Public workshop on
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Inland water ecosystems: critical issues in the management of water quantity and quality and monitoring priorities

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ALPINE CONVENTION

www.alpconv.org

Main areas of the National Strategy of Italy for the Adaptation to Climate Changes (chair S. Castellari CNR_INGV and CMCC)

In blue: areas and sub-areas directly related to water quantity and quality

1. Water resources (quantity and quality)
2. Desertification, land degradation and drought
3. Hydrogeological hazards
4. Biodiversity and ecosystem functions and services
   - Terrestrial Ecosystems
   - Marine Ecosystems
   - Inland and transitional aquatic ecosystems
5. Climate and health: risks and impacts, and environmental and climate drivers
6. Forests and forestry
7. Agriculture, fisheries and aquaculture
   - Agriculture and food production
   - Catch Fishing
   - Aquaculture
8. Energy
9. Coastal areas
10. Tourism
11. Urban settlements
12. Critical infrastructure
    - Cultural heritage
    - Transport
13. Special cases:
    - Mountain areas: Alps and Apennines
    - Po River District

Main issues and priorities for inland aquatic ecosystems

the scientific knowldege is an essential support to planning and decision making

climate change pressures and ecosystem responses can be properly assessed only with a long term approach

inland water ecosystems are interconnected by upstream-downstream cascade relationships

adaptative management has to be undertaken with step-by-step actions
- actions have to be monitored and eventually corrected
- actions have to be framed in the integrated planning of water and soil uses, with an ecosystem based approach

CRITICAL ISSUES

Glaciers

1. expected (further) retreat

Lakes

1. physical conditions are changing with effects on water mixing (oligomixis – meromixis)
2. lake watershed are exposed to erosion with greater solid transport and nutrient loadings due to ice and permafrost melting
3. water levels are man-managed with effects on ecosystem processes and water quality
4. shallow and small lakes are subject to siltation
5. high altitude lakes are exposed to the risk of siltation and disappearance

Streams

1. expected disappearance of glacial streams
2. increased variability of alpine stream hydrology
3. increased solid transport

Dammed rivers and reservoirs

1. disruption of the tri-dimensional connectivity
2. risk of siltation
3. hydrology alteration (hydropeaking and residual flow)
4. alteration of the ecological stoichiometru of elements/nutrients
5. appearance of nuisance and toxic algal blooms in reservoirs

water demand ↑   water availability ↓

Example of conflicting environmental issues

river and lake damming

− minimum environmental flow
− ecological flow
− hydropeaking
− lateral and longitudinal connectivity

management of lake levels

- impact on littoral
- effects on mixing

Inland water and aquatic resources in Italy (Ghetti, 1992)

More than 70% is concentrated in the main South-Alpine lakes

About 75% of the Italian territory is affected by water scarcity

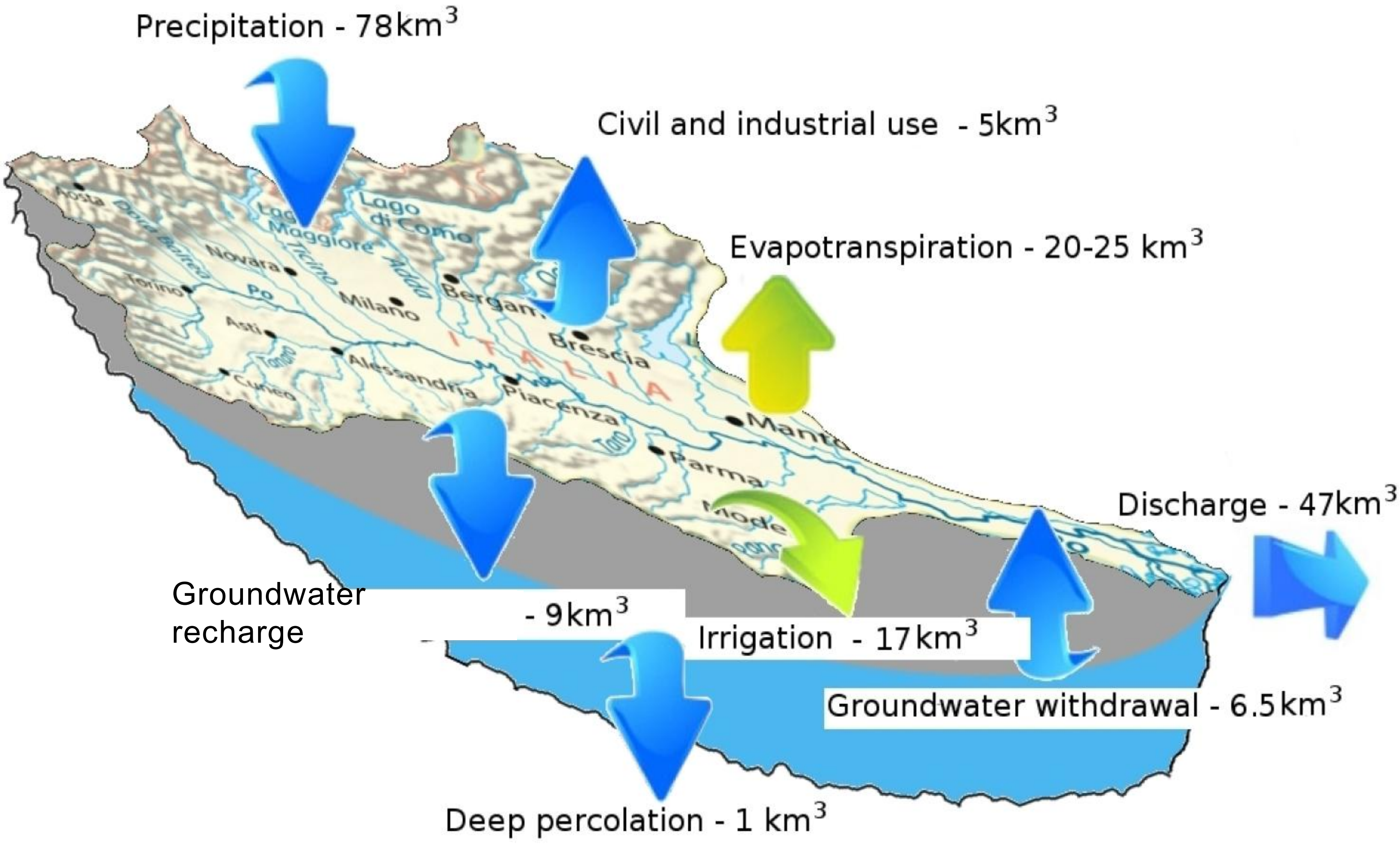
lake	km^3	% total of Italy
Maggiore	37.5	22.8
Como	22.5	13.7
Iseo	7.5	4.6
Garda	49.0	30.0
Great lakes	116.5	71.0
Italy	164.0	100.0

