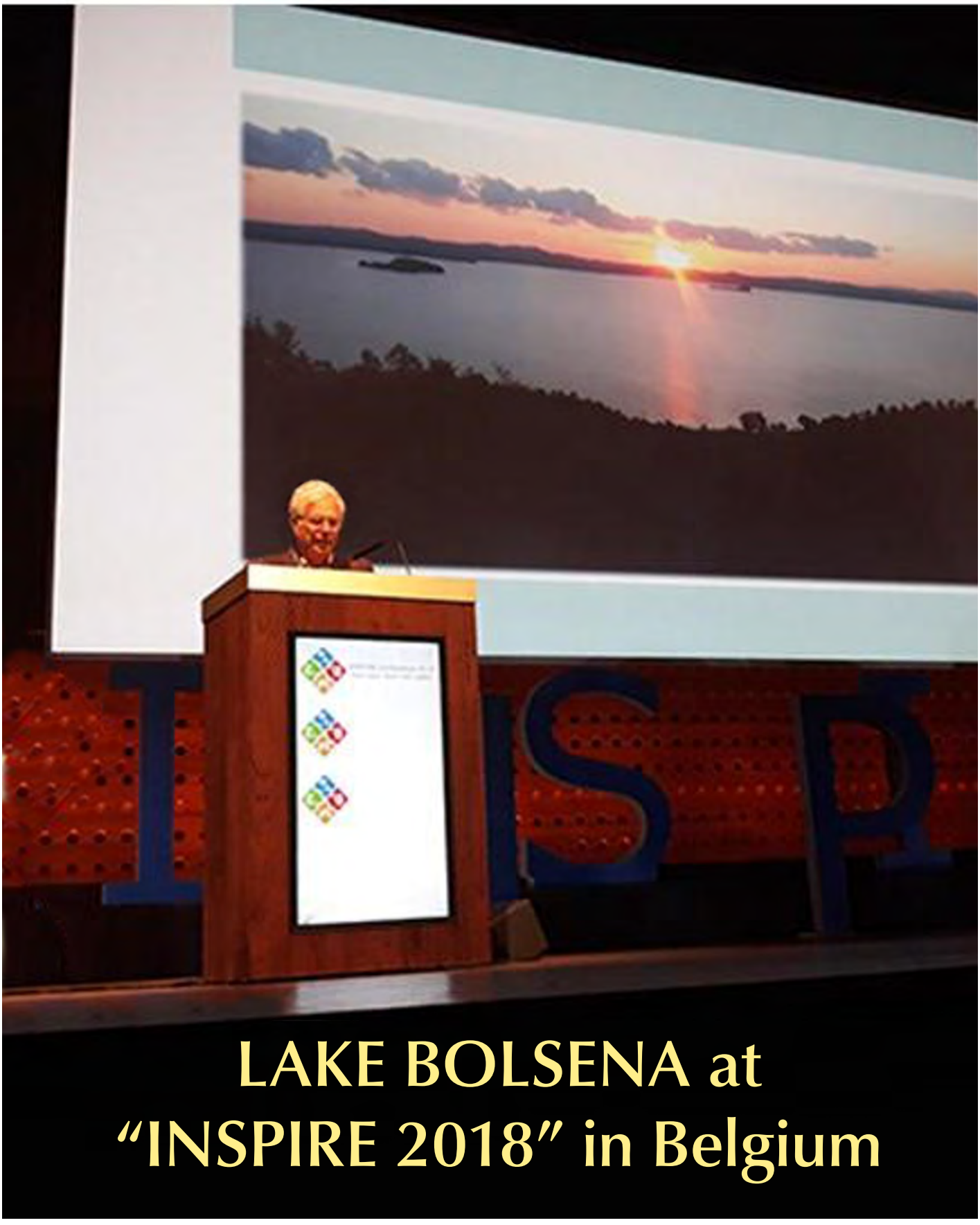
Lake Bolsena 2018



LAKE BOLSENA at "INSPIRE 2018" in Belgium

Fondazione Carivit

Associazione Lago di Bolsena volontariato

BLEU bolsenalagodeuropa

la porticella

Lions Club Montefiascone
Falisco-Vulsineo

Dedicated to the memory
of the Volonteers
who have left us.

Alessandro Fioravanti
Giovanni del Drago
Enrico Brenciaglia
Piero Carosi
Sonja Zantl

Those whom we have loved
and have lost
are no longer where they were,
but they are wherever we are.

St. Augustine

Lake Bolsena at Antwerp

The conference 'INSPIRE 2018', with the theme "Make it work together", recently held in Antwerp (Antwerp), Belgium, on September 18-21, has been an important event for Lake Bolsena.

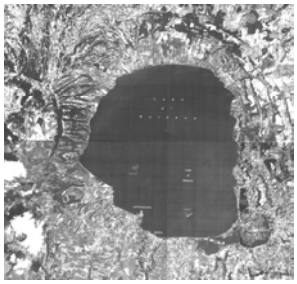
At the opening session, with an audience of 700 people from all over the world, key representatives of the European Commission and Dutch Governmentas well as the Belgian Minister of Defense spoke. Dr. Piero Bruni also gave a presentation on behalf of the “Associazione Lago di Bolsena”, as representative of the active citizenship of the Union.

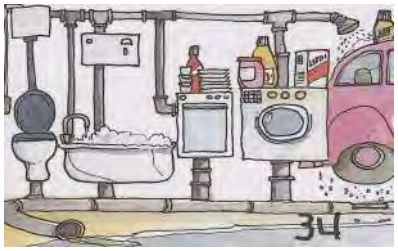
The conference was organized by the Directorate General for the Environment of the European Commission in cooperation with the Belgian and Dutch Governments, with the aim of promoting the implementation of the European directive INSPIRE (Infrastructure for Spatial Information in Europe). The aim of the directive is the acquisition of spatial data in the fields of environment, agriculture, transport, etc., and their standardization, accessibility and dissemination, in order to facilitate the planning and implementation of Community policies.

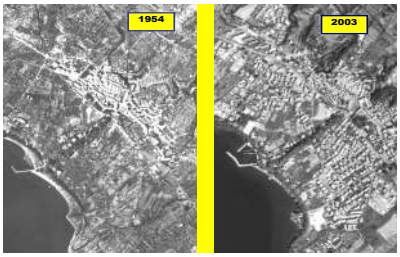
Piero Bruni spoke about the history of active citizenship around the lake and the role that this has had in the acquisition of a unique set of environmental data, thanks to which it has been possible to observe the evolution of the ecological quality of the lake over a period of almost 20 years. This work is the subject of a recent international scientific publication. Dr. Bruni’s presentation was greeted with great applause. Thanking the speaker, the representative of the European Commission noted that the EU is aware of the problems of the lake Bolsena and closely follows its developments.

The event hosted numerous workshops, oral presentations and posters as well as an exhibition area for companies, institutes and agencies working within INSPIRE. For the Lake Bolsena delegation, the conference was undoubtedly a precious opportunity to acquire new tools and expand the support network for the future of the lake.

Georg Wallner
“Associazione La Porticella”







Limnologica
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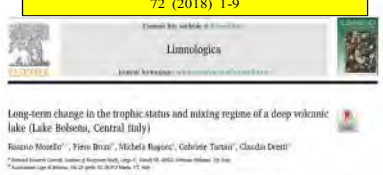


R. Mosello et al.

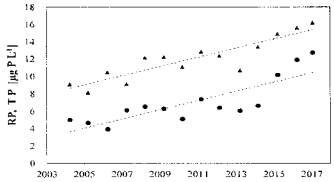


Fig. 8. Volume weighted concentrations of RP (dots) and TP (triangles) measured in Lake Bolsena at winter overturn in the period 2004-2017.

PIERO BRUNI'S PRESENTATION

I come from Lake Bolsena in Italy. I have the honor of having been invited here because, I can personally witness how the lake was, almost a century ago. This because I am 91 years old and I can testify to the many errors that have been made in the lake management and how important the battles and the results obtained by the citizen associations have been**.**

First of all, I would like to introduce you to Lake Bolsena[DIA 1] just at the moment of a sunset. The lake is surrounded by several historic medieval villages. Here are three examples[2, 3, 4.] There are also two islands that are volcanic craters[5, 6].

The lake is located in a volcanic caldera[7]. It has a surface area of 114 square kilometers and has a depth of 150 meters. Like all volcanic lakes, it has a very small rainfall catchment area compared to the volume of the lake[8], consequently it takes 300 years for its emissary river[9] to empty the volume of the lake. Actually, everything that enters the lake remains there forever, hopefully not in solution but steadily fixed at the bottom of the lake. Bolsena is a beautiful lake, but, as you can appreciate, it is a sensitive and vulnerable lake.

When I was a boy, the lake water was drinkable. My uncle worked on Bisentina Island. We used to go there every morning. There were no motor boats and while I rowed, my uncle fished. Along the way we drank water from the lake. When on the island, at lunch time, we ate the freshly caught fish. I was allowed to drink a glass of the local white wine.

At the beginning of the century, Marta was, and still is, a village of fishermen. There were no refrigerators. As you can see from the picture[10] the water entered the cellars of the houses where the fish were kept alive and sold directly to the public.

This old slide[11] was used in schools to illustrate to young people what life was like before the last war. There was no drinking water in the houses. The women took the water from the village fountain and carried it in jugs elegantly balanced on their heads. Outside the village, rainwater was somehow collected. There were no kitchen scraps, all the left overs were given to the pigs and the hens. There were no toilets and everything was thrown out of the window on the ground behind the house. There were billions of flies. In this type of civilization the effect of man on the lake was practically non-existent.

Then the war came. Italy lost it, but strangely enough, well-being arrived. The network of drinking water was built, the sewers dumped the human load of over 20.000 inhabitants directly into the lake[12]. There has been rapid urban development[13]. Intensive agriculture has been encouraged, which has polluted the lake with fertilizers and chemicals. More than 1.000 water wells have been drilled in the hydrogeological basin upstream of the lake, thus reducing still further the flow rate of the emissary. In just a few years, the human load on the lake has gone from nonexistent to very significant.

