AQUA COSM

2ND INTERNATIONAL AQUATIC MESOCOSM RESEARCH SYMPOSIUM

FROM LOCAL PROCESSES TO CROSS-DOMAIN INTERACTIONS

April 2021 12-16

Virtual Symposium

www.aquacosm.eu/events/symposium

Organized by

hcmr
ΕΛΚΕΘΕ

FINAL PROGRAM & ABSTRACT BOOK

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Preface

Mesocosms are a well-established technique filling in the gradient in approaches from strictly controlled laboratory experiments to observational studies of natural ecosystems. They have been introduced more than 80 years ago and have been used in a range of research contexts to advance understanding of the food web interactions and ecosystem functioning, to examine food web dynamics, diversity, community composition and resource partitioning, nutrient pathways and carbon flow, to study effects of perturbations/hazards at the ecosystem level, to investigate phenomena including climate change, and to investigate nature-based solutions to mitigate negative impacts.

Technological innovation has stimulated the development of mesocosm facilities of various shapes and scales with a diversity of supplementary equipment and oriented towards a wide range of objectives. Building directly on the marine MESOAQUA (FP7), the **AQUACOSM** project was designed to strengthen, connect and enlarge a solid European network of mesocosm research facilities in freshwater and marine environments. It offers access to >29 mesocosm facilities, covering rivers, lakes, estuaries, benthic and pelagic marine environments.

The aim of the "**2nd International Aquatic Mesocosm Research Symposium - from local processes to cross-domain interactions**" is to exchange ideas and experiences in aquatic mesocosm research and to map future research directions in a broader context. Therefore, it covers a range of aspects related to the technique itself, its use to understand the structure and function of various aquatic ecosystems and to study their response to perturbations and hazards, both natural and anthropogenic. Networking with other related RIs and networks is also a scope of this Symposium.

Initially planned to take place in October 2020 in Heraklion, Crete, Greece, due to COVID-19 pandemy, the Symposium had to be re-scheduled and finally held virtually, in April 2021. Adjusting to a new normal, a state-of-the-art platform will be used to ensure the maximum possible degree of interaction.

A total of 53 oral presentations (including 5 keynote ones) and 36 posters from Europe, North and South America and Asia are included in the program of the Symposium; with more than 300 registrations at the moment this preface was written, attendees from all over the world will interact and discuss about important topics of the aquatic research. We would like to welcome you to this virtual event and we hope we will all enjoy a successful Symposium with vivid and stimulating discussions in a fresh and interactive format.

Paraskevi Pitta
Symposium Chair on behalf of the local Organising Committee

CET Time

DAY 1 Monday 12 April 2021

11:00 - 11:20	**Welcome & Opening** **Aris Karageorgis** (HCMR) – **Paraskevi Pitta** (HCMR) **The AQUACOSM project** **Jens Nejstgaard** (FVB- IGB)	Channel 1
11:20 – 11:30	Coffee Break	
11:30 – 13:00	Oral Talks - Parallel Sessions I	
11:30 – 13:00	**Understanding ecosystem functioning through mesocosm research I** *Moderator:* ***Jay Piggot*** *(TCD)*	Channel 1

O1. Testing mesopredator effects in large rocky shore mesocosms

Mr Hartvig Christie[1]

[1]Norwegian Institute for Water Research (NIVA), Oslo, Norway

O2. Combined impacts of brownification and iron concentration on the marine planktonic foodweb (BIPWeb)

María Segovia, Víctor Vázquez, Carolina Santana- González, David González-Santana, Librada Ramírez, Veronica Arnone, Pablo León, María López-Parages, Aud Larsen, Anna Grytaas, Carlos Jiménez, Magdalena Santana-Casiano, Melchor González-Dávila, Sergio Cañete, Tatiana Tsagaraki, Jens C. Nejstgaard, Stella A. Berger, Jorun K. Egge

[1]Department of Ecology Faculty of Sciences University of Malaga, Malaga, Spain

O3. Partitioning of phytoplankton mortality between viral lysis and microzooplankton grazing during mesocosm phytoplankton blooms

Dr Kyle Mayers[1], Dr Katrine Sandnes Skaar[1], Ms Sigrid Mugu[1], Dr Aud Larsen[1], Dr Elizabeth Harvey[2]

[1]NORCE Norwegian Research Centre, Bergen, Norway, [2]University of New Hampshire, Durham, USA

O4. Microbial respiration response under variable simulated upwelling events

Ms Isabel Baños[1], Mr Javier Arístegui[1], Ms Mar Benavides[2], Mr Moritz Baumann[3], Mr Joaquín Ortiz[3], Mr Kai Schulz[4], Ms Andrea Ludwig[3], Mr Ulf Riebesell[3]

[1]Instituto de Oceanografía y Cambio Global, IOCAG, Universidad de Las Palmas de Gran Canaria ULPGC, Spain, [2]Aix-Marseille Université , Université de Toulon, CNRS, IRD, Mediterranean Institute of Oceanography (MIO), UM 110, 13288, France, [3]GEOMAR Helmholtz Centre for Ocean Research Kiel, , Germany, [4]Centre for Coastal Biogeochemistry, School of Environment, Science and Engineering, Southern Cross University, Lismore, Australia

O5. Mismatch between primary production, chlorophyll and nutrients' availability in a Peruvian coastal upwelling: constraints for modelling primary production

Prof. Javier Arístegui[1], Nauzet Hernández-Hernández[1], Isabel Baños[1], Alba Filella[1], Dr. Lennart T. Bach[2], Dr. Kai G. Schulz[3], Elisabeth von der Esch[4], Dr. Andrea Ludwig[5], Ulf Riebesell[5]

[1]Instituto de Oceanografía y Cambio Global, IOCAG, Universidad de Las Palmas de Gran Canaria, ULPGC, Las Palmas, Spain, [2]Institute for Marine and Antarctic Studies, University of Tasmania, Hobart, Tasmania, Australia, [3]Centre for Coastal Biogeochemistry, School of Environment, Science and Engineering, Southern Cross University, Lismore, New South Wales, Australia, [4]Institute of Hydrochemistry, Chair of Analytical Chemistry and Water Chemistry, Technical University of Munich, Munich, Germany, [5]GEOMAR Helmholtz Centre for Ocean Research Kiel, Kiel, Germany

CET Time

DAY 1 Monday 12 April 2021

11:30 – 13:00 **Oral Talks - Parallel Sessions I**

11:30 – 13:00 **Climate change / Hazards and nature-based solutions I** **Channel 2**
Moderator: ***Maria Stockenreiter*** *(LMU)*

O25. Multiple agricultural stressor effects on freshwater community structure and ecosystem functioning

Mr Francesco Polazzo[1], Mr Talles Oliveira[2], Dr Alba Arenas-Sánchez[1], Dr Susana Romo[3], Prof Marco Vighi[1], Dr Andreu Rico[1]

[1]IMDEA Water Institute, Alcalà de Henares, Spagna, [2]University of Koblenz-Landau, Landau, Germany, [3]Universidad de Valencia, Valencia, Spain

O26. Interaction between heat waves and pesticide contamination on zooplankton communities: does the timing of stressor matter?

Ms Ariadna García-Astillero[1], Ms Claudia Martínez-Megías[1], Ms Alba Arenas-Sánchez[1], Mr Francesco Polazzo[1], Mr Andreu Rico[1,2]

[1]IMDEA Water Institute, Science and Technology Campus of the University of Alcalá, Alcalá de Henares, Spain, [2]Cavanilles Institute of Biodiversity and Evolutionary Biology, University of Valencia, Paterna, Spain

O27. Disentangling direct and indirect effects of agricultural run-off and climate warming on regime shifts in shallow aquatic systems

Prof. Elisabeth Maria Gross[1], Mrs. Vinita Vijayaraj[1], Dr. Joey Allen[1], Mrs Nora Kipferler[2], Mr. Bastian Polst[3], Dr. Martin Laviale[1], Dr. Gregorio A. López Moreira Mazacotte[4], Dr. Franz Hölker[4], Dr. Mechthild Schmitt-Jansen[3], Dr. Sabine Hilt[4], Dr. Joséphine Leflaive[5], Prof. Herwig Stibor[2]

[1]Université de Lorraine, LIEC UMR 7360 CNRS, Metz, France, [2]Ludwig-Maximilians University Munich, Department of Biology, Munich, Germany, [3]Helmholtz-Centre for Environmental Research UFZ, Department of Bioanalytical Ecotoxicology , Leipzig, Germany, [4]Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB), Berlin, Germany, [5]Université de Toulouse, Laboratoire d'Ecologie Fonctionnelle et Environnement UMR 5245 CNRS, Toulouse, France

O28. Impacts of Different Quality of Dissolved Organic Carbon (DOC) Pulse Disturbance on Microbial Loop: A Mesocosm Research

Ms Gulce Yalcin[1,2], Ms Dilvin Yıldız[2], Ms Melisa Metin[2], Ms Sinem Yetim[2], Ms Maria Calderó-Pascual[3], Dr Mikkel René Andersen[3], Prof Kemal Ali Ger[4], Dr Valerie McCarthy[3], Prof Erik Jeppesen[1,5], Prof Meryem Beklioğlu[1,2]

[1]Ecosystem Research and Implementation Center (EKOSAM), Middle East Technical University , 06800, Ankara, Turkey, [2]Limnology Laboratory, Biological Sciences Department, Middle East Technical University, 06800, Ankara,Turkey [3]Centre for Freshwater and Environmental Studies, Dundalk Institute of Technology, Dundalk, Marshes Upper, Co. Louth, A91 K584, Ireland, [4]Centre for Coastal, Limnological, and Marine Studies (CECLIMAR), Interdisciplinary Department, Federal University of Rio Grande do Sul, Imbé, RS, 95625-000, Brazil, [5]Department of Bioscience, Aarhus University, Vejlsøvej 25building B2.22 8600 Silkeborg , Denmark

O29. Characterisation and impact of different allochthonous organic matter additions in a mesocosm experiment investigating pulse disturbance events in Mediterranean freshwater lakes

Ms Maria Caldero Pascual[1], Ms Dilvin Yildiz[2], Ms Gülce Yalçin[2,3], Ms Melisa Metin[2], Ms Sinem Yetim[2], Ms Claudia Fiorentin[4], Dr Mikkel René Andersen[1], Dr Eleanor Jennings[1], Dr Erik Jeppesen[2,6], Dr Kemal Ali Ger[5], Dr Meryem Beklioğlu[2,3], Dr Valerie McCarthy[1]

[1]Centre for Freshwater and Environmental Studies, Dundalk Institute of Technology, Dundalk, Ireland, [2]Limnology Laboratory, Biological Sciences Department, Middle East Technical University, Ankara, Turkey, [3]Ecosystem Research and Implementation Centre, Middle East Technical University, Ankara, Turkey, [4]Public Institution Natura Histrica, Pula, Croacia, [5]Centre for Coastal, Limnological, and Marine Studies (CECLIMAR), Interdisciplinary Department, Federal University of Rio Grande do Sul, Imbé, Brazil, [6]Department of Bioscience, Aarhus University, Aarhus, Denmark

13:00 – 14:00 **Lunch Break**

CET Time

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DAY 1 Monday 12 April 2021

14:00 – 14:45 **Keynote Lecture I** Channel 1
Moderator: ***Paraskevi Pitta*** *(HCMR)*

Understanding microbial population dynamics in mesocosms. Applying simple principles to a complex system
Speaker: **Frede Thingstad**
UNIVERSITY OF BERGEN, NORWAY

14:45 – 15:00 **Coffee Break**

15:00 – 16:15 **Oral Talks - Parallel Sessions II**

15:00 – 16:15 **Understanding ecosystem through mesocosm research II** Channel 1
Moderator: ***Zsofia Horvath*** *(MTA)*

O6. The impact of eutrophication and warming on freshwater macrofauna communities and its effect on the diffusive and ebullitive methane emission from aquatic ecosystems

Mr Quinten Struik[1], Mrs Annelies Veraart[1], Mr Ralf Aben[1], Mr Thomas Davidson[2], Mrs Sarian Kosten[1]

[1]Radboud University, Nijmegen, The Netherlands, [2]Aarhus University, Aarhus, Denmark

O7. Changes in phytoplankton structure and size distributions in response to nutrient and temperature variations: high-throughput analysis of multi-years mesocosm data

Ms Veronika Dashkova[1,2], Mr Dmitry V Malashenkov[3], Ms Assel Baishulakova[1], Mr Thomas A Davidson[4], Mr Ivan A Vorobjev[1,5], Mr Erik Jeppesen[4,6,7,8], Ms Natasha S Barteneva[1,5,9]

[1]School of Science and Humanities, Nazarbayev University, Nur-Sultan, Kazakhstan, [2]School of Engineering and Digital Sciences, Nazarbayev University, , Kazakhstan, [3]Department of Hydrobiology, Moscow State University, Moscow, Russian Federation, [4]Department of Bioscience, Aarhus University, Silkeborg, Denmark, [5]National Laboratory Astana, Nur-Sultan, Kazakhstan, [6]Sino-Danish Centre for Education and Research, Beijing, China, [7]Limnology Laboratory, Department of Biological Sciences and Centre for Ecosystem Research and Implementation, Middle East Technical University, Ankara, Turkey, [8]Institute of Marine Sciences, Middle East Technical University, Mersin, Turkey, [9]The Environmental Research and Efficiency Cluster (EREC), Nazarbayev University, Nur-Sultan, Kazakhstan

O8. An integrated assessment of ecological stability in plankton communities to multiple disturbances across time and space

Dr Pablo Urrutia Cordero[1,2,3], Prof. Silke Langenheder[1], Dr Maren Striebel[3], Dr David Angeler[4], Prof Stefan Bertilsson[4], Prof Peter Eklöv[1], Prof Lars-Anders Hansson[5], Egle Kelpsiene[6], Prof Hjalmar Laudon[7], Maria Lundgren[8], Dr Linda Parkfelt[9], Dr Ian Donohue[10], Prof Helmut Hillebrand[2,3,11]

[1]Department of Ecology and Genetics/Limnology, Uppsala University,, Uppsala, Sweden, [2]Plankton Ecology Lab, Institute for Chemistry and Biology of the Marine Environment, Carl von Ossietzky University Oldenburg, Oldenburg, Germany, [3]Helmholtz-Institute for Functional Marine Biodiversity at the University of Oldenburg [HIFMB], Oldenburg, Germany, [4]Department of Aquatic Sciences and Assessment, Swedish University of Agricultural Sciences, Uppsala, Sweden, [5]Department of Biology/Aquatic Ecology, Lund University, Lund, Sweden, [6]Department of Biochemistry and Structural Biology, Lund University, Lund, Sweden, [7]Forest Ecology and Management, Swedish University of Agricultural Sciences, Umeå, Sweden, [8]Linnaeus University, Department of Biology and Environmental Science, Kalmar, Sweden, [9]Sweden Water Research AB, Lund, Sweden,, [10]Department of Zoology, School of Natural Sciences, Trinity College Dublin, Dublin, Ireland, [11]Alfred-Wegener-Institute, Helmholtz-Centre for Polar and Marine Research, Bremerhaven, Germany

O9. Effects of a Microplastics Mixture on the Food Web of Shallow Lakes: An In-Situ Mesocosm Experiment

Dr. Heidrun Feuchtmayr[5], Dr Meryem Beklioglu[1], Dilvin Yıldız[2], Gülce Yalçın[1], Assoc.Prof. Boris Jovanović[2], Professor David S. Boukal[3], Lucie Vebrova[3], Derya Riha[3], Jelena Stanković[4], Dimitrija Savić-Zdraković[4], Melisa Metin[1], Yasmin Naz Akyürek[1], Deniz Balkanlı[1], Professor Djuradj Milošević[4], Dr. Jessica A. Richardson[5]

[1]Limnology Lab & Ecosystem Research and Implementation Centre, Middle East Technical University , Ankara, Turkey, [2]Department of Natural Resource Ecology and Management, Iowa State University, Ames, IA, USA, , USA,, [3]Department of Ecosystem Biology, University of South Bohemia, České Budějovice, Czech Republic, Czech Republic , [4]Department of biology and ecology, Faculty of Sciences and Mathematics, University of Niš, Niš, Serbia, , Serbia, [5]UK Centre for Ecology & Hydrology, Lancaster Environment Centre, Lancaster, UK

CET Time

DAY 1 Monday 12 April 2021

15:00 – 16:15 Oral Talks - Parallel Sessions II

15:00 – 16:15 Climate change / Hazards and nature-based solutions II

Channel 2

Moderator: ***Johan Wikner*** *(UMU)*

O30. The use of lotic mesocosms as a tool to study the direct and indirect effects of organic and inorganic chemical substances on freshwater ecosystems

Ms Sandrine Joachim[1], Mr Rémy Beaudouin[1], Mr. Jean-Marc Porcher[1]

[1]INERIS, Verneuil-en-halatte, France

O31. Operation efficiency of two-stage hydrophyte mesocosm for waste water treatment

Dr Yurii Krot[1], Dr Ihor Konovets[1], Dr Mariia Goncharova[1]

[1]Institute of Hydrobiology NAS of Ukraine, Kyiv, Ukraine

O32. Viral and prokaryotic community responses upon exposure to silver nanoparticles versus silver ions in coastal seawater

Dr Anastasia Tsiola[1], Dr Paraskevi Pitta[1], Dr Alan Barozzi[2], Mr Michalis Chronakis[3], Dr Ioanna Kalantzi[1], Mr Iordanis Magiopoulos[1], Mr Emmanouil Mavrakis[3], Dr Gregoire Michoud[2], Prof Spiros Pergantis[3], Prof Daniele Daffonchio[2], Dr Manolis Tsapakis[1]

[1]Hellenic Centre for Marine Research, Institute of Oceanography, Heraklion Crete, Greece, [2]King Abdullah University of Science and Technology (KAUST), Biological and Environmental Sciences and Engineering Division (BESE), Thuwal, Saudi Arabia, [3]Environmental Chemical Processes Laboratory, Department of Chemistry, University of Crete, Heraklion Crete, Greece

O33. Short term resilience to nanosilver in the protist-metazoan planktonic food web

Ms Katerina Symiakaki[1], Dr Anastasia Tsiola[1], Mr Iordanis Magiopoulos[1], Dr Tim Walles[2], Dr Jens C. Nejstgaard[2], Dr Manolis Tsapakis[1], Dr Paraskevi Pitta[1], Dr Hans H. Jakobsen[3]

[1]Hellenic Centre for Marine Research (HCMR), Heraklion, Greece, [2]Leibniz Institute for Freshwater Ecology and Inland Fisheries (IGB), , Germany, [3]Department of Bioscience, Aarhus University, Roskilde, Denmark

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CET Time

DAY 2 Tuesday 13 April 2021

11:00 - 11:20 **AQUACOSM & AQUACOSM –plus Activities I** **Channel 1**
Moderator: ***Silke Langenheder*** *(UU)*

Transnational Access at AQUACOSM and AQUACOSM-plus facilities
Speaker: **Stella Berger** (FVB- IGB)

11:20 – 11:30 **Coffee Break**

11:30 – 13:00 **Oral Talks- Parallel Sessions III**

11:30 – 13:00 **Understanding ecosystem functioning through mesocosm research III** **Channel 1**
Moderator: ***Meryem Beklioglu*** *(METU)*

O10. Staying put or moving on? The influence of a fine sediment pulse on benthic and drifting invertebrates
Dr Tory Milner[1], Professor Ian Maddock[2], Dr Iwan Jones[3], Dr George Bunting[2]
[1]University of Huddersfield, Huddersfield, United Kingdom, [2]University of Worcester, Worcester, United Kingdom, [3]Queen Mary University of London, London, United Kingdom

O11. Mean emergence time and biodiversity of the emerging insect community in outdoor mesocosms over a span of six years
Mr Lukas Kruckenfellner[1], Mr Juergen Schmidt[1], Prof. Dr. Klaus Peter Ebke[1]
[1]Mesocosm GmbH, Homberg/Ohm, Germany

O12. Value of mesocosm studies in explaining causality at deviations in long-term ecological time series: The Gulf of Bothnia case
Prof. Johan Wikner[1]
[1]Umeå Univeristy, Umeå, Sweden

O13. Reconstructing food webs in a multi-site mesocosm facility - Iberian Pond Network
Dr Zeynep Ersoy[1], Cátia L. Pereira[1,2,3], Thomas P. Gilbert[4,5], Miguel B. Araujo[1,3], Miguel G. Matias[1,3]
[1]Rui Nabeiro Biodiversity Chair, MED – Mediterranean Institute for Agriculture, Environment and Development, Universidade de Évora, Évora, Portugal, [2]Center for Macroecology, Evolution and Climate, Globe Institute, University of Copenhagen, Copenhagen, Denmark, [3]Museo Nacional de Ciencias Naturales, CSIC, Madrid, Spain, [4]Centre for Evolutionary Hologenomics, Globe Institute, University of Copenhagen, Copenhagen, Denmark, [5]University Museum, NTNU, Trondheim, Norway

O14. Eco-evolutionary effects of invasive crayfish on aquatic ecosystems:call for a long-term and cooperative research effort
Dr Olivier Dezerald[1], Ms Caroline Go rzerino[1], Mr Damien Fourcy[1], Mr Marc Collinet[1], Ms Julie Coudreuse[2], Dr Eric Edeline[1]
[1]INRAE, Rennes, France, [2]Institut Agro, Rennes, France

CET Time

DAY 2 Tuesday 13 April 2021

11:30 – 13:00 Oral Talks- Parallel Sessions III

11:30 – 13:00 Climate change / Hazards and nature-based solutions III — Channel 2
Moderator: ***Tatiana M. Tsagaraki*** *(UIB)*

O34. Ocean winter warming induced starvation of predator and prey
Dr Frank Melzner[1]
[1]GEOMAR, Kiel, Germany

O35. Means and extremes - effects of climate warming scenarios on plankton communities
Ms Huong Huynh Ngoc Thu[1], Ms Zsófia Horváth[2], Mr Péter Dobosy[2], Ms Vivivien Kardos[2], Mr K Pálffy[2], Ms B Szabó[2], Mr CF Vad[2]
[1]Eötvös Loránd University, Budapest, Hungary, Budapest, Hungary, [2]Balaton Limnological Institute, Centre for Ecological Research, Tihany, Hungary, Tihany, Hungary

O36. No rapid adaptation to heatwaves in semi-natural populations with manipulated evolutionary potential
Dr Stew Plaistow, Dr Franziska Brunner, Dr Alan Reynolds, Dr Ian Wilson, Dr Stephen Price, Prof. David Atkinson, Prof. Steve Paterson
[1]University of Liverpool, Liverpool, UK

O37. Warming reduces the phytoplankton spring bloom and shifts planktonic composition and succession: an *in situ* mesocosm experiment in a French Mediterranean coastal lagoon supporting *in situ* observations
Trombetta Thomas[1]*, Francesca Vidussi[1], Justine Courboulès[1], Sébastien Mas[2], Behzad Mostajir[1]
[1]MARBEC (Marine Biodiversity, Exploitation and Conservation), Univ Montpellier, CNRS, Ifremer, IRD, Montpellier, France., [2]MEDIMEER (Mediterranean platform for Marine Ecosystems Experimental Research), OSU OREME, Univ Montpellier, CNRS, IRD, IRSTEA, Sète, France

O38. Temperature fluctuation effects on a natural phytoplankton community depend on the frequency but do not diminish ecosystem functioning: a mesocosm experiment
Dr Maren Striebel[1], Charlotte Kunze[1], Marrit Jacob[1], Niklas Franke[1], Prof. Helmut Hillebrand[1,2]
[1]University of Oldenburg, Wilhelmshaven, Germany, [2]Helmholtz-Institute for Functional Marine Biodiversity at the University of Oldenburg [HIFMB], Oldenburg, Germany

13:00 – 14:00 Lunch Break

14:00 – 14:45 Keynote Lecture II — Channel 1
Moderator: ***Behzad Mostajir*** *(CNRS – MARBEC)*

Mesocosm research on carbon dioxide removal approaches
Speaker: **Ulf Riebesell**
GEOMAR, HELMHOLTZ CENTRE FOR OCEAN RESEARCH KIEL, GERMANY

Program

CET Time

AQUACOSM

DAY 3 Wednesday 14 April 2021

11:00 - 11:20 **AQUACOSM & AQUACOSM –plus Activities II** **Channel 1**
Moderator: ***Heidrun Feuchtmayr*** *(UKRI)*

AQUACOSM Joint Mesocosm Experiments (JOMEX)
Speaker: **Herwig Stibor** (LMU)

11:20 – 11:30 **Coffee Break**

11:30 – 13:00 **Oral Talks- Parallel Sessions IV**

11:30 – 13:00 **Understanding ecosystem functioning through mesocosm research IV** **Channel 1**
Moderator: ***Stella Berger*** *(FVB- IGB)*

O15. Phytoplankton rare species loss effect on ecosystem functioning is nutrient context dependent

Dr Miriam Gerhard[1], MSc Alexandra Schlenker[1,2,3], Prof. Dr. Helmut Hillebrand[1,4,5], PD Maren Striebel[1]

[1]Institute for Chemistry and Biology of Marine Environments (ICBM), Carl-von-Ossietzky University Oldenburg, Oldenburg, Germany, [2]Institute of Hydrobiology, Dresden University of Technology, Dresden, Germany, [3]Experimental Aquatic Ecology, Department of River Ecology, Helmholtz Centre for Environmental Research, Leipzig, Germany, [4]Helmholtz-Institute for Functional Marine Biodiversity at the University of Oldenburg, Oldenburg, Germany, [5]Alfred Wegener Institute, Helmholtz-Centre for Polar and Marine Research, Bremerhaven, Germany

O16. Zooplankton diel vertical and horizontal migration across dissolved oxygen concentrations in replicated lake systems

Prof. Jason Stockwell[1], Prof. Jonathan Doubek[2], Ms. Rosaura Chapina[1], Dr. Sarah Fiorini[3], Dr. Gérard Lacroix[4], Mr. Jonathan Rickwood[1], Ms. Heather Wander[5], Ms. Savannah Zigic[1]

[1]University of Vermont, Burlington, United States, [2]Lake Superior State University, Sault Ste Marie, United States, [3]CNRS-CEREEP-Ecotron IleDeFrance, Saint Pierre-lès-Nemours, France, [4]iEES-Paris, Institut d'Ecologie et des Sciences de l'Environnement de Paris, Paris, France, [5]Virginia Tech, Blacksburg, United States

O17. Performance of evolutionarily divergent three-spined sticklebacks (Gasterosteus aculeatus) and eco-evolutionary feedback in sympatric metapopulations

Mr Juan Camilo Cubillos Moreno[1], Gerard Lacroix[2,3], Sarah Fiorini[3], Gabriele Gerlach[1], Arne W. Nolte[1]

[1]Carl von Ossietzky University of Oldenburg, Institute of Biology and Environmental Sciences (IBU), Oldenburg, Germany [2]Sorbonne Université, Université Paris Diderot, UPEC, CNRS, INRA, IRD, Institut d'Ecologie et desSciences de l'Environnement de Paris (iEES-Paris), Paris, France

[3]Ecole Normale Supérieure, PSL Research University, CNRS, Centre de recherche en écologieexpérimentale et prédictive (CEREEP-Ecotron IleDeFrance, Saint-Pierre-lès-Nemours, France

O18. Mesocosm research on the effects of nutrient limitation on periphyton quality

