



Contents lists available at ScienceDirect

## Progress in Oceanography

journal homepage: [www.elsevier.com/locate/pocean](http://www.elsevier.com/locate/pocean)

## Planktonic prokaryote and protist communities in a submarine canyon system in the Ligurian Sea (NW Mediterranean)



Celussi Mauro<sup>a,\*,1</sup>, Quero Grazia Marina<sup>b,1</sup>, Zoccarato Luca<sup>c,d,1</sup>, Franzo Annalisa<sup>a</sup>, Corinaldesi Cinzia<sup>e</sup>, Rastelli Eugenio<sup>b,f</sup>, Lo Martire Marco<sup>f</sup>, Galand Pierre E.<sup>g</sup>, Ghiglione Jean-François<sup>h</sup>, Chiggiato Jacopo<sup>i</sup>, Coluccelli Alessandro<sup>f</sup>, Russo Aniello<sup>f,j</sup>, Pallavicini Alberto<sup>c</sup>, Fonda Umani Serena<sup>c,2</sup>, Del Negro Paola<sup>a</sup>, Luna Gian Marco<sup>k</sup>

<sup>a</sup> Oceanography Division, Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS), IT-34151 Trieste, Italy

<sup>b</sup> Stazione Zoologica Anton Dohrn, IT-80121 Napoli, Italy

<sup>c</sup> Department of Life Science, University of Trieste, IT-34127 Trieste, Italy

<sup>d</sup> Department of Limnology of Stratified Lakes, Leibniz Institute of Freshwater Ecology and Inland Fisheries, Stechlin, Germany

<sup>e</sup> Department of Sciences and Engineering of Materials, Environment and Urbanistics, Polytechnic University of Marche, IT-60131 Ancona, Italy

<sup>f</sup> Department of Life and Environmental Sciences, Polytechnic University of Marche, IT-60131 Ancona, Italy

<sup>g</sup> Sorbonne Université, CNRS, Laboratoire d'Ecogéochimie des Environnements Benthiques (LECOB), Observatoire Océanologique de Banyuls, Banyuls sur Mer, France

<sup>h</sup> Sorbonne Université, CNRS, Laboratoire d'Océanographie Microbienne (LOMIC), Observatoire Océanologique de Banyuls, Banyuls sur Mer, France

<sup>i</sup> Consiglio Nazionale delle Ricerche, Istituto di Scienze Marine (CNR-ISMAR), IT-30122 Venezia, Italy

<sup>j</sup> NATO Science and Technology Organization, Centre for Maritime Research and Experimentation (CMRE), 19126 La Spezia, Italy

<sup>k</sup> Consiglio Nazionale delle Ricerche, Istituto per le Risorse Biologiche e le Biotecnologie Marine (CNR-IRBIM), IT-60131 Ancona, Italy

## ARTICLE INFO

## Keywords:

16S rRNA gene

18S rRNA gene

Mesopelagic and bathypelagic realms

Dissolved inorganic carbon fixation

Exoenzymatic activities

Submarine canyon

## ABSTRACT

Submarine canyons are large geomorphological features that incise continental margins and act as highly dynamic conduits of sediments from shallow to the deep-sea regions. They are often regarded as biodiversity and biomass hotspots, but their role in influencing plankton communities is still poorly known. We studied the ecology of planktonic deep-sea microbes in a submarine canyon system (Polcevera and Bisagno canyons) in the Ligurian Sea (NW Mediterranean Sea), aiming at testing whether these large-scale incisions are peculiar systems, in comparison to the overlying water and the adjacent uncarved slope, in terms of biogeochemical and biological features. We analysed microbial communities' composition by high-throughput sequencing of 16S and 18S rRNA genes and their functional attributes by measuring heterotrophic carbon production, dissolved inorganic carbon fixation, respiration and the activity of the exoenzymes leucine aminopeptidase, alkaline phosphatase, beta-glucosidase and lipase. We found that both prokaryotic and eukaryotic communities were not significantly different inside the canyons (if compared to the close slope and overlying water), but they were rather shaped by the water masses dynamics in the area. The shallowest Modified Atlantic Waters, Levantine Intermediate Waters and Winter Intermediate Waters hosted higher percentages of Alphaproteobacteria, Bacteroidetes and Dinophyta, while the deepest Western Mediterranean Deep Waters hosted a higher fraction of Gammaproteobacteria, Chloroflexi, Discoba and Fungi. Among the functional measurements, only leucine aminopeptidase activity showed higher rates within the canyons. However, local hotspots within the canyons

**Abbreviations:** AMA, leucine aminopeptidase activity; AP, alkaline phosphatase activity; BGLU, beta-glucosidase activity; DIC, dissolved inorganic carbon; DIC<sub>d</sub>, dissolved inorganic carbon fixation rate: dissolved fraction; DIC<sub>cp</sub>, dissolved inorganic carbon fixation rate: particulate fraction; DIC<sub>tot</sub>, dissolved inorganic carbon fixation rate: total fraction; DOC, dissolved organic carbon; HCP, heterotrophic carbon production; LIP, lipase activity; LIW, Levantine Intermediate Water; MAW, Modified Atlantic Water; PCD, Prokaryotic Carbon Demand; PCoA, principal coordinate analysis; PN, Particulate Nitrogen; POC, particulate organic carbon; dbRDA, distance-based redundancy analysis; WIW, Winter Intermediate Water; WMDW, Western Mediterranean Deep Water

\* Corresponding author at: Oceanography Division, Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS), v. A. Piccard, 54, 34151 Trieste, Italy.

**E-mail addresses:** [mcelussi@inogs.it](mailto:mcelussi@inogs.it) (M. Celussi), [grazia.quero@szn.it](mailto:grazia.quero@szn.it) (G.M. Quero), [zoccarato@igb-berlin.de](mailto:zoccarato@igb-berlin.de) (L. Zoccarato), [afranzo@inogs.it](mailto:afranzo@inogs.it) (A. Franzo), [c.corinaldesi@univpm.it](mailto:c.corinaldesi@univpm.it) (C. Corinaldesi), [eugenio.rastelli@szn.it](mailto:eugenio.rastelli@szn.it) (E. Rastelli), [m.lomartire@univpm.it](mailto:m.lomartire@univpm.it) (M. Lo Martire), [pierre.galand@obs-banyuls.fr](mailto:pierre.galand@obs-banyuls.fr) (P.E. Galand), [ghiglione@obs-banyuls.fr](mailto:ghiglione@obs-banyuls.fr) (J.-F. Ghiglione), [jacopo.chiggiato@ismar.cnr.it](mailto:jacopo.chiggiato@ismar.cnr.it) (J. Chiggiato), [a.coluccelli@univpm.it](mailto:a.coluccelli@univpm.it) (A. Coluccelli), [a.russo@univpm.it](mailto:a.russo@univpm.it) (A. Russo), [pallavic@univ.trieste.it](mailto:pallavic@univ.trieste.it) (A. Pallavicini), [pdelnegro@inogs.it](mailto:pdelnegro@inogs.it) (P. Del Negro), [gianmarco.luna@ve.ismar.cnr.it](mailto:gianmarco.luna@ve.ismar.cnr.it) (G.M. Luna).

<sup>1</sup> Celussi Mauro, Quero Grazia Marina and Zoccarato Luca contributed equally to this work.

<sup>2</sup> Oceanography Division, Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS), 34151 Trieste, Italy.

<https://doi.org/10.1016/j.pocean.2018.10.002>

Available online 04 October 2018

0079-6611/ © 2018 Elsevier Ltd. All rights reserved.