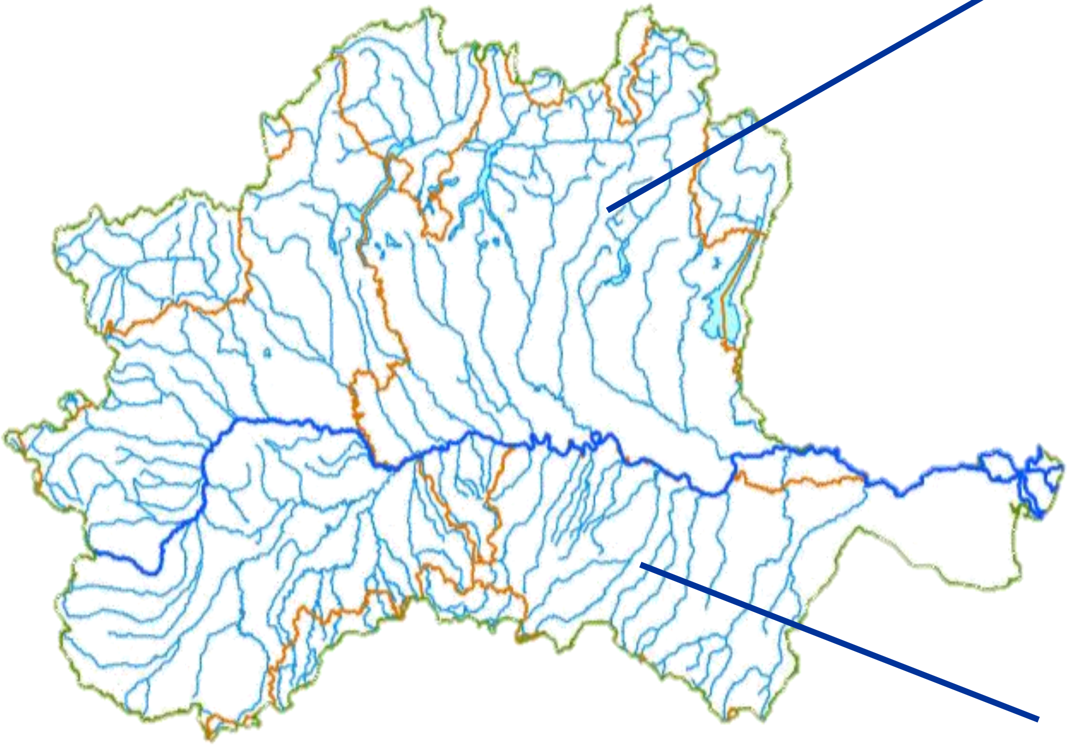
The Po river basin is a case study because accounts for 40% GDP in ~ 23% surface of Italy (data from Po river Authority, 2006; Viaroli et al., 2010, Montanari, 2012)