In the 60s, a disastrous project was to be introduced. The National Electricity Company, in anticipation of the construction of a nearby nuclear power plant, decided to use the lakes of central Italy as storage tanks. It was planned to use excess electricity production, to pump water from the murky Tiber River into Lake Bolsena so as to produce additional hydroelectric energy when the demand was high.

A 4-meter level variation was planned for Lake Bolsena. It was exactly this project which inspired citizens to form the first committees for the protection of the lake. The voluntary associations organized a large national press campaign against the plan.

The government was forced to submit the project to the Institute of Ecosystem Studies of Verbania - Pallanza, which was in charge of the study of the lakes of Northern Italy. Following their evaluation, the government stopped the project, despite the fact that work had already begun.

In the meantime, the problem of lake pollution had become pressing. The environmental volunteers obtained the funding for the sewage collector and the purification plant, but they were excluded from the project by the political parties, who, after sharing the contracts among themselves, constructed an unfinished sewage ring around the lake[14].

Citizen Science is a recent term, but it has a long history around Lake Bolsena. In the year 2000, since no studies of the lake were made after 1960, the Lake Bolsena Association somehow collected the necessary equipment[15] to conduct a study on its own. Having no funding, the Association asked a public Administration to lend their multiparametric probe.

In addition, a friendly agreement was made with the Pallanza Institute for technical support and chemical analyzes. From the year 2000, to the present, the Association has made over 150 multiparametric logs and two withdrawals of pelagic water samples during the periods of mixing and maximum stratification of the lake. The Pallanza Institute made about 20 chemical analyses on each water sample. Seven depths, twice a year, over 18 years, makes a total of about 5000 analyses at top professional level.

A few days ago, the data was published in the international scientific journal LIMNOLOGICA[16] thus concluding a cycle of 18 years of monitoring. The work shows that the eutrophication of the lake is under way[17] and that the situation could worsen in the future, also due to the increase in global temperatures.

Among the activities of the voluntary associations, it is worth mentioning education in schools on lake ecology which was extended to all 850 middle school children in the basin. They take samples of the plankton with a net and then examine it under microscopes[18]. It is also worth mentioning the problem of high-enthalpy geothermal plants that would pollute the lake with arsenic.

The European Community has made many directives for the protection of lakes[19], but the Italian Public Administrations seem uninterested in their application, or in citizen participation. Transparency is absent, the involvement of citizens is seen as a menace, not as a resource, but the associations do their best to keep citizens informed by means of their blogs[20].

I am here to share our experience of how a citizen association has been able to construct a unique longtime dataset. Without our work, no information would be available on the eutrophication of Lake Bolsena. In order to further develop our monitoring in coming years, we need help and feedback. We have managed so far, despite not having a multiparametric probe and the related equipment of our own, but we are not certain that this external support will last much longer. I am also here to share the experience of the difficulties that a group of informed citizens encounters in defending its environment.

We have understood that without pressure from the European Community, environmental lake protection is not going to happen. In conclusion, our hope is that the European Community adopt Lake Bolsena as its symbol for environmental protection and that they help the citizens by pressing local administrations to apply the pertinent laws, *in primis* the Water Framework Directive.

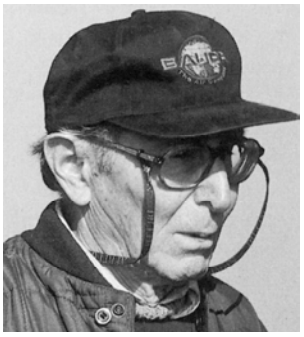
We trust that this will be done.

Thank you

Are the Voluntary Associations of Lake Bolsena harmful or are they useful resources?

This is not a rhetorical question: the correct information on lake degradation has been considered harmful by tourism entrepreneurs and town mayors, rather than a necessary reflection for far-sighted improvement of the ecological status of the lake. Recently, in order to collaborate with the entrepreneurs, our association avoided the public dissemination of videos and news that might degrade the tourist image of the lake, but sent them only to the institutions that should remedy this situation.

Numerous initiatives have been carried out by active citizenship since the post-war period. At the beginning there was voluntary service of individual citizens, then the association, then the first educational activities, and finally the monitoring of the lake that collected useful information for both educational activities and to combat its degradation. We wish to bear witness to the old and forgotten battles and the results achieved by the sparse volunteers, sometimes solitary, sometimes associated in groups.



The collection of water from springs

In the 50s a heavy uptake of the best springs that feed the lake began. The first environmentalist volunteer was certainly Alessandro Fioravanti (1917-2013), a citizen of Bolsena, who led a popular uprising, succeeding in saving the source of the Burano. In the following years Fioravanti devoted himself to underwater archeology with significant success: the discovery of the submerged Etruscan settlement of Gran Carro and the discovery of two archaic pirogues. Fioravanti organized one of these canoes as an exhibit in the museum of Capodimonte. During the protest of Enel's "Angelini project" Fioravanti was the promoter of the revolt from below, involving citizens to stop the ongoing works for the excavation of a tunnel to connect the lake with the river Paglia.

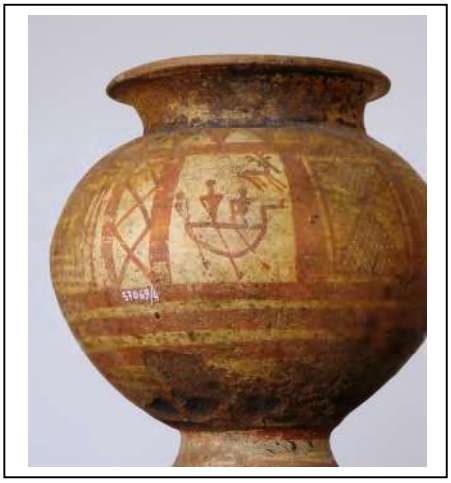
The Angelini project

In the 60s, Angelini (President of ENEL), in view of the construction of the Montalto nuclear power plant, decided to use the central Italian lakes as storage tanks. Since nuclear power plants work well at a steady rate without following the variability of energy demand, Angelini planned to use the excess electricity production to pump water from the Paglia and Tiber rivers and introduce it into the Trasimeno, Bolsena, Vico and Bracciano lakes. The water thus accumulated would become a reserve to produce hydroelectric energy when necessary. But the lakes would have been polluted by the murky water of the rivers and would have changed their level, up and down, by a few meters. The then Mayor of Bolsena, Prince Giovanni del Drago (1933-2016), invited the owner of Corriere della Sera, Donna Giulia Maria Crespi, to the Bisentina island, to solicit her intervention. A very effective press campaign against the project was organized at a national level, while Fioravanti, on his behalf, promoted an energetic action of dissent from below.

The opposition extended to Capodimonte, where some citizens joined as a separate section of "Italia Nostra", among them: Massimo Faggiani, Piero Bruni, and many others. That was the first known form of an association. The challenge led the Ministry of Public Works to commission the Italian Institute of Hydrobiology of Verbania Pallanza on Lake Maggiore (now Institute for the Study of Ecosystems - ISE - incorporated by the CNR in 1977), to carry out an environmental impact assessment. The Director of ISE was the Prof. Livia Tonolli, a patriotic scientist, who carried a tricolor ring with a diamond in the center and on the sides a ruby and an emerald (like the Italian Flag). The project was stopped just after the work had begun. And this avoided a disaster for the lake.

The archaeological bond in the area of Monte Bisenzio

Some time later, the beautiful site of Monte Bisenzio, to the west of Capodimonte, a possible site of the Etruscan "Vesentum", was threatened by speculation. A Political Secretary at that time, planned to subdivide it for his construction business. Everyone thought that such a powerful person could not be stopped. Here instead, the small section of Italia Nostra, thanks to the personal commitment of Fabiano Fagliari Zeni Buchicchio and Rosanna Faggiani, obtained from the Superintendence a vast archaeological ban on the area which stopped the building speculation. The jar, shown in the photo, was found near Mount Bisenzio in the locality of Olmo Bello. The logo of the “Lago di Bolsena Association” has been copied from this jar. In the 1970s the area was studied by archaeologists Jürgen Driehaus and Klaus Raddatz, Professors of the University of Göttingen; currently the area is being studied by the archaeologist Andrea Babbi, as part of the "Bisenzio Project", funded by the German scientific community.



The circumlacuale pipeline collector

With the passage of time the problem of pollution became more pressing. The "Associazione Lago di Bolsena" was established with the same members, who had previously belonged to “Italia Nostra”. It is difficult to evaluate how much the work of technical divulgation has influenced the decisions of the Public Administrators, but it is a fact that all the slaughter houses that shed blood into the lake were transferred and the municipal landfills that were percolated into the underground water bed were closed. The circumlacuale pipeline for the collection of urban waste-water was funded and then built: an event of great importance for the protection of the lake. There was a strong protest against the political parties that divided up the work among themselves with two construction managers, thus slowing down the construction of the collector. The slogan of the volunteers, widely disseminated with flyers, was a drawing representing a string tied to a finger, with the inscription "we will remember".

The geothermal power plant of Latera

About 20 years ago ENEL built a geothermal plant in Latera, that is harmful to both health and the environment. Stinky miasmas came as far as Montefiascone.

Dr. W. Wirbatz from Germany, organized a popular protest against the Plant with the support of the Hon. Laura Allegrini, now Counsellor of the Municipality of Viterbo. The Lake Bolsena Association documented the great risk of pollution of the aquifer with hydrogeological arguments.

Finally, thanks to the assessments of the Province, the definitive closure of the plant was established.

An international conference in Bolsena

In 2002, the Pallanza ISE and the Lake Bolsena Association organized a three-day international conference in Bolsena on "RESIDENCE TIME IN LAKES: SCIENCE, MANAGEMENT, EDUCATION". The work was published in a special issue of the Journal of Limnology in 2002 (Residence time in lakes: Science, Management, Education, J.L 62).

