We used three decades (1983-2015) of monitoring data from Lake Lugano (Switzerland and Italy) to assess the effects of eutrophication management on phytoplankton biomass and the interactions between phytoplankton and zooplanktonic grazers. We hypothesized that the eutrophication management would lead to: [1] a reduction in phytoplankton biomass, and [2] an increase in the relative importance of grazer control (i.e., top-down control) on phytoplankton biomass. Top-down control was expected to increase from hypertrophic to moderately eutrophic conditions because of increased palatability of phytoplankton and reduced fish predation. As expected, during the study period summer phytoplankton biomass decreased significantly in the lake, paralleling declines in P concentrations and trophic level (from hypertrophic to mesotrophic). Most of the decrease in phytoplankton biomass occurred during the first decade of the study, when P concentrations also showed the largest decline. Grazer control on phytoplankton biomass did not increase monotonically as hypothesized but showed a unimodal pattern, peaking during the middle of the study period. This pattern paralleled changes in the density of two large-bodied grazers (*Eudiaptomus gracilis* and *Daphnia longispina-galeata*), which were responsible for most grazing activity. A potential explanation for the decline in grazer control toward the end of the study period (which is now being tested) is that external pressures, including increased N loading and surface-water warming, reduced the resource quality of phytoplankton. Our results suggest that rising environmental pressures unrelated to P enrichment (e.g., warming and N-loading) can alter the expected trajectories of lakes recovering from eutrophication and lead to unforeseen ecological states.

39-O   Nitrogen dynamics in a meromictic subalpine lake: from watershed to in lake processes.

Daniele Nizzoli [1] - Marco Bartoli [1] - Roberta Azzoni [1] - Giuseppe Castaldelli [2] - Daniele Longhi [1] - Pierluigi Viaroli [1]

Department of Life Sciences, University of Parma, Parma, Italy [1] - Department of Life Sciences and Biotechnology, University of Ferrara, Ferrara, Italy [2]

Inputs of anthropogenic reactive nitrogen (Nr) to watersheds in excess of their processing and storage capacity, results in Nr export causing a cascade of detrimental effects in receiving aquatic ecosystems. Mass balance studies have demonstrated that lakes and reservoirs are landscape components that both process and sequester Nr in the terrestrial to marine aquatic continuum. However, little is known about the relative importance of different Nr retention/elimination mechanisms or factors that regulate these mechanisms, particularly in deep meromictic lakes. Prolonged stratification, persistent anoxia and the establishment of reducing conditions may profoundly influence the fate of Nr loads in these lakes. In this study, we analysed the spatial and temporal variability of microbial N-transformations in a sub-alpine meromictic lake (Lake Idro, Italy), in order to elucidate the role of denitrification as a N-sink for net anthropogenic nitrogen inputs (NANI) to the watershed.
Lake Idro is a highly productive lake that undergoes stable, and persistent thermal and chemical stratification, resulting in the accumulation of reducing compounds and dissolved nutrients in the monimolimnion (~50% of lake volume). Denitrification dominated microbial N-transformations in the oxic to anoxic transition zones of the epilimnion. In contrast, the monimolimnion was a source of regenerated ammonium and had a low capacity to buffer the incoming nitrogen load. NANI was relatively low, and dominated by atmospheric deposition and feed and food N-imports. Overall, the watershed had a relatively low capacity to retain/eliminate Nr inputs and annual Nr export accounted for close to 50% of the NANI.

39-O   Spatial and temporal dynamics of antibiotic resistance genes in subalpine Lake Maggiore and in its catchment area.   *Gianluca Corno, Andrea Di Cesare, Ester Eckert, Mario Contesini, Roberto Bertoni, Cristiana Callieri*

Institute of Ecosystem Study,ISE CNR, Microbial Ecology Group (MEG), Verbania, Italy

Spread and persistence of antibiotic resistances (either Antibiotic Resistant Bacteria, ARB, or Antibiotic Resistance Genes, ARGs) in aquatic environments exposed to human activities is a major threaten for health systems at the global scale.
The microbial communities of lakes and rivers subjected to anthropic impact become a long term reservoir of ARGs, as a consequence of a number of ecological stressors sometimes not even related to the direct presence of the antibiotic itself. ARGs, which are often located on multifunctional mobile genetic elements, can be selected and co-selected as

adaptation to pharmaceuticals, to heavy metals, or to other chemicals or ecological constrains. For this reasons, once an ARG spreads within a microbial community is not surprising that its presence becomes constitutive for a long time.