Socio-economic context	
Surface area	71,000 km^2
Agricultural area	32,000 km^2
Human population	~17,000,000
Cattle population	~3,500,000
Pig population	~6,000,000
Population equivalent	~110,000,000
35% of Domestic Agriculture Production	
55% of Domestic Livestock Production	
40 % of Gross Domestic Product	
32 % of domestic thermo-electric power	
48% of domestic hydro-electric power	
600 dams (mainly in Alpine tributaries)	

River discharge 1961-90 ($m^3\ yr^{-1}$)	
Min	$28.1x10^9$
Max	$82.8x10^9$
Median	$47.5x10^9$
River Discharge 2003-07 ($m^3\ yr^{-1}$)	
Min	$26.3x10^9$
Max	$45.3x10^9$
Median	$29.7x10^9$
Storage in great Alpine lakes (m^3)	$116x10^9$
Water Demand ($m^3\ yr^{-1}$)	
Agriculture	$16.5\ x10^9$
Industry	$1.5\ x10^9$
Potable	$2.5\ x10^9$

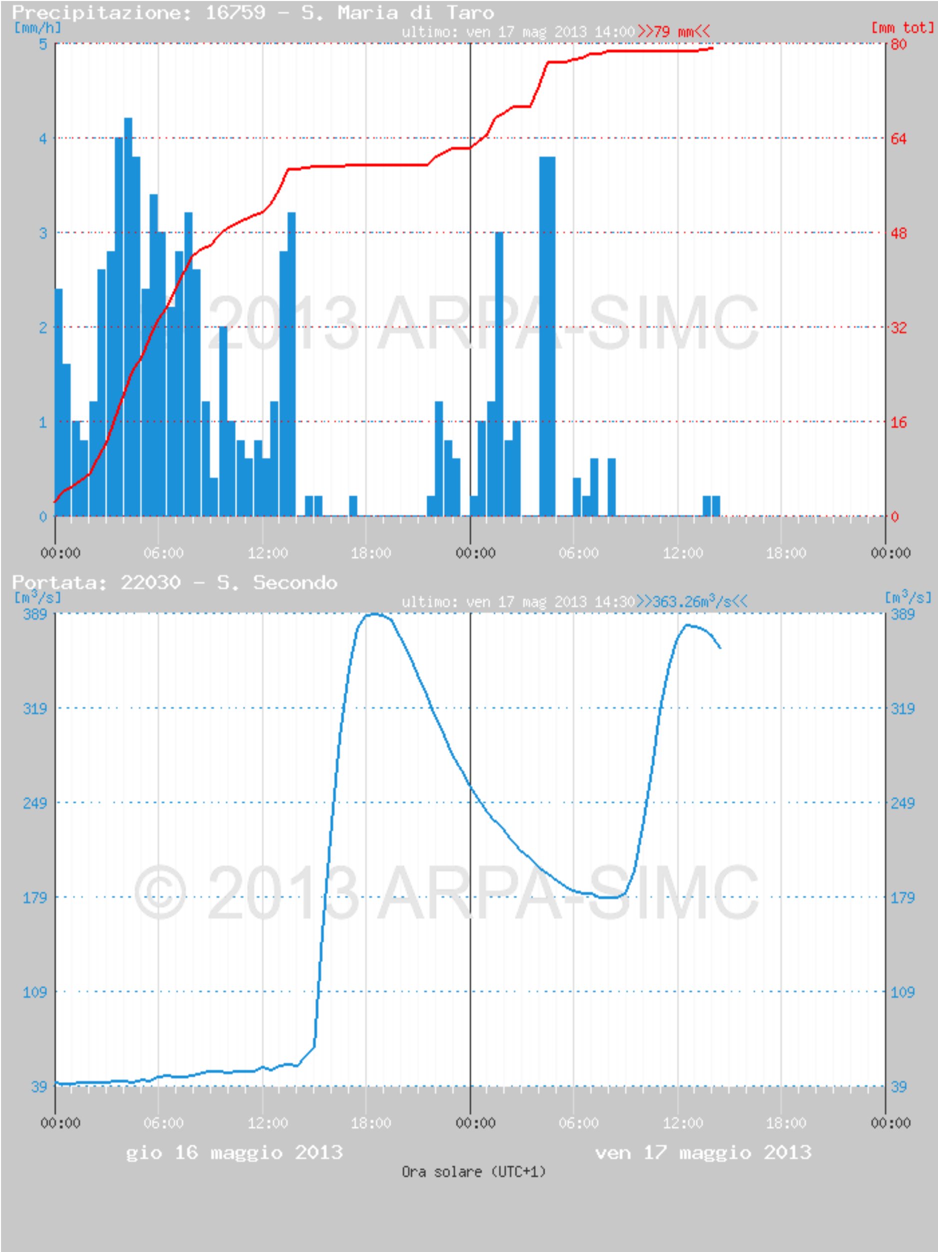
Mean water flow in the Po river basin from 1961 to 1990 (Montanari A., 2012. Hydrology of the Po River:looking for changing patterns in river discharge. Hydrol. Earth Syst. Sci., 16, 3739–3747





