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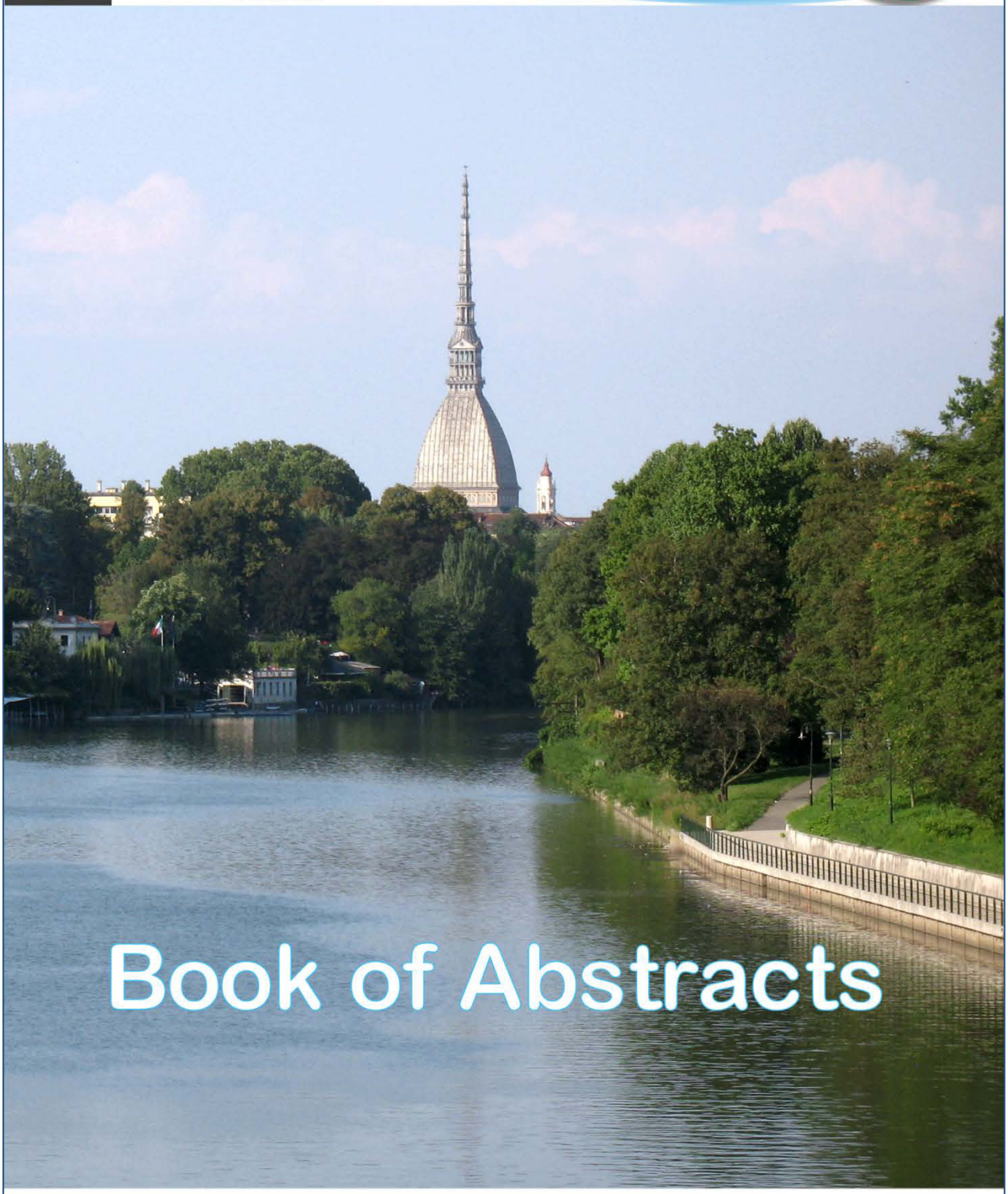