We are presenting the results from our long-term (2013-today) study of the resistome of Lake Maggiore, the sixth largest Western European lake, and the most important Italian reservoir of freshwater.

We could assess at least two ARGs (against sulphonamides and tetracyclines) as constitutive within the microbial community of the lake, and other three genes against beta-lactams, macrolides, and aminoglycosides as occasionally present, sometimes even in very high concentrations. We therefore also measured the concentrations of those ARGs in other, less impacted, high mountain lakes and springs in the Lake Maggiore catchment area, in the six main tributaries and in two wastewater treatment plants discharging their effluxes directly into the lake.

Our results, coupled with a number of concomitant measures of the main limnological and microbiological variables for each sampling date and station, allows a depiction of the routes of antibiotic determinants contamination in the catchment area of Lake Maggiore, distinguishing between inputs of agricultural or urban origin and the related temporal variations.

The catchment area of Lake Maggiore represents the first geographically defined territory where such integrated monitoring is being performed, providing fundamental insights for the management of antibiotic release in anthropized environments.

39-O   Incorporating greenhouse gas emissions into ecosystem models with application to Lake Iseo.

Steven Chapra [1] - Marco Pilotti [2] - Giulia Valerio [2] - Andreai Treccani [2]

Civil & Environmental Engineering Dept., Tufts Univ Ersity, Medford, Ma, United States [1] - Dipartimento di Ingegneria Civile, Architettura, Territorio, Ambiente e Matematica, Università degli Studi di Brescia, Brescia, Italy [2]

Management-oriented ecosystem models were originally developed in the early 1970's to assess the impact of nutrient loadings on lake eutrophication. As a consequence, their characterization of water chemistry was rudimentary at best. In the mid-1980s, stimulated by concern with acid rain, two principle modeling advances provided the theoretical basis for upgrading the chemistry in lake ecosystem models. First, the methodology for coupling fast equilibrium reactions with slow nutrient/phytoplankton kinetics was developed. Second, the modeling of sediment-water fluxes of solutes and gases was rigorously established. Although most currently available, open-source lake water-quality frameworks still focus primarily on nutrients and phytoplankton dynamics, the theoretical advances now make it possible to incorporate equilibrium chemistry into these frameworks. One benefit is that such expanded frameworks can be used to examine interesting questions beyond the traditional nutrient overenrichment problem.

In the present talk we focus on one such question: the determination of changes in greenhouse gas emissions as a lake becomes eutrophic. We do this using LAKE2K, an open-source, seasonal, 1D coupled hydrodynamic-ecological-chemistry model. The hydrodynamic model simulates the lake as a one-dimensional system consisting of three vertical layers and computes the interlayer mixing based on wind speed and water density. As is commonplace, the ecological model includes the simulation of plant photosynthesis/respiration, organic carbon decomposition, nitrification, denitrification, sediment nutrient and oxygen fluxes. However, several novel features are incorporated including new chemical state variables and algorithms to simulate alkalinity, inorganic carbon (and hence pH and CO_2), methane, sulfate, hydrogen sulfide, and nitrous oxide. Post processing provides lake managers with results in a decision-support format. This includes typical time series of nutrients, phytoplankton and oxygen, but additionally with time series and annual totals of greenhouse gas fluxes across the air-water interface as well as key optical variables (Secchi depth, turbidity, light extinction). An application to the Italian pre-Alpine Lake Iseo illustrates how the model can provide information supportive of management and decision making for lake systems that are experiencing watershed and climate modifications.

39-O   Chemical profiling of the bioactive metabolites produced by invasive cyanobacteria in perialpine lakes.   *Leonardo Cerasino, Camilla Capelli, Nico Salmaso*

Iasma Research And Innovation Centre, Fondazione Edmund Mach, San Michele all'Adige, Trento, Italy

Cyanobacteria are known to produce toxic metabolites, such as microcystins, nodularins, anatoxins, and saxitoxins. Cyanobacteria proliferation represents, therefore, a serious risk in natural and artificial water bodies. Besides the ones