Northern side
River discharge and water availability depend on alpine glaciers and snow and are regulated by lakes

Southern side
River discharge and water availability depend directly on wet deposition
- intermittent flow
- flash floods



Taro River (Parma Province)

Relationships between wet deposition in the uppermost meteorological station (S.Maria del Taro, upper panel) and river discharge in the closing section of the watershed (gauged station of San Secondo lower panel).
Time from 00:00 on 16.05.2013 to 15.00 on 17.05.2013
Figure downloaded on 17 May 2013 from http://www.arpa.emr.it/sim/?idrologia/dati_e_grafici

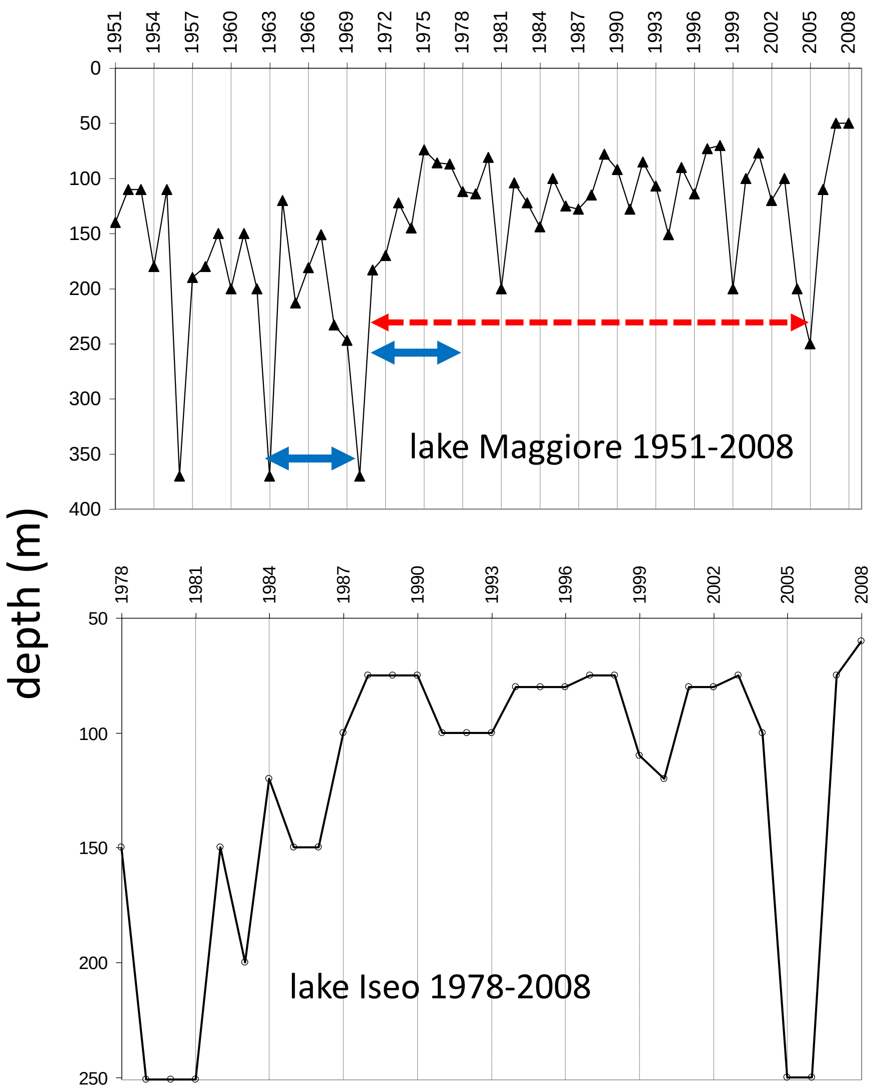
Flooded area in the Po river floodplain near Ostiglia (MN) - Photo WWF ©

Dry riverbed - Po river at isola Serafini (PC), July 2012 (Photo by R. Bolpagni)

Residual flow in the mid stretch of the Baganza torrent (PR) in late spring (photo by R. Bolpagni)

Visual examples of hydrological exyermes in the Po river watershed.
Altered hydrology is impacting both environmental and socio-economical resilience