# Book of Abstracts

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phosphorus (TP); the introduction of new cyanobacteria, i.e. the establishment of the water-bloom forming *Dolichospermum lemmermannii* since the 1990s, and the very last discovery of *Tychonema bourrellyi*, a species producing anatoxin-a (ATX, a neurotoxin). These changes will be critically described considering in detail the results obtained in the Long-Term Ecological Research station of Lake Garda.
From 1991 to 2015, the long-term increase of the mean annual water temperatures in the mixolimnion (0-50 m) showed a positive and significant trend (>0.025 °C $yr^{-1}$). The warming was confirmed also considering the satellite measurements of temperature of the surface waters since the 1980s. The deep hypolimnion (< 200 m) showed periods of warming caused by a downward transport of heat by turbulent diffusion during stratification, interrupted by irregular cooling and overturn during harsh winters. Overall, the frequency of mixing episodes decreased. The last circulation was observed in 2006; since then, the waters below 200 m showed a continuous warming reaching, in 2015, unprecedent temperature values, between 8.5 and 8.7 °C. These changes were paralleled by a continuous increase of TP in the whole water column until 2002 (ca. > 20 µg P/L), followed by a decrease (17-18 µg P/L). These changes concurred to affect the ecological features of the lake.
The first surface blooms of *D. lemmermannii* in Lake Garda were recorded in the 1990s. The introduction (in the 1960s) and expansion of this species was linked to the incipient eutrophication and to the lake warming, which is a general positive factor for the development of gas-vacuolated cyanobacteria. Nevertheless, while the impact of *Dolichospermum* was limited to the development of summer surface "oligotrophic" blooms, recent investigations showed that *Tychonema* was able to develop with biomasses as high as those of *P. rubescens*. These findings induce to change an important paradigm in the phytoplankton ecology of the southern perialpine lakes. In fact, until now, *Planktothrix* was the dominant cyanobacterium, and the only producer of microcystins (MCs, hepatotoxins). Conversely, many strains of *Tychonema* isolated in Lake Garda and in the other large perialpine lakes tested positive for the presence of the genes encoding ATX, and for the production of ATX. Since 2009, the increasing role of *Tychonema* was confirmed by the increase of ATX and the decrease of MCs. The causes will be discussed considering in particular the interactions between changes in the trophic level and lake warming.

## 39-O A multi-proxy sediment study to assess long-term effects of nutrients and climate variability on the ecological dynamics of the largest Italian lake (Lake Garda).

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The study of lake sediments allows to place limnological investigations within a secular temporal perspective, providing a longer time-span compared to monitoring data. A multi-site and multi-proxy paleoecological approach was applied to Lake Garda, the largest Italian lake, in order to disentangle the effects of local anthropogenic forcings, such as nutrients, and climate variability on the lake ecosystem during the last few centuries.Short sediment cores were collected from the deepest point of the two lake basins: Brenzone (350 m depth) and Bardolino (81 m depth). Biological indicators(diatoms and Cladocera) were used to reconstruct changes in the aquatic food web and to define the lake reference conditions, while sediment geochemistry, analyzed by wavelength-dispersive X-ray fluorescence spectroscopy (WD-XRF), was investigated to obtain information on different physical or chemical processes affecting the lake and its catchment.
The selected biological proxies suggested stable oligotrophic conditions of Lake Garda until the 1960s, while the following lake nutrient enrichmentled to a drastic change in the phytoplankton community. The major climatic anomalies,i.e. the Medieval Climatic Anomaly and the Little Ice Age, did not apparently affect planktonic diatom taxonomic composition, while Cladocera showed changes in total abundance and speciescompositions. On the other hand, diatoms showed an indirect response to climate variabilitysince the beginning of the nutrient enrichment phase in the 1960s, while Cladocera revealed a weaker climate-response during this nutrient-driven period. This different response to nutrients and climate was put in relation with the thermal dynamics of large and deep lakes. In fact, climate variability regulates magnitude and frequency of thermal circulationin large and deep lakes, which in its turn controlthe degree of nutrient fertilization of the entire water column and the related phytoplankton growth.
Geochemical data showed a pronounced change in elemental composition since the middle of the 20$^{th}$ century, when major elements and lithogenic tracers started to decrease, while elements related to redox conditions and contamination (trace elements) increased. The general trends agreed with the biological records. However, some differences recorded in the two different basins of Lake Garda reflected the effects of local hydrological and sedimentation patterns.

