2 : Range of TKN values of wastewater discharged between 11/2005 and 11/2006. Total Kjeldahl Nitrogen = organic N + NH₃ + NH₄⁺ (Data, Système d'Information Eau Bassin Rhône-Méditerranée, Corse)

Time	Seasonal : 11/2005 to 11/2006
Locations	5 sites gradually exposed to urban sewage (fig. 1)
<i>P. caerulea</i>	6 individuals per site (muscles)
biofilms	Punctual surface sampling (fig. 3b, 4b)
Depth	~ 4 m (11/2006, fig. 4a)
Horizontal small scale	<i>P. caerulea</i> and biofilms : 30m away points (11/2006, fig. 4a)



C & N stable isotope ratios : mass spectrometry

Results

Seasonal & site comparisons

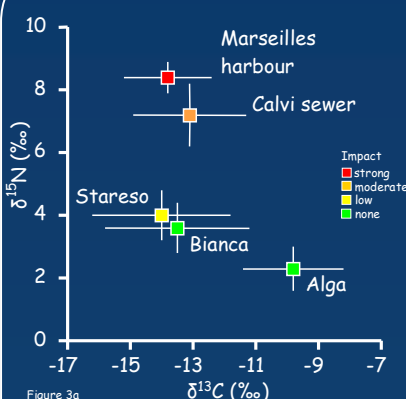


Figure 3a

Small scale horizontal & depth-related variations

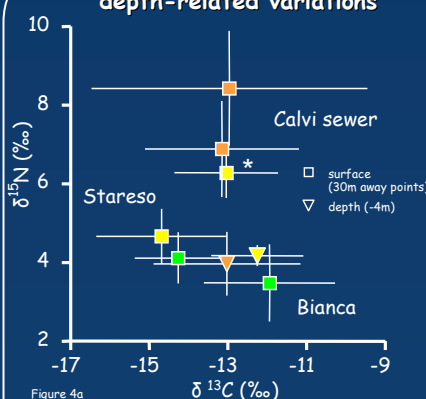


Figure 4a

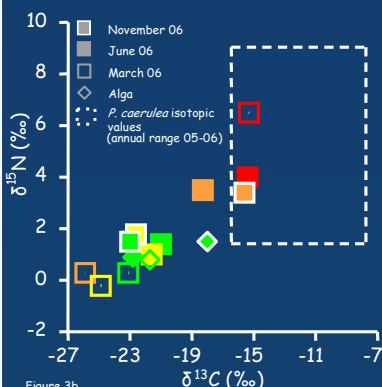


Figure 3b

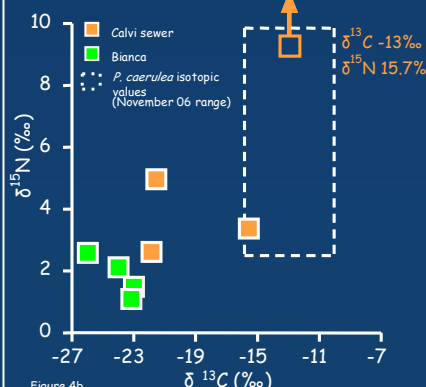


Figure 4b

Figure 3a : Annual means (± SD in ‰) of *P. caerulea* isotopic values between November 05-06. Gradual colors as referred on Fig. 1.
Figure 3b : *P. caerulea* isotopic values (in ‰) in March, June and November 06.

Figure 4a : Horizontal and depth-related variations of *P. caerulea* isotopic values at Calvi sewer and Stareso sites in November 06 (mean ± SD in ‰). Sampling point (*) is located near septic tank outfall.
Figure 4b : Horizontal variations of biofilms' isotopic values at Bianca and Calvi sewer sites in November 06 (30 m away points). Cleared square = out of range value from a point source of wastewater discharge at Calvi sewer site. Gradual colors as referred on Fig. 1.

Discussion

Wastewater influence : δ15N pattern

- Reflects sites' exposure to urban sewage (2,4,5) but unrelated to nitrogen loads (fig.2)
- First evidence for local septic tank influence at Stareso site (fig. 4a)
- Limited wastewater vertical extent (freshwater spread) (fig. 4a)
- Under disturbed conditions : wider spatial & seasonal variations of biofilms' values than limpets' ones (fig. 3b, 4b).

Temporal integration

- Steady limpets' values over seasons : muscles provide an integrated signal vs. biofilms which composition and / or isotopic signatures may vary greatly in time and space (fig. 3b, 4b) (1,7,8).

Trophic view point

- Isotopic variance of *P. caerulea* values = generalist feeding behaviour (6).
- Surface and depth populations of *P. caerulea* do not overlap (fig. 4a).
- Mismatch between limpets' muscles & biofilms' values (fig. 3b, 4b) : selective assimilation of some biofilms' components?, docoglossan radulae allow grazing on endolithic material (6)?, heterogeneity of biofilms' structure (8)?, mixed diet with macroalgae?

Conclusions & Perspectives

- N stable isotope ratios of *P. caerulea* : allow to detect long term exposure to sewage and its depth extent even in low impacted areas.
- Biofilms as eutrophication indicators : requires further study to distinguish between natural and human induced isotopic variations.

Further investigations :

- *P. caerulea* gut content analyses : inter and intra-site compositions, comparison between gut content and available food C, N isotopic signatures.
- Fine scale sampling of biofilms

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