There were interesting presentations by scientists from all over the world: Moshe Gophen, Arkadi Parparov and Alon Rimmer (ISRAEL); Glen George (UK); Johan Varekamp and Stepnen Threlkeld (USA); Roberto Bertoni, Paolo Cordella, Rosario Mosello, Arturo Paganelli, Antonio Leone, Romano Pagnotta, Fiorenza Margaritora, Giovanni Nappi, VezioCottarelli, and Nico Salmaso (ITALY); Hartmut Barth (BELGIUM); Marjukka Dyer (FINLAND); Sven E. Jørgensen (DENMARK); Charles R. Goldman; A. C. Stacy and William W. Taylor (USA); Ken Hall and Patricia L. Keen (CANADA); Helmut Klapper (GERMANY); Iwona Wagner Lotkowoska (POLAND); Mark Richard James (NEW ZEALAND); Mikio Kumagai (JAPAN); Jim Xiangcan (CHINA); Valentina N. Podchivalina (RUSSIA); Maria Josè Boavida (PORTUGAL); Martin Doculil and Ulrike Nickus (AUSTRIA) and many others.

The conference was a great opportunity to introduce our lake to the international scientific community. It was then, that the church of San Francesco was transformed into the current and very useful meeting room.

Associations operating today

However, the past is history. The present and the future see the lake even more threatened. Sewerage collapse, eutrophication in progress, geothermal energy, hazelnut crops in the hydrogeological basin are problems that need to be addressed urgently.

There are three associated voluntary associations that are addressing these issues:

The “Associazione Lago di Bolsena”, based in Marta, founded in 2/5/1987 by Prince Giovanni del Drago, is engaged in lake monitoring, in teaching, in opposition to geothermal energy and in contact with the European Commission.
President: Piero Bruni

“Bolsena Lake of Europe”, based in Montefiascone, officially founded in 2017, characterized by the significant participation of European citizens residing or frequenting Lake Bolsena.
President: Angelo Bertea.

“La Porticella”, based in Capodimonte, characterized by many cultural activities: literature, yoga, and organic farming. This association is also very active in the protection of the lake and participates in contacts with the European Commission.
President: Catherine Bardinet.

The joint activity of the three associations is illustrated in detail in the following pages.

"Citizen Science"
The science of the citizens of Lake Bolsena

It is no coincidence that science education in schools and the study of the lake ecosystem began and grew together. In fact, it was necessary to acquire new knowledge to transmit to schools. The year of the birth of these two activities is uncertain, but we can consider them as started in 1997 when we built some gadgets to gauge rainfall and placed them in schools.

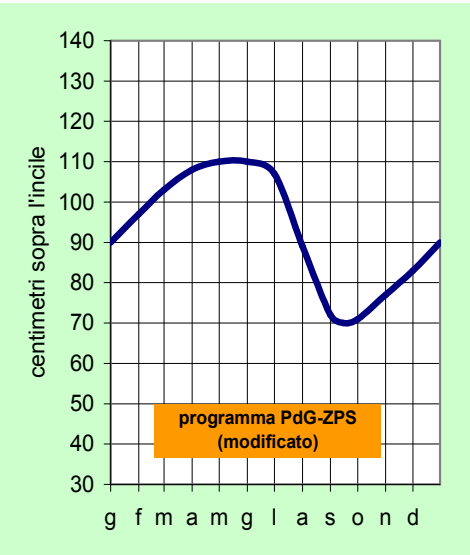
It was the beginning of quantitative and qualitative cognitive characteristics of the lake, developed by active citizens for over 20 years. Following the indications of the European Community, which encouraged "Citizen Science", we gave it the name "Science of the citizens of Lake Bolsena".

At that time the study of the level of the lake was important for the fact that the Municipality of Bolsena wanted a low level to widen the beach, the Municipality of Marta wanted it high to increase the depth of the port, and ENEL wanted a constant and conspicuous flow to feed the electrical power plants on the outlet river. The technician, who had to regulate the outflow of the emissary river and with it the level of the lake, not being able to please everyone, was overwhelmed by solicitations and criticism.

From the year 2000 to 2015 the Lake Bolsena Association kept an accurate graphic recording of the lake level, measured with a water gauge located in the port of Capodimonte.

The graph below represents a proposal for the optimal variation of the lake level with respect to the stone threshold at the bottom of the outlet river, which indicates the boundary between the lake area and the beginning of the outlet river.

The level of the lake with respect to the above-mentioned threshold allows an immediate visualization of the situation: in fact, if the level of the lake drops to zero, the outflow from the lake would cease and the emissary would dry up in its initial part. If the level rises to 140 cm the water reaches the surface of the piers and reduces the width of the beaches.

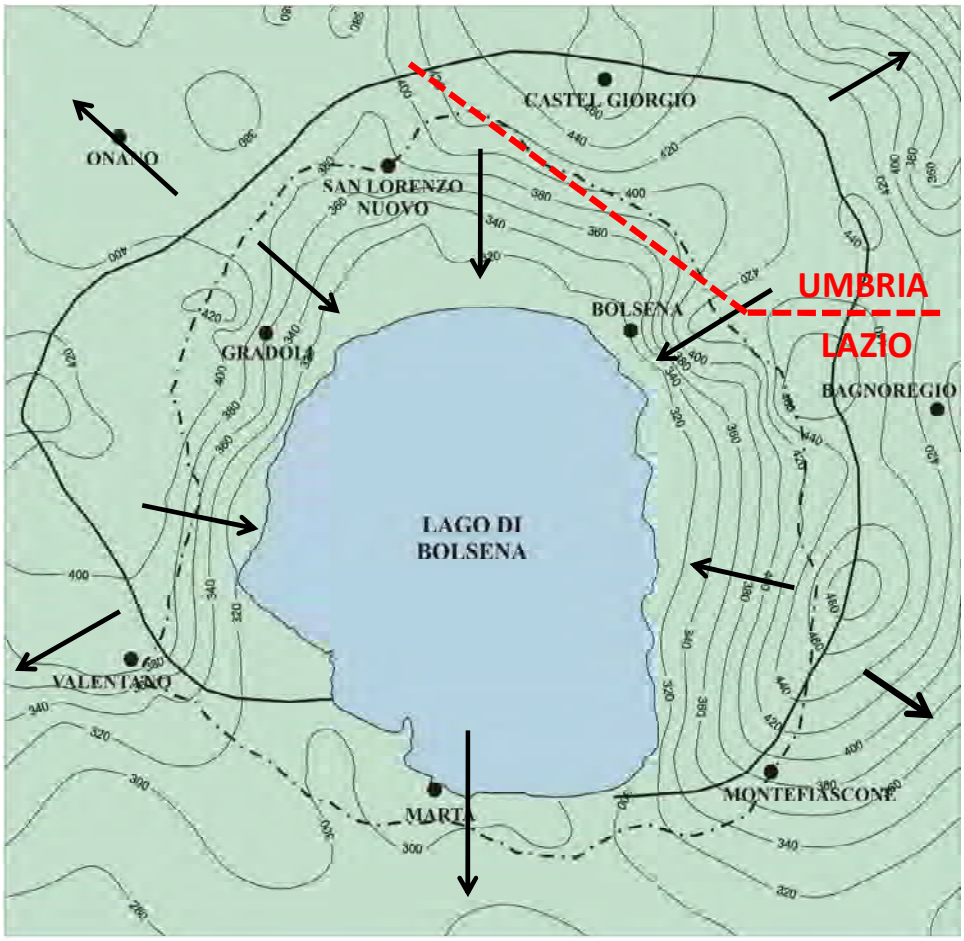


When the level drops to 40 cm, stones emerge along the Marta lakefront. Therefore, the extreme levels to avoid are 40 and 140 cm. The level halfway between the two is 90 cm. From the studies a seasonal fluctuation of 40 cm appears manageable, with a minimum level of 70 cm in the dry season and a maximum level of 110 cm in the rainy season. The minimum possible fluctuation protects the health of lacustrian reeds, which are a must around a lake, and must not be cut as is now the case.

At the end of 2005, due to an error in the management of the bulkheads, the level reached the upper limit of 140 cm. It was considered a dangerous flooding and urgent action was needed to "avoid damage to people and property".

Presumably, on the basis of this episode, in order to avoid the silting up of the outlet, a pier was built in front of it. The shores of the river were covered along three kilometers with expensive barriers of tree trunks. As far as we know, the silting of the outlet had never happened before, it has been cleaned up by the outflow towards the emissary, while the lakefront of Marta has been covered by sand over the years.

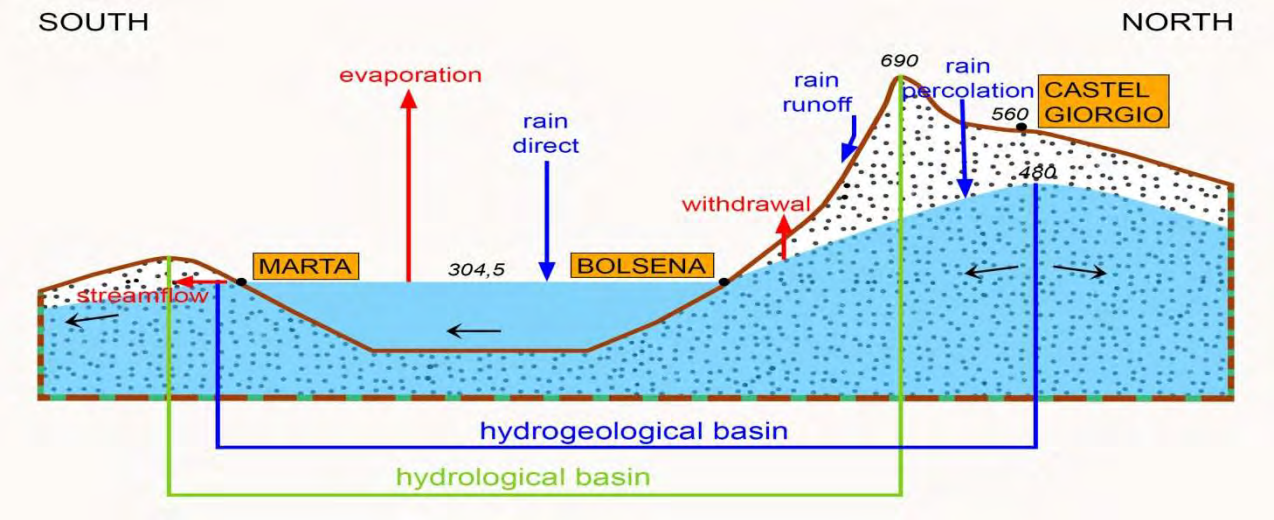
The works were contracted in a state of emergency at a cost of several million euros. It would have been much better to spend those millions to settle the sewage collector, which was then already in a bad state, rather than carry out these works of dubious utility.