Global warimng impacts on the great South Alpine lakes by altering water mixing



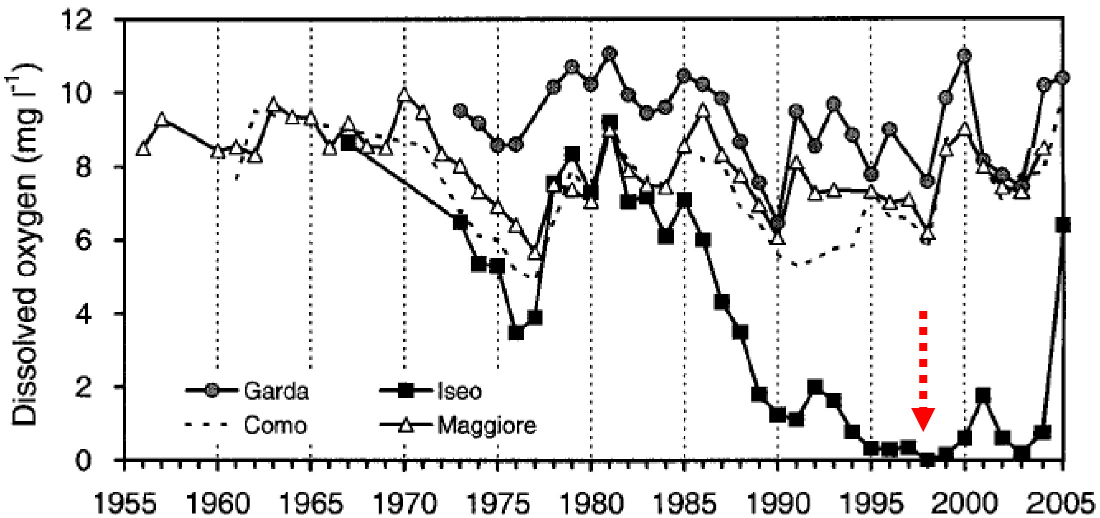
In the large sudalpine lakes global warming has resulted in higher water temperatures (0.1-0.2 C/decade) with a more persistent thermal stratification of the water mass. Possible effects are:

- oligomixis (less frequent mixing of the water column) and even meromixis (only partial mixing of the water column)
- increased eutrophication due to greater phytoplankton growth rates

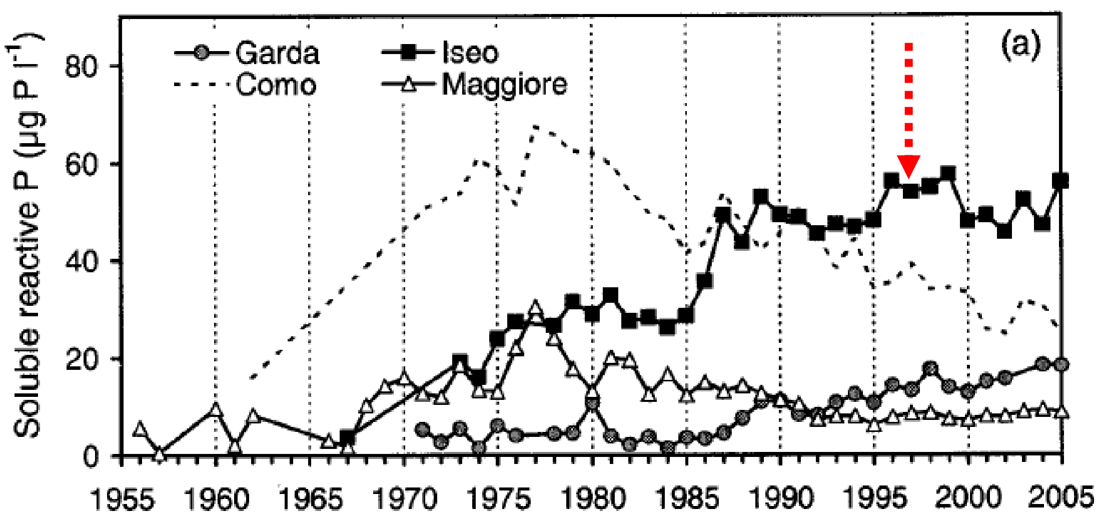
Salmaso N., Mosello R., 2010. Limnological research in the deep southern subalpine lakes: synthesis, directions and perspectives. Advances in Limnology and Oceanography 1: 29-66.

Oligomixis and meromixis are the main cause of oxygen depletion in the bottom waters of Alpine lakes (Salmaso et al., 2007, *Fundamental and Applied Limnology* 170: 177-196)

Dissolved oxygen in the bottom waters (from 200 m depth to the bottom)