Dr Carolina Trochine[1], Dr Florencia Cuassolo[1], Dr Ursula Strandberg[2], Dr Thomas Davidson[3], Prof. Dr. Erik Jeppesen[3,4]

[1]Department of Ecology, INIBIOMA CONICET-Universidad Nacional del Comahue, San Carlos de Bariloche, Argentina, [2]Department of Environmental and Biological Sciences, University of Eastern Finland , Joensuu, Finland, [3]Department of Bioscience, Aarhus University, Silkeborg, Denmark, [4]Department of Biology, Middle Easter Technological University, Ankara, Turkey

O19. Floating wetlands and their potential for nitrogen removal in estuarine waters: a mesocosm study

Ms Isabel Sanchez-viruet[1], PhD Lora Harris[1], PhD Jeremy Testa[1], Allan Straughan[2]

[1]University of Maryland Center for Environmental Science, Solomons, United States of America, [2]Koolhof Earth, Pasadena, United States of America

DAY 3 Wednesday 14 April 2021

11:30 – 13:00 Oral Talks- Parallel Sessions IV

11:30 – 13:00 Climate change / Hazards and nature-based solutions IV

Channel 2

Moderator: ***Marko Reinikainen*** *(AIRCLIM)*

O39. Phytoplankton diversity and functional traits under extreme climate events simulated by a pelagic mesocosm experiment

Dr Serena Rasconi[1], Frédéric Rimet[1], Louise Campione[1,2], Isabelle Domaizon[1], Stéphan Jacquet[1], Viet Tran-Khac[1], Philippe Quetin[1], Pascal Perney[1], Laura Crépin[1], Laurent Espinat[1], Clémentine Gallot[1,3]

[1]INRAE CARRTEL, Thonon les Bains, France, [2]GREBE eau sol environnement, Lyon , France, [3]Laboratoire d'Océanologie et de Géosciences, France

O40. Zooplankton dominance shift in response to changing salinity in the Baltic Sea

Ms Clio Hall[1], Dr. Aleksandra Lewandowska[1]

[1]Tvärminne Zoological Station, University of Helsinki, J.A. Palméns väg 260, FI-10900, Finland

O41. Dispersal increases recovery of ecosystem productivity after an extreme climatic event

Dr Csaba Vad[1,2,3], Dr András Abonyi[1], Dr Mia M Bengtsson[4], Anett Hanny-Endrédi[2], Dr Pavel Kratina[5], Dr Ekaterina Mironova[6], Dr David S Murray[7], Dr Adam Petrusek[8], Christian Preiler[1], Dr Larysa Samchyshyna[9], Dr Evangelia Smeti[10], Dr Sofie Spatharis[11], Dr Hanrong Tan[5], Dr Ioannis Tsakalakis[12], Dr Robert Ptacnik[1]

[1]WasserCluster Lunz, Lunz am See, Austria, [2]Balaton Limnological Institute, Centre for Ecological Research, Tihany, Hungary, [3]Laboratory of Aquatic Ecology, Evolution and Conservation, KU Leuven, Leuven, Belgium, [4]Institute of Microbiology, University of Greifswald, Greifswald, Germany, [5]School of Biological and Chemical Sciences, Queen Mary University of London, London, UK, [6]A.N. Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences , Moscow, Russia, [7]School of Biological Sciences, University of East Anglia, Norwich, UK, [8]Department of Ecology, Faculty of Science, Charles University, Prague, Czech Republic, [9]Institute of Evolutionary Ecology of NAS of Ukraine, Kyiv, Ukraine, [10]Institute of Marine Biological Resources and Inland Waters, Hellenic Centre for Marine Research, Anavyssos, Greece, [11]School of Life Sciences, University of Glasgow, Glasgow, UK, [12]Institute for Chemistry and Biology of the Marine Environment (ICBM), University of Oldenburg, Oldenburg, Germany

O42. Ocean Acidification impacts on elemental stoichiometry: A data synthesis of in situ mesocosm experiments

Dr Jan Taucher[1], Dr Tim Boxhammer[1], Dr Lennart Bach[2], Dr Allanah Paul[1], Dr Markus Schartau[1], Dr Friederike Prowe[1], Dr Karin Kvale[1], Prof Ulf Riebesell[1]

[1]GEOMAR Helmholtz Centre for Ocean Research, Kiel, Germany, [2]Institute for Marine and Antarctic Studies, University of Tasmania, Hobart, Australia

O43. Mesocosm approaches addressing the role of environmental variability in a changing climate

Dr Christian Pansch-Hattich[1], Dr. Martin Wahl[2]

[1]Abo Akademi University , Turku, Finland, [2]GEOMAR Kiel, Kiel, Germany

13:00 – 14:00 Lunch Break

14:00 – 14:45 Keynote Lecture III

Channel 1

Moderator: ***Lisette Senerpont Domis*** *(NIOO- KNAW)*

A mesocosm experiment to question foundational concepts in marine microbiology

Speaker: **Flora Vincent**

WEIZMANN INSTITUTE OF SCIENCE, ISRAEL

14:45 – 15:00 Coffee Break

AQUA COSM

DAY 3 Wednesday 14 April 2021

15:00 – 16:15 Poster Session I – Parallel Sessions

15:00 – 16:15 Understanding ecosystem functioning through mesocosm research I — Channel 1

EP1. Dispersal limitation leads to trophic downgrading of the microbial food web in freshwater metacommunities

Dr Mia Bengtsson[1,2], Mr Robert Ptacnik[2,1], Dr S Lena Eggers[3,1], Dipl Ing Christian Preiler[1], MA Thersa Lumpi[7,1], Dr Zsófia Horváth[6,1], Dr Csaba F Vad[6,1], Dr Alexey Ryabov[4], Dr Steven Declerck[5], Dr Robert Ptacnik[1]

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EP2. The metabolic landscape evolving during algal bloom succession as revealed by an exometabolomics approach

Dr Constanze Kuhlisch[1], Dr Guy Schleyer[1], Prof. Assaf Vardi[1]

[1]Weizmann Institute of Science, Rehovot, Israel

EP3. Competition and coexistance patterns in the microbial plankton of an oligotrophic sea

Dr Ioulia Santi[1,2], Prof Dr Tron Frede Thingstad[3], Dr Tatiana Margo Tsagaraki[3], Dr Shunyan Cheung[4], Dr Antonia Giannakourou[6], Dr Panagiotis Kasapidis[1], Mr Iordanis Magiopoulos[7], Mr Eftihis Nikiforakis[5], Dr Andreas Oikonomou[7], Dr Nafsika Papageorgiou[5], Dr Christina Pavloudi[1], Dr Stella Psarra[7], Ms Katerina Symiakaki[7], Mr Xiaodong Zhang[4], Dr Paraskevi Pitta[7]

[1]Hellenic Centre for Marine Research (HCMR), Institute of Marine Biology, Biotechnology and Aquaculture (IMBBC), Heraklion, Crete, Greece, [2]EMBRC-ERIC Headquarters, Sorbonne Université, Paris, France, [3]University of Bergen, Bergen, Norway, [4]The Hong Kong University of Science and Technology, Hong Kong, China, [5]Department of Biology, University of Crete, Heraklion, Crete, Greece, [6]Hellenic Centre for Marine Research (HCMR), Institute of Oceanography, Anavissos, Greece, [7]Hellenic Centre for Marine Research (HCMR), Institute of Oceanography, Heraklion, Crete, Greece

EP4. Modelling early larval growth (and more) of the Peruvian anchovy (Engraulis ringens)

Ms Fanny Rioual[1], Dr Claudia Ofelio[2], Ms Maryandrea Rosado-Salazar[1], Mr Jhon Dionicio-Acedo[1], Dr Arturo Aguirre-Velarde[1]

[1]Laboratorio de Ecofisiología Acuática, Instituto del Mar del Peru (IMARPE), Callao, Peru, [2]Institute of Marine Ecosystem and Fisheries Science (IMF), University of Hamburg, Hamburg, Germany

EP5. Assessing the dynamics of the microbial plankton community in mesocosms experiments using a NPZD model

Dr Jose González[1], Dr Emilio Fernández[1], Dr Francisco G. Figueiras[2]

[1]Centro de Investigacións Mariñas - Universidade de Vigo, Vigo, Spain, [2]Instituto de Investigacións Mariñas, CSIC, Vigo, Spain

EP6. Identifying keystone species

Ziga Ogorelec[1], Carsten Wunsch[1], Dr. Alessandra Kunzmann[1], Pelita Octorina[1], Dr Jana Isanta-Navarro[1,2]

[1]University of Konstanz, Limnological Institute , Konstanz, Germany, [2]Flathead Lake Biological Station, Polson, USA

EP7. Effects of added humic substances and nutrients on photochemical degradation of dissolved organic matter in a mesocosm amendment experiment in the Gulf of Finland

Ms Kun Ma[1], Dr. Jay Brandes[1]

[1]Skidaway Institute of Oceanography, Department of Marine Sciences, University of Georgia, Savannah, USA

EP8. The presence of silver nanoparticles reduces demand for dissolved phosphorus to the benefit of biological nitrogen fixation in the coastal eastern Mediterranean Sea

Ms Eleonora Faraggiana[1,2,3], Dr Karen Tait[1], Dr Mauro Celussi[4], Ms Eleni Dafnomilli[5], Dr Vincenzo Manna[4], Dr Andrew Manning[1], Ms Snežana Živanović[5], Dr Andy Rees[1]

[1]Plymouth Marine Laboratory, Plymouth, United Kingdom, [2]University of Plymouth, Plymouth, United Kingdom, [3]Ca' Foscari University of Venice, Venice, Italy, [4]Istituto Nazionale di Oceanografia e di Geofisica Sperimentale, Trieste, Italy, [5]Hellenic Centre for Marine Research, Heraklion, Greece,

DAY 3 Wednesday 14 April 2021

15:00 – 16:15 Poster Session I – Parallel Sessions

15:00 – 16:15 Understanding ecosystem functioning through mesocosm research I — Channel 1

EP9. Phytoplankton dynamics and productivity modeling from remote sensing and limnological measurements- the Lake Maggiore experiment

Ms Ilaria Cesana[1], Dr Mariano Bresciani[2], Prof Sergio Cogliati[1], Dr Claudia Giardino[2], Ms Remika Gupana[3,4], Dr Dario Manca[5], Dr Stefano Santabarbara[6], Dr Monica Pinardi[2], Dr Federica Braga[7], Ms Martina Austoni[8], Dr Andrea Lami[5], Prof Roberto Colombo[1]

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EP10. Evaluating stream CO2 outgassing via drifting and anchored flux chambers in a controlled flume experiment

Dr Filippo Vingiani[1], Nicola Durighetto[1], Marcus Klaus[2], Jakob Schelker[3,4], Thierry Labasque[5], Gianluca Botter[1]

[1]Department of Civil, Environmental and Architectural Engineering, University of Padua, Padua, [2]Department of Forest Ecology and Management, Swedish University of Agricultural Sciences, Umeå [3]Department of Limnology and Oceanography, University of Vienna, Vienna, [4]WasserCluster Lunz GmbH, Lunz am See, , [5]Géosciences Rennes, Université de Rennes 1, Rennes

EP11. Elevated temperature results in higher compositional variability of pioneer phytoplankton communities in a mesocosm system

Dr Károly Pálffy[1], Dr. Attila Kovács[2], Ms. Vivien Kardos[1], Ms. Imola Hausz[3], Dr. Gergely Boros[2]

[1]Centre for Ecological Research, Budapest, Hungary, [2]Balaton Limnological Institute, Tihany, Hungary, [3]Directorate for Defence Health Issues, Hungarian Defence Forces Medical Centre, Budapest, Hungary

EP12. Carbon:Nitrogen Relationships in Freshwater Closed Ecological Systems

Prof. Frieda Taub[1]

[1]School of Aquatic and Fishery Sciences, University of Washington, Seattle, USA

EP13. Effects of starvation on the respiration rate and motility of the copepod Limnocalanus macrurus in a mesocosm experiment

Dr Larysa Samchyshyna, Ms Ezgi Emiş Türkeri, Dr Larysa Samchyshyna, Prof. Melek İşinibilir Okyar, Dr Yuliia Hromova, Prof Ahmet Erkan Kıdeyş, Prof Maiju Lehtiniemi, Dr Outi Setälä, Prof Jukka Seppälä, Mr Lucka Schenone, Prof Montse Sala, Mr Ulice Lora, Dr Leonid Svetlichny

[1]Institute of Zoology NASU, Kyiv, Ukraine

DAY 3 Wednesday 14 April 2021

15:00 – 16:15 Poster Session I – Parallel Sessions

15:00 – 16:15 Climate change / Hazards and nature-based solutions — Channel 2

EP27. Effects of brownification in a highly productive coastal sea: a mesocosm experiment in the Baltic Sea

Dr Kristian Spilling[1], Dr Eero Asmala[2], Dr. Lumi Haraguchi[1], MSc Kaisa Kraft[1], MSc Anne-Mari Lehto[1], Dr Aleksandra Lewandowska[2], Dr Joanna Norkko[2], Dr Jonna Piiparinen[1], Dr Jukka Seppälä[1], MSc Mari Vanharanta[1,2], Dr Anu Vehmaa[2], MSc Pasi Ylöstalo[1], Dr Timo Tamminen[1]

[1]Finnish Environment Institute, Helsinki, Finland, [2]Tvärminne Zoological Station, University of Helsinki, Hanko, Finland

EP28. Patterns and processes of ch4 production and oxidation in different habitats of a freshwater mesocosm system

Ms Chiara Esposito[1,2], Mr ThomasP.A. Nijman[3], Mr Joachim Audet[1,2], Ms Eti E. Levi[1,2], Ms Annelies J. Veraart[3], Mr Thomas A. Davidson[1,2]

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EP29. Mixotrophs may benefit from reduced top-down control by crustacean zooplankton in the recovery phase after a heatwave

Dr Robert Fischer[1], Dr Andras Abonyi[1], Dr Mia Bengtsson[2], MSc Marina Ivankovic[1], Dr Robert Ptacnik[1], Dr Csaba Vad[1,3,4]

[1]WasserCluster Lunz , Lunz am See, Austria, [2]University of Greifswald, Institute of Microbiology, Greifswald, Germany, [3]Balaton Limnological Institute, Centre for Ecological Research , Tihany, Hungary, [4]KU Leuven, Laboratory of Aquatic Ecology, Evolution and Conversation, Leuven, Belgium

EP30. The differential response of marine plankton in the Mediterranean Sea to chronic exposure of silver nanoparticles and silver ion

Dr Yingdong Li[1], Dr Hongbin Liu[1]

[1]Hongkong, Hongkong, Hongkong

DAY 4 Thursday 15 April 2021

11:00 - 11:20 **AQUACOSM & AQUACOSM –plus Activities III** Channel 1
Moderator: ***Eric Jeppessen*** *(AU)*

Communicating grand challenges in aquatic ecology during a grand challenge - report from the AQUACOSM-plus webinar series
Speaker: **Robert Ptacnik** (WCL)

11:20 – 11:30 **Coffee Break**

11:30 – 13:00 **Oral Talks- Parallel Sessions V** Channel 1

11:30 – 13:00 **Understanding ecosystem functioning through mesocosm research V**
Moderator: ***Johan Wikner*** *(UU)*

O20. Estimating metabolic rates in a mesocosm experiment to investigate the effects of increased water temperature and agricultural run-off on shallow lake ecosystem functioning and resilience
Dr Gregorio Alejandro López Moreira Mazacotte[1], Nora Kipferler[2], Vinita Vijayaraj[3], Bastian Polst[4], Dr. Joey Allen[3,5], Dr. Martin Laviale[3], Dr. Joséphine Leflaive[5], Dr. Mechthild Schmitt-Jansen[4], Dr. Elisabeth Gross[3], Dr. Herwig Stibor[2], Dr. Sabine Hilt[1], Dr. Franz Hölker[1]

[1]Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB), Berlin, Germany, [2]Ludwig-Maximilians University Munich, Department of Biology, Munich, Germany, [3]Université de Lorraine, LIEC UMR 7360 CNRS, Metz, France, [4]Helmholtz-Centre for Environmental Research – UFZ, Department of Bioanalytical Ecotoxicology, Leipzig, Germany, [5]Université de Toulouse, ECOLAB UMR 5245 CNRS, Toulouse, France

O21. HyTec- flume experiments at different scales evidencing different responses of fish, algae and macroinvertebrates to combined hydropeaking and thermopeaking
Dr Lisa Schülting[1], Dr Elisabeth Bondar-Kunze[1], MSc Stefan Auer[1]

[1]University of Natural Resources and Life Science, Vienna, Vienna, Austria

O22. Effects of heat waves on virioplankton and virus-driven processes in the planktonic food web - the viral component of the HeatPlank3R- mesocosm experiment Summer in Spring
Dr Andrea Malits[1], M Sc Clara Natalia Rodríguez Flórez[1], M Sc Tanguy Soulié[2], Dr Sébastien Mas[3], Dr Francesca Vidussi[2], Dr Behzad Mostajir[2]

[1]Biological Oceanography Laboratory, Austral Center for Scientific Research (CONICET), Ushuaia, Argentina, [2]Marine Biodiversity, Exploitation and Conservation (MARBEC), Univ Montpellier, CNRS, Ifremer, IRD, Montpellier, France, [3]MEDIMEER (Mediterranean platform for Marine Ecosystems Experimental Research), OSU OREME, Univ Montpellier, CNRS, IRD, IRSTEA, Sète, France

O23. Investigating the microzooplankton "black box" under warming: Top-down control and micrograzer interactions in a spring bloom community in a coastal lagoon in the North-West Mediterranean Sea
Ms Katharina Bading[1], Dr. Justine Courboulès[2], Dr. Thomas Trombetta[2], Dr. Sebastien Mas[2,3], Dr. Francesca Vidussi[2], Dr. Behzad Mostajir[2], Dr. Nicole Aberle[1]

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O24. Dust-associated airborne microbes affect primary and bacterial production and N2 fixation rates: a mesocosm approach
Dr Eyal Rahav[1], Dr Esra Mescioglu[2], Dr Adina Paytan[2], Prof. Barak Herut[1]

[1]Israel Oceanographic and Limnological Research, Haifa, Israel, [2]University of California, Santa Cruz, USA

DAY 4 Thursday 15 April 2021

11:30 – 13:00 **Oral Talks- Parallel Sessions V** **Channel 2**

11:30 – 13:00 **Methodology and Technology in mesocosm research**
Moderator: ***Ulf Riebesell*** *(GEOMAR)*

O44. Fine-tuning biodiversity assessments of a multi-site mesocosm network by pairing eDNA metabarcoding and morphological approaches

Ms Cátia Lúcio Pereira[1,2,3], Dr Zeynep Ersoy[2], Dr M. Thomas P. Gilbert[4,5], Dr Miguel B. Araujo[1,2,3], Dr Miguel Matias[2,3]

[1]Center for Macroecology, Evolution and Climate, Globe Institute, University of Copenhagen, Copenhagen, Denmark, [2]Rui Nabeiro Biodiversity Chair, MED – Mediterranean Institute for Agriculture, Environment and Development, University of Evora, Evora, Portugal, [3]Museo Nacional de Ciencias Naturales, CSIC, Madrid, Spain, [4]Centre for Evolutionary Hologenomics, Globe Institute, University of Copenhagen, Copenhagen, Denmark, [5]University Museum, NTNU, Trondheim, Norway

O45. Sensor technology provides early warning signals for functional destabilization of phytoplankton communities by lake salinization

Dr Pablo Urrutia Cordero[1], Norman Gobeler[2], Samuel Hylander[3], Ola Langvall[4], Lovisa Lind Eirell[5], Maria Lundgren[3], Sofia Papadopoulou[1], Maren Striebel[6], Gesa Weyhenmeyer[1], Silke Langenheder[1]

[1]Department of Ecology and Genetics/Limnology, Uppsala University, , Sweden, [2]Tvärminne Zoological Station, University of Helsink, , Finland, [3]Linnaeus University, Department of Biology and Environmental Science, , Sweden, [4]Unit for Field-based Forest Research, Swedish University of Agricultural Sciences, , Sweden, [5]Department of Environmental and Life Sciences, Karlstad University, , Sweden, [6]Plankton Ecology Lab, Institute for Chemistry and Biology of the Marine Environment, Carl von Ossietzky University Oldenburg, , Germany

O46. Latest advances in the on-going development of the FlowCam

Mr Harry Nelson[1]

[1]Yokogawa Fluid Imaging Technologies, Scarborough, United States

O47. Zooming in on host-virus dynamics of a blooming algae one cell at a time

Dr Gur Hevroni[1], Dr Flora Vincent[1], Dr Chuan Ku[2], Dr Uri Sheyn[3], Dr Daniella Schatz[1], Prof Assaf Vardi[1]

[1]Department of Plant and Environmental Sciences, Weizmann Institute of Science, Rehovot, Israel, [2]Institute of Plant and Microbial Biology, Academia Sinica, , Taiwan, [3]Department of Oceanography, School of Ocean and Earth Science and Technology, University of Hawai'i at Manoa, Honolulu, USA

O48. Effects of multiple stressors on shallow freshwater habitats - suspended mesocosms mimicking a benthic-pelagic habitat

Ms Nora Kipferler[1], Ms Vinita Vijayaraj[2], Dr. Gregorio A. López Moreira M.[3], Dr. Franz Hölker[3], Dr. Sabine Hilt[3], Bastian H. Polst[4], Dr. Mechthild Schmitt-Jansen[4], Joey Allen[5], Dr. Joséphine Leflaive[5], Prof. Elisabeth M. Gross[2], Prof. Herwig Stibor[1]

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13:00 – 14:00 **Lunch Break**

14:00 – 14:45 **Keynote Lecture IV** **Channel 1**
Moderator: ***Herwig Stibor*** *(LMU)*

Studies across scales to understand impacts of environmental change

Speaker: **Shelley Arnott**

QUEEN'S UNIVERSITY, CANADA

14:45 – 15:00 **Coffee Break**

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CET Time

DAY 4 Thursday 15 April 2021

15:00 – 16:15 Poster Session II – Parallel Sessions

15:00 – 16:15 Understanding ecosystem functioning through mesocosm research II — Channel 1

EP14. Evidence for intact polar lipid remodeling among phytoplankton communities in response to multi-environmental stressors in mesocosm experiments

Mr Sebastian Cantarero[1], Dr Paulina Aguayo[2,8], Dr Cristian A. Vargas[2,8], Mr John E. Jr. Tamahana[3], Mr Bentley C. Scholz[3], Dr Lennart T. Bach[4], Dr Carolin R. Löscher[5], Dr Ulf Riebesell[6], Dr Balaji Rajagopalan[7], Dr Nadia Dildar[1], Dr Julio Sepúlveda[1,2]

[1]Department of Geological Sciences, Institute of Arctic and Alpine Research, University of Colorado, Boulder, Boulder, USA, [2]Millennium Institute of Oceanography (IMO), Universidad de Concepción, Concepción, Chile, [3]Laboratory for Interdisciplinary Statistical Analysis, University of Colorado, Boulder, Boulder, USA, [4]Institute for Marine and Antarctic Studies, University of Tasmania, Hobart, Australia, [5]Department of Biology, Nordcee, Danish Institute for Advanced Study, University of Southern Denmark, Odense, Denmark, [6]GEOMAR Helmholtz Centre for Ocean Research Kiel, Kiel, Germany, [7]Cooperative Institute for Research in Environmental Sciences, Department of Civil, Environmental, and Architectural Engineering, University of Colorado, Boulder, Boulder, USA, [8]Department of Aquatic System, Faculty of Environmental Sciences & Environmental Sciences Center EULA Chile, Concepción, Chile

EP15. Adaptation enhances the positive effect of temperature on Microcystis aeruginosa growth and competitive abilities

Dr Bogdan Druga[1], Elisabeth Ramm[2], Dr. Edina Szekeres[1], Dr. Cecilia Chiriac[3], Dr. Adriana Hegedus[1], Dr. Maria Stockenreiter[4]

[1]Institute of Biological Research Cluj, Cluj-Napoca, Romania, [2]Institute of Meteorology and Climate Research, Atmospheric Environmental Research (IMK-IFU), Karlsruhe Institute of Technology (KIT), Garmisch-Partenkirchen, Germany, [3]Biology Centre of the Czech Academy of Sciences, Institute of Hydrobiology, České Budějovice, Czech Republic, [4]Ludwig-Maximilians-Universität München, Department Biology II, Experimental Aquatic Ecology, Planegg-Martinsried, Germany

EP16. Community structure has greater effect on water column ammonium cycling than nutrients and temperature in shallow lake mesocosms

Ms Shannon Collins[1], Trevor Brannon[1], Silvia Newell[1], Erik Jeppesen[2], Justin Myers[1], Mark McCarthy[1]

[1]Wright State University, Dayton, USA, [2]Aarhus Universitet, Institut for Bioscience, Silkeborg, Denmark

EP17. Nutrients and light trigger the competitive capability and toxicity of the harmful cyanobacterium Planktothrix rubescens in a mesocosm experiment

Mr Manuel Weisser[1], Prof. Thomas Posch[2], Prof. Frank Peeters[1]

[1]University of Constance, Constance, Germany, [2]University of Zurich, Zurich, Swizzerland

EP18. Understanding allocation of organic carbon in prokaryotes under the influence of temperature and nutrient additions: a mesocosm approach

Dr Ashish Verma[1], Mr. Dennis Amnebrink[2], Prof. Jarone Pinhassi[2], Prof. Johan Wikner[1,3]

[1]Department of Ecology and Environmental Sciences, Umeå University, Umeå, Sweden, [2]Centre for Ecology and Evolution in Microbial Model Systems - EEMiS, Linnaeus University, Kalmar, Sweden, [3]Umeå Marine Sciences Center, Norrbyn 557, Hörnefors, Sweden

EP19. Effects of Labile and Recalcitrant DOC sources on Zooplankton Community

Ms Dilvin Yıldız[1], Ms Maria Calderó Pascual[2], Ms Gülce Yalçın[1,3], Ms Melisa Metin[1], Ms Sinem Yetim[1], Ms Nur Filiz[1,3], Ms Pınar Kavak[4], Prof Kemal Ali Ger[5], Prof Valerie McCarthy[2], Prof Erik Jeppesen[6], Prof Meryem Beklioğlu[1,3]

[1]Middle East technical University, ankara, Turkey, [2]Dundalk Institute of Technology, Dundalk, Ireland, [3]METU Ecosystem Research and Implementation Center, ankara, Turkey, [4]Hacettepe University , ankara, Turkey, [5]Federal University of Rio Grande do Sul, Imbé, Brazil, [6]Aarhus University, Silkeborg, Denmark

EP20. Combined bottom-up effects of DOC and top-down effects of zooplankton with contrasting traits on phytoplankton biomass and composition

Ms Melisa Metin[1], Ms Sinem Yetim[1], Ms Dilvin Yıldız[1], Ms Gülce Yalçın[1], Ms Maria Calderó Pascual[2], Ms Nur Filiz[1], Ms Claudia Fiorentin[3], Prof. Meryem Beklioğlu[1], Prof. Kemal Ali Ger[4]

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DAY 4 Thursday 15 April 2021

15:00 – 16:15 Poster Session II – Parallel Sessions

15:00 – 16:15 Understanding ecosystem functioning through mesocosm research II — Channel 1

EP21. Effects of an invasive mysid shrimp on plankton dynamics

Ms Katalin Patonai[1], Ms Anett Hanny-Endrédi[2], Dr Péter Borza[3], Dr Péter Dobosy[3], Dr Károly Pálffy[2], Dr Zsófia Horváth[2,4,5], Dr Csaba Vad[2,4]

[1]Eötvös Loránd University, Budapest, Hungary, [2]Centre for Ecological Research, Balaton Limnological Institute, Tihany, Hungary, [3]Centre for Ecological Research, Danube Research Institute, Budapest, Hungary, [4]Laboratory of Aquatic Ecology, Evolution and Conservation, KU Leuven, , Belgium, [5]WasserCluster Lunz, Lunz, Austria

EP22. Effects of Dissolved Organic Carbon and Zooplankton Grazing Pressure on Bacteria and Ciliates

Ms Sinem Yetim[1], Ms Melisa Metin[1], Ms Dilvin Yıldız[1], Ms Gülce Yalçın[1], Ms Maria Caldero Pascual[2], Ms Claudia Fiorentin[3], Prof Meryem Beklioğlu[1], Prof Kemal Ali Ger[4]

[1]Middle East Technical University, Ankara, Turkey, [2]Dundalk Institute of Technology, , Ireland, [3]Public Institution Natura Histrica, , Croatia, [4]Federal University of Rio Grande do Sul, , Brazil

EP23. Morphology, mixing and mesocosms: shape and turbulence interactions within a phytoplankton community

Mr Russell Arnott[1], Dr Mehdi Cherif[2], Dr Danielle Wain[3], Dr Lee Bryant[1]

[1]University of Bath, Bath, UK, [2]Umeå University, Umeå , Sweden, [3]7 Lakes Alliance, Waterville, USA

EP24. Warming effects on a native and an invasive macroalgae-grazer and parasite system: who is the winner?