The map above shows the hydro-geological basin of Lake Bolsena. In it the whole line represents the perimeter of the hydrogeological basin. Rainwater that falls inside this line feeds the basin, while that which falls outside, feeds other basins (Tiber, Fiora, etc.) as indicated by the arrows.

The stretch-point line indicates the catchment basin, also called hydrographic, which is the line that joins the summit of the hills surrounding the lake that, with their slope, form a funnel down which the rainwater flows towards the lake. The thin lines, called isopiezes, indicate the elevation above sea level, to which the underlying aquifer lies.

The basins of most lakes are formed by impermeable rocks: where the water ends, the rock begins. The hydrogeological basin of Lake Bolsena is instead formed by vulcanites, which are porous and permeable rocks, so that water is present not only in the basin, but also in the surrounding rock. In fact, the lake is the outcropping part of a large aquifer, as indicated in the schematic section of the hydrogeological basin.



On the SOUTHERN side of the lake, the basin starts from the coast of Marta, it descends 150 meters to the maximum depth of the lake, then goes up to the coast of Bolsena where the emerged part begins. On the NORTHERN side, the emerged part of the basin reaches 690 m altitude above sea level, then descends to 560 meters at Castel Giorgio in Umbria, and then descends again towards the plain of Orvieto.

The surface of the outcropping part of the aquifer is on average at 304.5 m above sea level, but it can vary in level as described on page 8. The level of the underground part is indicated by the isopieze in the hydrogeological map on the previous page, which has not been updated since the year 1998. Currently the culmination of the aquifer, which is located under Castel Giorgio, is no longer at an altitude of 480 m, but could have fallen to about 460 (Pagano). The culmination defines an underground watershed: on the SOUTHERN side the water flows towards the lake, on the NORTHERN side it flows towards the Tiber basin.

The blue arrows indicate the rains that fall inside the hydrogeological basin: one part falls directly over the lake, another flows down through the ditches in the catchment basin, the remaining part, in spite of evaporation from the ground, percolates through the vulcanites reaching the aquifer. The fact that the underground aquifer is at a higher level than the lake is due to the recharge of the percolated rain.

The red arrows indicate the exits: a large percentage is due to the evaporation from the lake surface and a part is due to the withdrawals from the wells, which were drilled for drinking and irrigation purposes (the withdrawals from wells have halved the original flow of the emissary). The little amount of water that remains from the water balance (difference between income and exits) flows out from the outlet. On average, the flow rate on a multi-year basis is 0.9 m^3 / sec.

This average is misleading. In winter the rains abound while evaporation is scarce: the level of the lake increases. In the summer rain is scarce, while evaporation increases: the level of the lake goes down uncontrolled. But this is the period in which the maximum irrigation and drinking water withdrawals are required; consequently, the summer outflow of the emissary is frequently less than 0.5 m^3 / sec, which is the minimum vital flow (DMV), of the outflow river. We are therefore in the presence of an obvious **quantitative emergency**, even though the lake contains a lot of water.

It is sufficient to observe the summer flow rate of the emissary, which is reduced to a rivulet, and to observe the lowering of the lake level and that of the underground aquifer during the drought year 2017 (same situation in Lake Bracciano). The lowering of the water table is due not only to the drought, but also to the excess of withdrawals, both inside and immediately outside the hydrogeological basin.

Any additional consumption is not sustainable because it involves consumption that exceeds the recharge. The limit of the Lake's hydrogeological basin is not a physical barrier: an increase in consumption in adjacent basins (for example, due to geothermal activity in Amiata, etc.) would also affect the Lake (Borgia).

The water renewal time is the time the emissary would take to drain a volume of water equal to the lake volume. The replacement time of Lake Bolsena was historically 120 years, but because of the water withdrawals through drilled wells, the lake outflow has halved; consequently, the renewal time has more than doubled, considering that rainfall has decreased by about 10% from 1960 to today.

The rain falling directly on the lake is quantitatively less than evaporation, therefore the outflow from the outlet is due to the rain collected from the emerged basin. Lake Bolsena is a “sensitive and vulnerable area” since the water renewal is practically non-existent. The pollutants that enter the lake remain there forever. It would be a lake of stagnant water if there were not an efficient living ecosystem, which within certain limits processes and breaks down the pollutants coming from the basin.

The soluble substances that are poured on the ground (for example agricultural fertilizers) enter into solution with rainwater and, together with it, they flow down towards the lake through the ditches or percolate to the underground aquifer, which also flows towards the lake.

Any polluting activity (intensive cultivation, farms, biological pits, etc.), for example, in the area of Castel Giorgio, could be considered non polluting because they are kilometers away from the lake, however, they are polluting because it is vertically just a few meters above the aquifer, whose flow is directed towards the lake.

The pollutants have a different specific weight: the heavy ones, like sand, settle on the bottom, while the light ones, like the oily substances, float on the surface and are then transported by winds and currents and deposited on the coasts, or flow out from the outlet. The soluble substances in the lake water are of various kinds, some are nutritious for plants, others are toxic like the herbicides and pesticides used in agriculture.

Plant nutrient are the phosphorus and nitrogen that are contained in urban sewage and agricultural fertilizers, but for Lake Bolsena, the determining factor is phosphorus. Its presence in a body of water, if excessive, causes eutrophication, which is a degenerative process that involves the growth of some invasive species of phytoplankton and the consequent alteration of the ecosystem and its state of health.

The arrival of phosphorus from the basin is hindered by the living ecosystem. Phosphorus is assimilated by phytoplankton and passes from it to the animals that feed on it. Phytoplankton and animals are living beings destined to die, their remains fall and settle on the bottom of the lake, dragging down the phosphorus contained in them. On the bottom, if the deep layer of water contains sufficient oxygen, the phosphorus is mineralized and fixed. If oxygen is lacking. or in the case of total anoxia, a release of phosphorus from the sediment to the water can occur (internal load).

Not all the phosphorus is broken down, what remains is supplementary to the new phosphorus coming from the basin, adding to its negative effects. It follows that the concentration of phosphorus, due to the prevailing oxygen deficiency, increases from season to season, accelerating the eutrophication process. The deterioration of lakes starts from the bottom and since it cannot be seen, no one worries about it, yet once it is seen on the surface it is too late to intervene.

In 1971 the Institute for the Study of Ecosystems (from now on called ISE), on the occasion of the opposition to the Angelini project, carried out lake monitoring that remained exemplary. During the following 20 years, no other monitoring was done . Around 1995, the then president of Cobalb Massimo Pasquini obtained a contribution from the EU to buy a boat and some tools to carry out new monitoring of the lake. The monitoring was actually done, but it was unfortunately unreliable due to the lack of a qualified laboratory for chemical phosphorus analysis.

After that attempt the *Associazione Lago di Bolsena* asked and obtained from Cobalb the equipment with which the association carried out monitoring from November 1997 to October 1998. The chemical analyses were done by the laboratories of the Institute of Agriculture of Bagnoregio and those of IPSIA of Acquapendente. Unfortunately, these laboratories were equipped to measure concentrations in mg/l instead of µg/l, so this monitoring also proved unreliable. Instead the study of zooplankton, carried out by Dr. Maria Ida Guancini at the department of Prof. Vezio Cottarelli of the Tuscia University, was valid.

From the year 2000 the *Associazione Lago di Bolsena* began to carry out professional monitoring in collaboration with the ISE with an informal agreement, mutually not onerous. According to which the Association would carry out operations on the lake while ISE would do the chemical analysis in its laboratory in Verbania Pallanza.

The Association bought a boat and procured the necessary equipment. More than six multiparametric recordings of temperature, oxygen and chlorophyll parameters and two seven-depth samples were performed each year. The samples taken were sent to Pallanza by fast courier and delivered the next morning. ISE performed over 15 analyses on each sample, that at 7 depths twice a year make over 200 analyses each year.

In April 2017, we invited and hosted for a week Prof. Londong, Dr. Englert and Dr. Stephanie Schneider of Bauhaus-University in Weimar. They accompanied a group of students who had done a thesis on Lake Bolsena and who wanted to check their work on site.

After having visited the sewage facilities and held a series of meetings with ARPA and other experts, they concluded their thesis with a summary that would be too long to report in full.

However here are the most significant excerpts:

".... Various environmental indicators show a deterioration of water quality. In particular, a significant increase of the phosphorus concentration was determined ... During an on-site inspection, it was found out that the existing wastewater infrastructure had serious defects .....The highest phosphorus imput loads originate from: wastewater discharge because of the improperly functioning sewage system, soil erosion of agricultural areas and combined sewer overflows during heavy rainfalls. These imputs hold the highest potential for improvement … In summary,, it can be concluded that only a combination of technical, institutional and informative measures can improve the situation at Bolsena Lake in long term…The current state is alarming, but not irreversible. Nevertheless, it could become irreversible with a sustained phosphorous imput. Therefore, the measures should be taken immediately to avoid further deterioration".

In 2018 the results of the monitoring of the last 15 years carried out by the collaboration between the ISE and the Lake Bolsena Association have been published in the international journal LIMNOLOGICA, including a study on the negative effects that in the future could cause the increase of the global temperature on the shuffling of the lake.

It is not a simple report, but a scientific work, published after a peer-review process by international reviewers. The original publication in English can be found on the Internet.