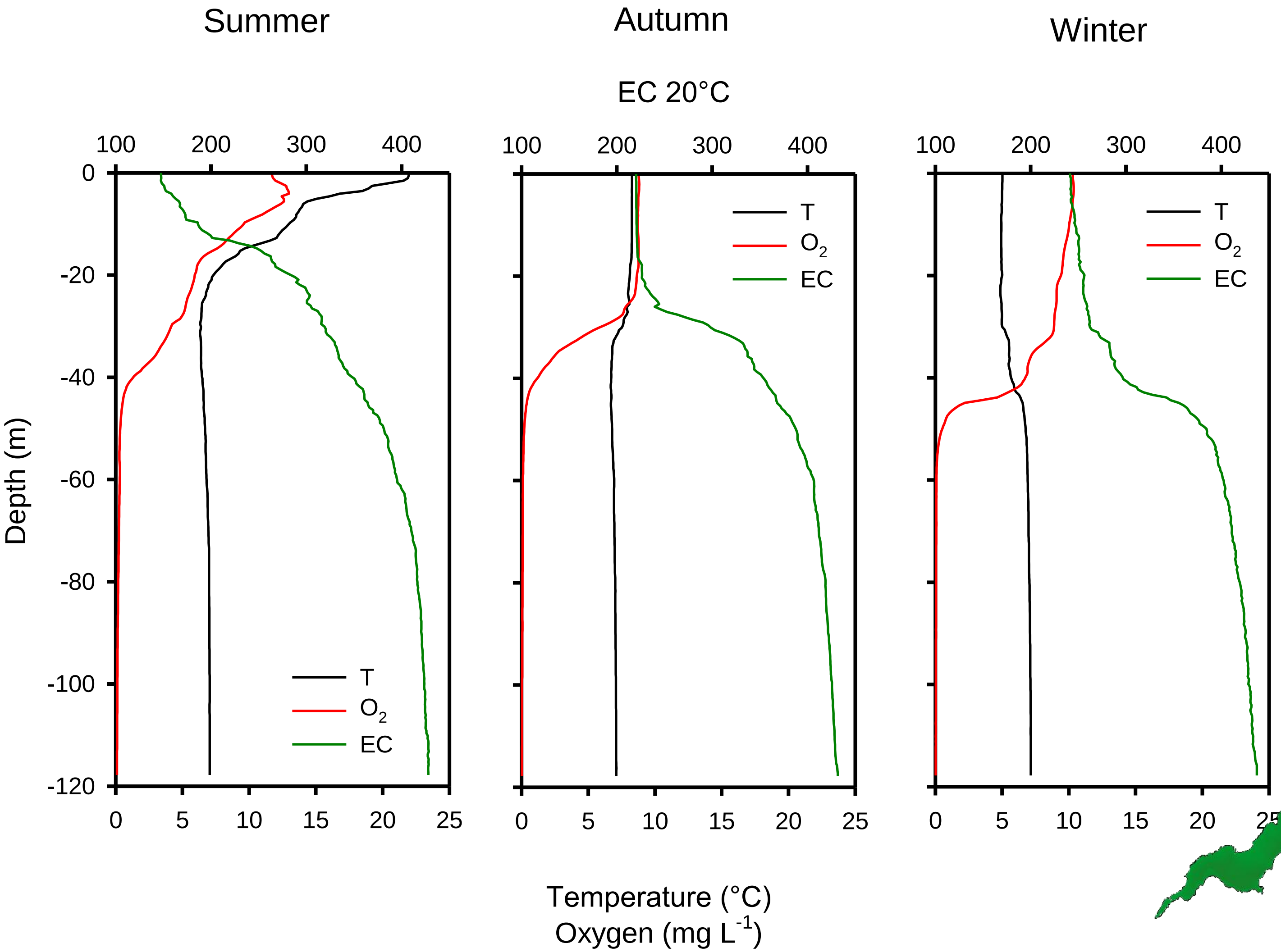


Under anoxia, in the bottom water phosphates, ammonia, sulphides increase (worst conditions)