This study outlined that the ecological conditions of large and deep lakes in Northern Italy, such as Lake Garda, are mainly driven by nutrient enrichment, and that climate change can effectively modulate the lake ecological response to nutrients. The results stresses that the establishment of sustainable management policies and realistic restoration goalsof large subalpine lakes, which are usually based on the definition of lake reference conditions, need to pay particular attention to lake-specific sensitivity.

## 39-O Degenerative processes in a deep meromictic lake: anoxia, reducing conditions and internal loadings.

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Ecological studies in Lake Idro (Northern Italy), performed in the last five years (May 2010 - April 2012 and September 2013 - November 2014), evidenced a progressive deterioration of water quality and ecosystem status. The water column is permanently stratified and the chemocline is presently at about 40-50 m depth, out of a maximum depth of 120 m. The monimolimnion, which is ~50% of the water volume, is devoid of oxygen, with a concurrent accumulation of $Fe^{2+}$ and $Mn^{2+}$, methane, dissolved sulphides, ammonium ($NH_4^+$), soluble reactive phosphorus (SRP) and dissolved reactive silica. Conversely, in the mixolimnion $NH_4^+$, SRP and trace metals are almost completely depleted, whilst nitrate is the main nitrogen species. The development of phytoplankton and the contribution of cyanobacteria to total biovolume are quite limited (<~10%), because of the moderate availability of nutrients in the upper layers. For the trophogenic waters, we can propose the term “meromictic induced mesotrophy”. The littoral zone (<10 m depth) is colonized by a wide macrophyte belt, with the dominance of invasive elodeids. The internal SRP regeneration is recognized as a major P source, whilst nitrogen is mainly imported from the watershed. The meromixis is a critical threat to lake recovery. The reducing compound bulk in the monimolimnion can potentially account for an oxygen demand which is nearly threefold the actual oxygen availability. Hence, in case of complete water overturn, oxygen dilution and consumption, might lead to a critical oxygen shortage with a possible collapse of the aquatic food web, coupled with and exceptional fertilization of the surface waters. In fact, the monimolimnion and the surface sediment horizon have accumulated a great quantity of phosphorus. Here, the strong reducing conditions of the monimolimnion favour the SRP release from sediments: At the same time a very small quota of inorganic nitrogen is recycled into the water column. The resulting inorganic N to P ratio is thus imbalanced and can be recognized as a possible trigger of the development of toxigenic cyanobacteria. The internal P recycling, which greatly exceeds the external P inputs, can counteract the effort aimed at reducing the external loading. However, the P speciation indicates that, a significant quota of the sedimentary P is not readily available, constituting the so called calcium bound fractions, either authigenic or detrital. The P speciation and its potential availability have also been analysed in sediments at different depth, with different oxygen concentrations, in order to explore the effects of oxic to anoxic conditions on sedimentary SRP retention and exchanges.

## 39-O Long-tern nutrient dynamics in a deep subalpine lake (Lake Maggiore, Italy): the role of atmospheric deposition, catchment sources and climate.

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Lake Maggiore, one of the deep subalpine lake (DSL) in Italy, achieved a stable oligotrophic status after a recovery process started at the beginning of the 1980s. As an effect of decreasing nutrient loads from the catchment, concentrations of total phosphorus (TP) in the lake reached values of 9-10 µg $L^{-1}$ at winter overturn in the late 1990s. The oligotrophic condition was also testified by chlorophyll concentration of about 3 µg $L^{-1}$ as annual mean.
TP concentrations constantly decreased within 1980-1995, whereas total nitrogen (TN) progressively increased in the same period and beyond, mostly due to nitrate ($NO_3$) concentrations. Despite the adoption of measures to control N input from the catchment, $NO_3$ increased in the lake, as an effect of the high atmospheric input of N affecting this area. Recently, a slight decrease of $NO_3$ and TN concentrations has been observed, mainly affecting summer values in the