Contents lists available at ScienceDirect

Limnologica

journal homepage: www.elsevier.com/locate/limno

Long-term change in the trophic status and mixing regime of a deep volcanic lake (Lake Bolsena, Central Italy)

Rosario Mosello[a,*], Piero Bruni[b], Michela Rogora[a], Gabriele Tartari[a], Claudia Dresti[a]

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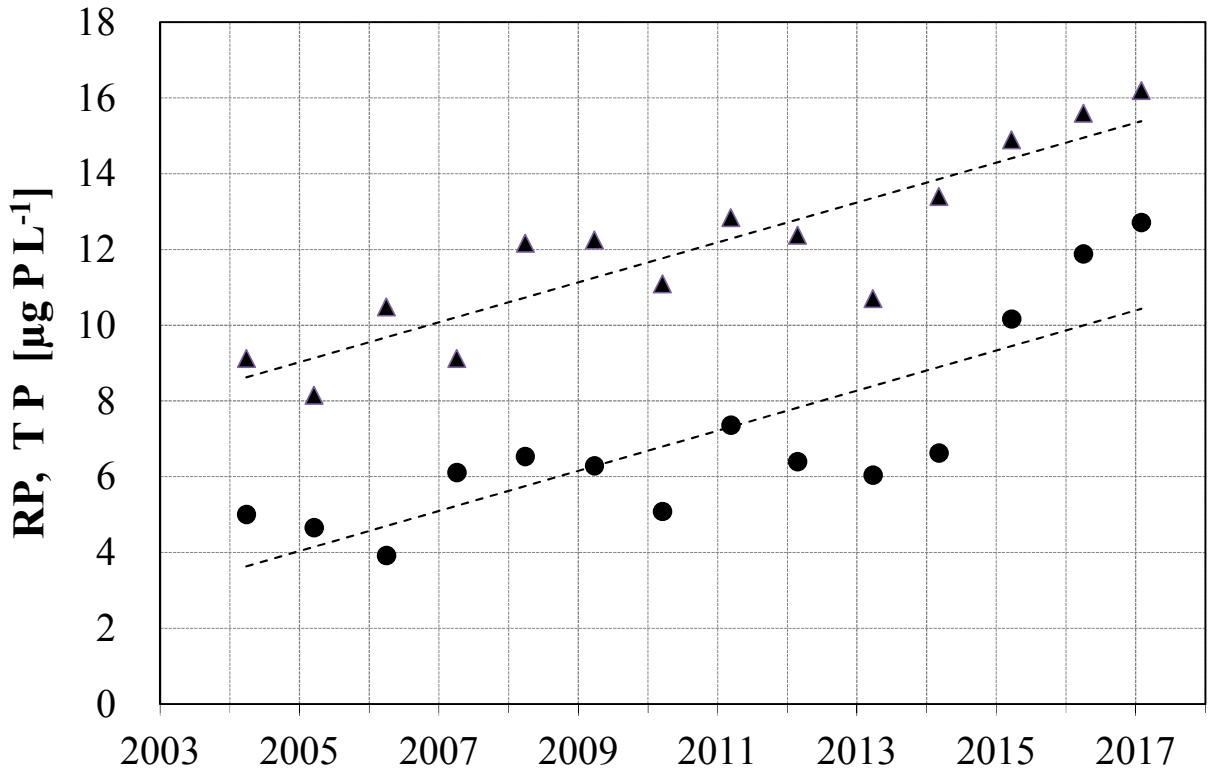
As for phosphorus, the work reports the results of the last 15 years of monitoring. The trend, having passed from 9 to 16 µg/l, is a serious increase.



Below is a summary of the work.

"Lake Bolsena, the fourth Italian lake for volume (9.2 × 109 m^3), must be considered highly sensitive to eutrophication for its extremely long water renewal time. In this paper, temperature and chemical characteristics of the lake, measured in the period 2003–2017, are used to discuss the mixing pattern and the variation in the oxygen and algal nutrient concentrations, as indicators of the trophic level.

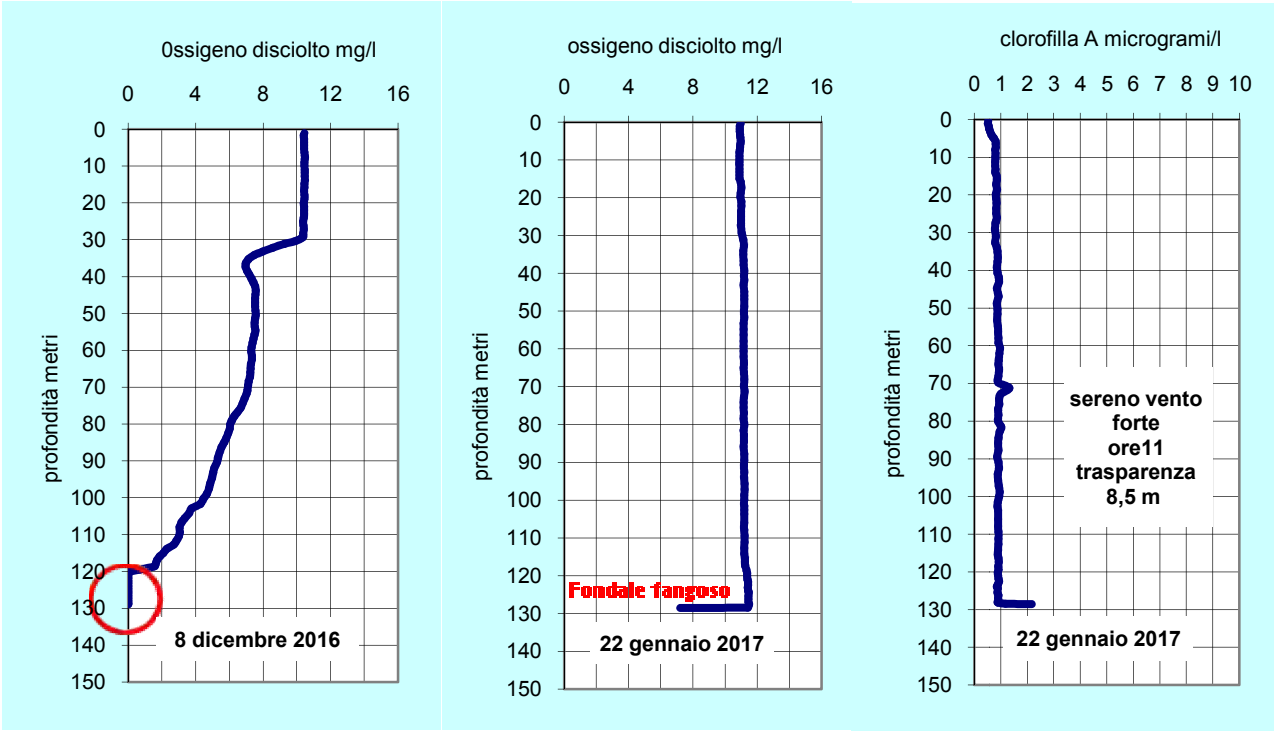
In the analyzed period the lake showed oligomictic characteristics, reaching the full overturn, with homogenization of the chemical profile over the whole water column, only in 4 out of the 15 considered years. A regular decrease of oxygen and increase of phosphorus concentrations in the deepest layers has been observed in the non-circulating multi-year periods.

The mean total phosphorus concentration showed a regular increase, reaching values close to 16 µg P/l in early Spring 2017, mostly because of the urban discharge from the watershed, not adequately collected from an existing sewage pipe. Chemical and mixing patterns are discussed in relation with a previous study, carried out in 1966–1971, confirming the recent increase of phosphorus concentrations and the lower frequency of full circulation.

The progressive deterioration of lake water quality indicates the need for prompt action to reduce the external nutrient load and of further studies on the physical and biological characteristics of the lake, still strongly missing".

In order to link the current 2018 situation with the previous ones, here below we report the situation at the end of 2016 when a serious episode of anoxia was recorded. The limnological year is lagging from the solar year: it begins with the period of mixing the water column when there are strong cold northern winds in February and ends with the period of maximum stratification that generally takes place in January of the following calendar year.

In each limnological year two chemical monitorings are carried out: the first in the overturn period, the second in that of maximum stratification. Multiparametric monitors are carried out at least six times a year, two of which are contemporary to sampling for chemical tests.



Limnological Year 2016 - During the period of maximum stratification the various layers of the water column have different characteristics. The recording of the amount of dissolved oxygen, registered on December 8th 2016, shows the very serious presence at the bottom of an anoxic layer with a thickness of 9 meters caused by the excessive arrival of phosphorus from the basin. The total phosphorus (TP) concentration was found to be 16 µg/l on 30/3/2016 during the mixing period.

Limnological Year 2017 - At the beginning of January an exceptional Siberian wind called Buran or Burian began, characterized by great intensity and persistence, which from January 2nd to 21st 2017 constantly mixed and blended the entire column of water.