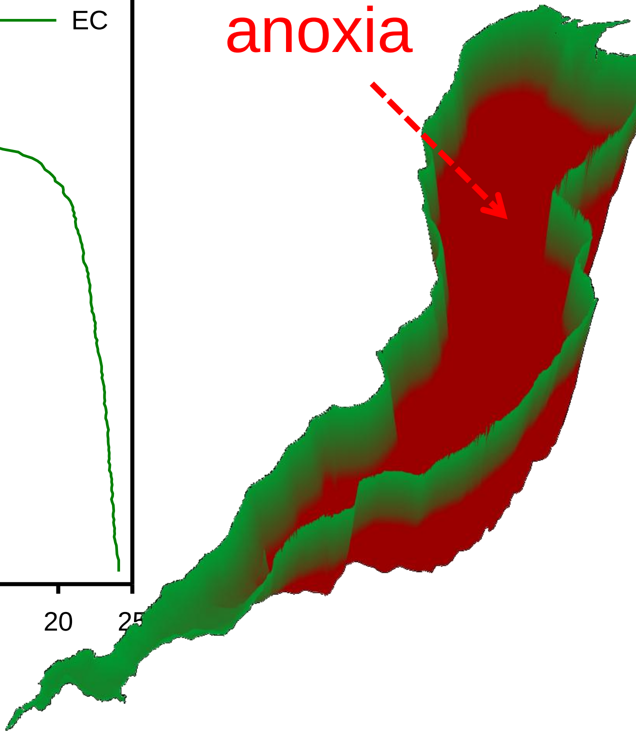


An example of meromictic lakes - Lake Idro

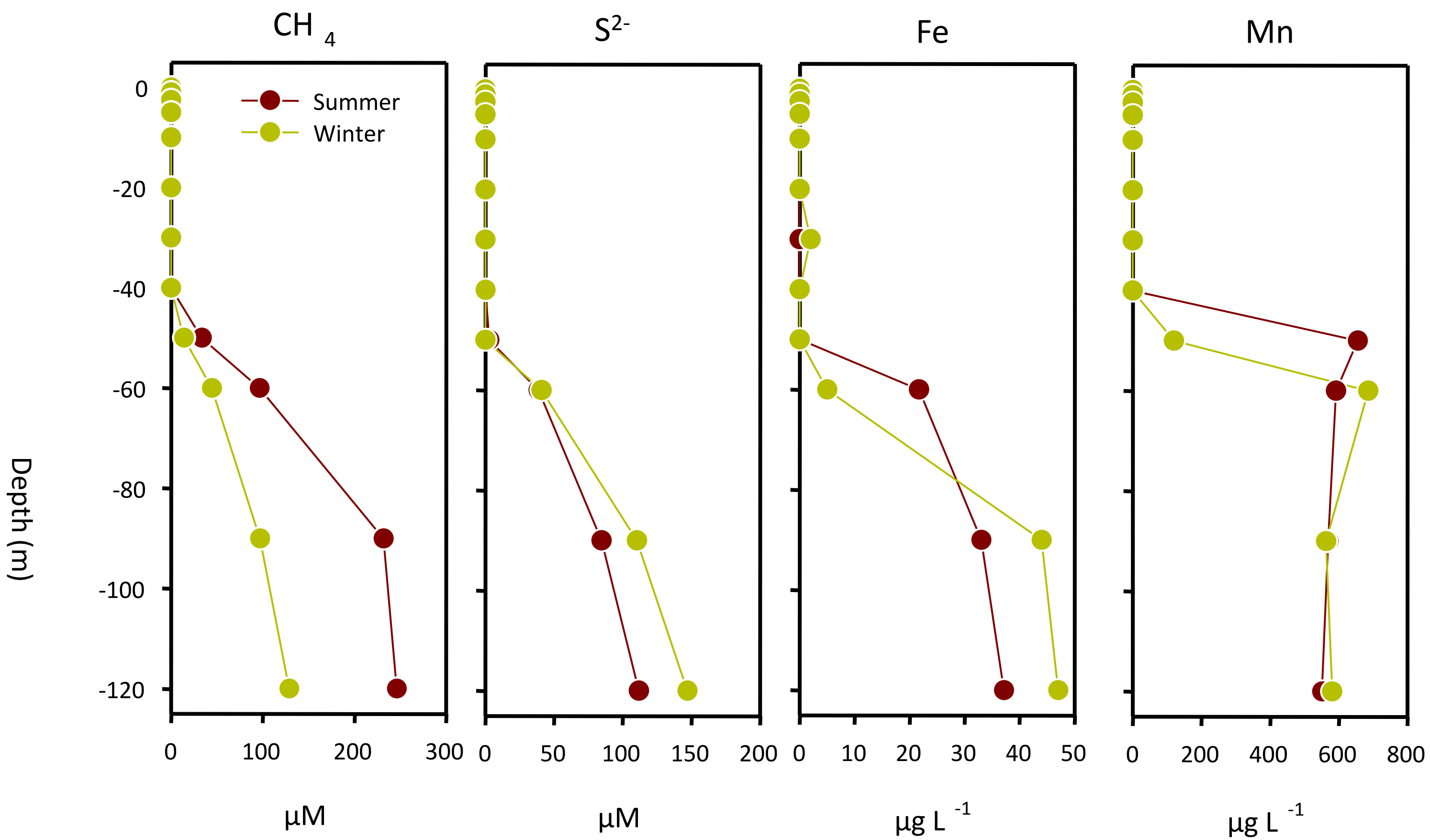
(results of the project funded by regione Lombardia and SILMAS Project Alpine Space Network)



Red = persistent anoxia



The combined effects of meromixis and eutrophication in the Lake Idro has caused the deterioration of water quality from 50 m depth to the bottom. The worst symptoms are increased concentrations of sulphide and methane (results of the project funded by regione Lombardia and SILMAS Project , Alpine Space Network)



GROWING CONCERN FOR ALPINE AND SUBALPINE LAKES

CONTAMINATION DUE TO ICE MELTING

Following ice melting of alpine glaciers, a peak of organochlorines (DDT) was detected in the last few years in sediment cores (Oberar) and mollusc species (Lakes Como and Iseo) . Glaciers are sources of DDT and other POPs which were banned since 1960s, but which accumulated in the ice cap.