Dr Claudia Bommarito[1], Miss Dakeishla Diaz-Morales[2], Dr Daniel Grabner[2], Dr Tamar Guy-Haim[3], Dr Simona Noè[3], Prof. Dr Gil Rilov[3], Prof. Dr. Bernd Sures[2], Prof. Dr. Martin Wahl[1]

[1]GEOMAR Kiel, Kiel, Germany, [2]University of Duisburg-Essen, Essen, Germany, [3]Israel Oceanographic and Limnological Research Institute (IOLR), Haifa, Israel

EP25. Brownification effects on the plankton community of a North Atlantic bay (Hopavågen, Norway) during an in situ mesocosm experiment combined with high-frequency sensor measurements of oxygen metabolism

Mr Tanguy Soulié[1], Pr Herwig Stibor[2], Dr Sébastien Mas[3], Pr Ulrich Sommer[4], Mr Benjamin Braun[2], Ms Johanna Knetchel[2], Dr Francesca Vidussi[1], Dr Behzad Mostajir[1]

[1]MARBEC (MARine Biodiversity, Exploitation and Conservation), Univ Montpellier, CNRS, Ifremer, IRD, Montpellier, France, [2]Department Biologie, Aquatic Ecology, Ludwig-Maximilians-Universität München, Martinsried-Planegg, Germany, [3]MEDIMEER (Mediterranean Platform for Marine Ecosystems Experimental Research), OSU OREME, Univ Montpellier, CNRS, IRD, INRAE, Sète, France, [4]GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel, Wischhofstraße 1-3, 24148 Kiel, Germany

EP26. Effects of experimental warming on an unexpected autumnal microbial community dominated by picophytoplankton in the Mediterranean coastal Thau Lagoon

Dr Justine Courboulès[1], Dr Francesca Vidussi[1], Mr Tanguy Soulié[1], Dr Sébastien Mas[2], Dr David Pecqueur[3], Dr Behzad Mostajir[1]

[1]MARBEC (Marine Biodiversity, Exploitation and Conservation), Univ Montpellier, CNRS, Ifremer, IRD, Montpellier, France, Montpellier, France, [2]MEDIMEER (Mediterranean platform for Marine Ecosystems Experimental Research), Observatoire de Recherche Méditerranéen de l'Environnement, Univ Montpellier, CNRS, IRD, IRSTEA, Sète, France, Sète, France, [3]BioPIC platform (Biology platform of Imaging and flow Cytometry) FR3724, Observatoire Océanologique de Banyuls-sur-mer Laboratoire Arago - SU/CNRS, Banyuls-sur-mer, France, Banyuls-sur-mer, France

DAY 4 Thursday 15 April 2021

15:00 – 16:15 Poster Session II – Parallel Sessions

15:00 – 16:15 Methodology and Technology in mesocosm research **Channel 2**

EP31. Evaluating air-water gas exchange velocities in running waters using noble gases and hydro-acoustics: a combined bubble plume-flume experiment

Dr Marcus Klaus[1], Dr. Thierry Labasque[2], Filippo Vingiani[3], Nicola Durighetto[3], Prof. Dr. Gianluca Botter[3], Dr. Dipl.-Hyd. Jakob Schelker[4,5]

[1]Swedish University of Agricultural Sciences, Department of Forest Ecology and Management, Umeå, Sweden, [2]Université de Rennes 1, CNRS, Géosciences Rennes, Rennes, France, [3]University of Padova, Department of Civil Architectural and Environmental Engineering, Padova, Italy, [4]WasserCluster Lunz Biologische Station GmbH, Biofilm and Ecosystem Research Group, Lunz am See, Austria, [5]University of Vienna, Department of Limnology & Bio-Oceanography, Vienna, Austria

EP32. Testing the PlanktoScope - a low-cost imaging flow cytometer

Ms Bronwyn Lira Dyson[1,2], Dr. Stella A. Berger[2], Dr. Jens C. Nejstgaard[2]

[1]Technische Universität Berlin, Berlin, Germany, [2]Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Stechlin OT Neuglobsow, Germany

EP33. Land-based mesocosms facilities at ECIMAT: a real-time monitored experimental design

Dr Jose González[1], Mr. Damián Costas[1]

[1]Centro de Investigación Mariña - Universidade de Vigo, Vigo, Spain

CET Time

DAY 5 Friday 16 April 2021

11:30 - 11:50 **AQUACOSM & AQUACOSM –plus Activities IV** — Channel 1
Moderator: ***Maren Striebel, Meryem Beklioglu*** *(METU)*

WP6 activities for early career scientists
Speaker: **Robert Ptacnik** (WCL)

11:50 – 12:00 **Coffee Break**

12:00 - 13:00 **RI presentations I** — Channel 1
Moderator: Jens Nejstgaard (FVB –IGB)

Assemble-plus
Speaker: **Panagiotis Kasapidis** (HCMR)

JERICO-RI
Speaker: **Ingrid Puillat** (IFREMER)

SITES – Swedish Infrastructure for Ecosystem Science
Speaker: **Stefan Bertilsson** (SLU)

13:00 – 14:00 **Lunch Break**

14:00 – 14:45 **Keynote Lecture V** — Channel 1
Moderator: ***Beatrix Beisnger*** *(UQAM)*

Fostering the human mesocosm: lessons learned from the grassroots Global Lake Ecological Observatory Network (GLEON)
Speaker: **Kathleen Weathers**
CARY INSTITUTE OF ECOSYSTEM STUDIES, USA

14:45 – 15:00 **Coffee Break**

15:00 – 16:00 **RI presentations II** — Channel 1
Moderator: ***Jens Nejstgaard*** *(FVB –IGB)*

AQUACOSM-plus: an expanded International Network for Experimental Mesocosm Studies 2020-2024, including international networking and RI-RI collaboration
Speaker: **Jens Nejstgaard** *(FVB –IGB)*

General Discussion, on RI-RI and any other topics for AQUACOSM-plus

16:00 -16:15 **Closing Ceremony**

Symposium Abstracts

Keynote Lecture I

Understanding microbial population dynamics in mesocosms. Applying simple principles to a complex system

Prof. Frede Thingstad[1]

[1]University of Bergen, Bergen, Norway

Whether the goal of a mesocosm experiment is "system understanding" or "understanding the consequences of anthropogenic impacts", the experimental design usually involves some kind of perturbation (nutrients, pH, dust, grazers....). The outcome of such experiments depend on two sets of conditions: the perturbations, and the state of the system when perturbed. In most laboratory systems, the system state is known, and the effects are (at least ideally), reproducible. In mesocosms, such control of the initial state is usually lacking. Whatever the number of controls and parallels, the reproducibility can therefore only be checked by (costly) repetition of the experiment. An alternative approach is to accumulate result from different experiments in one generic model where this model's successes and failures hopefully builds a framework useful for planning of new experiments and challenging by new results. I will try to argue that there is a relatively simple "minimum" version for the microbial food web that captures enough of the complexity, both to explain what happens when it works, and even to suggest what is "special" in experiments where it is too simple.

Keynote Lecture II

Mesocosm research on carbon dioxide removal approaches

Ulf Riebesell

GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany

With the Paris Climate Agreement 195 countries have adopted a treaty to keep global warming well below two degrees and pursue efforts to limit it to 1.5 degrees. In October 2018, the Intergovernmental Panel on Climate Change presented a special report stating that the 1.5-degree target is still achievable, but only if anthropogenic CO_2 emissions start falling sharply now and reach net zero by 2050. The report also made clear that net zero emissions will not be achievable without employing some form of active CO_2 removal, termed negative emission technologies (NETs). The focus with NETs presently lies on possible solutions on land, such as afforestation and bioenergy with carbon capture and storage (BECCS). These and other land-based options are often in conflict with other societal interests, such as food security, urbanisation and ecosystems conservation. Surprisingly, little attention has been paid to possible measures for climate intervention in the ocean. By absorbing 93% of the extra heat generated by global warming and more than 25% of the CO_2 released from human activities, the ocean already serves as a powerful buffer in the Earth's climate system. Research on ocean-based CO_2 removal strategies, however, such as blue carbon enhancement, marine permaculture, artificial upwelling, and ocean alkalinity enhancement, is still in its infancy. Questions about their CO_2 removal potentials and the associated environmental risks, ecosystem side effects and possible co-benefits need to be addressed urgently for an integrated assessment of possible NET technologies. Here mesocosm research will likely play a key role in allowing for manipulative experimentation of nature-based solutions at relevant scales of biological complexity. It will form the backbone for determining community-level dose-response relationships and critical thresholds, discovering indirect effects through food web interactions, disentangling ecological responses and their biogeochemical impacts and identifying possible co-benefits for environmental protection and ecosystem health. In my presentation I will introduce approaches considered for ocean-based CO_2 removal, outline some of the related knowns and unknowns, and propose how mesocosm experimentation can advance this emerging field of research.

Keynote Lecture IV

Studies across scales to understand impacts of environmental change

Shelley E Arnott
Department of Biology, Queen's University Kingston, Ontario, K7L 3N6

Freshwater ecosystems are facing environmental challenges that contribute to the loss of species, changes in community structure, and reduced ecosystem function. Salinization is an emerging issue associated with changing climate, mining activities, agriculture, and in regions that experience cold winters, the application of deicing salts to paved surfaces. In Canada, we apply approximately 7 million tonnes of salt, mostly NaCl, to roads each year. In the USA, they apply more than 24 million tonnes of salt each year. Much of this salt moves through watersheds into lakes, streams, and wetlands, resulting in increasing concentrations through time. Chloride is toxic so water quality guidelines have been developed by governments to protect aquatic life. In Canada, our guidelines were derived from species sensitivity distributions based on controlled laboratory studies using a variety of aquatic species. However, recent studies have demonstrated that some cladoceran zooplankton experience reduced reproduction and increased mortality at concentrations well-below water quality guidelines. To investigate the generality of this response among lakes in Canada, USA, Spain, and Sweden, we conducted a coordinated 6-week mesocosm study (the Global Salt Experiment) at 16 sites during summer 2018. At each site, we assessed changes in abundance of major zooplankton taxa along a chloride gradient ranging from ~5 to 1500 mg Cl^-/L. We found that, at most sites, crustacean zooplankton were sensitive to chloride at concentrations below Canadian and USA guidelines, and in half of the sites, losses in zooplankton were associated with increased phytoplankton abundance, measured as chlorophyll *a*. Unexpectedly, local nutrient and ion concentrations did not explain variation in chloride sensitivity across sites for most taxa. This study demonstrates the value of coordinated regional/global experiments to generalize or contextualize aquatic community responses to environmental challenges and suggests that current water quality guidelines for chloride need to be revised to ensure the protection of aquatic life.

AQUACOSM & AQUACOSM-plus Activities

Transnational Access at AQUACOSM and AQUACOSM-plus facilities

Dr Stella A. Berger[1], Dr. Tatiana M. Tsagaraki[2], Prof. Silke Langenheder[3], Dr. Katharina Makower[1], Dr. Jens C. Nejstgaard[1]

[1]Leibniz Institute of Freshwater Ecology and Inland Fisheries (IGB), Stechlin, Germany, [2]University of Bergen, Bergen, Norway, [3]Uppsala University, Uppsala, Sweden

Since 2017, the H2020 AQUACOSM project has funded ca. 9 000 Transnational Access (TA) person-days to leading mesocosm research infrastructures in Europe, ranging from rivers to lakes, estuaries and marine systems. Starting 2020, the follow-up AQUACOSM-plus project will fund >13,000 TA person-days for a wide range of external users, including scientists, students, industry and developers, from the whole world by significantly widening the network and scope of services offered. The 31 partners in AQUACOSM-plus include >60 mesocosm facilities covering all biogeographic regions across Europe. TA users will be offered training building on the experience gained at the facilities during decades and unique opportunities to conduct ecosystem-scale experimental studies in all European Climate Zones. These networks of experimental research facilities can e.g. be used for large-scale process-based studies to test models based on trend or response observations from long-term-data, in order to understand underlying mechanisms of ecosystem functioning relating to the present global Grand Challenges (climate change, biodiversity loss, eutrophication, emerging pollutants, etc.). Interested persons are also welcome to suggest other uses of these research facilities, such as conducting ecosystem solution-based experiments to enable effective management in aquatic ecosystems. Co-designed European experiments and global cross-disciplinary collaboration will foster competence building and transfer of knowledge. One scientific focus is designing internationally harmonised experiments targeting the most pertinent Global Grand Challenges. Effective open data flow for the TA activities will benefit from new developments in primary data collection, data visualisation, a metadata catalogue, and an open database. The scientific services of the TA program i.e. access to leading mesocosm facilities in Europe and the environment in which users will be embedded varies among locations, but scientifically strong, active and open-minded research groups associated with AQUACOSM-plus facilities typically ensure a stimulating and rewarding research experience during TA activities. We will inform about funding options for TA activities in 2021, 2022 and 2023.

AQUACOSM Joint Mesocosm Experiments (JOMEX)

Herwig Stibor, Tom Davidson, Aud Larsen, Paraskevi Pitta, Timo Tamminen

Mesocosms are an important experimental tool in aquatic ecology. Mesocosms allow doing experimental manipulations at larger scales and higher complexity compared to laboratory microcosm experiments. Hence, a large number of aquatic research groups have facilities and infrastructure to perform mesocosm experiments. In most cases, mesocosm experiments are performed at a single site, without doing the same experiment also at other sites. However, doing the same experiment at different sites can have certain advantages. The results of experimental manipulations are not independent of the environment and the local biological community at the site the experiment is performed. Not surprising, the same experimental manipulations done at different sites can even deliver opposing results. Joint mesocosm experiments can help to separate site specific responses to experimental manipulations from general response patterns.

Within the project AQUACOSM, a pilot study of such a combined experimental strategy has been performed. At various European sites, from Arctic to Mediterranean regions and freshwater, brackish and marine waters, harmonized experiments investigate the effects of increasing runoff of terrestrial material (DOC) into aquatic systems. First results point towards clear site specific responses to the same experimental manipulation, however effect sizes of the manipulations were comparable.

WP6 activities for early career scientists

Robert Ptacnik (WCL)

We want to highlight two WP6 activities addressing early career scientists. AQUAsummit will organize writing retreats where young scientists (PhDs, PostDocs) write papers on timely and upcoming topics in aquatic ecology. Papers can address both conceptual and data-driven studies. Senior scientists form the consortium will provide support and guidance during the process. Further, a hands-on meta-analysis workshop is organized within WP6, which again will in the end aims to produce one or several scientific papers

AQUACOSM-plus: an expanded International Network for Experimental Mesocosm Studies 2020-2024, including international networking and RI-RI collaboration

Dr Jens Christian Nejstgaard[1], Dr Stella A. Berger[1], Dr Katharina Makower[1]

[1]Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB), Stechlin, Germany

This presentation will introduce the new EU-funded Research Infrastructure (RI)-project AQUACOSM-plus (www.aquacosm.eu, 2020-2024). Building on the two first EU network projects for aquatic mesocosm RIs, FP7-MESOAQUA and H2020-AQUACOSM, the H2020-AQUACOSM-plus will extend its services in many fields and:

- Offer Transnational Access funding to >60 research facilities across the EU
- Is linked to world-wide cooperation through the MESOCOSM.ORG portal, a virtual network of >100 research facilities.
- Provide and share standards on various open platforms such as Wiki, regarding conduction of mesocosm experiments
- Provide trainings in hands-on summer schools, webinars and more
- Break new ground in the use and re-use of mesocosm science by providing near-real-time Open Data flows and improved metadata, thus advancing Open Mesocosm Science.
- Deploy high-throughput imaging technology, including affordable methods to obtain high-frequency data on community change and greenhouse gas fluxes, and develop effective mobile large-scale mesocosm approaches, where such applications are required to tackle critical questions and address the Grand Challenges, and establish new facilities in new EU member states (Hungary and Romania).
- Intensify the collaboration with other Research Infrastructures and science fields, by conducting pilot-cross-RI experiments such as process studies in mesocosms testing models based on long-term-observations. The aim is to better understand mechanisms of ecosystem functioning and increase European readiness and collaboration to better tackle the current and future Grand Challenges.
- Conduct novel ecosystem solution-based experiments to enable effective management in aquatic ecosystems.
- Increase the involvement of small companies and non-governmental organisations to reach new stakeholders.

Oral Talks

Understanding Ecosystem functioning through mesocosm research

O1

Testing mesopredator effects in large rocky shore mesocosms

Mr Hartvig Christie[1]

[1]Norwegian Institute for Water Research (NIVA), Oslo, Norway

Over exploitation of top predators may lead to release of smaller predators (mesopredators). To test effects of increasing mesopredators in the field is difficult, and aquarium experiments do not provide realistic conditions. NIVA has established 12 large mesocosms where over years diverse shallow rocky reef community have developed. There densities of mesopredators like small fish (wrasses) and green crabs has been manipulated in controlled experiments. The experiments showed how these small predators affected beds of small mussels and barnacles leading to bare rocky surfaces. Further experiments showed how these predators enhanced eutrophication effects under certain conditions, and to a lesser extent under other conditions resulting in different top down or bottom up pathways. The results will be presented as well as a presentation of the possibilities of these large mesocosms.

O2

Combined impacts of brownification and iron concentration on the marine planktonic foodweb (BIPWeb)

María Segovia, Víctor Vázquez, Carolina Santana-González, David González-Santana, Librada Ramírez, Veronica Arnone, Pablo León, María López-Parages, Aud Larsen, Anna Grytaas, Carlos Jiménez, Magdalena Santana-Casiano, Melchor González-Dávila, Sergio Cañete, Tatiana Tsagaraki, Jens C. Nejstgaard, Stella A. Berger, Jorun K. Egge

[1]Department of Ecology Faculty of Sciences University of Malaga, Malaga, Spain

A mesocosm experiment was carried out in the Raunefjord, off Bergen, Norway (June 2019) to investigate the interactive effects of brownification and increased dissolved iron (dFe) on the plankton food web. Twelve mesocosms (11.8 m3) covered by PAR and UVR transparent lids were used. Mesocosms were fertilised at the onset (day 0) of the experiment, by addition of 10 μM nitrate and 0.3 μM phosphate to induce a bloom of the coccolithophore Emiliania huxleyi. On day 2 of the experiment, 2mgL-1 of humin feed (+B treatment) and 70 nM of the siderophore desferoxamine B (DFB) (+D treatment) (final concentrations) were added to half of the mesocosms. Browning produced a significant increase ($p<0.05$) in CDOM absorbance at 275nm. The addition of DFB increased dFe ˜3-fold, whilst the combination of browning and DFB (+B+D) resulted in a ˜ 5-fold increase in dFe. During the experiment, the plankton community structure shifted, and two distinct phases were observed. The first phase (experiment days 0-8) the phytoplankton community responded significantly to the treatments and was dominated by picoeukaryotes followed by cryptophytes, the rest of nanoeukaryotes and large diatoms (>20 μm) , while Synechococcus constantly decreased. Ciliates, bacteria and heterotrophic nanoflagellates were abundant in this phase too, but they were not affected by the treatments ($p>0.05$). In the second phase (days 9-21), we found a well-established top-down control in all the mesocosms. Nauplii and adult stages of mesozooplankton significantly increased. These together with ciliates and dinoflagellates, brought bacteria, heterotrophic nanoflagellates and phytoplankton biomasses down to low levels except for Synechococcus, which resumed growth after day 14. Viruses did not change throughout the experiment. The relevance of these results within a global biogeochemical perspective will be discussed attending to: (i) what extent brownification had the potential to structure the plankton community providing traits to the components of the different trophic levels; (ii) whether dFe contributed to the optical properties of CDOM; (iii) whether DOC regulated dFe availability and, iv) whether increased dFe had an effect on changing , reverting, and/or mitigating the effects of brownification on the different plankton functional groups.

O3

Partitioning of phytoplankton mortality between viral lysis and microzooplankton grazing during mesocosm phytoplankton blooms

Dr Kyle Mayers[1], Dr Katrine Sandnes Skaar[1], Ms Sigrid Mugu[1], Dr Aud Larsen[1], Dr Elizabeth Harvey[2]

[1]NORCE Norwegian Research Centre, Bergen, Norway, [2]University of New Hampshire, Durham, USA

Phytoplankton are important regulators of global climate and carbon cycling through the production and export of organic carbon. The most significant sources of phytoplankton mortality in marine ecosystems is grazing by heterotrophic protists (microzooplankton) and viral lysis. Whether an organism is grazed or lysed, and the rate at which this occurs, has important implications for microbial food webs and biogeochemical cycles. Production which is grazed will pass along to higher trophic levels, whereas lysed material can fuel further production through the regeneration of nutrients. On average, microzooplankton grazing leads to ˜62% of phytoplankton mortality per day, with up to 25% of photosynthetically fixed carbon being lysed due to viruses. However, exactly which process dominates mortality rates within time and space in natural populations remains an open question.

In this study, rates of phytoplankton growth, grazing, and viral lysis were measured throughout a mesocosm experiment, conducted in Raunefjorden, Norway. Two successive blooms were identified during the 22-day experiment, the first composed of pico- and nanoeukaryotes, and the

second being a bloom of the calcium-carbonate bearing coccolithophore Emiliania huxleyi. By using chlorophyll-a and flow cytometry, rates on both the whole phytoplankton community and 4 specific phytoplankton groups (pico-, nanoeukaryotes, E. huxleyi, and Synechococcus spp.) were estimated at 16 time periods throughout the mesocosm experiment. At 9 of these time points, incubations were also conducted for molecular assays targeting two important bloom forming taxa, E. huxleyi and Micromonas sp. By size fractionating the population into predator (20-μm) and prey associated (0.6-μm) we used high sensitive digital droplet PCR (ddPCR) to determine gene copy numbers, and compare these to measured rates of microzooplankton grazing.
Mortality rates were variable throughout the successive blooms, with grazing and viral lysis rates ranging from 0.0 – 2.4 d-1 and 0.0 – 0.7 d-1. Viral lysis rates were able to be calculated from all groups (aside from Synechococcus spp.), with the highest rates being observed during periods of peak biomass. Using group specific carbon conversion factors to convert mortality rates into carbon losses, microzooplankton grazing was found to be the dominant loss process for picoeukaryotes (93%), Synechococcus spp. (98%) and nanoeukaryotes (69%), however, for E. huxleyi the dominant carbon loss process was viral lysis (85%). Molecular data did not always match with estimated microzooplankton grazing rates and detection within the predator size fraction. However, it did provide greater insight into taxa specific dynamics during the mesocosm experiment than flow cytometry alone. This experiment provided high resolution rates of both microzooplankton grazing and viral lysis mortality. We show how these rates can vary throughout blooms, and specific phytoplankton size classes can be differentially impacted. Additionally, we were able to trace how mortality was partitioned between grazing and viral lysis, gaining estimates for the flow of carbon over time under bloom conditions. These results highlight the importance of capturing mortality dynamics of marine phytoplankton to better understand mechanisms of bloom formation and demise, as well as carbon cycling within aquatic ecosystems.

O4

Microbial respiration response under variable simulated upwelling events

Ms Isabel Baños[1], Mr Javier Arístegui[1], Ms Mar Benavides[2], Mr Moritz Baumann[3], Mr Joaquín Ortiz[3], Mr Kai Schulz[4], Ms Andrea Ludwig[3], Mr Ulf Riebesell[3]

[1]Instituto de Oceanografía y Cambio Global, IOCAG, Universidad de Las Palmas de Gran Canaria ULPGC, Spain, [2]Aix-Marseille Université, Université de Toulon, CNRS, IRD, Mediterranean Institute of Oceanography (MIO), UM 110, 13288, France, [3]GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany, [4]Centre for Coastal Biogeochemistry, School of Environment, Science and Engineering, Southern Cross University, Lismore, Australia

Eastern boundary upwelling systems (EBUS) are amongst the most productive regions in the ocean. In these systems, microbial communities play a pivotal role in controlling the balance between organic matter respiration and transfer towards higher trophic levels. Climate change is expected to alter the frequency and intensity of upwelling events, perturbing nutrient inputs and the resulting productivity of EBUS. Hence, understanding how future changes in upwelling regimes may impact microbial metabolic activity is of outmost importance. In order to decipher how variable upwelling events would affect microbial community respiration (CR), we carried out a mesocosm study simulating different upwelling events in terms of intensity and frequency. The experiment lasted 37 days during which nutrient-rich deep water was added to sea surface oligotrophic waters, either as single large additions or recurring smaller additions. CR changed in response to shifts in the community structure with marked differences between treatments and according to the percentage of nutrient-rich deep water added. The highest accumulated CR was achieved during the extreme single nutrient addition treatment, coinciding with a bloom of microphytoplankton. The relative contribution of bacteria and phytoplankton groups to CR also changed among treatments. Nanoplankton and microplankton dominated under extreme nutrient addition treatments during both single and recurring treatments, being the diatoms the main contributors to the observed variability on CR (55% and 45%, respectively). Instead, heterotrophic bacteria contributed to explaining part of the variability observed in CR under low and medium single nutrient additions (32% and 25%, respectively) and medium and high recurring nutrient additions (17% and 14%, respectively). Picoplankton, mainly cyanobacteria, played a minor role and only explained part of the variability in CR during the continuous treatment (16% on average). We also explored the relationship between CR and ETS activity, in order to use the enzymatic assay as a fast proxy to map respiratory metabolism in upwelling regions. Our results, however, showed that the CR/ETS relationship varied among treatments, questioning the use of a unique relationship to convert ETS into CR in heterogeneous and variable systems (in terms of shifts in community structure), like coastal upwelling regions.

