

# Marine protist diversity in European coastal waters and sediments as revealed by high-throughput sequencing

Ramon Massana,<sup>1\*</sup> Angélique Gobet,<sup>2,3</sup>  
Stéphane Audic,<sup>2,3</sup> David Bass,<sup>4</sup> Lucie Bittner,<sup>2,3,5</sup>  
Christophe Boutte,<sup>2,3</sup> Aurélie Chambouvet,<sup>6</sup>  
Richard Christen,<sup>7</sup> Jean-Michel Claverie,<sup>8</sup>  
Johan Decelle,<sup>2,3</sup> John R. Dolan,<sup>9</sup> Micah Dunthorn,<sup>5</sup>  
Bente Edvardsen,<sup>10</sup> Irene Forn,<sup>1</sup> Dominik Forster,<sup>5</sup>  
Laure Guillou,<sup>2,3</sup> Olivier Jaillon,<sup>11</sup>  
Wiebe H. C. F. Kooistra,<sup>12</sup> Ramiro Logares,<sup>1</sup>  
Frédéric Mahé,<sup>5</sup> Fabrice Not,<sup>2,3</sup> Hiroyuki Ogata,<sup>13</sup>  
Jan Pawlowski,<sup>14</sup> Massimo C. Pernice,<sup>1</sup>  
Ian Probert,<sup>2,3</sup> Sarah Romac,<sup>2,3</sup> Thomas Richards,<sup>6</sup>  
Sébastien Santini,<sup>8</sup> Kamran Shalchian-Tabrizi,<sup>10</sup>  
Raffaele Siano,<sup>15</sup> Nathalie Simon,<sup>2,3</sup>  
Thorsten Stoeck,<sup>5</sup> Daniel Vaulot,<sup>2,3</sup> Adriana Zingone<sup>12</sup>  
and Colomán de Vargas<sup>2,3</sup>

<sup>1</sup>Institut de Ciències del Mar (CSIC), ES-08003, Barcelona, Catalonia, Spain

<sup>2</sup>Ecologie Systematique Evolution, CNRS, FR-29682, Roscoff, France

<sup>3</sup>UMR7144 – Equipe Eppo: Evolution du Plancton et PaléoOcéans, UPMC Université Paris 06, Roscoff, France

<sup>4</sup>The Natural History Museum, London SW7 5BD & Cefas, Weymouth, Dorset DT4 8UB, UK

<sup>5</sup>University of Kaiserslautern, D-67663 Kaiserslautern, Germany

<sup>6</sup>Biosciences, University of Exeter, Exeter, EX4 4QD, UK

<sup>7</sup>CNRS, UMR 7138, Université Nice Sophia Antipolis, FR-06108 Nice, France

<sup>8</sup>CNRS, UMR 7256, Aix-Marseille Université, FR-13288 Marseille, France

<sup>9</sup>CNRS, UMR 7093, UPMC Université Paris 06, Laboratoire d'Océanographie de Villefranche, FR-06230 Villefranche-sur-Mer, France

<sup>10</sup>Department Biosciences, University of Oslo, N-0316 Oslo, Norway

<sup>11</sup>CEA, Genoscope, 2 rue Gaston Crémieux, FR-91000 Evry, France

<sup>12</sup>Stazione Zoologica Anton Dohrn, Villa Comunale, I-80121 Naples, Italy

<sup>13</sup>Institute for Chemical Research, Kyoto University, Uji, Kyoto 611-0011, Japan

<sup>14</sup>University of Geneva, CH-1211 Geneva, Switzerland

<sup>15</sup>Ifremer DYNECO/Pelagos, BP 7029280 Plouzané, France

## Summary

Although protists are critical components of marine ecosystems, they are still poorly characterized. Here we analysed the taxonomic diversity of planktonic and benthic protist communities collected in six distant European coastal sites. Environmental deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) from three size fractions (pico-, nano- and micro/mesoplankton), as well as from dissolved DNA and surface sediments were used as templates for tag pyrosequencing of the V4 region of the 18S ribosomal DNA. Beta-diversity analyses split the protist community structure into three main clusters: picoplankton-nanoplankton-dissolved DNA, micro/mesoplankton and sediments. Within each cluster, protist communities from the same site and time clustered together, while communities from the same site but different seasons were unrelated. Both DNA and RNA-based surveys provided similar relative abundances for most class-level taxonomic groups. Yet, particular groups were overrepresented in one of the two templates, such as marine alveolates (MALV)-I and MALV-II that were much more abundant in DNA surveys. Overall, the groups displaying the highest relative contribution were Dinophyceae, Diatomea, Ciliophora and Acantharia. Also, well represented were Mamiellophyceae, Cryptomonadales, marine alveolates and marine stramenopiles in the picoplankton, and Monodofilosa and basal Fungi in sediments. Our extensive and systematic sequencing of geographically separated sites provides the most comprehensive molecular description of coastal marine protist diversity to date.

Received 28 January, 2015; revised 9 June, 2015; accepted 12 June, 2015. \*For correspondence. E-mail: ramonm@icm.csic.es; Tel: (+34) 93 2309500; Fax: (+34) 93 2309555.