Bettinetti et al., 2008. Is meltwater from Alpine glaciers a secondary DDT source for lakes? Chemosphere 7: 1027–1031

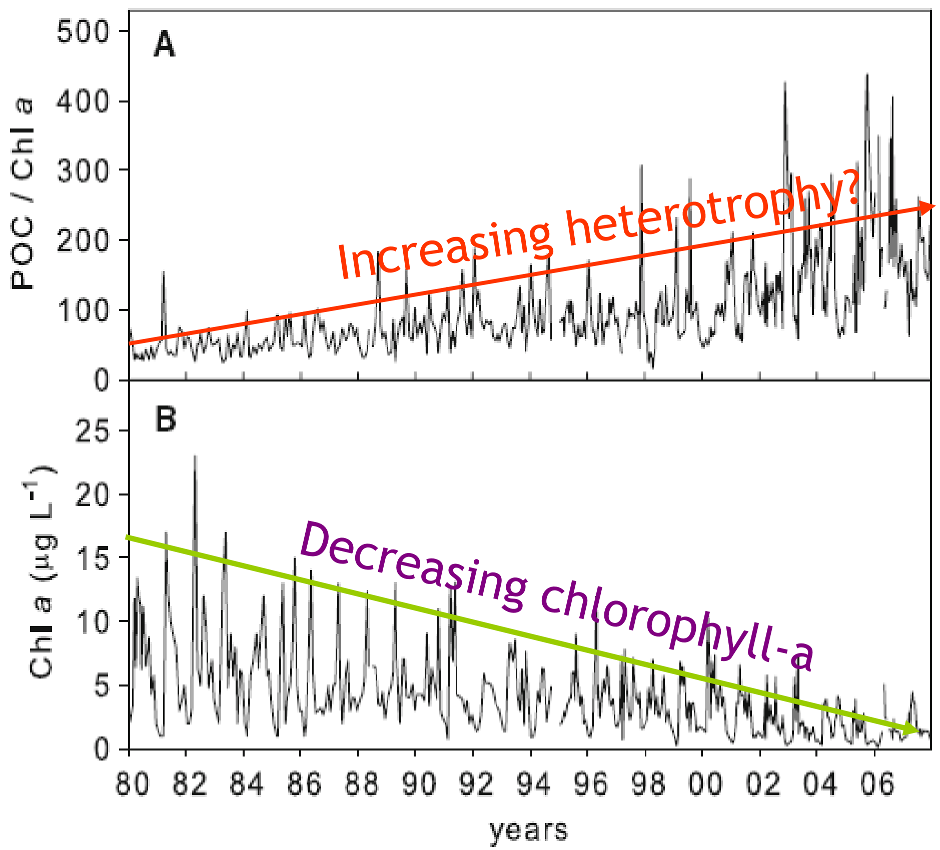
Bogdal et al., 2009. Blast from the past: melting glaciers as a relevant source for persistent organic pollutants. Environmental Science and Technology 43: 8173–8177

OLIGOMIXIS AND MEROMIXIS

Actions possible only in the watershed for avoiding eutrophication and/or restoring oligotrohic conditions

LAKE RESTORATION

There are cases of successful restoration of lakes in which oligotrophic conditions were recovered with reliable environmental policies (e.g. lake maggiore). However, ecosystem responses are often unclear. This is a challenging issue for research and policy makers.



Lake Maggiore: oligotrophic ation was followed by a significant decrease of phytoplankton chlorophyll-*a* concentrations, and increase of heterotrophic metabolism (Bertoni et al, 2010, Hydrobiologia 664: 279-287). Heterotrophy could be seen as a non positive symptom . See also: Duarte CM & Prairie YT, 2005. Prevalence of heterotrophy and atmospheric CO_2 emissions from aquatic ecosystems. Ecosystems 8: 862–870

RECOMMENDATION FOR MONITORING

The main issues of aquatic ecosystem responses to climate changes and adaptation strategies and policies need strong monitoring and research efforts with a long term perspective.

The long term research program (LTER) is a powerful tool for detecting and tackling emerging environmental problems/issues and facing societal needs. The stronger attribute of LTER are (Peters, 2010):

Long term monitoring (LTEM)

Long term ecological research (LTER)

Long term research on ecosystem services to support societal needs (LTSER)

Operationally, it can be viewed as a pyramid

LTSER platforms – ecological research supports societal needs

LTER – much fewer sites with research focus on emerging problems
networks of qualified research centers

LTEM – many sites with a minimum requirement of highly predictive variables

(support from non research agencies: meteorological organizations, regional environmental agencies, etc)

See also Mirtl et al., 2009. LTER Europe design and implementation plan. Umweltbundesamt, Vienna