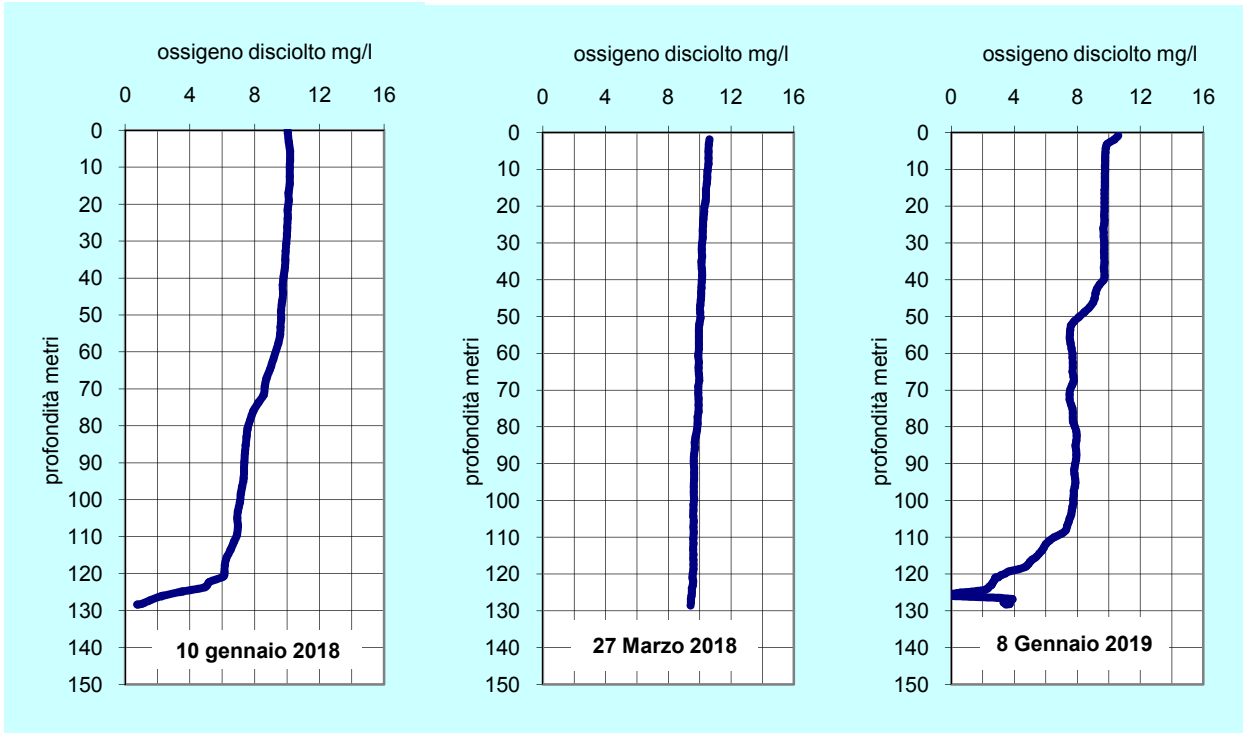
The shuffling period arrived unusually early and, as seen from the registration of January 22th 2017, the concentration of oxygen at the bottom had exceeded 11 mg/l. The shuffling was so effective as to drag phytoplankton with it, as is clear from the simultaneous registration of chlorophyll.

There was a drastic reduction of phosphorus (TP 13 µg/l), presumably due to the oxidation of the phytoplankton mortal remains that fluctuate up and down along the well-oxygenated water column.

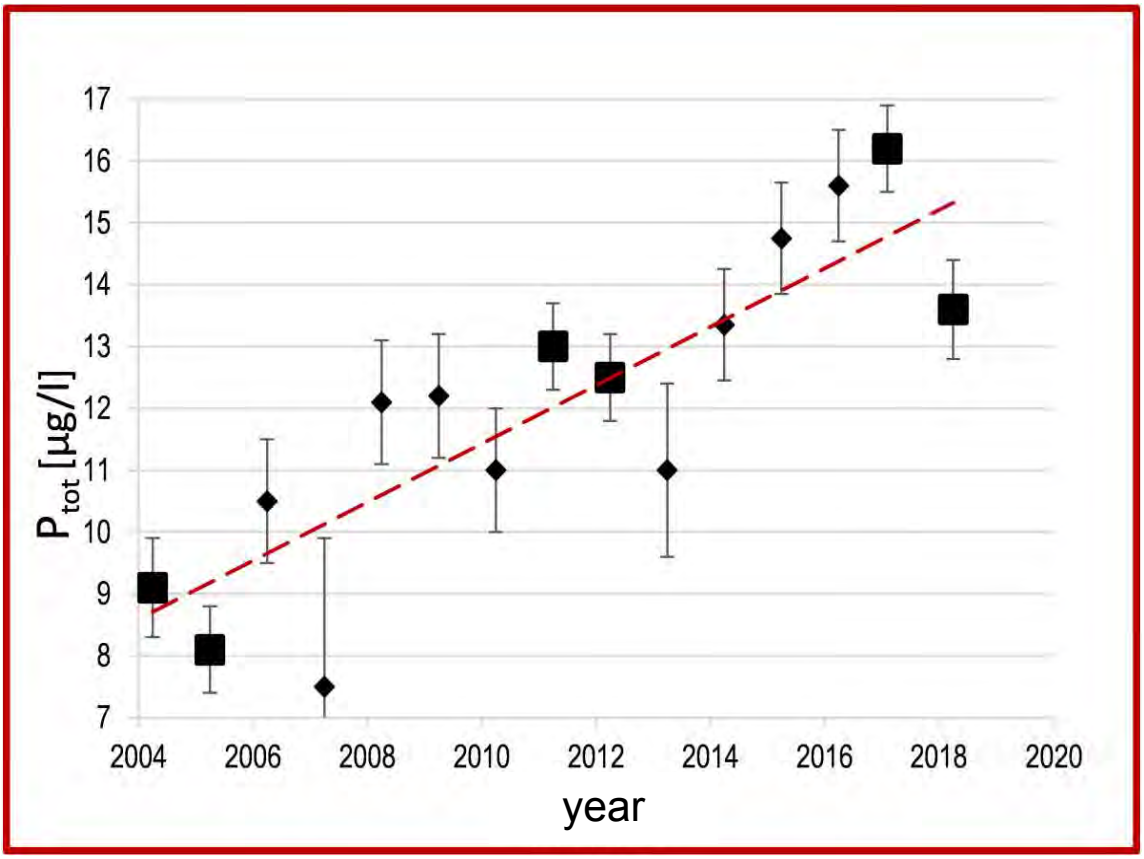
The monitoring of the 2017 Limnological year ended with the registration of January 10th, 2018 which shows the significant depletion of oxygen along the stratified column. It is interesting to remember that the burian wind also blew in February 2012, bringing snow to the lake: the complete mixing is reported on the underlying graph of TP.

2018 Limnological Year - The complete mixing took place in Spring as shown in the registration of March 27, 2018 (TP 14 µg / l). The maximum stratification was recorded on January 8th2019. At the bottom an anoxic layer of almost 3 meters was formed. The recording shows an interference, currently under study, probably caused by substances rising from the lakebed (TP 15 µg/l).

2019 Limnological Year - At the date of publication of this brochure, the mixing has not yet taken place. We hope that the burian wind will blow again, like in the years 2012 and 2017.



Water samples for chemical analyses are taken at seven depths in a pelagic station. When the mixing is complete, the values of the chemical analyses are equal at all the depths. When they are not the same, as always happens during the period of maximum stratification, it is necessary to make a weighted average attributing to each analyzed sample a volume taken from the hypsographical chart of the volumes. This leads to additional inaccuracy.



The black squares in the above graph indicate the years in which the mixing was complete, while the small rhombi indicate the years in which the mixing was partial. It is striking that the years with the complete mixing follow each other in pairs, but this seems to be meteorological randomness. It is also striking that the second year of a complete mixing shows a lower concentration of phosphorus concentration as compared to the previous one.

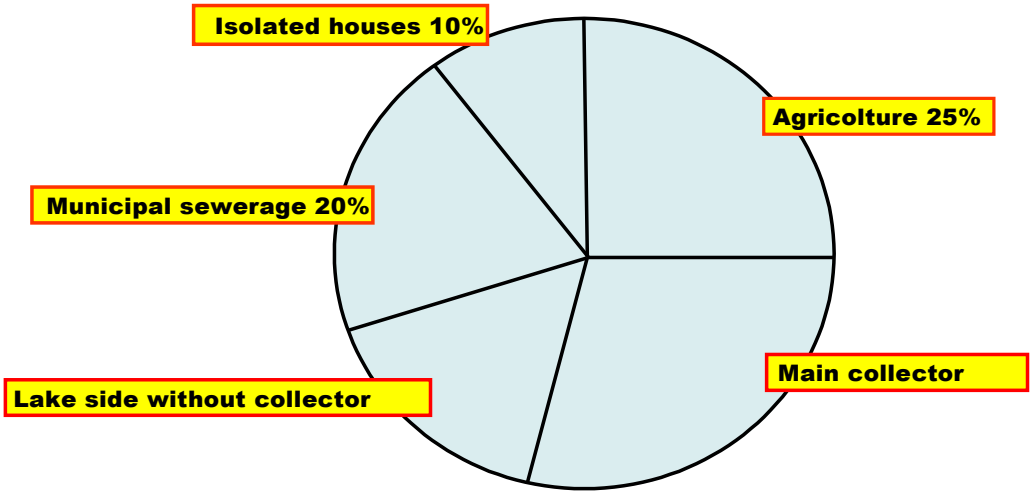
This can be explained by the fact, suggested by what happened in 2018, that together with the total mixing, there is also a reduction in the concentration of phosphorus. Due to new substantial additions from the basin, the phosphorus increased again during the following months. In fact, the analyses carried out on January 8, 2019 show that the TP has risen again to 15 µg/l. Because those analyses are related to a period of maximum stratification they are not shown in the graph.

Taking into account the analyses and the lake volume (9.2 km^3), it is estimated that in 2005 the amount of phosphorus in the lake was 75 tons while in 2017 it had increased to 150 tons. The increase of 75 tons of phosphorus in the 12 years considered is attributable to various causes. Unfortunately, there are no studies to quantify the percentage of each cause. The graph shown on the following page is a rough estimate, but it gives an overall picture of the situation.

The good news is that on December 30th 2018 the work on the collector's lifting stations was “more or less” completed. The following works are still missing: the repair of some sections of the pipelines; the verification of the tightness of all the pipes of the collector, the solution for the future maintenance of the collector and the study of a possible solution of the future legal-administrative management of the entire system.

As far as the immediate functionality is concerned, we hope that the arrival of pollutants due to leaks from the collector and from the lifting stations has been eliminated, except for occasional spills caused by excessive rains which overload the lifting stations.

Estimated contribution of phosphorous to lake Bolsena from 2005 to 2017 due to agriculture and to leaks of the sewerage system



The completion of the repairs on the collector is certainly good news for the tourism operators who, for many years, have hoped to see the bathing situation improved. However, we recall that the real problem for the future of the lake is the eutrophication in progress. In recent years, sewage spills have affected not only the bathing situation, but also the load of phosphorus that has accumulated in the lake. In order to achieve the rehabilitation to the “good” ecological pf state of the lake, much is still lacking, as is shown in the above graph. Details are described in the chapter dedicated to PTAR. Therefore, we still are in a ***qualitative emergency***.