O5

Mismatch between primary production, chlorophyll and nutrients' availability in a Peruvian coastal upwelling: constraints for modelling primary production

Prof. Javier Arístegui[1], Nauzet Hernández-Hernández[1], Isabel Baños[1], Alba Filella[1], Dr. Lennart T. Bach[2], Dr. Kai G. Schulz[3], Elisabeth von der Esch[4], Dr. Andrea Ludwig[5], Ulf Riebesell[5]

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Chair of Analytical Chemistry and Water Chemistry, Technical University of Munich, Munich, Germany, [5]GEOMAR Helmholtz Centre for Ocean Research Kiel, Kiel, Germany

Eastern Boundary Upwelling Systems (EBUS), cover less than 3% of the world ocean surface but host among the most productive ocean ecosystems, playing a significant role in the world climate system. In spite of the relevance of these regions, there are scarce in situ measurements of primary production in some EBUS, like the Peruvian upwelling, necessary to validate biogeochemical and remote-sensing productivity models. Here we have explored the relationships between gross production (GPP), net community production (NCP) and community respiration (CR) with chlorophyll (Chla) and nutrients' availability along a simulated upwelling episode off the coast of Callao (Perú), during February/March 2017, coinciding with a coastal El Niño event. Nutrient-rich water from the subsurface oxygen minimum zone was added to eight (55 m3) mesocosms. The evolution of the metabolic balance and community structure of the planktonic community was monitored during 50 days, simulating an offshore drifting parcel of water, and compared with the ambient conditions close to the mesocosms. The phytoplankton inside the mesocosms shifted from a diatom-dominated to a dinoflagellate-dominated community once the inorganic nitrogen was exhausted a few days after nutrient fertilization. In spite of nutrient exhaustion, NCP and Chla remained rather stable along most of the course of the experiment, with NCP ranging between 10-30 µmolO2 L-1 d-1, and Chla between 5-10 mg m-3. Ambient waters, however, were dominated by diatoms and presented higher and more variable NCP (40-140 µmol L-1 d-1), but with Chla and CR values comparable to the inside of the mesocosms. Drastic drops in NCP were associated with low-salinity water intrusions caused by coastal runoff due to El Niño event. The variable correlations between GPP/NCP, Chla and nutrients' availability found in our study highlights the need to expand the database of in situ productivity measurements in EBUS, in order to understand the causes of this variability to improve regional biogeochemical and remote-sensing models, based on nutrients and Chla, respectively.

O6

The impact of eutrophication and warming on freshwater macrofauna communities and its effect on the diffusive and ebullitive methane emission from aquatic ecosystems

Mr Quinten Struik[1], Mrs Annelies Veraart[1], Mr Ralf Aben[1], Mr Thomas Davidson[2], Mrs Sarian Kosten[1]

[1]Radboud University, Nijmegen, The Netherlands, [2]Aarhus University, Aarhus, Denmark

Background: Wetlands are large contributors to natural methane (CH_4) emission to the atmosphere. CH_4 production is a microbial process that takes place under anoxic conditions and in the presence of easily degradable organic matter, while the majority of CH_4 consumption takes place under oxic conditions. CH_4 is mainly being released from the sediment into the atmosphere via ebullition and diffusion. Due to warming and eutrophication macrofauna communities change; however, yet to date it is unclear how. These changes in macrofauna community composition affect an important ecosystem service: mitigation of CH_4 produced in wetland sediments. Bioturbation by macrofauna, such as burrowing and resuspension of sediments, can increase sediment oxygen concentrations. In theory, this results in higher methane oxidation rates, reducing diffusive sediment CH_4 release. Nonetheless, some studies found higher CH_4 emissions from the sediment when bioturbators were present. These contrasting results may be caused by bioturbation traits of the macrofauna community, which is in turn shaped by environmental conditions such as eutrophication and possibly warming. Moreover, yet to date it is unclear how bioturbation affects ebullition. Here we explore if macrofauna community composition could be an underestimated controller in altering CH_4 emissions from wetlands, and how presence of bioturbating macrofauna affects methane ebullition.

Objectives: Hence, the objectives of this research were to: (I): Unravel the effect of nutrient loadings and warming on the benthic macroinvertebrate community of wetlands; (II): Investigate the effect of different benthic macroinvertebrate communities on CH_4 emission and (III): Assess the overall relationship between the macrofauna community and the sediment microbial community responsible for CH_4production and oxidation.

Methods: We sampled macrofauna communities collected in a mesocosm cross experiment of warming scenarios and nutrient treatments (Aarhus University, LMWE). We sampled macrofauna communities during summer, using cage traps placed in the mesocosms for approximately 8 weeks. To test the impact of macrofauna on CH_4 emissions, we incubated the macrofauna corresponding to the mesocosms in 4-liter microcosms, while monitoring diffusive and ebullitive CH_4release. At the end of the microcosm experiment the microbial community responsible for CH_4 production and oxidation was assessed using quantitative PCR. Furthermore, at the end of the experiment we measured the bioturbation depth by using luminophores.

Results: Our preliminary results show that macrofauna density tended to decrease with both warming and eutrophication. Moreover, we also see a shift in macrofauna community composition, with a lower biodiversity for the eutrophic and/or warmed conditions accompanied with differences in species abundance. The emission of CH_4 seems to be affected by macrofauna community. Bioturbator density and depth seems to be positively related with a higher abundance of methanotrophs and fewer methanogens. In the controls, the abundance of methanotrophs was lowest, while the abundance of methanogens was lowest in the nutrient-addition treatments. In addition, luminophore-analysis showed that macrofauna could mix the sediment up to 3 cm depth, while sediments of the controls remained unperturbed. Our first results underline the importance of macrofauna in understanding greenhouse gas emissions from freshwater ecosystems.

O7

Changes in phytoplankton structure and size distributions in response to nutrient and temperature variations: high-throughput analysis of multi-years mesocosm data

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Future climate change conditions will put a strong pressure on freshwater aquatic ecosystems, altering structure of trophic food webs, community composition, and intensifying the magnitude of eutrophication. However, the response of freshwater phytoplankton communities to the changes in both temperature and nutrient loading is uncertain. High-throughput methods, such as imaging flow cytometry, enable generation of large data sets of single-cell measurements and allow for capturing a response of plankton communities more accurately, compared to a traditional microcopy approach.
The aim of this study was to assess the effect of N availability on the phytoplankton community structure in different temperature regimes in freshwater high-nutrient (HN) mesocosms using imaging flow cytometry. The experiment was conducted during 2018-2019 summers as a part of the Lake Mesocosm Warming Experiment (LMWE) in Aarhus University, Denmark, that has been continuously running from 2003. As a part of this experiment, N supply was terminated in the summer 2018 (-N) and was resumed the following summer (+N) along with an uninterrupted supply of P in HN tanks. Water samples were collected weekly and bi-weekly from May to September and assessed for main environmental parameters (water temperature, turbidity, conductivity, dissolved oxygen, pH, TN, TP, NO3+2, NH4, PO4, Fe, Chl-a). Samples preserved with 1% glutaraldehyde were analyzed for phytoplankton structure using a benchtop FlowCam VS-4 imaging particle analyzer (Yokagawa Fluid Imaging, USA) equipped with 532 nm laser and color digital camera Acquired cell images were classified into taxonomic phytoplankton groups using VisualSpreadsheet software. Cell concentration and size parameters were exported from the software and used for biomass estimation and statistical analysis.
We have found a significant effect of temperature on phytoplankton composition and biomass. Phytoplankton structure of the highest-temperature tanks A2+50% was significantly different from lower-temperature regimes AMB and A2. Phytoplankton community of A2+50% tanks mainly consisted of chlorophytes and cryptomonads, whereas AMB and A2 tanks were dominated by cyanobacteria and chlorophytes. Also, the highest temperature treatment resulted in the significant reduction of total phytoplankton biomass. Phytoplankton community structure differed significantly between -N and +N treatments. According to SIMPER analysis, changes in chlorophytes, cyanobacteria, cryptophytes, contributed mostly to the observed dissimilarities between the N treatments. N addition resulted in a decrease in biomass of cyanobacteria and cryptophytes, and a proportional increase of chlorophytes.
During the -N treatment period we observed dominance of N-fixing filamentous cyanobacteria and non-N-fixing Microcystis spp. with few blooming events during the summer in AMB and A2 tanks. Addition of N (+N treatment) resulted in the substantial decrease of biomass of cyanobacteria and an increase of chlorophyte representatives, mainly Pediastrum spp. and bloom-forming species Micractinium spp. CCA analysis revealed that TN was the main environmental parameter, contributing to the phytoplankton community variation along the whole study period. We conclude that both N availability and temperature are important for shaping phytoplankton communities in climate change conditions at high nutrient loading conditions.

O8

An integrated assessment of ecological stability in plankton communities to multiple disturbances across time and space

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Key ecosystem services provided by many lakes worldwide are increasingly being constrained by the multifaceted impacts of global change driven by human activities. As a result, there is growing interest from scientists, politicians and water managers to understand and disentangle the mechanisms underpinning the overall stability of lake communities and ecosystem functions in response to multiple environmental disturbances, including press and pulse disturbances. Here coordinated distributed mesocosm experiments are important tools to depict general trends of multiple dimensions of functional and compositional responses to environmental disturbances and fluctuations that are independent of differences in local environmental conditions. However, no single dimension of stability, such as resistance, recovery, temporal turnover and resilience, in isolation can fully reflect the overall response to environmental change and a common vulnerability assessment that integrates across multiple stability components simultaneously is needed. Here we tested functional and compositional responses to both pulse and press disturbances across three trophic group using a new integrative metric of overall ecological vulnerability (OEV) using data from a modularized experiment replicated in five lakes across a large climate gradient over two seasons. The results demonstrate that OEV comprises a robust framework to: (1) capture simultaneously multiple functional and compositional stability components, and (2) quantify the functional consequences of biodiversity change. Together, our approach therefore provides the basis for an overarching experimental and statistical framework for quantifying overall vulnerability of ecosystems to environmental change across time and space and opens new possibilities for risk assessment and management strategies.

O9

Effects of a Microplastics Mixture on the Food Web of Shallow Lakes: An In-Situ Mesocosm Experiment

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Anthropogenic activities contribute to the global problem of microplastics (MP) ubiquitous presence in not only marine but also in freshwater ecosystems. MP research on aquatic organisms to date is focused on marine ecosystems and laboratory experiments, thus leaving a major knowledge gap on the community-level effects of MP in freshwaters, especially in lakes. To understand the impact of MP pollution in lake ecosystems, an in situ mesocosm experiment was carried out using different most abundant combinations of MP polymers found in freshwaters added to the water surface water column, and sediment. The treatments comprised two different MP concentrations, one simulating both a current and a future scenario (10x higher concentration). It was expected that (a) zooplankton, especially daphnids and copepods will ingest ample amount of microplastics leading to the reduction of zooplankton biomass, (b) microplastics will be transferred between trophic levels, e.g. zooplankter to odonates, (c) microplastics will be ingested by the chironomids that will have an impact on their morphology and reduction in their emergence (d) emerging insects will transfer microplastics ingested during the larval stage from freshwater to the terrestrial environment. Water column concentrations of MP declined sharply especially within the first week of the experiment. Zooplankton, mainly large Daphnia, ingestion of microplastics was very low. MP ingestion did lead to Daphnia biomass reduction whereas total zooplankton did not. Trophic transfer of microplastics from zooplankton to odonate larvae probably included both direct and indirect pathways. Although the overall effect on chironomid emergence patterns is limited, the observed changes in the wing size and shape of male C. riparius suggest that microplastics contamination can significantly affect individual benthic organisms. For the first time, microplastic transfer to terrestrial ecosystems by emerging aquatic insects was confirmed in situ though it was not significant. In conclusion, exposure to current MP concentrations showed no significant effect on littoral community of lakes, nor on cross ecosystem transfers.

O10

Staying put or moving on? The influence of a fine sediment pulse on benthic and drifting invertebrates

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In river ecosystems, high fine sediment loading is a global threat to ecosystem functioning and community dynamics that typically lowers macroinvertebrate diversity by increased drift and altering trophic resources and physical habitat. The infiltration of fine particles into benthic sediments, commonly known as colmation or clogging modify benthic macroinvertebrates community structure. The legacy effects of previous sedimentation events form a habitat template on which subsequent ecological responses occur. Therefore, past fine sediment pulses may have a long-lasting influence on benthic community structure. This study examined the influence of colmation (representing a legacy effect of fine sediment deposition) and a fine sediment pulse on benthic macroinvertebrates and drift patterns. Our study used 12 outdoor stream mesocosms that were divided into two equal sections of 6.2 m in length (24 mesocosm sections in total). Each mesocosm section contained a coarse bed substrate with clear bed interstices or a fine bed substrate representing a colmated streambed. After 69 days, a fine sediment pulse with three differing fine sediment treatments was applied to the stream mesocosms. Added fine sediment influenced macroinvertebrate movements by lowering benthic density and taxonomic richness and increasing drift density, taxonomic richness, and altering drift assemblages. Our study found the highest dose of sediment addition (an estimated suspended sediment concentration of 1112 mg l-1) caused significant differences in benthic and drift community metrics and drift assemblages compared with the control treatment (30 l of water, no added sediment). Our results indicate a rapid response in drifting macroinvertebrates after stressor application, where ecological impairment varies with the concentration of suspended sediment. We found bed sediment had no effect on macroinvertebrate behavioural responses to the fine sediment pulse.

O11

Mean emergence time and biodiversity of the emerging insect community in outdoor mesocosms over a span of six years

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The aim of scientific experiments is to optimize the understanding of nature and the influences of stressors like chemicals or changes in biotic and abiotic parameters, such as increasing temperatures caused by the climate change. Many ecotoxicological studies focus on lethal effects on organisms. However, not only lethal effects can influence the species composition in the environment. Since mesocosms are built to simulate conditions close to nature, it seems self-evidently to examine all endpoints, which might influence the bioscoenosis and ecosystem. Therefore, a general understanding of the system and the annual variabilities is useful to find conclusions that are more reliable in future experiments. Usage of concentrations in experiments, which are way above realistic or predicted environmental concentrations, to force lethal effects seem not meaningful for the nature. Sublethal effects, induced by endocrine disruptive compounds, such as delayed emergence or switched sex ratio can influence the reproductive success of certain species as well. Other substances may influence the growth of larvae and lead to delayed development and cause reproductive failure. Preferably, mesocosms contain comparable species compositions in different years. However, unlike in laboratory experiments, the biocoenosis in bigger (outdoor) mesocosm experiments is only definable to a certain degree. Thus, only relative comparisons of treatments to the control are possible. Adding to this challenge, organisms like midges or mayflies leave the system periodically. These individuals can not be counted alive or fixed due to the fact that they left the system. Given the fact the test substance affects the time of development, enclosures (replicates) with a higher concentration may contain more larvae of certain species compared to the control. The conclusion, that there is no or a positive effect could be wrong. The effect in this case might be delayed development time, not mortality. Therefore, it is useful to examine the species diversity and mean emergence time over a course of many years. Linking this data and other parameters like temperature or sunshine duration will give an overview of the changes in the insect community due to emergence. Another advantage of this approach is the possibility to gain knowledge about the annual variation of the species composition and dominance ratios. The aim of this comparison of mesocosm data of different studies over a timespan of six years is to validate the procedure and assess seasonality and differences between different mesocosms at the test facility.

O12

Value of mesocosm studies in explaining causality at deviations in long-term ecological time series: The Gulf of Bothnia case

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Mesocosm studies constitute a valuable complement to long ecological time series. Hypotheses to explain observed deviations in the field can be tested in a controlled experiment at a relevant scale. Here we present a good example by a case from the Gulf of Bothnia.

High precipitation during 1998-2001 in the Gulf of Bothnia region caused all-time–high freshwater discharge (+20 %) in a 70-year time series, approaching levels in climate projections. Concomitant increase in discharge of nitrogen and phosphorous did, however, not lead to increased phytoplankton production. Instead, a 3-fold suppression of phytoplankton production occurred, while bacterioplankton productions was maintained, resulting in a shift in trophic balance towards heterotrophy. The bacterio- to phytoplankton (B:P) ratio increased by a factor of 2.2. A significant relationship between specific discharge of riverine dissolved organic carbon and the trophic balance pointed toward organic carbon as a driving factor, but causality could not be proven in the field data.

A mesocosm experiment was designed with two factors at the indoor Umeå Marine Science Centre mesocosm facility. Organic carbon (factor 1) was either left a natural level or elevated (totally + 68 % of C pool) by recurring addition of commercially available humic acids (Sigma-Aldrich) and yeast extract (Difco) in a realistic ratio (80:20). Pycnocline depth (factors 2) was used to simulate different light climates by using two different depths of the photic zone, corresponding to 3.3 and 7.6 m in the field.

The addition of DOM reproduced the effect on the trophic balance of a similar magnitude as observed in the field time series. The bacterio- to phytoplankton ratio was 1.24 ± 0.41 (mean and 95 % C.I.) for Deep+DOM, and 0.42 ±0.16 for Deep-DOM (i.e., B:P ratio of 2.9). The effect was due to both reduced light irradiance to the photic zone and assumed increased competition from bacterioplankton for inorganic nutrients, based on maintained growth rate of bacterioplankton.

This showed that increased input of DOC to an estuarine ecosystem is one of the major causes reducing phytoplankton production, shifting the ecosystem towards heterotrophy. The DOC component in river discharge may thus override effects of increased nitrogen and phosphorous. Only with added DOM did the pycnocline depth have a significant influence on the B:P ratio (i.e., higher B:P when deep).

The combination of mesocosm experiment and long-term field study in the Gulf of Bothnia case therefore provided convincing evidence for the suppressing role of DOC in the context of coastal productivity. The case represents one good example of the value of mesocosm experiments for advancing the understanding of ecology in the field.

O13

Reconstructing food webs in a multi-site mesocosm facility - Iberian Pond Network

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Functional traits are good predictors of ecological interactions and ecosystem functioning. Matching between foraging and vulnerability traits of consumers and resources, respectively, influence the probability of trophic interactions. Trait-matching approaches have been used to infer ecological networks across different ecosystems. Using a novel dataset from the multi-site mesocosm facility - Iberian Pond Network, which comprises six locations (Murcia, Toledo, Évora, Porto, Jaca, and Madrid) covering a variety of climates ranging from arid to alpine, we reconstructed tri-trophic aquatic food webs (phytoplankton, zooplankton, macroinvertebrates) using the trait-matching approach. For this, we used an independent database with known interactions collected from the literature (training dataset) and predicted the interactions between consumers and resources in the Iberian Pond Network as a function of their traits (explanatory variables) using random forest models (RF). We selected traits reflecting their trophic interactions, including body mass, feeding guild, movement type, habitat type, and phylogeny. All traits except body mass, which was measured using microscopy, were gathered from the literature review, public databases, or expert knowledge. Taxonomy is used as a latent trait. We obtained taxonomic distances between all species (first two axes) using PCoA (principal coordinates analysis), using the "ape" R package. Our preliminary results showed that body mass and phylogeny are the most important traits shaping the interactions. However, there are several challenges associated with trait databases, such as insufficient trait information (e.g. lack of target traits) and low-quality traits (e.g. low taxonomic resolution, lack of temporal or spatial resolution, and information on the developmental stages). So, we recommend the collection of key trait information at the same time with the sampling events to increase the predictive power when inferring the food webs. This kind of approach would be useful to improve the assessment of food webs responses to climate change across spatial and temporal scales in mesocosm research.

O14

Eco-evolutionary effects of invasive crayfish on aquatic ecosystems:call for a long-term and cooperative research effort

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Biological invasions represent one of the most pervasive threats faced by aquatic ecosystems. However, we are still lacking a detailed, mechanistic understanding of how whole ecosystems may respond to biological invasions on the long term. This limitation, we believe, stems from (i) a relative paucity of experimental approaches in invasion biology, (ii) time and publication constraints urging researchers to favour short-term approaches, (iii) an overlook of the potential roles of rapid phenotypic changes on ecological interactions and (iv) the huge workforce needed to holistically measure eco-evolutionary dynamics at ecosystem scales. Here, we describe the inception of an experiment aiming at tackling issues through manipulating densities of the red swamp crayfish (Procambarus clarkii) in vegetated freshwater mesocosms. The twelve, 11 m2 mesocosms are designed for long-term use (up to 10 years) and are fully-dedicated to this experiment, thus securing the possibility for a long-term approach starting in 2022. We plan to track phenotypes and abundances in small- to large-sized organisms (phytobenthos, plankton, macroinvertebrates, macrophytes) using automated image analysis. To that aim, we have two FlowCams available (8000 and Macro), and we are developing novel tools for the automated analysis of macroinvertebrate videos and UAV images of primary producers. However, we are still facing a workforce bottleneck for the analysis of numerous samples (zooplankton), and the monitoring of microbes (viruses, bacteria, protists) and crucial aspects of ecosystem functioning (decomposition, metabolism). We are therefore looking for collaborators eager to participate in this long-term experiment in the context of Aquacosm+ and beyond.

O15

Phytoplankton rare species loss effect on ecosystem functioning is nutrient context dependent

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Biodiversity-ecosystem functioning relationships are mediated by functional diversity, but theoretical studies suggest that environmental variability is also fundamental for detecting a positive effect of diversity on functioning. Thus, phytoplankton diversity is expected to enhance biomass production under variable nutrient scenarios due to high species complementarity in resource use. However, this prediction has been poorly tested under experimental conditions. Here, we conducted a mesocosm experiment coupled with an additional microcosm experiment to evaluate the interactive effects of diversity and nutrient availability (concentrations and ratios) on ecosystem functioning (resource use efficiency and standing biomass) and phytoplankton stoichiometry. We manipulated a natural phytoplankton community to generate a diversity gradient simulating non-random losses of rare species. This diversity gradient was exposed to different nutrient conditions based on nitrogen (N) and phosphorous (P) manipulations. We found a positive diversity effect on ecosystem functioning when a wide range of nutrient ratios was supplied. This effect was driven by the extreme diversity levels and mediated by nutrient ratios. In contrast, changes in nutrient concentrations maintaining similar ratios did not show significant differences in ecosystem functioning among diversity and nutrient treatments. Hence, our results show that under uniform environmental conditions, the effects of diversity loss on ecosystem functioning was compensated by the prevalence of common species in the community. However, under variable environmental conditions the loss of rare species might have important consequences for ecosystem functioning, supporting theoretical predictions.

O16

Zooplankton diel vertical and horizontal migration across dissolved oxygen concentrations in replicated lake systems

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Eutrophication and climate change have increased the frequency of hypoxic conditions in the hypolimnia of lakes and reservoirs worldwide. Hypoxia can alter zooplankton migration from vertical to horizontal because zooplankton require oxygen for respiration, and thus may be forced to littoral refuges during the day to avoid visual predators in surface waters and hypoxia in bottom waters. We tested the hypothesis that zooplankton exhibit a greater magnitude of horizontal versus vertical migration under hypoxic versus oxic hypolimnetic conditions. We sampled zooplankton and other environmental variables during summer 2019 at PLANAQUA, a 16-lake experimental system that is a member of AQUACOSM. Dissolved oxygen (DO) conditions varied across the lakes providing a gradient to explore zooplankton migration behavior. Zooplankton were sampled day and night, in the epilimnion and hypolimnion of the open water habitat and just outside and inside of the vegetated littoral zone. We will report zooplankton density and biomass in littoral vs. pelagic zones, and their diel vertical and horizontal movements, as a function of DO conditions.

O17

Performance of evolutionarily divergent three-spined sticklebacks (Gasterosteus aculeatus) and eco-evolutionary feedback in sympatric metapopulations

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Fitness and adaptive landscapes are generally regarded as the ecological and evolutionary drivers of population trajectories, leading to species radiation, niche partition, and speciation. The three-spined stickleback (G. aculeatus) shows several ecotypes in environmental gradients that differ in their dispersion, physiology, and morphology; nonetheless, these ecotypes are still subject to gene flow and migration. These processes are thought to slow the effects of natural selection and have a homogenizing ecological and genetic effect, but empirical data are scarce for sympatric lineages and metapopulations undergoing rapid adaptational divergence. Here we investigated the genetic architecture of ecotypes in a marine-freshwater gradient and its effect on ecological performance in a common garden experiment. We found genomic regions of differentiation undergoing selection associated with major physiological traits such as osmoregulatory (NADH+) and armour-development genes previously described for this species. Our results suggest that G. aculeatus ecotype body conditions, mortality, and trophic effects differ and are linked to their genetic architecture. Marine ecotypes had a higher mortality, but the potential to outcompete freshwater ecotypes. Furthermore, their intraspecific F1 Hybrids and backcrosses provided new insights into the hybrid swarm process. Hybrid G. aculeatus showed lower or equal mortality (10-20%) to those of saltwater, but higher relative growth rates and trophic changes in the ecosystem compared to their parental species. We predict that such divergences in juvenile survival and ecological performance might lead to changes in population dynamics along the environmental gradient and a niche partition with an intermediate ecotype found under natural conditions

O18

Mesocosm research on the effects of nutrient limitation on periphyton quality

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Periphyton is a key contributor to primary production, particularly in environments with a developed littoral area. The quality of periphyton, however, may differ under differing nutrient and warming conditions. Particularly, omega-3 long-chain polyunsaturated fatty acids EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid) are markers of nutritional quality, as they are physiologically essential biomolecules for consumer's growth and reproduction. Besides, these FA are mostly coming from the diet.
The objective of the present study was to elucidate how nutrient limitation affects periphyton quality (measured as EPA+DHA content) in eutrophic systems with contrasting temperatures - before and after a major change in external N loading. We performed the investigation at AU Lake Mesocosm Warming Experiment (LMWE): 24 mesocosms mimicking shallow lakes with two nutrient treatments (unenriched and enriched [weekly amended with P and N]) and three temperatures (A0, ambient, A2, IPCC A2 and A2+, IPCC A2+50%). In the enriched mesocosms, the external N-loading was stopped in June 2018 for one year (only external P loading continue). N-loading was re-started in June 2019. We added nutrient diffusion substrata (NDS, 2% agar alone or releasing N, P and combined N and P with a GF-F filter on top) to these 12 mesocosms on two occasions, before and after returning to the normal high N-loading. The NDS were kept in the mesocosms for 21 days to allow colonization by periphyton. We then assessed periphyton EPA+DHA (μg/mg DW) content. The external N loading did not significantly change the quality of periphyton. However, we found that nutrient supply through the NDS (+P, +N, +NP) affects the quality of the periphyton. The addition of nutrients showed differential effects on the EPA+DHA content of periphyton that were further related to the temperature scenarios. The EPA+DHA content of periphyton was not significantly affected by P supply through the NDS in any temperature scenario. However, temperature affected periphyton EPA+DHA content when combined with N availability; the lowest values were found in response to N supply (+N) in the warmest temperature scenario (A2+). We related these changes to specific fatty acids markers that identify changes in periphyton community composition: rich EPA+DHA taxa as e.g. diatoms we more abundant in the control and +P treatments, while +N and +NP treatments evidenced higher abundances of low quality algae, e.g., cyanobacteria. These results have implications in the food web perspective, which we plan to explore in detail through a follow up AQUACOSM TA project design to investigate the impact of nutritional changes in periphyton to the FA composition of primary consumers.

O19

Floating wetlands and their potential for nitrogen removal in estuarine waters: a mesocosm study

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Nutrient enrichment of estuarine waters remains a problem globally. Recently, new efforts have sought to promote conditions for nutrient removal by constructing habitats that may support enhanced nitrogen removal. These include the construction of restored oyster reefs, stream wetlands, and, more recently, floating estuarine wetlands. Each of these habitats has been suggested to be "hotspots" for nitrogen removal. However, the quantification of their impact is difficult due to various other processes that influence nitrogen transformation and loss within tidal estuarine waters. To measure the potential of nitrogen removal by floating wetlands, we ran mesocosm experiments under estuarine conditions for twelve weeks. To calculate nitrogen removal, we used a mass balance approach and in-situ incubation experiments. Preliminary results demonstrate considerable particulate nitrogen removal via deposition and increased denitrification rates throughout the length of the experiment. Future work includes the analysis of plant nitrogen content to complete the nitrogen mass balance. If proven, efficient floating wetlands in tidal waters may have the potential to be certified as a Best Management Practice.

O20

Estimating metabolic rates in a mesocosm experiment to investigate the effects of increased water temperature and agricultural run-off on shallow lake ecosystem functioning and resilience

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Shallow lakes are by far the most abundant lake type worldwide. Most of these ecosystems are becoming warmer due to climate change. Moreover, in agricultural regions, they are regularly subjected to pulses of Agricultural Run-Off (ARO) containing several pesticides and fertilisers. In many regions of the world, this pollution mechanism is enhanced by: (1) an increasing demand for agricultural products; (2) more frequent and intense rainfall events due to changing weather patterns; and (3) human-driven land cover alterations that favour run-off over infiltration (e.g., deforestation of rural catchments). The French-German project CLIMSHIFT investigates how these multiple stressors, acting in combination, may affect the ecological functioning of shallow lakes and their resilience to abrupt shifts between alternative stable states. In the summer of 2019, an 8-week experiment was carried out using 16 outdoor mesocosms (640 L) inoculated with periphyton, phytoplankton, zooplankton, benthic macroinvertebrates (Dreissena polymorpha and Lymnaea stagnalis) and macrophytes (Myriophyllum spicatum, Potamogeton perfoliatus and Elodea nuttallii). Other naturally occurring macroinvertebrates and microorganisms were also present therein throughout the experiment. Half of these mesocosms were artificially heated up, constantly kept 3°C warmer than the non-heated ones. A gradient of eight concentrations of our 'ARO' mix of organic pesticides (terbuthylazine, tebuconazole and pirimicarb), copper sulfate and potassium nitrate was applied to each group as a single, initial pulse. Oxygen, water temperature and illuminance loggers were installed in all mesocosms. Based on these data and information from local weather stations, we applied the diel oxygen technique to estimate daily, whole-mesocosm metabolic rates within a Bayesian statistical framework. Estimates indicate all mesocosms remained net autotrophic despite the presence of the herbicide in the water, hinting at their resilience to remain net oxygen producers through community adaptation and acclimation processes. Observations from this and other experiments suggest that increased water temperature and ARO-related pollution might affect net ecosystem productivity in opposite directions, likely through indirect, cascading effects. By using a series of mathematical modelling approaches and examining responses in light of complementary data, we aim to disentangle these effects and thus better understand the complex response of shallow lake ecosystems to these multiple stressors.

O21

HyTec- flume experiments at different scales evidencing different responses of fish, algae and macroinvertebrates to combined hydropeaking and thermopeaking

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Hydro-electric peaking operation, i.e. hydropeaking (HP) leads to modifications of hydrological characteristics, such as the wetted width, water depth, flow velocity as well as bottom shear stress. Furthermore, hydropeaking is frequently accompanied by rapid changes in water temperature, i.e. thermopeaking (TP). Consequently, river biota have to deal with abrupt changes in habitat conditions, thermal stress, food depletion and a risk of drifting or stranding. Only few studies have emphasised the combined effects of hydro- and thermopeaking (THP) on aquatic organisms and these are usually limited to selected organism groups.

Here we present outcomes from a comprehensive experimental study assessing effects of THP on periphyton, fish and macroinvertebrates, conducted in the Hydromorphological and Temperature Experimental Channels (HyTEC) in Lunz am See, Lower Austria. The facility provides different experimental units from large outdoor flumes to mesocosm setups, which are fed with nutrient-poor lake water, taken from two different depths. The amount of the extracted water as well as the water temperature can be manipulated, allowing the simulation of HP and TP at the same time.

During the THP experiments the temperature change generally started during flow increase. For fish higher drift and stranding was observed when HP was combined with cold TP compared to warm TP and the drift occurred closer to the shoreline. This indicates that habitats with reduced flow velocities were preferred to compensate reduced swimming ability and activity due to lower water temperature. In contrast, when HP was combined with cold TP macroinvertebrates showed significantly lower total drift rates, possibly due to reduced activity above the substrate surface and following lower flow exposure. Drift rates were generally higher during night and differences between the THP experimental settings more pronounced, however with strong taxon-specific response patterns.

Experiments on periphyton showed that not only the direction of temperature change (warm/cold THP) but also the morphological setting (riffle/pool) affected structural and functional patterns. In pool sections cold THP enhanced chlorophyll-a concentration due to better growth conditions for diatoms. In riffle sections warm THP led to reduced periphytic algal biomass and the composition changed from a diatom-dominated to a more green algae dominated-community.

The results of this study show that combined THP can reduce biomass availability for primary consumers in large areas of impacted streams and therefore may affect food web structures. Short-term thermopeaking affects fish and macroinvertebrates in different ways. On a long term it may additionally lead to changes in life cycle patterns, however the role of temperature fluctuations combined with hydropeaking remais poorly understood.

O22

Effects of heat waves on virioplankton and virus-driven processes in the planktonic food web - the viral component of the HeatPlank3R- mesocosm experiment Summer in Spring

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Viruses are the most abundant biological entities in the ocean and play a pivotal role in the biogeochemical cycles, in controlling the biomass of the microbial community and in maintaining genetic diversity amongst it. While recycling organic carbon und nutrients, viral lysis shifts the food web towards a more regenerative pathway, weakening the carbon flux to higher trophic levels, increasing system heterotrophy and finally reducing the efficiency of the biological carbon pump. Since viral replication rates and viral life style (lytic versus lysogenic) are closely linked to host abundance and metabolism, it is reasonable to assume that viral infection rates respond directly to temperature effects on host cells but existing data are scarce. Moreover, no conclusive data on viral lysis rates of heterotrophic bacteria and the induction of lysogens in combination with short-term temperature increases have been reported. An in situ mesocosm experiment was performed during 20 days in the frame of a project entitled "Summer in Spring – Heat wave effects on Mediterranean Plankton communities: Resistance, Resilience and Recovery (Heat Plank 3R)" at MEDIMEER which was supported by Transnational Access of H2020 AQUACOSM project (2017-2021). During this experiment, water temperature of three in situ mesocosms followed the surrounding natural ambient water temperature (Control mesocosms) during 20 days, whereas water temperature of three other mesocosms was increased by 3°C relative to that of Control mesocosms (Heated mesocosms) during 10 days simulating a heat wave, and then followed the natural ambient water temperature like the Control mesocosms during the last 10 days of the experiment. We monitored daily the dynamics of total viral abundance and viral subpopulations in all mesocosms during the experiment. Moreover, phage mediated mortality of bacteria and lysogeny were determined in the presence and absence of nanoflagellate grazers on day 1, 6, 9 and 15 in order to study the potential effects of virus driven processes on biogeochemical cycles in marine systems facing heat waves during spring. Total viral abundance and the low and medium fluorescence cytometric populations, which are essentially bacteriophages, were increased during the experimental course, while the high fluorescence cytometric population, mostly cyanophages and viruses infecting picoeukaryotes, decreased. No discernable effect of the heat wave treatment on viral populations could be detected. Phage production rates and phage mediated bacterial mortality increased with time and were significantly higher in the absence of grazers in the heat wave treatment suggesting preferential grazing on infected bacteria. Moreover, the heat wave stimulated phage production in the presence of grazers. No discernable effect of heat waves on lysogeny could be detected. The consequences for the plankton carbon fluxes in this global change scenario are discussed.

O23

Investigating the microzooplankton "black box" under warming: Top-down control and micrograzer interactions in a spring bloom community in a coastal lagoon in the North-West Mediterranean Sea

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Motivation: Microzooplankton (MZP), here protist and micrometazoan grazers between 20-200 µm, are an important trophic intermediary linking the microbial loop with higher trophic levels. In the wake of global warming, it is pivotal to expand and deepen the functional understanding of MZP communities since warming is expected to influence structure and functioning of pelagic ecosystems. Even though the impact of MZP grazing is widely acknowledged, these micrograzers are still considered as a "black box" (Calbet et al. 2008) regarding their functional diversity (incl. intra-guild predation) and group-specific types of top-down control. Here, we aimed to elucidate the functional roles of different MZP components (protists and micrometazoans) during spring bloom succession as well as their interplay and sensitivity to simulated global warming.

Methodological approach: A pelagic in situ mesocosm experiment was carried out in the coastal Thau lagoon at the MEDIMEER facility, NW Mediterranean Sea, during a spring 2018 campaign investigating direct and indirect effects of warming on marine pelagic food webs. The factor water temperature was manipulated in situ (ambient vs. +3°C) combined with the factor predator cut-off (< 200 vs. < 1000 µm) resulting in four different treatments. The experiment was part of the French ANR PHOTO-PHYTO project opened also to the Transnational Access (TA) of the AQUACOSM European project which supported the TA participants.

Results: At the beginning of the experiment, phytoplankton abundance was suppressed through high protist abundance dominated by small ciliates. In all four treatments, this was followed by an abrupt reduction of protists coinciding with a conspicuous increase in micrometazoans such as rotifers, bivalve, and polychaete larvae. With the decrease in protist abundance, a pronounced phytoplankton bloom formation was observed in all treatments. The depletion of protists was accelerated under elevated temperature conditions. A small second increase in protist abundance developed after phytoplankton bloom peak in all treatments, apart from the control (i.e. ambient < 1000 µm). Micrometazoans showed group-specific abundance patterns in response to the different treatments and played a substantial role in initiating and modulating the phytoplankton spring bloom formation.

Conclusion: Our results stress the importance of MZP intra-guild predation and its sensitivity towards warming scenarios. Further, the results support the hypothesis that MZP top-down control and selective grazing can create "loopholes" sensu Irigoien et al. (2005) for phytoplankton to escape from MZP grazing pressure and form blooms.

References: Calbet et al. 2008, Irigoien et al. 2005

O24

Dust-associated airborne microbes affect primary and bacterial production and N2 fixation rates: a mesocosm approach

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Desert dust storms are frequent in the Northern Red Sea (NRS) region, providing nutrients (i.e., PO4) and trace-metals (i.e., Fe) that may stimulate microbial activity and dinitrogen (N2) fixation. Dust also carries a high diversity of airborne microbes (bacteria, archaea), including diazotrophs, that may remain viable during transport and upon deposition. Here we evaluate the impact of atmospheric deposition and its associated airborne microbes on ambient microbial biomass, diversity and activity (primary and bacterial production, N2 fixation) in the surface water of the low-nutrients NRS, using mesocosm bioassay experiments. We compared the chemical (nutritional) and sole airborne microbial impact of aerosol additions on the abovementioned variables using 'live-dust' (release nutrients/trace-metals and viable airborne microorganisms) and 'UV-killed dust' (release only chemicals). Primary production was suppressed (as much as 50%), and bacterial production increased (as much as 55%) in the 'live dust' treatments relative to incubations amended with 'UV-treated dust' or the control. The diversity of eukaryotes was lower in treatments with airborne microbes. Airborne diazotrophy accounted for about one-third of the measured N2 fixation (0.35±0.06 nmol N L-1 d-1 and 0.29±0.06 nmol N L-1 d-1, for 'February 2017' and 'May 2017', 'live-dust' additions, respectively). Two nifH sequences related to cluster III diazotrophs were amplified from the dust samples, consistent with the N2 fixation measurement results. Our results suggest that the airborne microorganisms can alter the surface microbial ecology of the NRS. Moreover, we postulate that the deposition of viable diazotrophs, may enhance N2 fixation, especially in marine provinces subjected to high aerosol loads. These results have implications on the C and N cycles in LNLC ecosystems, which are expanding, and are especially important since dust storms are predicted to increase in the future due to desertification and expansion of arid regions.

O25

Multiple agricultural stressor effects on freshwater community structure and ecosystem functioning

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Pesticides are considered to be a major threat for freshwater biodiversity due to their widespread use in agriculture and their high toxicity for aquatic organisms. To date, there is little understanding on how pesticide mixtures affect freshwater communities under different nutrient availability scenarios. Moreover, only few studies have investigated the impact of pesticides on ecosystem functioning using a realistic species assemblage. We performed a mesocosm experiment testing the single and combined effects of two widely used pesticides (an insecticide and an herbicide), under two different nutrient enrichment conditions (mesotrophic and eutrophic). Our main objectives were to investigate the temporality of the multiple stressor effects, the influence of community composition on the observed responses, and the relationship between biodiversity and ecosystem functioning under different stress conditions. We found that all agrochemicals individually had significant effects on community composition and species richness. Interactions between stressors were significant at different time points. Particularly, late interactions were found to compromise the recovery of community composition in the long term, indicating that multiple stressor research should consider species interactions and ecosystem dynamics. Our experiment also shows that eutrophication modifies community composition and fosters the dominance of some species, which were found to be more resilient to the tested pesticides. Furthermore, we found that ecosystem functioning was generally less affected by chemical stress than community structure and that it was independent from species diversity, suggesting that functional redundancy allows to maintain constant levels of functioning even under stressful environmental conditions. However, we found the correlation between biodiversity and relevant ecosystem functions such as primary productivity to be shifted from generally positive to negative under particular multiple stress conditions.

O26

Interaction between heat waves and pesticide contamination on zooplankton communities: does the timing of stressor matter?

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Extreme weather events, such as heat waves, and pesticide pollution are two major stressors threatening biodiversity in Mediterranean wetland ecosystems. These stressors can occur with different temporal dynamics: from a perfect overlap to a complete asynchrony. Although few studies have addressed the single and combined effects of these two stressors occurring simultaneously, there is limited information about how different exposure orders may modify the overall effects on aquatic populations and communities. Yet, the exposure order of the stressors appears to be of central relevance, as interactions between warming and pesticides are known to be dependent on the application order. The toxicity of many chemicals may increase for organisms previously exposed to warming, the so-called "climate change induced toxicant sensitivity" (CITS) concept. Conversely, pesticides can reduce the heat tolerance of organisms, the so called "toxicant induced climate change sensitivity" (TICS) concept. This work aimed to assess the single and combined effects of heat waves and an insecticide on zooplankton communities collected from a Mediterranean coastal lagoon (Albufera of Valencia), as well as whether the timing of these stressors influences the populations and community responses. An indoor microcosm experiment was designed with six treatments and four replicates each (n = 4): 1) control (no insecticide, no heat wave), 2) heat wave (no insecticide), 3) insecticide application (no heat wave), 4) heat wave before insecticide application, 5) heatwave and insecticide application at the same time, 6) heat wave after insecticide application. The heat wave treatment lasted for one week and the temperature increase corresponded to approximately 7 °C (from 22 °C to 29 °C). The selected pesticide was the organophosphorus insecticide chlorpyrifos. The insecticide was applied as a single pulse at a concentration of 0.8 μg/L. The impacts of these stressors were monitored on water quality parameters, phytoplankton and cyanobacteria biomass (measured as chlorophyll-a and phycocyanin concentration) and zooplankton community (structure, diversity, abundance, and single taxa responses) for 72 days. Preliminary results have pointed out Cladocera as the most sensitive taxonomic group to the insecticide. Moreover, the overall effects of the insecticide on this zooplankton group were increased by the application of the heat wave. Specifically, Daphnia magna showed the highest sensitivity to both single and combined stressors while other cladocerans (e.g. Diaphanosoma sp. and Moina sp.) seemed

more tolerant to the temperature increase. The experiment also showed that cyanobacteria increased their abundance during the heat wave event. Finally, our results highlight that different taxa followed dissimilar recovery trajectories depending on the stressors' application order.

O27

Disentangling direct and indirect effects of agricultural run-off and climate warming on regime shifts in shallow aquatic systems

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Shallow eutrophic lakes are widespread in agricultural landscapes, yet their high surface-to-volume ratio render them very susceptible to negative effects caused by multiple stressors e.g. agricultural run-off (ARO) or climate warming. We tackled these stressors in our French-German (ANR-DFG) project CLIMSHIFT and by support from AQUACOSM for our experiment CICLimARO at the mesocosm facility at LMU Munich. The main objectives of our project were (I) to understand and predict the response of complex interacting benthic-pelagic systems to multiple stressors by global warming and ARO based on a mechanistic understanding of stressor interactions, (II) to evaluate if both stressors act in an additive, synergistic or antagonistic way on organism physiology, community and ecosystem processes and (III) to determine potential thresholds for shifts in ecosystem functions (metabolism, energy transfer, flux of elements) for single and combined stressors. We investigated the direct and indirect effects of these multiple stressors on the first two trophic levels in a series of micro- and mesocosms experiments, using different exposure scenarios and different levels of complexity. Our project goes beyond the common studies of alternative stable states in these shallow systems by including periphyton besides phytoplankton and macrophytes as functional group of primary producers, combined with appropriate primary consumers with different feeding modes, such as zooplankton (Daphnia or natural zooplankton community), mussels (Dreissena) and snails (Lymnaea). We developed an ARO cocktail composed of nitrate, copper as inorganic fungicide and three organic pesticides, an herbicide, a fungicide and an insecticide, and concentrations were based on published data on environmentally relevant levels and on known ecotoxicity towards the chosen organisms for expected low, sublethal effects. The microcosm experiments served to investigate the dose-response relationship for ARO, to test if a single or multiple pulses of the same total concentration will have different effects, to disentangle the effects of the main components of ARO (e.g. positive effects by nitrates versus negative effects by inorganic and organic pesticides) and to see if sediment- or water exposure matters. Based on these results we designed the outdoor mesocosms experiment at LMU Munich using a gradient approach for ARO combined with ambient and heated (+3°C) temperature. Despite very clear effects on primary producer dynamics with a defined ARO level used in the microcosm experiments, results were more difficult to interpret in the mesocosms. While the mesocosms at ambient temperature showed some dose-response effects, specifically when looking at the phytoplankton dynamics, this was not obvious in the heated mesocosms. We assume that a higher complexity of the phyto- and zooplankton used in mesocosms, together with other processes masked some effects, making it difficult to identify clear thresholds for a shift towards the turbid, phytoplankton dominated state in our gradient-approach. Despite these difficulties, the combination of micro- and mesocosms experiments together with modelling allowed us to identify direct and indirect effects of the multiple stressors on the benthic-pelagic systems.

O28

Impacts of Different Quality of Dissolved Organic Carbon (DOC) Pulse Disturbance on Microbial Loop: A Mesocosm Research

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Freshwater ecosystems are exposed to a variety of stressors driven by climate change that alter lake ecosystem's structure and functioning essentially. Recent increase in precipitation and flush-floods lead to higher inputs of allochtonous material such as dissolved organic carbon (DOC) to freshwaters. Resultant decrease in light and increase in nutrients may alter the composition and biomass of microbial loop (ML) communities. While the effect of DOC is heavily investigated for bacteria, studies testing the effect of DOC quality on ML are underrepresented in the literature. Therefore, during summer 2019, the impacts of two different quality of DOC pulses on ML were investigated with a-36 days long-mesocosm experiment (4x4) in Turkey. The treatments included: leachates of alder tree leaf as a labile DOC source (DOC-L), Humin Feed as a recalcitrant DOC source (DOC-R) and combination of both (DOC-MIXED). Firstly, we hypothesized that there will be a bottom-up impact where DOC quality promote bacteria when it is labile (DOC-L),eventually affecting other ML communities. Results support this hypothesis, since bacteria biomass increased sharply after the pulse in DOC-L and DOC-MIXED but not in DOC-R. Ciliates responded with both significant biomass increase (in DOC-L) and compositional change in feeding groups (in DOC-L and DOC-MIXED). Secondly, we hypothesized that, there will be a top-down impact where zooplankton affect ML communities negatively through predation/competition pressure. However, only treatment-dependent top-down impact was observed on bacteria by zooplankton; therefore, we partially accepted this hypothesis. Lastly, we hypothesized that the analysis of functional stability of bacteria biomass would reveal a quality dependent response with a final recovery. We accepted this hypothesis as bacteria showed response in only DOC-L and DOC-MIXED treatment with full final recovery. We concluded that the quality of DOC matters for ML and therefore should be considered to better understand the impacts of climate-induced DOC disturbance.

O29

Characterisation and impact of different allochthonous organic matter additions in a mesocosm experiment investigating pulse disturbance events in Mediterranean freshwater lakes

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Short periods of extreme precipitation are becoming more intense, as are longer drought periods. Such conditions boost the transport of allochthonous organic matter (allo-OM) to freshwater ecosystems, yet, little is known about the changes in seston elemental stoichiometry and dissolved organic matter (DOM) quality when different allo-OM sources affect planktonic communities. To date, studies of pulses in allo-OM availability following extreme precipitation are scarce, not least for lakes in warm climates. Mesocosm studies offer a way to investigate these effects. During summer 2019, a mesocosm experiment located in a Turkish freshwater lake examined the alterations in the quantity and quality of carbon (C), nitrogen (N) and phosphorus (P) in dissolved and seston fractions following the addition of three different allo-OM analogues. These were HuminFeed® (HF), used to examine the effects of increasing water colour, a local leaf leachate source (L) used to examine the effects of the extra energetic inputs, and a combination of both sources (HFL) to test the interactions of the single treatment effects. Results indicated that the L treatment added more colour than the HF treatment. There was also an increase in the proportion of high recalcitrant humic-like DOM components in the HF treatment, in contrast to an increase in less aromatic microbially derived humic-like molecules for the L source. The HF treatment increased seston N concentrations while the L source resulted in higher seston P concentrations. Seston C:P ratios remained below a severe P-limiting threshold for plankton growth in all tanks, however, temporal dynamics of seston C:P ratios did not depend on the treatments. In contrast, seston N:P ratios differed significantly between treatments, in that the L source reduced severe P-limiting conditions, while the HF treatment increased them. The temporal dynamics of chlorophyll a (Chl-a), a proxy of phytoplankton biomass, showed a significant trend over time which was treatment dependent. Chlorophyll a values in control and HF treatments decreased until day 12 and then remained stable for the rest of the study period. In contrast, HFL and L treatments also reached minimum values of Chl-a around day 12 but a significant increasing trend was observed reaching pre-disturbance conditions towards the end of the experiment. Unexpectedly, Chl-a in the HF treatment did not differ from controls despite the increased water colour. Moreover, Chl-a was also highest in the combined treatment where browning but also nutrients concentrations were at a maximum, suggesting that potential phytoplankton light limitation was hidden by nutrient additions. We conclude that it is crucial to consider how the resources used to mimic allo-OM inputs to freshwater systems influence the conditions in mesocosm tanks and the final experimental outcomes. Consequences for planktonic communities will depend on the type of allo-OM used. New mesocosm studies should better characterise the allo-OM sources used in their experiments in order to understand the mechanistic responses within the system to alterations in carbon and nutrient quantity and quality.

O30

The use of lotic mesocosms as a tool to study the direct and indirect effects of organic and inorganic chemical substances on freshwater ecosystems

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A lotic mesocosm platform composed of twelve 20-meter-long channels and located in the north of France has been used for the past twenty years to study the fate, direct and indirect effects of chemical substances (eg : copper, chlorpyrifos, diclofenac, bisphenol A) on primary producers and consumers. For each experiment, the mesocosms are set up with artificial sediments, macrophytes, periphyton, benthic and pelagic invertebrates, decomposers and one fish species (Gasterosteus aculeatus). After three months of ecosystem stabilization, treatment to a single and/ a mixture of substances is performed during 6 to 18 months. Periphyton biomass, macrophyte biovolume, zooplankton and invertebrate abundance and diversity, and fish individual physiological responses along with population dynamics are the measured biological endpoints. Chemical substances are monitored in water and depending on the project in certain organisms (eg : macrophytes and fish). In parallel of our experimental work, a dynamic energy budget (DEB) coupled to an individual based model (IBM) was developed to help us analyze the effects on fish population dynamics.

After a brief description of our installation along with our standardized biological methods, examples of direct and indirect effects at different levels of biological organization (individual, population, community and ecosystem levels) will be described and discussed using results obtained in different National and/or European projects. We will also illustrate how our results (mainly NOECs; no observed effect concentrations) can help to evaluate the reliability and relevance of environmental threshold values.

O31

Operation efficiency of two-stage hydrophyte mesocosm for waste water treatment

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Hydrobionts play a vital role in the self-purification processes in water ecosystems due to their ability to accumulate, utilize and transform pollutants. In the course of their life, they enrich water with oxygen, facilitate the sedimentation of suspended solids, and absorb nutrients and certain organic substances. Therefore, natural and artificial "bioplateau" with the use of aquatic organisms of different trophic levels are often used in the modern water purification constructions.

This paper represents the data obtained on experimental 1 m^3 two-stage hydrophyte mesocosm consisting of higher aquatic plant, edificator species Phragmites australis, microorganisms and other accompanying hydrobionts and intended for additional treatment and conditioning of wastewater.

The simulated input medium was characterized by turbidity index in the range of 75–85 NTU, COD 71–91 mg O/dm^3, BOD_5 7.7–9.7 mg O_2/dm^3, concentration of N-NH_4 1.6–3.0 mg/dm^3, low content of N-NO_2, N-NO_3 and P-PO_4 and corresponded to the stage of incomplete organic matter oxidation – initial nitrification. The purification capacity of the two-stage hydrophyte mesocosm was investigated at flow rates of 0.064 and 0.046 m^3/h (exchange rate about 1.5 and 1.1 working volumes per day).

According to the main hydrochemical indexes, purification efficiency of the mesocosm with a flow rate 0.064 m^3/h after 24 h was as follows: COD 69 %, BOD_5 81 %, suspended solids 88 %, turbidity index 80 %. Comparative analysis of quality indexes dynamics in simulated input medium and efflux water shows acceleration of organic matter mineralization in the mesocosm. Purified water was characterized by considerable decrease in pH value and N-NH_4 content, an increase in the concentration of N-NO_2. Under low vegetative activity of common reed, the content of nitrogen and phosphorus mineral compounds decreased in media mainly due to the microorganisms biomass growth. In the process of the mesocosm operation, a decrease in the dissolved oxygen content to 4.5 mg/dm^3 was registered, which could negatively affect the ammonification processes, but was not critical for nitrification.

Decreasing of the flow rate to 0.046 m^3/h and, accordingly, an increasing of the residence time of contaminated water in mesocosm (~0.9 day) led to a significant drop in dissolved oxygen content up to 2.11 mg/dm^3 and more noticeable decrease of pH value compared to the system with higher flow rate (residence time ~0.67 day). Decrease in dissolved oxygen concentration up to 3.0–2.5 mg/dm^3 inhibited nitrification processes, but organic matter oxidation by heterotrophic microflora slightly decreased after 24 h of operation, and intensity of the nitrification was restored. According to the main hydrochemical indexes, purification efficiency of mesocosm with a flow rate 0.046 m^3/h was as follows: COD 70 %, BOD_5 86 %, turbidity index 98 %.