Summarizing: the path of the cognitive project of Lake Bolsena began in 1997 with the measurement of rain by means of a modest handmade rain gauge. The project has been gradually upgraded for over twenty years, until reaching an international publication in 2018.

The project isthe merit of many active citizens who have solicited the indispensable collaboration of public and private institutions, whom we thank. Among these, for scientific advice: the ISE (Drs Rosario Mosel, Gabriele Tartari, Michela Rogorà, Claudia Dresti), the University of Tuscia (DEB: Prof. Giuseppe Nascetti and Dr. Fabrizio Scialanca), the various experts (geologists Giuseppe Pagano and Mario Mancini, the mathematician Gian Giacomo Spinucci and the physicist Georg Wallner).

For financial and instrumental support the Carivit Foundation (Pres. Dr. Marco Lazzari), the Province of Viterbo (President Pietro Nocchi, Dr. Ernesto Dello Vicario, Mario Busatto, Paolo Andreani), the Hydrographic and Mareographic Office of Rome (Dr. Cristina Pompi) and the Municipalities of the lake basin.

The project has been widely disseminated in the social community with the collaboration of the Schools, their Executives and Teachers, as described in the chapter "Didactics". Every citizen has contributed voluntarily, some a lot, some little, some only in his own interests, but all without receiving any compensation, indeed often contributing from their own pocket. It is for this collective engagement that we have given the project the deserved name of "***Science of the Citizens of Lake Bolsena***".

The Educational Program

As previously mentioned, it is not accidental that the teaching in schools and the study of the lake ecosystem started and grew together, around 1997. It was in fact necessary to acquire technical knowledge and then be able to transmit it to schools.

Here a photo of that period shows two girls, from the second year of the Valentano Middle School, who are measuring the rain with the first home-made rain gauge.

The following photo is also from 1997. It shows the students of the Valentano Middle School with Professors Carla Carsetti, Milvio Sassara and Piero Bruni. The Professor is holding a graduated pitcher to measure the amount of water collected in the rain gauge.

In the same year young students from Montefiascone organized the comic journal "ScholaFalisca". Funny and informative is the story of the time machine that could show both the past and the future. The “Pythagorean Whitefish”, with its invention of the time machine, had predicted as early as 1997 what effectively would happen to the lake if no action were taken.

In the school year 1997-1998 the students of the Middle School of Marta, with the coordination of prof. Antonella Bedini, invented the game of the lake named ECOLAGO, which was afterwards called LAG'OCA, and was presented on the Bisentina island.

In the year 2000, with the cooperation of Prof. Cetty Canestrelli the LAG'OCA was developed with two tracks, one track tells the story from the Etruscans to the European Community, the other track tells the geological, chemical and biological characteristics of the lake.

The LAG'OCA, was publicly played by the students, in the presence of their parents, in several Municipalities: in a square of Valentano; on the lakefront of Capodimonte; in Montefiascone and in other schools located on the southern side of the basin. In June 2013 the student teams of three schools, Valentano, Grotte di Castro and Montefiascone, who had studied the teaching handouts, played a large collective game.

In 2003/2004 the “Pithagoric Whitefish” was animated in a beautiful CD, made by the Elementary School of Grotte di Castro, with the title A LAKE TO BE LOVED, coordinated by the teachers Silvia Camilli, Laura Catteruccia and Prof. Filippo Belisario, with Cinzia Seggiani as animator.

The project has been consolidated through a special teaching quiz game, such as RISCHIALAGO, with a final award. Field visits and many other activities have contributed to the spreading of serious interest in our lake and for our project in all the schools of the lake district.

In the 2017-2018 school year, the educational program "Get to know Lake Bolsena" was extended to all the 850 Middle School students around the lake. The above illustration shows the initial slide of the presentation of the 2018 awards ceremony in the theater of San Francesco at Bolsena.

In the current school year 2018-2019 the educational program has been expanded and has taken the title "Knowing Lake Bolsena: opportunities for sustainable business". The novelty is the flanking of socio-economic issues with environmental issues. The project, in fact, in addition to providing students with the tools for a critical assessment of human behavior and activities that affect the health of the lake, intends to stimulate a reflection on job opportunities offered in the local context, with a view to environmental sustainability.

The program is divided into two levels: one is dedicated to the students of the Middle Schools of 4 Comprehensive Institutes (Valentano, Grotte di Castro, Montefiascone and Canino) which consists of almost 850 children from 12 municipalities of the lake basin; the other level is dedicated to teacher training, with the collaboration of the University of Tuscia, through the LABFORM sector, and the Scientific Degrees Plan (this teacher training course is accredited by the Ministry of Education and is aimed at all the teachers of the lake basin).

For the first classes the program includes geological notions relating to the genesis of Lake Bolsena and its effluent, the various hydrogeological parameters such as: the lake retention time, the level of the lake, the rains, water withdrawals and evaporation. RISCHIALAGO is a team game activity to check the concepts learned in an amusing way.

Two external experts intervene: The geologist Giuseppe Pagano, to teach the geological formation of Lake Bolsena and the historian Giancarlo Breccola for the history and cultural traditions of the towns around the lake

For the second classes the study of the lake ecosystem is integrated with an excursion on a public boat to fish phytoplankton and zooplankton with a special net.

The collected material is immediately brought to shore and observed by the students under a microscope with the assistance of the biologist Imola Bellavita (responsible for the Aquarium of Bolsena).

In case of adverse weather conditions, as an alternative to the trip on the public boat, the plankton withdrawal is carried out in the port and completed with a visit to the Aquarium of Bolsena or to the Capodimonte Museum of Navigation.

In the second classes two external experts are also involved: Georg Wallner (physicist) who explains the impact of human activities on the environment of the lake and Franco Strada (history teacher) who relates the most important historical events of the lake

For the third classes, until it is possible to visit the wastewater treatment plant, now in disarray, the students are taken to visit the organic farm "Il Pulicaro" of Torre Alfina, where they receive important information on organic farming and breeding; this is to understand how important environmentally friendly agriculture is for the lake

The two experts involved in the third classes are Carla Carsetti (science teacher) who explains what protective measures have so far been implemented and the restoration measures still missing. Rina Onorati (geography teacher) reports on the economic potential of the territory.

The Association of Lake Bolsena, despite its limited resources, has guaranteed the four Institutes to cover the expenses related to the project as regards: the publication of educational documentation; the intervention of external experts; the plankton fishing nets; the availability of microscopes; the material for preparing the slides for the microscopes; the organization of a large exhibition at the end of the school year in which the students' work will be displayed, including their logos for the future bio-district.

Last year, a gesture of solidarity towards the schools, was requested from the 12 Municipalities around the lake. They sponsored the project with a small, but symbolic contribution, of 100 euros each.

We would like to thank the Municipalities of Montefiascone, Marta, Capodimonte, Piansano, Valentano, Ischia di Castro, Farnese, Gradoli, Grotte di Castro, Latera, San Lorenzo Nuovo, Bolsena, the Executives of the four Comprehensive Institutes involved, all Middle School teachers, the University of Tuscia (in particular the LABFORM, sector coordinated by Patrizia Sibi and the Scientific Master Plan coordinated by Felice Grandinetti), the external volunteer experts, the "Pulicaro" farm in Torre Alfina, the "Navigabolsena" service in Capodimonte, the "Navigazione Altolazio" service in Bolsena, the Bolsena Aquarium, the Capodimonte Museum of Navigation, the Carivit Foundation, the SIMULABO and all the volunteers of the Associations that have taken part in the teaching activities.

In particular we warmly thank the kind leaders of the Didactic Project: teachers Carla Carsetti, Rosella Di Stefano, Rina Onorati, Emanuela De Rossi and Imola Bellavita.

The Regional Plan for Water Protection (PTAR)

The Regional Plan for Water Protection (called PTAR), which includes the Management of all the Basins of the Latium Region(as required by the Water Framework Directive – WFD -, Art. 13), before being approved, must be submitted to the stakeholders (Province, Municipalities, Associations, etc.) as required by the WFD itself.

The Plan was presented by means of the DGR 819 of the year 2016 and has not been updated since then. The stakeholders were asked to submit their written observations before October 21 2018. Their oral observations could have been presented by participating in a hearing at the Environment Commission of the Lazio Region three days earlier.

The Plan is very important to us, as we live near the lake. In fact, it establishes an order of importance for the various protection and restoration interventions and allocates funds according to the needs of the various basins. If no one reads the plan or doesn't make observations, "he who keeps silent agrees" and the plan will be approved in the state in which it was proposed. For the population and for our lake it would be a disaster because it contains unacceptable evaluations and programs. The Region has not solicited the Municipalities to study the PTAR, so that no Municipality in the basin of Lake Bolsena has presented observations. Those, like our Association, who booked for the audition, received via e-mail, just one day in advance, the text of the Plan, consisting of over 1,200 pages.

The aspects of main interest for our lake are bathing and the eutrophication process, actually in progress. As for bathing, it is sufficient to recall the well-known videos, recorded during the summer, showing excrements floating in the vicinity of some pumping stations of the sewerage collector, which were leaking waste water into the lake.