Analysis of obtained data demonstrates that water flow rate, working volume and area of Phragmites australis root system are the main factors influencing purification ability of two-stage hydrophyte mesocosm. To intensify biochemical processes, it is necessary to provide a sufficient dissolved oxygen, the lack of which can inhibit nitrification processes and adversely affect the vital functions of aquatic organisms.

O32

Viral and prokaryotic community responses upon exposure to silver nanoparticles versus silver ions in coastal seawater

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Although it is widely accepted that nowadays silver nanoparticles are produced and released in the marine

environment with high rate and in large amounts, the scientific community still faces difficulties in understanding the toxicity of this material. Regarding the reasons behind this gap in understanding, it is apparent that
1) improper media are frequently used for toxicity tests such as pre-treated communities that do not resemble the natural environment,
2) there is uncertainty concerning the concentrations of silver nanoparticles in the future or current oceans and 3) as a result, too high concentrations are frequently studied making the outcomes unrealistic,
while 4) the exact toxicity mechanism is not fully explored.
Within the AQUACOSM project, a mesocosm experiment was conducted in May 2019 at the CRETACOSMOS facility (Cretan Sea, Eastern Mediterranean). In this experiment, 3 m3 of coastal seawater were treated with silver nanoparticles (NP) vs. silver ions (Ag) in triplicates and the differential effects on the microbial plankton community were compared. Non-treated mesocosms served as control. The addition of silver nanoparticles and silver ions was done in a stepwise manner (50 ng L-1 per day for 10 days), so the final concentration was as low as 500 ng L-1. A range of abiotic and biotic measurements was taken for 13 days after the onset of the incubations, targeting major microbial plankton size fractions (fempto, pico, nano, micro, meso- plankton). Additionally, a 3-day microcosm experiment was designed at the end of the mesocosm to explore the effect of silver nanoparticles vs. silver ions after the addition of nutrients in the starved community.
This presentation will give a detailed insight into the mesocosm experimental setup that has been substantiated and designed based on high throughput chemical analytical tools, and that mainly took place before the experiment. The presentation will also describe in depth the responses of the viral and prokaryotic communities in terms of abundance and community structure.
Analyses so far have shown that neither viruses nor prokaryotes were significantly affected in numbers during the 13-day incubation (data derived through flow cytometry analysis). However, a noticeable and significant decrease in Synechococcus cells at both NP and Ag treatments was seen after dissolved inorganic nitrogen and phosphate were added (RM ANOVA, $p<0.05$), confirming the susceptibility of this autotrophic taxa. The prokaryotic community at the genera level did not respond to any of the chemical treatments (data derived through 16S amplicon sequencing). In contrast, the effect of experimental time was strong and explained the largest portion of variability in prokaryotic community composition. Finally, the viral community is under investigation (data derived from whole metagenome sequencing and processing) aiming to reveal changes in community composition or gene content, as seen in a previous experiment with a similar setup in the CRETACOSMOS facility.

O33

Short term resilience to nanosilver in the protist-metazoan planktonic food web

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The pelagic microbial food web communities were studied under exposure to ionic and nanoparticle bound silver (Ag^+ vs. AgNP) during a mesocosm experiment in the oligotrophic Eastern Mediterranean Sea on May 2019. The hypothesis is that nanoparticles (60 nm) enter and go up the the food web through bacteria and nano-grazers with an increasingly adverse effect on higher trophic levels, to ultimately limit zooplankton recruitment. Repeated doses of 50 ppt silver per day were added accordingly to each treatment. The abundance of picoalgae, diatoms, ciliates and copepods remained unaffected by the treatments, whereas dinoflagellates appeared denser in both treatment mesocosms than in control. Nevertheless, there was a significant temporal shift in the communities, each of them responding differently to time. Interestingly, nauplii production in all treatment increased towards the end of the experiment indicating higher growth rates and fecundity for copepod communities. The effect of silver was explored further in a microcosm experiment by adding low doses of growth-stimulating nutrients to each treatment to combat extreme nutrient limitation created in the mesocosm bags. Consequently, a negative response was initiated in the silver treatments on cyanobacteria only. In conclusion, results point out that short-term, low-dose addition of silver ions or nanoparticles in this environment does not seem to disrupt the carbon flow between the microbial food web's trophic levels and the metazoan top predator.

O34

Ocean winter warming induced starvation of predator and prey

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Ocean warming impacts the fitness of marine ectothermic species, leading to poleward range shifts and change of community composition. While the strong effects of summer heat waves have been studied comparatively well, little is known about the impacts of winter warming on marine species. Many species benefit from low winter temperature-induced reductions in metabolism, as these allow for conservation of energy reserves that are needed to support reproductive processes in spring. We used a unique outdoor mesocosm system, the Kiel Outdoor Benthocosms (KOB), to expose a coastal predator, the sea star Asterias and its prey, the blue mussel Mytilus, to different winter warming conditions. We found that the body condition of mussels decreased in a linear fashion with rising temperature. Surprisingly, sea star growth also decreased, which was a function of unaltered predation rates and decreased mussel body condition. Asterias relative digestive gland mass also declined over the studied temperature interval. This could have strong implications for reproductive capacity in the following spring, as digestive glands provide reserves (e.g. lipids) to maturing gonads. Thus, both predator and prey suffered from a mismatch of energy acquisition versus consumption in warmer winter scenarios, with pronounced consequences for food web energy transfer in future oceans.

Melzner, F., Panknin, U., Buchholz, B., Wall, M. (2020). Ocean winter warming induced starvation of predator and prey, Proceedings of the Royal Society B 287: 20200970

O35

Means and extremes - effects of climate warming scenarios on plankton communities

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The ongoing global warming is characterized by a gradual increase in annual mean temperatures and an increased frequency and intensity of extreme heatwaves. Both can induce changes in the abundance, diversity, and richness of plankton communities, but comparative studies are largely lacking. Therefore, in a mesocosm experiment, we tested the effects of constantly increased (by 3oC) temperatures and recurring heat waves (+6oC) in a setup where both treatments received an identical energy input. This lasted for four weeks, followed by another four weeks where no treatment was applied to study ecosystem resilience. As a model community, we used the natural plankton of the large shallow Lake Balaton. Heatwaves were followed by an immediate increase in phytoplankton biomass. This was most likely a result of reduced grazing pressure by the decreasing densities of rotifers, likely driven by increased predation rates of copepods. At the end of the experiment, copepod abundances were significantly higher in heatwave treatments. The effects of constant warming were less visible in the short term, but phytoplankton biomass increased significantly towards the end. Our findings show that heatwaves can have immediate effects on biodiversity and trophic interactions, while the effects of constantly increased temperatures became only visible on a longer-term, in line with the concept of press and pulse disturbances.

O36

No rapid adaptation to heatwaves in semi-natural populations with manipulated evolutionary potential

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Human activities are altering our planet at an unprecedented rate. In order to mitigate, or even effectively manage, human disturbance we must understand what limits the evolutionary potential of populations and the consequences that adaptation, or a lack of adaptation, has for populations, communities and ecosystems. Progress towards understanding what limits evolutionary potential is limited by a lack of studies that explicitly tease apart the contributions of phenotypic plasticity and genetic diversity to evolutionary responses in natural environments with ecological complexity. In shallow freshwaters, heatwaves are a major threat to biodiversity because large surface area-to-volume ratios make shallow freshwater bodies especially vulnerable to high temperatures, and shallow freshwaters are often bounded limiting the potential for organisms to disperse. To disentangle plastic and evolutionary responses to heatwaves, we set-up we set-up 48 identical shallow freshwater communities in 3000L mesocosms with Daphnia magna populations that varied in their genetic diversity, and whether clones were plastic or not and locally adapted or not. We then exposed them to programmed month-long heatwaves each summer for two years using a natural heatwave recorded from the same mesocosms in July 2006 as a template. Changes in phenotypic evolution, clonal selection, and population and community dynamics were then monitored over the duration of the experiment.
We found that mesocosms that were exposed to heatwaves experienced higher thermal maximums compared to the controls and had a significantly higher probability of experiencing extreme temperatures for much of their development (> 96 hours). Offspring from heated mesocosms grew faster as juveniles and reached maturity earlier than D. magna from control mesocosms but these effects were transient, disappearing within 3-months of a heatwave. In the 6-clone treatments, we found no evidence that shifts in clone-frequencies were linked to heatwaves. Moreover, phenotypic shifts in response to heatwaves were not greater for treatments with more evolutionary potential. Finally, there was no difference in the clonal richness and clonal diversity of the 43-clone heatwave mesocosms and 43-clone control mesocosms over the second heatwave. Thus we conclude that phenotypic responses to heatwaves were based on a transgenerational plastic response rather than a shift in clone frequencies. As a result, D. magna populations established from a single clone were functionally similar to a D. magna population established with many clones and manipulating evolutionary potential therefore had no effect on community dynamics. Our findings contrast with previous

studies that have concluded that Daphnia populations have a high capacity to evolve thermal tolerance, or that thermal tolerance evolves rapidly in natural Daphnia populations.

O37

Warming reduces the phytoplankton spring bloom and shifts planktonic composition and succession: an *in situ* mesocosm experiment in a French Mediterranean coastal lagoon supporting *in situ* observations

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Phytoplankton spring bloom supports a consistent part of the annual marine ecosystem productivity. To better understand phytoplankton communities' response to warming and highlight the role of the micro- and mesozooplankton during a phytoplankton bloom, an *in situ* mesocosm experiment was carried out in the coastal Mediterranean Thau lagoon, south of France, in April 2018. Four treatments of two factors (temperature × zooplankton community) were applied: 1) natural planktonic community with natural water temperature (Control: C), 2) natural planktonic community with +3°C (T), 3) natural plankton community with exclusion of mesozooplankton (< 200 μm) with natural water temperature (MicroZ), and 4) natural plankton community with exclusion of mesozooplankton with +3°C (TMicroZ). Warming strongly modified the phytoplankton biomass accumulation, composition, and succession. The bloom in warm conditions (T) was two-times lower, and the bloom lasted one day earlier compared to the Control treatment. The mesozooplankton exclusion revealed that microzooplankton is the main phytoplankton predator, whereas the mesozooplankton is mainly a secondary phytoplankton consumer. Therefore, the differential phytoplankton response to warming with or without mesozooplankton suggested that the bloom reduction is probably an indirect response to the strengthening of biological interactions, such as grazing pressure. Furthermore, warming promoted smaller green algae and dinoflagellates at the expanse of diatoms and prymnesiophytes. In addition, warming also induced a modification of the phytoplanktonic succession throughout the experiment, with an early bloom of small green algae and a late bloom of diatoms, probably due to remineralisation, that did not occur in control mesocosms. These experimental results corroborate well *in situ* observations in the Thau lagoon during two consecutive years, one as 'normal year' and another with the 'warmer winter ever recorded'. Thus, combination of both observations and experimental results suggest that if similar warmer environmental condition would occur in the future, phytoplankton spring bloom might be weaker with a predominance of the smaller phytoplankton taxa, causing a reduction of the carbon transfer to higher trophic levels.

O38

Temperature fluctuation effects on a natural phytoplankton community depend on the frequency but do not diminish ecosystem functioning: a mesocosm experiment

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With increasing frequency and intensity of climate change events, the temperature tolerance of primary producers is an important thermal trait. In a controlled indoor-mesocosm set-up, we tested the effect of a fluctuation frequency gradient, when maintaining the same amplitude and mean temperature, on a natural phytoplankton community. We found that the effect of temperature fluctuations depends on the fluctuation frequency, but that ecosystem functioning could be generally maintained. Temperature fluctuation with higher frequency than natural diurnal fluctuations acted performance-enhancing and accelerated biomass production. Whereas, under temperature fluctuation with lower frequency than diurnal fluctuation performance could be maintained or was slightly reduced compared with the constant control. In addition, minor differences in diversity and composition were observed. These rather small effects of temperature fluctuations indicate that phytoplankton communities may be already well adapted to fluctuating environments, and thus, may be more resilient towards temperature change than previously thought.

O39

Phytoplankton diversity and functional traits under extreme climate events simulated by a pelagic mesocosm experiment

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In July 2019, we ran the MESOLAC experiment in Lake Geneva to study the responses of the plankton community during simulated extreme events (floods, storms) and its ability to recover after perturbation. Nine pelagic mesocosms (about

3 m deep, 1 m in diameter) were deployed for four weeks in situ near the lake shore at INRAE CARRTEL (Thonon les Bains, FR). The experimental design included three treatments each replicated three times: a control treatment (no treatment applied – named C) and two different treatments simulating extreme weather events. The high intensity treatment (named H), aimed at reproducing short and intense weather events such as violent storms. It consisted of a short-term intense stress applied during the first four days, with high pulse of dissolved organic carbon (DOC 5x increased concentration compared to the control), transmitted light reduced to 15% and water column manual mixing applied daily for 15 minutes. After this period, the treatment was exposed to control conditions (covered with a 95% transmitted light filter, no further DOC increase and no mixing). The medium intensity treatment (named M), simulated less intense and more prolonged exposures such as during flood events. It was maintained through the four weeks of the experiment and consisted of 1.5x increased concentration of DOC compared to the control, transmitted light reduced to 70% and water column manual mixing applied daily for 5 minutes. Physico-chemical parameters (temperature, conductivity, dissolved oxygen and dissolved CO_2) were monitored in situ every 15 minutes using automated data loggers. Twice a week the mesocosms were sampled for full physico-chemical analyses (pH, conductivity, stoichiometry, nutrients concentration...) and phytoplankton population dynamic and activity.

The H treatment had the strongest effect at the intensity peak of the treatment (day 4). The high-frequency oxygen data showed a strong decrease and at the same time a peak in the CO_2 concentration was observed. The phytoplankton community was mainly characterized by lower diversity (Shannon and evenness) compared to the C and M treatments. The M treatment showed the maximum diversity according to the intermediate disturbance hypothesis, but had less effect on phytoplankton composition. The phytoplankton classified as pure autotrophic was lower in the H treatment during the entire experiment, while mixotrophs increased in both H and M treatments compared to C. The community turnover showed maximum values in the H and M treatments during the experiment and then was again similar to C at the end, suggesting that the lake ecosystem is resilient.

These results provide evidence of the effect of climate events of different level of stress on the phytoplankton diversity and functional traits by favoring species more adapted to changing conditions as showed by the low diversity and fast turnover during the peak of the treatments.

O40

Zooplankton dominance shift in response to changing salinity in the Baltic Sea

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Current climate change predictions indicate declining salinity in the Baltic Sea with negative implications for plankton food webs; an important baseline for functioning of marine ecosystems. In this study, we investigate the effect of salinity change on plankton communities under different salinity change scenarios of the Baltic Sea. Projections for future salinity change derived from regional physical-biogeochemical models were used to set-up an outdoor mesocosm experiment in the coastal area of the Gulf of Finland. Each mesocosm was inoculated with natural plankton using a mixture of both marine and freshwater communities, mimicking the natural influx of freshwater species from rivers into the Baltic Sea. As the water column either declined or increased in salinity, the productivity of phytoplankton increased. This had an indirect effect on higher trophic levels through altered resource availability. Zooplankton diversity and composition changed possibly due to different salinity tolerances among the species. Among zooplankton, rotifers dominated in low salinities and cladocerans and copepods in high salinities. Collectively, our results indicate that freshening of the Baltic Sea will result in a restructuring of the plankton community through bottom-up effects of increased phytoplankton productivity controlling zooplankton populations through resource competition or niche complementarity. The zooplankton community will shift to a rotifer dominated community in low salinities due to the intolerance of other zooplankton groups to freshening.

O41

Dispersal increases recovery of ecosystem productivity after an extreme climatic event

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Global warming is characterized by an increasing frequency, magnitude, and duration of heat waves, which may alter biodiversity more dramatically than changes in the mean regimes. Understanding how communities can withstand or recover from heat waves is, therefore, critical. There is evidence that habitats connected to a diverse regional species pool are less vulnerable against perturbations, as their functioning can be maintained by the immigration of more tolerant species ('Spatial Insurance Hypothesis'). Here we tested, by using alpine lake plankton as model communities in a mesocosm study, whether dispersal from natural lakes could counteract the negative effects of a heat wave on isolated local communities. Mesozooplankton proved to be especially sensitive to heat stress and decreased in biomass, which was not modulated by dispersal. The failed top-down control on algae resulted in overall higher phytoplankton biomass and a shift towards bottom-heavy food webs in heated mesocosms. We furthermore found a positive interactive effect of dispersal and heat wave on phytoplankton biomass, suggesting that dispersal contributed to a faster recovery of primary productivity under warming conditions. Our results suggest that a relatively short heat wave can have serious consequences on aquatic ecosystem functioning. While dispersal can modulate the response of communities, the effect may depend on the investigated trophic level.

O42

Ocean Acidification impacts on elemental stoichiometry: A data synthesis of in situ mesocosm experiments

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Ocean acidification (OA) will affect marine biotas from the organism to the ecosystem level. Yet, global-scale consequences on key plankton groups and biogeochemical cycles are still unclear.

Here we synthesized sediment-trap data from in situ mesocosm studies in different marine biomes and demonstrate that OA considerably alters the elemental stoichiometry of sinking material

C:N ratios of exported organic matter display distinct but highly variable impacts of OA, reaching up to a 20% increase/decrease under pCO2 conditions projected for 2100. These changes are driven by pCO2 effects on a variety of plankton taxa and corresponding shifts in food-web structure. Notably, our findings suggest a pivotal role of heterotrophic processes in controlling the response of C:N to OA, thus contradicting the paradigm of primary producers as the principal driver of biogeochemical responses to ocean change.

Furthermore, Si:N ratios respond more uniformly to OA, displaying an increase in Si:N of 17% until the end of the century. Implementation of this sensitivity into a model reveals that this could lead to a profound redistribution of silicic acid in the world oceans, with far-reaching consequences for diatoms.

O43

Mesocosm approaches addressing the role of environmental variability in a changing climate

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Environmental variability can be found in distinct earth's systems, across environmental drivers, and exists at diverse temporal and spatial scales, which may lead to unpredictable environmental extremes such as heatwaves. This talk will exemplify environmental variability in costal marine systems, and present different approaches testing the influence of short-term variability and environmental extremes on marine hard- and soft-bottom benthic communities, materializing mesocosm to bench-top setups that are applied in conjunction. Using the Kiel Fjord, Western Baltic Sea as model system, we characterized thermal, pH/pCO2, oxygen, salinity and nutrient regimes across temporal scales. These environmental fluctuations may significantly modulate the responses of biological systems to environmental trends at diverse levels of organization due to e.g., nonlinearity in predictor-performance relationships (Jensen's Inequality), acclimation (stress memory), recovery during benign phases of stress, and selection pressure during environmental extremes.

In the study system, seawater temperature fluctuates with strong seasonal patterns. We investigated the differential effects of timing and strength of marine heatwaves. We demonstrate very species-specific impacts with implications on the community level. Generally, marine heatwaves did most dramatically influence benthic communities during peak summer season and winter, while the effects were beneficial or neutral during spring and autumn. Yet, diurnal thermal variability, a prevalent temperature pattern in shallow coastal habitats, acted as refuge during the occurrence of thermal extremes. Marine heatwaves are occasionally interrupted by upwelling events, which may, depending on season, be of differing quality (nutrient-enriching, cooling, acidifying, or hypoxic), with likely taxa to phyla-specific impacts. We investigated the differential effects of subsequent upwelling events coupled with warming (0 to 5 °C above ambient). Warming had beneficial effects when ambient temperature remained at sub-optimal levels but was stressful to most

organism when levels were closer to or higher than the species' thermal optima. Upwelling of cooler water mitigated the impacts of ocean warming during peak-temperature season, yet was stressful to most, but not all, components of the community when the upwelled water appeared to be hypoxic in late summer. We demonstrate that environmental variability may have differential impacts on different taxa and species in a community, and that these impacts may differ depending on the scale and strength of the environmental variability applied. Yet, another often overlooked aspect may be the timing of events and we exemplify that the experience of a benign marine heatwave may be beneficial for coping with hypoxic upwelling later during the season.
We conclude that: (i) Environmental variability should be considered over static treatment regimes. (ii) State-of-the-art mesocosm infrastructures should be able to implement variability in different global and locally relevant environmental drivers and should ideally be able to record species and community responses at high temporal resolution. (iii) A sound knowledge about the environment of interest will help setting and understanding the influence of natural environmental ocean change drivers on species to communities. And (iv) bench-top side experiments may help understanding community-level effects.

O44

Fine-tuning biodiversity assessments of a multi-site mesocosm network by pairing eDNA metabarcoding and morphological approaches

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Quantifying biodiversity accurately is a long-standing challenge in ecology. Taxonomical inventories based on environmental (e)DNA have been shown to improve detection capability, taxonomic resolution and cost-effectiveness when compared to morphological-based approaches, therefore may allow to accurately measure biodiversity. We assessed biodiversity and compared eDNA- and morphological-based approaches at a multi-scale. Biodiversity surveys were conducted across biogeographic gradients, ranging from semi-arid to alpine environments, using the multi-site mesocosm facility - Iberian Pond Network, combining eDNA metabarcoding and morphological-based approaches. Different markers were used to amplify DNA from different trophic levels (phytoplankton, zooplankton, and macroinvertebrates). Organisms were also collected with conventional methods, and were identified and enumerated under the microscope. With our datasets, preliminary results indicate that using eDNA we obtained higher taxonomic resolution; morphological approaches presented higher α–diversity than eDNA; but the latter showed higher β-diversity across mesocosms in the different regions. However, both approaches showed the same gradients, with regions exposed to greater environmental filters, e.g., higher temperatures in southern regions or colder temperatures in mountain tops, having fewer numbers of species than regions with intermediate temperatures. These data highlight several on-going challenges for both approaches, including incomplete sequence reference databases and the difficulty to morphologically identify some taxa due to their life stage. We developed an integrated methodology to fine-tune biodiversity surveys that pairs eDNA metabarcoding with morphological data, following a series of taxonomic and geographic filters. By building up on the strengths that these two approaches offer, with our framework we were able to improve taxonomic resolution of 30% of the taxa and assign species' traits to 85% of the taxa in hybrid datasets. These results indicate that eDNA-based assessments can complement, but not always replace conventional approaches. Integrating conventional and modern eDNA metabarcoding approaches, already available in the ecology's toolbox, gets us closer to enhance biodiversity assessments.

Methodology and Technology in mesocosm research

O45

Sensor technology provides early warning signals for functional destabilization of phytoplankton communities by lake salinization

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Many freshwater ecosystems around the globe show a substantial anthropogenic-driven increase in their salt concentration, which pose a major threat to biodiversity and ecosystem functioning. However, most studies lack a high temporal resolution and thereby miss small-scale ecological responses to salinization. Here we conducted a mesocosm experiment in an oligotrophic, boreal lake using high frequency sensor technology in order to gain a mechanistic understanding of both, compositional and functional responses of natural phytoplankton communities to salinization. High frequency chl-a fluorescence data revealed a profound suppression of day and night signal cycles with increasing salinity, thus suggesting physiological stress from the impairment of photosynthesis via effects on the photosystem II. Importantly, the suppression of these fluorescence signals long-preceded the functional consequences from salinization. We found strong multifaceted impacts of salinization, including (1) a profound loss of phytoplankton diversity and compositional re-organization, (2) shifts towards a smaller community size structure, (3) a strong reduction of the overall phytoplankton standing stock and (4) exacerbated water quality degradation driven by increased cyanobacterial bloom intensity. High frequency sensor technology may therefore be a promising tool to capture early warning signals predicting the functional destabilization of lake ecosystems from environmental disturbances in the form of salinization.

O46

Latest advances in the on-going development of the FlowCam

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Responding to the need for the "rapid counting, imaging, measurement and identification of individual plankton cells in natural populations", researchers at the Bigelow Laboratory for Ocean Sciences in 1999 developed the FlowCam, an imaging particle analyzer designed specifically to support aquatic microbial research. Since 1999 over 500 FlowCams in 60+ countries have been utilized in the study and monitoring of microorganisms in both freshwater and marine systems, including many facets of aquatic mesocosm research. Here we will present an overview of the latest advances in the FlowCam technology along with examples of how the FlowCam is being used in the support of aquatic research.

O47

Zooming in on host-virus dynamics of a blooming algae one cell at a time

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Blooms of the microalga Emiliania huxleyi have been associated with global carbon cycle and biological climate forcing from local to geological time scales. E.huxleyi blooms are terminated by a specific giant virus imposing a top-down control by infecting and lysing the host cell. Recently, these algae-virus interactions have been proposed to represent a new entity, the 'virocell', where an infected cell represents a metabolic state that is different from either the non-infected cell, or the virus. Virocells pose a potential impact on the structure and evolution of microbial populations, and possibly influence global biogeochemical processes. However, we know little about their prevalence, metabolic function, or cell fate. Here, we use single-cell approaches to probe algae-virus interactions with unprecedented resolution, striving to elucidate the virocell entity.

O48

Effects of multiple stressors on shallow freshwater habitats - suspended mesocosms mimicking a benthic-pelagic habitat

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Due to their special characteristics, shallow aquatic freshwater habitats provide vital ecosystem functions but are also vulnerable to multiple stressors. These stressors can have a multitude of effects on pond communities. Interactions between organisms, indirect effects and the combination of more than one stressor make predictions about how stressors affect ecosystem dynamics nearly impossible.

In this five-laboratory German-French cooperation project funded by DFG and ANR we investigated the combined effect of elevated temperatures and a pulse of agricultural runoff (ARO) including biocides, copper and nitrate on pond food web dynamics. We analysed how these combined stressors influence dynamics, functional diversity and abundance of benthic and pelagic primary producers and primary consumers.

Artificial outdoor ponds were exposed to a gradient of ARO, either at ambient temperature or +3°C. In order to heat all mesocosms equally and from the outside, they were suspended in two larger ponds. This had the additional benefit of the mesocosms behaving like larger bodies of water in terms of temperature changes. Each mesocosm contained a 70 cm water column above a 10 cm layer of sediment on the bottom and was inoculated with macrophytes, periphyton and phytoplankton, as well as zooplankton, snails and mussels. After the ARO pulse, the mesocosms were surveyed with sensors and organisms were sampled regularly for eight weeks with focus on interactions between the different functional groups of benthic and pelagic primary producers and associated consumers that could affect shifts between alternative stable regimes. Ecotoxicological stress indicators such as growth and biomarkers were combined with functional community/ecosystem approaches looking at ecosystem metabolism and dynamics.

Understanding Ecosystem functioning through mesocosm research

EP1

Dispersal limitation leads to trophic downgrading of the microbial food web in freshwater metacommunities

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The role of dispersal limitation for microbial taxa is still debated nearly 85 years after Baas-Becking stated his famous hypothesis. Whereas substantial experimental evidence has shown that "everything is everywhere" does not hold, "the environment selects" (i.e. species sorting) is without doubt a powerful force in shaping microbial communities. However, under which environmental conditions dispersal limitation (i.e. connectivity) matters for microbial diversity, which taxa are affected and if and how ecosystem function is impacted is still poorly understood especially due to the challenging functional complexity of microbial communities. Here we address the influence of connectivity on microbial community structure and ecosystem function under two different nutrient- and grazing regimes, on a scale relevant for real-world ecosystems. This was achieved by a mesocosm experiment involving natural freshwater plankton (phytoplankton, eukaryotic consumers and bacteria). Connectivity was realized by addition of a weekly pooled inoculum from nearby lakes, which were the source of the initial communities. We found that lack of connectivity resulted in lower diversity and different community composition over time. In particular, microbial predators (ciliates) and parasites (aquatic fungi) were lower in abundance than in connected mesocosms. This was linked to higher biomass of opportunistic green algae, especially in treatments with higher nutrient levels and absence of mesozooplankton grazers. This findings underline the importance of connectivity as key driver of microbial community composition. Limited connectivity may specifically affect microbial consumers, with implications for food webs structure and diversity.

EP2

The metabolic landscape evolving during algal bloom succession as revealed by an exometabolomics approach

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Dissolved organic matter (DOM) is estimated to account for 662 Pg carbon, and is thus one of the largest global inventories of carbon in the ocean. Lytic viral infection of the marine microalga Emiliania huxleyi leads not only to a profound remodelling of host metabolism but also to a release of organic matter from infected cells to the DOM pool, a process called 'viral shunt'. Currently, we lack quantitative tools to assess changes in the marine DOM pool as a consequence of the 'viral shunt'.

In this study, we mapped in high temporal resolution the exometabolite landscape during growth and demise of E. huxleyi blooms that were induced in semi-natural mesocosm set-ups near Bergen, Norway. Using an untargeted exo-metabolomics approach based on a solid phase extraction method, we revealed profound and dynamic changes during phytoplankton bloom succession. A suite of halogenated metabolites was characteristic of the viral infection-derived DOM and may provide a tool to directly quantify the 'viral shunt'.

The evolving exometabolic landscape has the potential to affect microbial community composition and may be used as a fingerprint to reconstruct algal bloom events even after their demise.

EP3

Competition and coexistance patterns in the microbial plankton of an oligotrophic sea

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Although the research interest around the planktonic food web is great and the achievements in this field are considerable, not all relationships among plankton groups have been completely clarified, especially when ecosystems encounter disturbances. We designed a mesocosm experiment to study deeper the life mode of marine plankton living under oligotrophic conditions. We treated the water by increasing the availability of nitrogen, phosphorus, and carbon sources to provoke the dynamic response of osmotrophic groups. Additionally, the top predator/grazer (mesozooplankton) abundance was minimized in one of the treatments. We focused on the response of all plankton groups, from viruses

to mesozooplankton, to the changed conditions.
Osmotrophic groups were the first to respond to the nutrient addition as expected, and their concurrent increase indicates competition among heterotrophic bacteria, pico- and nano-autotrophs. The reduction of mesozooplankton favored the populations of dinoflagellates and diatoms towards the end of the experiment. In addition, ciliates increased during the chlorophyll-a bloom and this is likely the reason why nano-plankton abundance declined during and after the bloom. Once these results are combined to the plankton community diversity data to be produced, we will be able to decipher the relationships among groups and the species that orchestrate them.

EP4

Modelling early larval growth (and more) of the Peruvian anchovy (Engraulis ringens)

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The Peruvian anchovy is a key species in the Humboldt Current System, supporting one of the world's largest single-species fisheries. In the actual context of global change, predicting how its early life stages are affected by environmental factors, such as temperature, is particularly important for recruitment dynamics, stock prediction and sustainable fisheries management. The aim of the present study was to provide a model for larval growth of the Peruvian anchovy, taking into account the effect of temperature. Eggs of Peruvian anchovy were naturally spawned in captivity, and larvae were successfully reared up to 33 days, at two different temperatures (14.5 and 18.5°C). Larval growth at 18.5°C was significantly higher: at the end of the experiment, larvae from 18.5°C reached a size of 20.49 ± 0.86 mm SL (33 days post-hatch [dph]), while larvae from from 14.5°C reached a size of 11.53 ± 0.65 mm (30 dph). The von Bertalanffy growth function (VBGF) was used to describe larval growth at the two temperatures, including a temperature correction parameter, based on Van't Hoff-Arrhenius equation describing the dependency of physiological rates on temperature. This simple bioenergetics-based model proved to capture well juvenile and adult growth, suggesting that temperature effect on Peruvian anchovy larvae can be extrapolated to the entire life cycle. Temperature plays a major role in the bioenergetics of this species, and the model presented here showed good potential for its use in fisheries management and environmental variability scenarios.

EP5

Assessing the dynamics of the microbial plankton community in mesocosms experiments using a NPZD model

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A mesocosms approach was used to assess the seasonal variability on the structure and dynamics of marine microbial plankton communities in a coastal upwelling system. To this aim, four experiments were conducted during the main characteristic periods of the seasonal cycle in the Ría de Vigo (NW of Spain): spring phytoplankton bloom, summer stratification, autumn upwelling and winter mixing. In each of these experiments, enclosed communities were monitored and key variables and rates were measured during 9 days. The data and the functional aspects of these communities were interpreted applying a simple NPZD (Nutrients-Phytoplankton-Zooplankton-Detritus) model in which the strategy was to maintain invariant as many model parameters as possible. The analysis of those parameters that were modified to accurately simulate the time evolution of the microbial communities in the mesocosms, provided important information about the main processes influencing the plankton structure and dynamics in the bags. This modelling approach allowed assessing the dynamics of the four communities just varying a few parameters: phytoplankton maximum growth rate, bacterial growth efficiency, microzooplankton grazing rates and phytoplankton sinking rates.
Using this model we detected that during most of the seasonal cycle, when large cells (mainly diatoms) dominate, the phytoplankton community seems to be bottom-up controlled. Nevertheless, during winter, when small phytoplankton prevails and nutrient concentration is higher, phytoplankton biomass is low, showing a tight coupling to microzooplankton biomass, which suggests a top-down control of the phytoplankton community.

EP6

Identifying keystone species

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To disentangle the role of individual zooplankton taxa in the food web of a large lake, we performed a mesocosm experiment in Lake Constance with natural phytoplankton and zooplankton communities. In three treatments with native, invasive or no fish predators, a large daphniid, Daphnia longispina, was the zooplankter most strongly predated by both fish species, and also had the highest top-down effects on phytoplankton. All other zooplankton taxa, including a small daphniid species, had minor roles in terms of both predation by fish and grazing on phytoplankton. Our study advances our understanding of species-specific roles of zooplankton in food webs and trophic cascades in oligotrophic pelagic environments. We demonstrate that considering both zooplankton and daphniids as uniform taxonomic groups, as it is common practice, might limit understanding of links between multiple trophic levels in aquatic ecosystems. We suggest that the genus Daphnia is not a keystone taxon, but rather that large Daphnia species such as D. longispina can control food web structure at trophic levels from phytoplankton to fish. Our observation of comparable top-down predation on D.longispina by fish with specialist and generalist feeding modes suggests that the keystone role of large daphniids in oligotrophic lake food webs could extend across ecosystems with different fish predation regimes.

EP7

Effects of added humic substances and nutrients on photochemical degradation of dissolved organic matter in a mesocosm amendment experiment in the Gulf of Finland

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Dissolved organic matter (DOM) is the second largest bioreactive carbon reservoir in the ocean. DOM of terrestrial origin (tDOM), such as humic substances, makes a significant contribution to the marine DOM and colored DOM (CDOM) pools in coastal areas, and photochemistry can be a major sink for tDOM. In many aquatic systems, there are increasing concerns of rising terrestrial input of humic substances to surface waters that lead to browning effects, which in turn can have many ecosystem impacts. However, relatively little work has been published on the effects of browning and eutrophication on photochemistry in estuaries and coastal waters. Through the JOMEX LightCycle project, we conducted photoirradiation experiments to investigate the effects of added humic substances (represent additional tDOM input) and nutrients on the photodegradation of CDOM/DOM in mesocosms in the coastal Baltic Sea (western Gulf of Finland). The humic- and humic-and-nutrients-amended water samples had higher CDOM absorption coefficients (ag) as expected. CDOM degraded in laboratory irradiation experiments as indicated by decreasing ag (CDOM fading) and molecular weight over irradiation time. The ag fading rates were not different between the humic-amended and control samples until 5 days after the initial amendment (day 6). The rates were higher in the humic-amended samples for a few days, but then became similar again in the humic-amended and control samples towards the end of the amendment experiment. These results suggest that the added humic substances led to in situ CDOM/DOM property changes that affected the rates of CDOM photodegradation. Furthermore, the higher dissolved inorganic carbon (DIC) photoproduction rates in the humic-amended samples compared to the control samples, suggested that the humic-amended samples had higher DOM photodegradation rates. It is possible that either at least some of the added humic substances was photodegraded to DIC, or the added humic substances stimulated the DIC photoproduction of the amended CDOM/DOM, or a combination of both. The addition of nutrients had no significant impact on CDOM fading rates or molecular weight changes from photodegradation. However, day 6 humic-and-nutrients-amended samples had lower DIC photoproduction rates when compared to samples taken right after the initial amendment (day 1), whereas the day 6 humic-amended samples had higher DIC photoproduction rates than day 1 samples. It is possible that the nutrient addition led to changes in CDOM/DOM properties in the humic-and-nutrients-amended mesocosm, which in turn led to decreasing DIC photoproduction rates over time. In conclusion, photochemistry has the potential to increase CDOM and DOM degradation rates when additional inputs of tDOM occur in this Baltic Sea system, and eutrophication could affect some aspects of the photodegradation. Further research including dark incubation and photochemical efficiency experiments and DOM composition studies are needed to better constrain the importance of photodegradation in removing added tDOM.

EP8

The presence of silver nanoparticles reduces demand for dissolved phosphorus to the benefit of biological nitrogen fixation in the coastal eastern Mediterranean Sea

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The release of silver nanoparticles (AgNPs) into the environment is expected to increase significantly as a consequence of the expanding nanotechnology industry and the numerous applications of AgNPs in different sectors. Despite previous experiments that have proved the toxic effects of silver nanoparticles (AgNPs) on a range of marine organisms, the impact of AgNPs on important biogeochemical processes such as marine nitrogen fixation is largely unexplored. With the purpose of bridging existing knowledge gaps, the effect of AgNPs and dissolved silver ions (Ag^+) on nitrogen fixation activity was assessed through a mesocosm experiment simulating the oligotrophic coastal waters of Crete (Greece). After eleven days of stepwise AgNPs and Ag^+

addition to the mesocosms (50 ng/L/day), nitrogen fixation rates were significantly higher in samples treated with AgNPs compared to Ag+ and control mesocosms ($X^2(2)=14.864$, $n=108$, $p<0.001$). Gene sequence analyses conducted on 16S and 18S rRNA data reported no significant changes in the bacterial community composition likely to be associated with nitrogen fixation activity, while some phytoplanktonic species (e.g. Chaetoceros muelleri and Leptocylindrus aporus) showed a lower relative abundance in the silver-treated mesocosms. We hypothesise that the relatively low concentrations of AgNPs and Ag+ used in this study caused moderate toxicity only to some phytoplanktonic species, while diazotrophic bacteria were able up-regulate their activity in the presence of AgNPs due to reduced competition for dissolved phosphorus.

EP9

Phytoplankton dynamics and productivity modeling from remote sensing and limnological measurements-the Lake Maggiore experiment

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This study presents the results relative to the Lake Maggiore experiment that was carried out in July 2019 to evaluate whether the phytoplankton diurnal dynamics could be characterized exploiting both hyperspectral remote sensed reflectance and fluorescence information. Furthermore, the link between fluorescence and photosynthesis has been used to develop and test several phytoplankton productivity models defined combining opportunely remote sensed quantities and then compared to the in-situ phytoplankton biovolume.
Continuous diurnal spectral measurements have been collected for several consecutive days (from the 03rd up to the 07th), by a ROX spectrometer, in the VIS-NIR spectral range (400-950 nm), with a spectral resolution of 1.5 nm, every minute. The ROX was mounted on a floating buoy, left far enough from the coastal zone to avoid the bottom contribute in the signal acquired. To characterize the water body bio-optical properties, water samples have been collected at two different depths (near surface 0.2-0.5 m and at the euphotic zone), in different illumination conditions, the 03rd and 04th of July. The first sampling day was characterized by clear sky conditions up to the solar noon then clouds appeared, while the latter one was completely cloudy. The water samples collected have been analyzed in laboratory to estimates chlorophyll-a concentration, pigments absorption spectra, fluorescence quantum yield, phytoplankton composition and biovolume.
Concerning the water samples, the rates of fluorescence (Ff) and absorbed light (Fa) have been evaluated according to Kiefer at al. (1989) at the two depths previously defined. Values referred to the euphotic depth show comparable diurnal trends in both the two days investigated, regardless the meteorological conditions. Conversely, the surface is more influenced by the weather variability inasmuch the parameters undergo to opposite evolutions from a day to the other.
Assuming the phytoplankton biovolume as proxy for the carbon assimilation (Fc), it was also possible to evaluate an experimental surrogate for the quantum yield of carbon fixation (Φ'c).
All the parameters described above have been compared to the spectral values and indices evaluated from the ROX hyperspectral measurements, specifically EPAR (integral of the irradiance over 400-700 nm) and FLH (Fluorescence Line Height), linked to the amount of fluorescence emitted by the water body. EPAR shows a linear trend with the FLH, both of them are strongly linked to the surface Fa and Ff, while the FLH/Fa ratio shows a trend coherent with Φc. These relationships have been exploited to define several phytoplankton productivity models: promising results have been observed when the Fa has been replaced by the FLH in the Fc equation. Since only few field measurements were available for this test, the analysis carried out was mainly qualitative. Nevertheless, these preliminary outcomes could be applied on remotely sensed images of lakes in future, as a potential approach able to follow the inland waters spatio-temporal dynamics linked to the phytoplankton evolution driven by the light availability and meteorological variations. Further investigation will be carried out during a more detailed experiment, planned in August 2021, at IGB LakeLab (Germany), with the frame of 'Aquacosm' mesocosms network.

EP10

Evaluating stream CO2 outgassing via drifting and anchored flux chambers in a controlled flume experiment

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Carbon dioxide (CO_2) emissions from running waters represent a key component of the global carbon cycle. However, quantifying CO_2 fluxes across air–water boundaries remains challenging due to practical difficulties in the estimation of reach-scale standardized gas exchange velocities (k600) and water equilibrium concentrations. Whereas craft-made floating chambers supplied by internal CO2 sensors represent a promising technique to estimate CO2 fluxes from rivers, the existing literature lacks rigorous comparisons among differently designed chambers and deployment techniques. Moreover, as of now the uncertainty of k600 estimates from chamber data has not been evaluated. Here, these issues were addressed by analysing the results of a flume experiment carried out in the Summer of 2019 in the Lunzer:::Rinnen – Experimental Facility (Austria). During the experiment, 100 runs were performed using two different chamber designs (namely, a standard chamber and a flexible foil chamber with an external floating system and a flexible sealing) and two different deployment modes (drifting and anchored). The runs were performed using various combinations of discharge and channel slope, leading to variable turbulent kinetic energy dissipation rates (1.5 × 10–3 < ε < 1 × 10–1 m2 s–3). Estimates of gas exchange velocities were in line with the existing literature (4 < k600 < 32 m2 s–3), with a general increase in k600 for larger turbulent kinetic energy dissipation rates. The flexible foil chamber gave consistent k600 patterns in response to changes in the slope and/or the flow rate. Moreover, acoustic Doppler velocimeter measurements indicated a limited increase in the turbulence induced by the flexible foil chamber on the flow field (22 % increase in ε, leading to a theoretical 5 % increase in k600). The uncertainty in the estimate of gas exchange velocities was then estimated using a generalized likelihood uncertainty estimation (GLUE) procedure. Overall, uncertainty in k600 was moderate to high, with enhanced uncertainty in high-energy set-ups. For the anchored mode, the standard deviations of k600 were between 1.6 and 8.2 m d–1, whereas significantly higher values were obtained in drifting mode. Interestingly, for the standard chamber the uncertainty was larger (+ 20 %) as compared to the flexible foil chamber. Our study suggests that a flexible foil design and the anchored deployment might be useful techniques to enhance the robustness and the accuracy of CO2 measurements in low-order streams. Furthermore, the study demonstrates the value of analytical and numerical tools in the identification of accurate estimations for gas exchange velocities. These findings have important implications for improving estimates of greenhouse gas emissions and reaeration rates in running waters.

EP11

Elevated temperature results in higher compositional variability of pioneer phytoplankton communities in a mesocosm system

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A crucial point in current research on plankton ecology is how global warming will change community functioning, which has led to numerous studies addressing the question with a variety of conclusions. We previously observed a long-term increase in the compositional variability of phytoplankton in a large shallow lake with a concurrent rise in mean temperature, and we conducted an experimental test of this hypothetical link in a mesocosm system. Following predictions of water temperature for the end of the century, twelve mesocosms were filled with pre-filtered and sterilized lake water with six of the tanks kept 3°C above ambient levels. Phytoplankton colonisation and subsequent changes in its composition were monitored using microscopic analysis and flow cytometry. Chlorophytes were the most successful colonizers, with no treatment-specific effect on dominant taxa. However, heated mesocosms showed higher variation in community structure (distance-based beta diversity), due to higher variability in subdominant species, a considerable portion of which were flagellated taxa. Our hypothesis of temperature-driven compositional variation was supported by both cytometric and taxonomic data, implying that higher spring temperatures can enhance variability in phytoplankton, which might increase the chance of alternate pathways during succession and thus reduce the predictability of its annual cycle.

EP12

Carbon:Nitrogen Relationships in Freshwater Closed Ecological Systems

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The Carbon:Nitrogen relationships in our freshwater microcosms were not consistent with the Redfield Ratio of 6.6 C:N. The Closed Ecological systems consisted of chemically defined medium and community of 3 species of green algae, unidentified microbes, and in some cases, the grazers Daphnia. The sealed microcosms had a light:dark cycle of 12:12 hr, and pH and dissolved oxygen were recorded every 5 minutes. Experiments were conducted for a month or more. The pH increased and Dissolved Inorganic carbon decreased far more than predicted from the Redfield Ratio given the nitrogen input. In general, dissolved Inorganic Carbon serves two roles in aquatic communities: a carbon source for phytoplankton and a pH buffer. If available nitrogen is scarce, enough carbon remains available to be an effective buffer and pH remains near neutral. But in these experiments, greater inorganic carbon was removed by photosynthesis, buffering capacity was diminished, and there was a marked increase in pH. In marine ecosystems, carbon over-consumption (carbon uptake greater than estimated by the Redfield ratio of 6.6 C:N) has been reported to be associated with the excretion of dissolved organic carbon. This could explain our experimental results. Given modest nitrate, the pH often exceeded 10 and eliminated the grazers. At high pH, carbonate is the dominant form of dissolved inorganic carbon, and may affect algal dominance relationships.

EP13

Effects of starvation on the respiration rate and motility of the copepod Limnocalanus macrurus in a mesocosm experiment

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The effect of starvation on Limnocalanus macrurus energy metabolism and behavioural response was studied in a short-term experiment during August-September 2019 at the mesocosm facilities of Finnish Environment Institute in Helsinki (SYKE). Planktonic copepods, such as Limnocalanus macrurus, are able to survive during unfavourable periods by using fat reserves in their bodies represented mainly by wax lipids. Throughout the entire period of the 11-day experiment the stomachs of L. macrurus remained empty and all the studied individuals had an oil sac to store lipids. During the experiment the total respiration rate of adult females decreased by 1.9 times from 0.91±0.13 to 0.47±0.08 μg O2 mg-1h-1 on day 11 while basal weight specific respiration rate remained on the quasi constant level (0.4±0.05 μg O2 mg-1h-1). The indicators of motion activity of copepods (total duration, distance and average swimming speed, frequency and duration of movements) decreased by about 60% during the experiment. Such a decrease in the activity of copepods during the experiment can be explained by the lack of "fast" energy source for muscle activity, which is usually replenished with the energy of food. Taking into account that L. macrurus is mostly a carnivorous species adapted to the consumption of heterotrophic food in summer, we assumed that the studied population, which consisted mostly of pre-overwintering adults and late copepodite stages, was not feeding as in natural conditions. The observed trend in total respiration rate without effect of starvation on basal respiration indicates that large energy reserves of this species are saved and kept for the future spring reproduction (egg production), but not for everyday energy expenditures associated with fast metabolic processes.

EP14

Evidence for intact polar lipid remodeling among phytoplankton communities in response to multi-environmental stressors in mesocosm experiments

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Intact polar lipids (IPLs) are cell membrane constituents with considerable chemotaxonomic value and are often applied to trace the presence and contribution of marine plankton and microbial functional groups to water column biomass in natural environments. Culturing studies have suggested that plankton may also remodel these membranes as a physiological response to changes in nutrient availability, providing potential pathways of adaptation to environmental changes. However, little is known about lipid remodeling in phytoplankton as a physiological response to multi-environmental stressors such as O2 and nutrient concentrations, pH, temperature, and light availability, particularly in experimental settings that simulate community-level dynamics that resemble the natural world. Here, we present evidence for statistically robust associations between nutrient stoichiometry, water column physical chemistry, and IPL distributions from a 2-month long mesocosm experiment off the coast of Peru. This analysis distinguishes the variability in IPL distributions attributable to shifts in phytoplankton community composition as well as environmental changes, with the most notable impacts due to nitrogen limitation, O2 concentration, and pH. These physiological adaptations could play a significant role in determining phytoplankton community composition under a changing ocean system, in addition to illuminating the concurring impacts of these adaptations on the biogeochemistry of coastal upwelling zones. Our study offers an overview of phytoplankton adaptation that informs further investigations on the specific biochemical controls on membrane lipid production, a refinement of IPL utility as chemotaxonomic biomarkers, and the potential consequences of lipid remodeling in the cycling of carbon, nitrogen, and phosphorus in the surface ocean.

Understanding Ecosystem functioning through mesocosm research

EP15

Adaptation enhances the positive effect of temperature on Microcystis aeruginosa growth and competitive abilities

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The positive effect of global warming on the growth of cyanobacteria has been widely predicted, but long-term studies targeting their adaptive potential to higher temperature are missing. Predicting the magnitude and impact of cyanobacterial blooms in the future as a response to global warming requires an understanding of how cyanobacteria might change in future scenarios. Here we examined the effect of heat adaptation on Microcystis aeruginosa, and its impact on plankton community composition. The evolutionary potential of three freshly isolated M. aeruginosa strains has been evaluated. One of the three strains displayed significantly higher growth rates after six months of cultivation at higher temperatures. Following inoculation into a natural plankton community, the overall cyanobacterial abundance increased in the cultures inoculated with heat-adapted strains of M. aeruginosa as compared to ambient-adapted ones. The structure of eukaryotic communities was impacted by both inoculated cyanobacteria and temperature during the experiments. We found evidence that, similar to some marine algae, metabolic plasticity of cyanobacteria might be an indicator of their evolutionary potential. The results of this study emphasize the remarkable adaptive potential of cyanobacteria to stressors, and strongly advocate for including adaptive evolution in future research programs concerning cyanobacterial blooms in a changing climate.

EP16

Community structure has greater effect on water column ammonium cycling than nutrients and temperature in shallow lake mesocosms

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Harmful algal blooms (HABs) impact lakes worldwide and are caused by excess nitrogen (N) and phosphorus (P) loading from watersheds. Climate warming and nutrient loading effects on N cycling were examined in shallow lake mesocosms in Denmark. N loading to some mesocosms ceased in June 2018 and resumed in June 2019. Ammonium (NH4+) uptake, regeneration, and nitrification and nitrate uptake rates were evaluated. High nutrient, ambient temperature mesocosms exhibited the highest NH4+ cycling rates. Before resumption of N loading in high nutrient mesocosms, NH4+ regeneration supported 46 % of potential microbial NH4+ demand, versus 24 % with N loading. Nutrient additions generally had a larger effect on rates than temperature changes; however, community structure (phytoplankton versus macrophytes) was the best predictor of NH4+ dynamics. In eutrophic, shallow lakes, where internal NH4+ regeneration can sustain HABs, as observed in some mesocosms, management strategies should aim to reduce external N and P loads and, if deemed necessary, implement biomanipulation methods to obtain macrophyte-dominated, clear-water states.

EP17

Nutrients and light trigger the competitive capability and toxicity of the harmful cyanobacterium Planktothrix rubescens in a mesocosm experiment

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In many pre-alpine lakes the filamentous cyanobacterium Planktothrix rubescens has developed substantial biomasses in the course of re-oligotrophication and has become the dominant phytoplankton species during stratified conditions. Higher nitrogen to phosphorus ratios and/or the increase in stratification due to climate warming may favour P. rubescens mass developments.

By a mesocosm experiment we investigated the effects of bottom up factors, i.e., of nutrient availability, stoichiometry, and light intensity, on the performance and toxicity of P. rubescens an. In total 18 mesocosms, each containing 450 L of 140 µm filtered lake water were amended with an inoculum of P. rubescens. In six treatments we studied mechanisms of competitive advantage and persistence of P. rubescens, as well as potential resilience or reversibility of the system. Bottom up factors were manipulated by changes in light intensities and temporal courses of nutrient additions. The mesocosms were sampled bi-weekly over 8 weeks.

Results of the mesocosm experiment confirmed our hypotheses that high nitrogen concentrations, as found in many re-oligotrophic lakes, are indeed an important driver of Planktothrix growth, while low light conditions contribute to its competitive success in relation to eukaryotic phytoplankton. The combination of these factors seems to support the long term persistence of P. rubescens not only in our experiments, but also in the field.

EP18

Understanding allocation of organic carbon in prokaryotes under the influence of temperature and nutrient additions: a mesocosm approach

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Heterotrophic bacteria and archaea (together referred to as Prokaryotes) are mainly responsible for the utilization of dissolved organic matter. Prokaryotes play an important role in the remineralization of organic matter and biogeochemical cycling of elements. In particular, the allocation of organic carbon in Prokaryotes is of vital importance in marine ecosystems, and the two main processes are synthesis of new biomass and the respiration of CO2 coupled to O2 consumption. Previously, a mesocosm study was setup in winter 2019/2020 to estimate the effect of temperature and nutrient supply on bacterial metabolism and growth efficiency with a full factorial design. The four different treatments with technical triplicates were: C (control), N (+nutrient), T (+temperature), and TN (+temperature and nutrient). The temperature of 1°C (C and N treatment) and 10° C (T and TN treatment) were selected to represent the winter and summer conditions in the Baltic Sea respectively. Recurrent additions of labile organic matter (abbreviated as N) in the form of yeast extract was done to mimic the flux of remineralized organic matter through increased zooplankton excretion (+23% of organic C addition). Using the bacterial growth efficiency (BGE) as a proxy for allocation of carbon, the BGE was hypothesized to be higher during the summer conditions (i.e., T and TN) as opposed to winter conditions (i.e., C and N). The average bacterial growth, abundance, respiration and growth efficiency in the TN treatment was found to be 18-fold, 2-fold, 2-fold, and 3-fold higher compared to the control treatment. Based on statistical analysis, temperature was found to positively influence the bacterial growth, abundance, respiration and BGEp<0.05/0.001 (partial ´ 2 =0.81-0.92). The addition of nutrients also accounted for variability in bacterial growthp<0.05 (partial´ 2 =0.57) and to some extent in respiration and BGEp=0.07 (partial ´ 2 =0.35). The differences among the abundance, growth, respiration and BGE were found to be statistically significant when comparisons were made between C and TN treatments (posthoc Tukey HSD testp<0.001). Among all pairwise multiple comparisons, nutrient additions were only significant at lower temperatures (C and N treatment) regarding BGE. This indicates that nutrient additions at higher temperature does not significantly increase BGE. However, higher temperatures may increase the pool of bioavailable organic compounds and their utilization. The BGE values ranging from as low as 0.05 to as high as 0.6 in our experiment displayed the accomplishment of the whole range of BGE values reported earlier in literature from marine ecosystems and estuaries. The full seasonal and global range of the presented variables could thereby be simulated in one mesocosm experiment, with potential application for various research questions. Our results further indicate that the temperature is a dominant factor in controlling the carbon allocation in prokaryotes, and to a lesser extent by addition and quality of nutrients.

EP19

Effects of Labile and Recalcitrant DOC sources on Zooplankton Community

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While the climate-induced increase of allochthonous dissolved organic carbon (DOC) input to freshwater ecosystems is well studied, however, the effects of different DOC sources and their impact on seston quality, and in turn on the food webs and particularly on zooplankton biomass and composition is poorly understood. Accordingly, we tested the effects of recalcitrant and labile DOC pulse disturbances on zooplankton communities via outdoor mesocosm experiments. We expected that (1) zooplankton community biomass would be enhanced with labile DOC source compared to the recalcitrant, (2) zooplankton community composition would differ between particular DOC sources, and (3) after DOC addition zooplankton species and functional richness as well as species and functional evenness would decrease. The treatments included a single pulse of alder leaf leachate (DOCL, labile DOC), Huminfeed (DOCR, recalcitrant DOC) and both together (DOCmixed) compared to controls (no DOC). After day 12 of the experiment, relative to the control, zooplankton biomass increased in the DOCL and DOCmixed , but did not change in the DOCR. The highest biomass increase was observed in DOCmixed. Before the pulse, Ceriodaphnia spp. dominated approximately 60% of the total zooplankton biomass. At the end of the experiment, the community composition was different for DOCL, DOCR and DOCmixed. Unlike control, Daphnia spp. dominated (approximately 90%) biomass in DOCL and DOCmixed, while Cyclopoid copepod and Diaphanosoma spp. were together (>50%) in DOCR. Despite the temporal variation, overall mean seston N:P ratio in DOCL (mean+std; 105.5+-47.1) and DOCmixed (102.1+-35.2) was lower relative to DOCR (256.8+-117.9) and controls (208.4+-108.7). Additional seston phosphorus coming from labile DOC source led to lower seston N:P (molar) and in turn, may have favoured Daphnia spp. in DOCL and DOCmixed. At the end of the experiment, only species and functional diversity indices in DOCL and DOCmixed were significantly different than control. Initial results demonstrated that labile DOC source could have major impacts on zooplankton biomass and composition, especially when it combined with recalcitrant DOC source.

EP20

Combined bottom-up effects of DOC and top-down effects of zooplankton with contrasting traits on phytoplankton biomass and composition

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While global climate change has major impacts on freshwater ecosystems, a mechanistic understanding of these effects on food web dynamics is poorly understood. A key effect of climate change is increased allochthonous dissolved organic carbon (DOC) input to aquatic environments, which serves as an energy source for heterotrophic plankton and alters food web dynamics. We aimed to link pattern and process in a plankton ecosystem by comparing the bottom-up effects of DOC (i.e., recalcitrant and leaf leachate DOC sources) to the top-down effects of zooplankton with contrasting grazing selectivity (Daphnia vs. calanoid copepods) on phytoplankton biomass and composition in a series of laboratory and in-situ mesocosm grazing assays. We expected that both DOC and zooplankton would reduce phytoplankton biomass; stronger herbivory by Daphnia compared to copepods; and stronger grazing on larger-sized phytoplankton. The laboratory experiment revealed that DOC reduced total phytoplankton biomass, and that smaller species were reduced more than larger ones. Both grazers reduced total phytoplankton biomass, though effects varied depend on species such that zooplankton increased the biomass of smaller phytoplankton while they reduced the biomass of larger phytoplankton species. Moreover, copepods had a stronger effect on phytoplankton biomass compared to Daphnia, but only in the treatments with DOC. The mesocosm experiments, however, showed that DOC sources increased total phytoplankton and species-specific biomass, except Chlorophyta spp., which declined in the recalcitrant DOC treatment. Overall, the results highlight DOC sources effects and the role of zooplankton grazing traits not only for regulating top-down effects but also for the bottom-up effects of DOC.

EP21

Effects of an invasive mysid shrimp on plankton dynamics

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Mysid shrimps of Ponto-Caspian origin are now widespread invaders in European rivers and lakes. Being fast-reproducing omnivorous species with an ability of selective feeding, a high impact on the trophic webs of the invaded communities can be expected. However, little is known about their community-structuring role and its relevance for community dynamics.
Here we experimentally tested the effects of Limnomysis benedeni on model planktonic communities. Previous studies showed that this mysid species selectively feeds on cladocerans, suggesting that its impact strongly depends on community composition. To test this, we manipulated the initial functional composition of the intermediate trophic level by shifting the Copepoda to Cladocera ratio. Experimental communities were assembled from Lake Balaton, Hungary where L. benedeni is commonly found. The experiment was run in outdoor mesocosms (160L volume, 4 treatment combinations with 6 replicates each). Nutrients, chlorophyll a concentrations and biomass of zooplankton functional groups (Copepoda, copepod nauplii, Cladocera, Rotifera) were monitored for 4 weeks.
After one week, clear treatment-specific differences started to develop in algal and zooplankton community structure and biomass. We found general differences in chlorophyll a dynamics related to zooplankton functional composition (stronger top-down control with Cladocera dominance). Moreover, in the treatments with Cladocera dominance, higher algal biomass in the presence of the mysid indicated its top-down control of zooplankton. However, this effect was only visible for a few days, possibly because of the rather low mysid density in the experiment.
Our results suggest that Limnomysis benedeni can alter plankton community structure via top-down trophic impact. Given its wide and still expanding distribution, we suggest further studies to better understand the consequences of its invasion.

Understanding Ecosystem functioning through mesocosm research

EP22

Effects of Dissolved Organic Carbon and Zooplankton Grazing Pressure on Bacteria and Ciliates

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A major consequence of global climate change is extreme precipitation events that increase allochthonous organic matter input into aquatic systems via flooding. Dissolved organic carbon (DOC) is a common allochthonous organic matter in the lakes. While DOC is a source of carbon and energy for heterotrophic organisms in aquatic systems, its effects on trophic interactions, and especially on the microbial food web, are poorly understood. Similarly, the top-down effect of contrasting zooplankton traits (i.e., generalist vs. selective) on DOC enriched food webs is also unknown. We compared both the bottom-up effects of DOC and the top-down effects of zooplankton with contrasting grazing selectivity on the biomass and composition of microbial food webs (i.e., bacteria and ciliates) in a series of laboratory and in-situ mesocosm grazing experiments. We predicted that the total biomass of bacteria and micro-grazers (i.e., ciliates) were enhanced by DOC pulse, especially with leaf leachate DOC (i.e., a labile carbon source), and reduced by grazers. Additionally, we expected that copepods would have higher grazing pressure on ciliates than Daphnia due to grazing mode (i.e., selective feeder). We found in the laboratory grazing experiment that both grazers (i.e., Copepod and Daphnia) and DOC had little effects on the biomass of bacteria. DOC had a positive effect on ciliate biomass, while grazers had a negative effect. Effects varied by orders of magnitude depending on the grazer and prey. Specifically, the top-down effect was in general stronger than the bottom-up effect and the strongest grazer effect was in the copepod – ciliate link. DOC had little effect on the functional feeding groups of ciliates (i.e., algivore, bacterivore, predator, nonselective), and copepods reduced relative biomass of algivore and nonselective ciliates, and increased bacterivores. In addition, in the in-situ grazing assays, we found little effect of DOC or grazers on bacteria. Moreover, leaf leachate DOC increased ciliates and grazers reduced them. Overall, the top-down effect increased with time, whereas the bottom-up effect decreased.

EP23

Morphology, mixing and mesocosms: shape and turbulence interactions within a phytoplankton community

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Aiming to determine to what extent phytoplankton morphology plays a role in species dominance under different turbulent regimes, we conducted a series of mesocosm experiments on a natural phytoplankton community found in the coastal Bothnian Sea, Northern Sweden.

A novel convective heating system was used to generate different mixing regimes within each mesocosm by altering the temperature profiles; more quiescent regimes were generated using stable temperature profiles concurrent with the region studied. Conversely, turbulent mixing was generated using gentle-bottom heating to promote convective overturning. While most phytoplankton-turbulence interaction studies utilise some form of mechanical agitation to generate turbulence, the temperature-controlled convective mixing of this nature offers many benefits including reduce risk of mechanical destruction and more realistic turbulence overturn scales. The turbulence produced across all regimes was quantified via microstructure profiling and acoustic Doppler velocimetry.

A FlowCAM system was used to enumerate cells and analyse morphological trends. Results suggest that shape and motility play a lesser role in determining success while turbulence intensity and depth were found to be significant determinants.

EP24

Warming effects on a native and an invasive macroalgae-grazer and parasite system: who is the winner?

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Global warming effects can potentially determine the fate of basal species and their related communities. This is the case of Fucus vesiculosus, a perennial algal species inhabiting the Baltic Sea and providing habitat for grazers, filter feeders and their related parasites. A potential competitor for F. vesiculosus is the invasive red seaweed Agarophyton vermiculophyllum, which is spreading at sites where F. vesiculosus is declining. Using outdoor benthocosms, we investigated the response of F. vesiculosus, A. vermiculophyllum and their related organisms in terms of growth and mortality to a 3°C increase of temperature. We particularly focussed on the mediation of warming effects by parasites. With this aim, the experiment comprised a macroalgae predominant mesograzer (the periwinkle Littorina littorea) and one of its main related parasites, the digenean trematode Himasthla elongata. The negative effects of warming were more deleterious in A. vermiculophyllum than F. vesiculosus, the former displaying a drastic decrease in biomass even without the presence of grazers. The strong effects were further amplified by a higher grazing of A. vermiculophyllum than F. vesiculosus by periwinkles, especially where those were infected by parasite. For the grazers, the effects of warming on growth and mortality were mostly negative when combined with parasite infection. Our results showed that warming is likely to negatively affect the future of both native and invasive macroalgae in the Baltic Sea, but with the former displaying a higher adaptation. The negative effects on invasive A. vermiculophyllum over F. vesiculosus might even be amplified by high grazing of periwinkles and the expected increase in parasitism. Furthermore, this experiment highlighted the advantage of performing mesocosms experiments to study complex ecological interactions.

EP25

Brownification effects on the plankton community of a North Atlantic bay (Hopavågen, Norway) during an in situ mesocosm experiment combined with high-frequency sensor measurements of oxygen metabolism

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An intensification of the brownification phenomenon due to terrestrial inputs was reported in freshwater and coastal ecosystems of the northern latitudes during the past decades. While this phenomenon and its consequences on plankton communities have been considerably studied for freshwater systems, little is known about the effect of this disturbance on coastal marine plankton assemblages. A joint field mesocosm experiment was conducted in the Bay of Hopavågen (Norway) in August 2019 as a part of jointly coordinated experiments within the Horizon 2020 project AQUACOSM (2017-2021). The objective of this study was to investigate the effects of brownification on the plankton community oxygen metabolism and on phytoplankton community composition using pigment biomarkers. For this purpose, six in situ mesocosms were filled with natural bay water. Three mesocosms served as control, and a highly-colored humic substance (HuminFeed®) was added to the other three mesocosms to simulate a brownification phenomenon. High-frequency sensor monitoring (one measurement every 15 minutes) of key environmental variables, such as dissolved oxygen concentration, water conductivity, water temperature and photosynthetically active radiation (PAR), was combined with a manual daily sampling for phytoplankton pigment composition and nutrient analyses. Plankton oxygen metabolism was estimated using the high-frequency dissolved oxygen concentration data taking into consideration variations in the day-night and dissolved oxygen cycles coupling. The addition of the humic substance reduced the available PAR at 1 m depth in the mesocosms, resulting in a decrease of almost 30% of both the Gross Primary Production (GPP) and the community Respiration (R). Moreover, the chlorophyll-a concentration decreased and the phytoplankton pigment composition changed, revealing an acclimation of the phytoplankton community to the reduced light conditions. In conclusion, results of this in situ mesocosm experiment revealed that brownification induced significant changes in the phytoplankton community composition and reduced GPP and R by almost a third in this northern latitude marine system.

EP26

Effects of experimental warming on an unexpected autumnal microbial community dominated by picophytoplankton in the Mediterranean coastal Thau Lagoon

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To gain understanding on the effects of warming on natural planktonic communities, an in situ mesocosm experiment was performed in the Mediterranean Thau Lagoon, using the MEDIMEER infrastructure in autumn 2018. The microbial community of Thau Lagoon was studied for 19 days within three control and three heated (+3°C) mesocosms deployed in situ. The microbial assemblage, encompassing virus, bacteria, pico- and nanophytoplankton, was daily monitored and growth and grazing rates on bacteria and small phytoplankton groups (<10 µm) were estimated at the beginning and in the middle of the experiment. Results revealed a peculiar microbial community that had never been reported in Thau Lagoon. In fact, in the present study, the phytoplankton community was dominated by picophytoplanktonic cells and hosted for the first time in Thau Lagoon very high abundances of Prochlorococcus-like and Picochlorum-like cells. Warming significantly increased the virio-, bacterio- and small phytoplankton (<10 μm) abundances. The only exception to this trend concerned the newly reported Picochlorum-like group, whose abundances decreased under warming leading simultaneously to the observed decrease in Chlorophyll-a concentrations in the heated treatment. Warming significantly enhanced phytoplankton growth at the middle of the experiment, while significantly depressing bacterial growth. This suggests a limitation of bacterial growth by resources quantity or availability under warming, potentially through competition with phytoplankton disadvantaging bacteria. Unexpectedly, warming significantly reduced the grazing rates of almost all studied microorganisms, suggesting an indirect effect on microbial grazers through potential trophic cascades occurring under elevated temperature.

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EP27

Effects of brownification in a highly productive coastal sea: a mesocosm experiment in the Baltic Sea

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Climate change is projected to cause brownification of some coastal seas, due to increased runoff of terrestrial organic matter such as humic-like substances. In order to investigate the effects of brownification, we carried out a mesocosm experiment on the SW coast of Finland. The experiment was set up in 2 m3 plastic bags moored outside the Tvärminne Zoological Station, and the experiment lasted 14 days. Four treatments were used, each with three replicates: control (Contr) without any additions and addition of inorganic nutrients (Nutr; an addition of 5.7 μM NH4 and 0.65 μM PO4), HuminFeed (Hum; 2 mg L-1) and combined Nutr and Hum (Nutr+Hum) addition. Samples were taken daily and measured variables included organic and inorganic nutrients, chlorophyll a (Chla), primary and bacterial production and particle counts by flow cytometry.
The bags with added inorganic nutrients developed a phytoplankton bloom that rapidly depleted inorganic nitrogen (N), and this was reflected in higher primary production (up to 2 μmol C L-1 h-1) and Chla increase (max of 17 μg Chla L-1) in the Nutr and Nutr+Hum treatments. Bacterial production was relatively stable throughout the experiment (0.1 - 0.2 nmol C L-1 h-1). BR was lowest in the Contr ($p < 0.02$), but similar in the three treatments receiving additions. There was a shift from larger nanophytoplankton at the onset of the experiment to picophytoplankton dominance after the depletion of inorganic N. During the second week, the biomass in the Nutr and Hum+Nutr treatments settled out and the Chla concentration was similar in all treatments at the end of the experiment.
The changes in dissolved inorganic carbon concentrations suggested a total carbon fixation of 32 μmol C L-1 during the first 6 days and there was an increase in particulate organic carbon of 17 μmol C L-1, suggesting sedimentation (export) of roughly half the produced biomass during the first week. Picoeucaryotes benefited from both Nutr and Hum addition after inorganic N depletion, and there was also a synergistic effect of these additions as the highest picoeucaryote concentrations was observed in the Nutr+Hum treatment, but without any this effect on the Chla concentration.
In conclusion, brownification did not reduce photosynthetic carbon fixation although it clearly reduced light penetration. Bacterial production increased similar by all additions compared to the Contr and the only distinct effect of the Hum addition was the increasing proportion of picoeucaryotes. Such a shift in the phytoplankton community composition towards smaller species could influence material fluxes, but our results suggests this shift only takes place after depletion of inorganic nutrients.

EP28

Patterns and processes of ch4 production and oxidation in different habitats of a freshwater mesocosm system

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Methane (CH_4) is a greenhouse gas and one of the major driver of radiative forcing. Wetlands, including shallow lakes, are the largest natural source globally. Therefore, it is important to understand the patterns and controls of emissions from shallow lakes.
The release of CH_4 as bubbles, ebullition, in shallow lakes increases with higher temperature and eutrophication. Recent studies have indicated that increased submerged macrophyte abundance is associated with markedly lower rates of CH_4 ebullition, while nutrient enrichment and increase of chlorophyll promotes CH_4 release as bubbles. Therefore, the identity of the dominant primary producer, that is submerged plants versus phytoplankton, is crucial in shaping ebullition, the mechanisms at work however, are still not clear. Therefore, the aim of the experiment was to characterize the methane production/oxidation patterns in shallow lakes in the different habitats at different temperature and nutrient levels, which also had different macrophyte abundance.
The experiment took place at the world's longest running (>16 years) eutrophication and warming shallow lake mesocosm experiment at AU, Denmark. The experimental setup consists of 24 mesocosms with two nutrient treatments (N/P fertilized or not fertilized) and three temperature treatments (ambient, +2/3°C, +4/5°C). Diffusive and ebullitive CH_4 emissions were estimated from dissolved gas concentrations and from bubble traps respectively. Using bottle incubations, potential methane production was estimated for the upper layer of the sediment. In addition, the activity rate of methane oxidizing bacteria (MOB) associated with the different primary producers has been measured in each habitat (plant surfaces, submerged and floating filamentous algae, periphyton, sediment and seston) and determined using bottle incubations. Results showed higher methane oxidation rates for the macrophytes (in particular for the above – than for the below – ground tissue) than for all the other habitats, that still showed methane oxidation activities. MOB abundance and MOB community composition per each habitat will then be analyzed and relate to methane oxidation rates of the

respective habitats. How community's composition of MOB influences the differences in methane oxidation rates in the different habitats, will then be discussed.

EP29

Mixotrophs may benefit from reduced top-down control by crustacean zooplankton in the recovery phase after a heatwave

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Freshwater ecosystems are under increasing pressure by global climate change, including global warming. While contemporary research mostly focuses on the effects of gradually increasing annual mean water temperatures, there is an increasing interest in climate variability, including extreme climatic events such as heatwaves, which are forecasted to occur in higher frequency, duration and magnitude.
In this study, which represents a subset of a larger mesocosm study performed in summer 2018 (TA project "DispersAlp"), we investigated the effects of an experimental 10-days heatwave on the phytoplankton community of the pre-alpine oligotrophic "Lake Lunz" (Austria). Specifically, we tested the impact of the heatwave on the proportion of mixotrophs, protists which combine photosynthesis and phagotrophy, in total pigmented protists. We assumed that increased water temperatures would not represent "stress" for mixotrophs, as they may adapt by enhancing the heterotrophic proportion of their nutrition. Hence, we expected to detect proportionally more (phago-) mixotrophy in the "heated" treatment. We sampled at three time points, immediately before the heating was applied, at the end of the experimental heatwave, and two and a half weeks after the experimental heatwave. We used the acidotropic dye "LysoSensor" to quantify mixotrophs via flow cytometry. We compared the LysoSensor-data, i.e. the proportion of mixotrophs in total pigmented protists, to relative proportion of taxonomic groups putatively containing mixotrophic species. This was done for molecular data and for microscopic count data, in both cases the proportion of mixotrophs according to LysoSensor-data and taxonomic data, respectively, were largely in accordance with each other. Our specific hypothesis was not validated, as we detected no direct effects of the heating on the proportion of mixotrophs in total pigmented protists, relative to the control treatment. However, we found a higher proportion of mixotrophs in total pigmented protists in the heated treatments at the sampling date two and a half weeks after the experimental heatwave was applied. We hypothesize that mixotrophs may have benefited in the heated treatment from reduced top-down control by crustacean zooplankton in the recovery phase after the heatwave, due to an adverse effect of increased water temperatures on crustacean zooplankton. In a situation in which light is available, but nutrients are limiting photosynthetic growth, acquisition of nutrients by phagotrophy gives mixotrophs a competitive edge over strict photoautotrophs. This advantage is depended on overall loss rates experienced by the organisms, because mixotrophs are assumed to have lower growth rates as compared to strict photoautotrophs, and hence should be more prone to increased loss rates. In conclusion, a heatwave, and with that regard any environmental change, may impact on mixotrophs particularly when it affects their loss rate. Further research is needed to validate this hypothesis.

EP30

The differential response of marine plankton in the Mediterranean Sea to chronic exposure of silver nanoparticles and silver ion

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With widely usage of antibacterial silver nanoparticles (AgNPs), their entry into marine system is inevitable. However, whether the effects of AgNPs on gut microbiota are driven by the same mechanisms underlying those of silver ion (Ag^+) are still uncertain. Therefore, we designed a mesocosm experiment with 11 days to access the effects of different forms of silver on the metabolisms of natural microbial communities in the ultraoligotrophic Mediterranean Sea. On each day, AgNPs and Ag+ were added to the corresponding mesocosms in a fixed amount to reach environmentally relevant concentration near the end of the experiment. We monitored changes in the gene expression of plankton at different time points through metatranscrptomic approach. We found that the AgNPs triggered a more severe suppression of genes expression for nutrient assimilation, photosynthesis, and bio-synthesis/export of polysaccharide in phytoplankton by the end of the experiment. In contrast, at the beginning of the experiment, AgNPs exposure caused a more obvious stimulation of bacterial genes encoding for nutrient assimilation, organic degradation and energy metabolism, though the expression of these genes were also severely affected by the end of the experiment. Additionally, the expression of genes encoding for reactive oxygen species (ROS)-scavenging, bio-synthesis/export of polysaccharide, and microbial organic degradation was strongly correlated with each other under AgNPs exposure, indicating bacterial degradation of organic matter may play a crucial role in the neutralization process of AgNPs. Therefore, comparing with other eutrophic regions, the bacterial remediation function for AgNPs has been limited in the Mediterranean Sea as the biosynthesis and exportation of organic were highly constrained by the ultraoligotrophic condition. Our study provides valuable insights to the risk assessment and pollution management of AgNPs.

EP31

Evaluating air-water gas exchange velocities in running waters using noble gases and hydro-acoustics: a combined bubble plume-flume experiment

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Many biogeochemical and ecological processes in aquatic ecosystems rely on the exchange of gases across the air-water interface. Quantifying the rate k at which a given gas is exchanged is difficult, in particular under the complicated combined influence of turbulence and bubbles in high-energy running waters. Here, we performed an outdoor flume experiment with integrated air bubble plumes to evaluate the interactive effects of turbulence and bubbles on k in running waters for a range of gases. We simulated a wide range of flow conditions by manipulating channel slope, bed roughness, water discharge and superficial gas velocities of air bubbles (U). We estimated k for artificially injected tracer gases helium, argon and xenon and natural abundance methane using a mass balance approach and membrane inlet mass spectroscopy. We also computed turbulent kinetic energy dissipation rates (ε) from three-dimensional flow velocity measurements and derived underwater sound spectra from hydrophone recordings. We found that k increased from 1–5 m/d under the least energetic conditions (ε = ˜5 · 10e-5 m^2/s^3, U = 0 m/d) to 18–67 m/d under the most energetic conditions (ε = ˜10e-1 m^2/s^3, U = 53 m/d), depending on the tracer gas. The data was consistent with existing mechanistic k models that account for ε, U, and tracer gas diffusivity and solubility. According to these models, bubble-mediated exchange contributed around 40–50% to the total k value but was only weakly dependent on U and the type of tracer gas, because bubbles never equilibrated with the surrounding water. We were able to conclude this from modeled bubble residence and equilibration times using bubble size distributions computed from the sound spectra. Interestingly, sound spectral signatures related to turbulence and bubbles correlated with ε and U and hold the potential for alternative 'acoustic' parameterizations of k models. Even though challenges remain in separating signals from noise in underwater sound spectra, we conclude that hydrophones open unique opportunities to improve our mechanistic understanding and ability to quantify gas exchange in bubbly running waters.

EP32

Testing the PlanktoScope - a low-cost imaging flow cytometer

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The PlanktoScope is a new, open-source, low-cost instrument for assessing plankton communities. But how does the PlanktoScope work? And how does it compare to other methods for counting pyhtoplankton? To evaluate its functionality, I built the PlanktoScope and have begun testing the instrument using microbeads, algal cultures, and lake water samples in order to compare it with classical and other modern phytoplankton counting techniques.

EP33

Land-based mesocosms facilities at ECIMAT: a real-time monitored experimental design

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Land-based mesocosms facilities at ECIMAT (Centro de Investigación Mariña - Universidade de Vigo, Spain) were constructed in 2020. This infrastructure is located in a highly productive area of the Atlantic upwelling region (Figueiras et al., 2002), with four characteristic oceanographic periods along the seasonal cycle: winter vertical mixing, upwelling, summer stratification and downwelling. Nevertheless, this is also a quite exposed coastal region and thus, in situ experimentation is difficult to conduct during the rough weather conditions in the winter months. In consequence, the objective of this infrastructure is double: 1) complementing the existing floating mesocosms platforms, allowing the mesocosms experimentation along the whole seasonal cycle, and 2) increasing the number of scenarios that can be tested, including both pelagic and benthic mesocosms, a higher control of the environmental variables and a better monitoring of the experimental conditions. To create different experimental scenarios, this facility is able to provide 30 m3/h of raw or filtered (up to 60 **m**m) seawater, cooled (up to 12°C) and filtered (up to 1**m**m) seawater or warmed (up to 25°C) and filtered (up to 1**m**m) seawater. In all these cases the water can UV disinfected and the experimental tanks include air and gasses supply (O2 and CO2) as well as fresh water.

This mesocosms setup includes four different sections, to allocate multiple experimental designs:

- Pelagic mesocosms: a 90 m3 tank to allocate nine 2 m3 real-time monitored mesocosms bags.
- Benthic mesocosms: twelve 0.7 m3 ponds (130 m2 surface), with a tide simulation system, salinity and water temperature

(12ºC-25ºC) regulation and real-time monitoring of the main variables.

- Microcosms: three methacrylate 1m3 and three 1 m^3 fiber tanks to allocate small scale experiments with water temperature control.
- Isothermal chamber: 40m^2 to allocate up to 18 tanks to conduct experiments at controlled temperature (5ºC-35ºC).

This design also includes real-time monitoring both of the environmental conditions (air temperature, rainfall, irradiance, UVA, UVB, PAR and wind) and of the main variables in the experimental tanks (as temperature, conductivity, pH or dissolved O_2). These values can be remotely visualized with any device connected to internet and alarms can be set up if any of the measured variables reach the defined critical values for each experiment, allowing a 24h control of the experimental setup. An on-site laboratory is available too, including 4ºC and -20ºC isothermal chambers, fume hood, etc. to facilitate the sampling tasks, and it is complemented with all the laboratories and equipment available at ECIMAT marine station (https://cim.uvigo.gal/ecimat/portal-de-reservas/en/).

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