ARPA LAZIO – Stato ecologico dei corpi lacustri – 2014 – 2015
determinato secondo cinque classi di qualità:
ELEVATO – BUONO – SUFFICIENTE – SCARSO - CATTIVO

Stazione	Corpo idrico	Fitoplancton*	LTLeco	Tab 1/b	Parametri critici	STATO ECOLOGICO
L1.30	LAGO DI CANTERNO	Cattivo	Sufficiente	Buono		CATTIVO
L1.32	LAGO DI POSTA FIBRENO	Buono	Elevato	Buono		BUONO
L3.39	LAGO DI VENTINA	Sufficiente	Buono	Buono		SUFFICIENTE
L3.40	LAGO DI RIPASOTTILE	Cattivo	Sufficiente	Buono		CATTIVO
L3.41	LAGO LUNGO	Cattivo	Buono	Buono		CATTIVO
L3.42	LAGO DI SCANDARELLO	Buono	Buono	Buono		BUONO
L3.44	LAGO DEL TURANO	Buono	Sufficiente	Buono		SUFFICIENTE
L3.45	LAGO DEL SALTO	Sufficiente	Sufficiente	Buono		SUFFICIENTE
L3.57	LAGO DI PATERNO	Sufficiente	Sufficiente	Buono		SUFFICIENTE
L4.26	LAGO DI BRACCIANO	Elevato	Sufficiente	Buono		SUFFICIENTE
L4.27	LAGO DI MARTIGNANO	Elevato	Buono	Buono		BUONO
L4.28	LAGO DI NEMI	Sufficiente	Sufficiente	Buono		SUFFICIENTE
L4.29	LAGO ALBANO	Buono	Sufficiente	Buono		SUFFICIENTE
L5.30	LAGO DI BOLSENA	Elevato	Sufficiente	Buono	→	SUFFICIENTE
L5.34	LAGO DI VICO	Buono	Sufficiente	Sufficiente	Arsenico	SUFFICIENTE
L5.70	LAGO DI MEZZANO	Buono	Sufficiente	Buono		SUFFICIENTE

Tab. 1 – Stato ecologico dei corpi lacustri. Il calcolo del parametro "fitoplancton" si è basato sulla sola metrica "clorofilla" in quanto i metodi di calcolo del biovolume sono variati in corso d'opera rendendo i risultati difficilmente confrontabili.

As regards the eutrophication, the European Water Framework Directive (WFD) implemented by Legislative Decree 152 - Water Framework Directive(article 77), requires that the lakes, which were in "sufficient" ecological status in 2008 should reach "good" status in 2015.

But, in our case, the reverse occurred: Lake Bolsena, that in 2008 was in "good" status, was instead degraded to "sufficient" in 2015, as certified by ARPALAZIO for the period 2014-2015 and afterwards confirmed during the triennium 2015-2017. Therefore, the restoration to the "good" status should be given high priority by PTAR.

When the repair works on the pumping stations and the pipeline sewage collector (improperly called "ring" collector), have been completed we can perhaps say that finally the problems of bathing and tourism have almost been solved, but certainly not that of the eutrophication in progress, for which the damage has already been done. In fact, the total phosphorus concentration increased from 8 μg/l in 2005 to 16 μg/l in 2017. As previously mentioned, the PTAR, in the proposed version of the year 2016,has clearly not been updated. Here is the summary of our observations, with reference to the PTAR page numbers.

1) The assessment of the quality of Lake Bolsena as "good" (pages 235 and 295) is erroneous. ARPA LAZIO in their summary table of the ecological and chemical status of the lakes, monitored during period 2014 – 2017, shows that the state of Lake Bolsena is currently "sufficient". An authoritative scientific publication (R. Mosello et al., Long-term change in the trophic status and mixing - The regime of a deep volcanic lake - Lake Bolsena, Central Italy) reached the same conclusion. The definition of the objectives ("maintenance", table 8-5, page 323), the criticality indexes (table 8-4, page 320) and the calculation of investments (table 6-5, page 225) should also be reviewed. Furthermore (page 333): "The minimum quality objective of the resource imposed by the Water Framework Directive (2000/60/EC) is the "good ecological status of the bodies of water". This objective is "non-negotiable" and places a ban on worsening. The above violations are the subject of an investigation by the European Commission.

2) We also dispute the classification of bathing waters as "excellent"(4.1.9 and table 4-1, page 162). In the lake area of S. Antonio, during several months of the summer of 2018, all the sewage waters of the four northern Municipalities were poured into the lake, in this same period the bathing waters were classified "excellent". This erroneous classification is a consequence of the low frequency of monitoring and the insufficient number of sampling points, in violation of Directive 2006/7/ EC concerning bodies of water with frequent "short-term pollution" such as Lake Bolsena.

3) The European Nature 2000 network protects the environment and preserves its integrity, thereby reducing the costs of restoration and conservation. The conservation measures adopted by the Lazio Region for Lake Bolsena do not meet the criteria of the Habitats Directive (92/43/EC), and consequently involve additional costs. The PTAR should request the adaptation of conservation measures as foreseen by the legislation.

4) The infringements of European legislation have a heavy cost. The EU PILOT 6800/14/ENVI pre-infringement procedure due to the missing application of Directive 91/271/EC is underway. Investigations are being conducted for the violation of the Water Framework Directive. The economic and critical indexes should take into account these investigations and the urgency of resolving violations of European legislation, even considering the heavy penalties following convictions by the European Courts (see convictions C-251/17 31 May 2018).In Italy three Prosecutors are investigating crimes against the environment related to Lake Bolsena pollution.

5) The heavy leaks of the final part of the "ring" collector and the total stop of the depuration plant, located along the emissary river Marta, have for years heavily polluted the river and its mouth on the Tarquinia shore. Actually, all the sewage waters of the Municipalities of the lake end up in the emissary river without purification, causing serious damage to the ecosystem of the river and to the bathing Municipality of Tarquinia. The PTAR should urgently solve these problems.

Consequently, the PTAR, in order to restore the "good" state, must foresee interventions on all the causes of pollution. The necessary interventions are as follows:

1. To update the restoration project of the existing sewage system - The sewage system restoration project dates back to 2012, while the tendering process was made in 2016. During the four years of postponements (six years by now) other works on the collector have proved necessary. This led to unanticipated additional costs, the budget dried up and no work has been started on the purifier.

The original restoration project, made in the year 2016, was presumably designed for economy because it did not include some essential items:

- the pressure testing of the pipeline, which is actually quite old;
- the telecontrol system;
- temporary catchment areas in the event of excessive rainfall,
- a reasonable supply of spare parts.

In order to avoid future deterioration of the sewerage system and the return to its previous state, annual funding for maintenance must be ensured. The costly disposal of the sludge lying in the treatment plant must be solved.

2. To study how the western coast can be protected without the ring collector
The extension of the current collector appears costly and complex. Local phyto-purification proposals should be studied. They could be financed by the European Community, if really innovative.

3. To repair the Municipal sewers pouring into the lake or into tributary ditches
These works are too burdensome for the Municipalities. In order to solve the problem, extraordinary Regional funding is needed.

4. Specific eco-friendly incentives for sustainable agriculture in lake basins
In the past, extensive agriculture was encouraged because water was apparently abundant. Quantitative problems then occurred, so much so that the flow of the emissary river was halved. Recently, despite the fact that hazelnut cultivations are highly polluting for lakes (see Lake Vico), they have been encouraged. The sustainability of water consumption for irrigation should also be assessed.

5. Measures to ban biological pits losing waste water in the hydrogeological basin
According to a rough estimation there are 300 isolated dwellings not connected to the collector, as well as zootechnical plants. In addition, in the frequent cases of malfunctioning of its pumps, the Felceti village in Valentano pours the sludge towards the lake instead of towards its own purifier located on the opposite side of the basin.

6. Opposition to geothermal plants in the hydrogeological basin
Geothermal plants for electricity production, inside or near the basin, in addition to unsustainable water consumption, can cause increased arsenic in the lake, causing additional arsenic pollution, which must absolutely be avoided. The Castel Giorgio plant in Umbria takes geothermal fluid from Umbria and unloads it into Lazio without authorization. The plant should be banned by the Lazio Region.

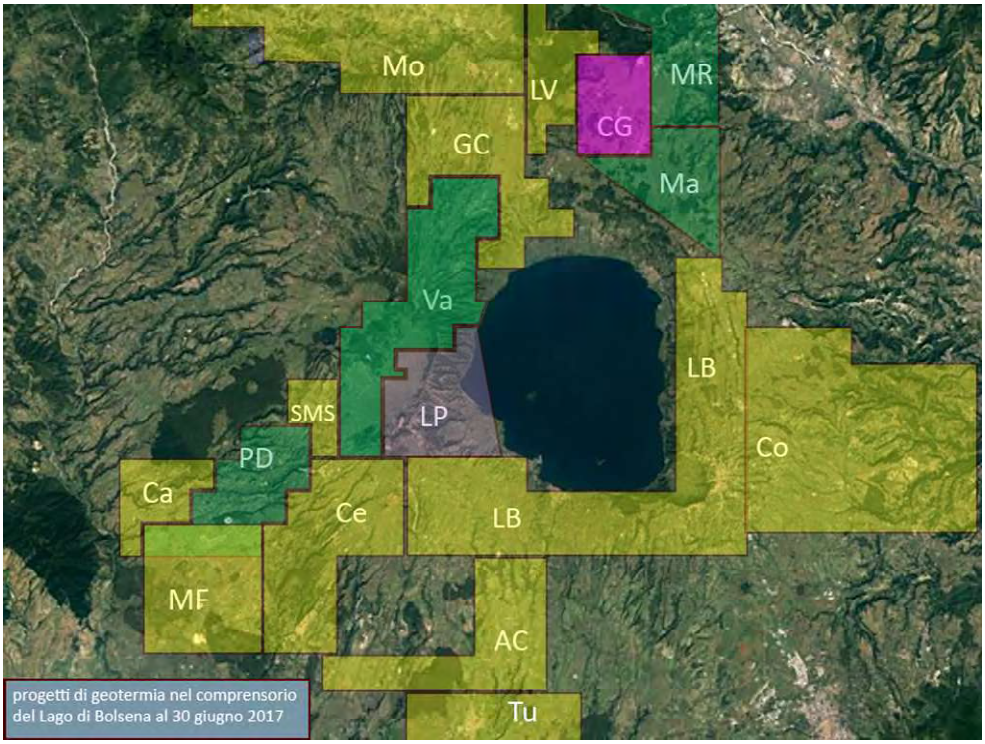
At the end of 2018 the good news came that the works on the existing collector and its lifting stations were “almost” complete, but there is still a long way to go before stopping the eutrophication in progress.

The Geothermal Plants

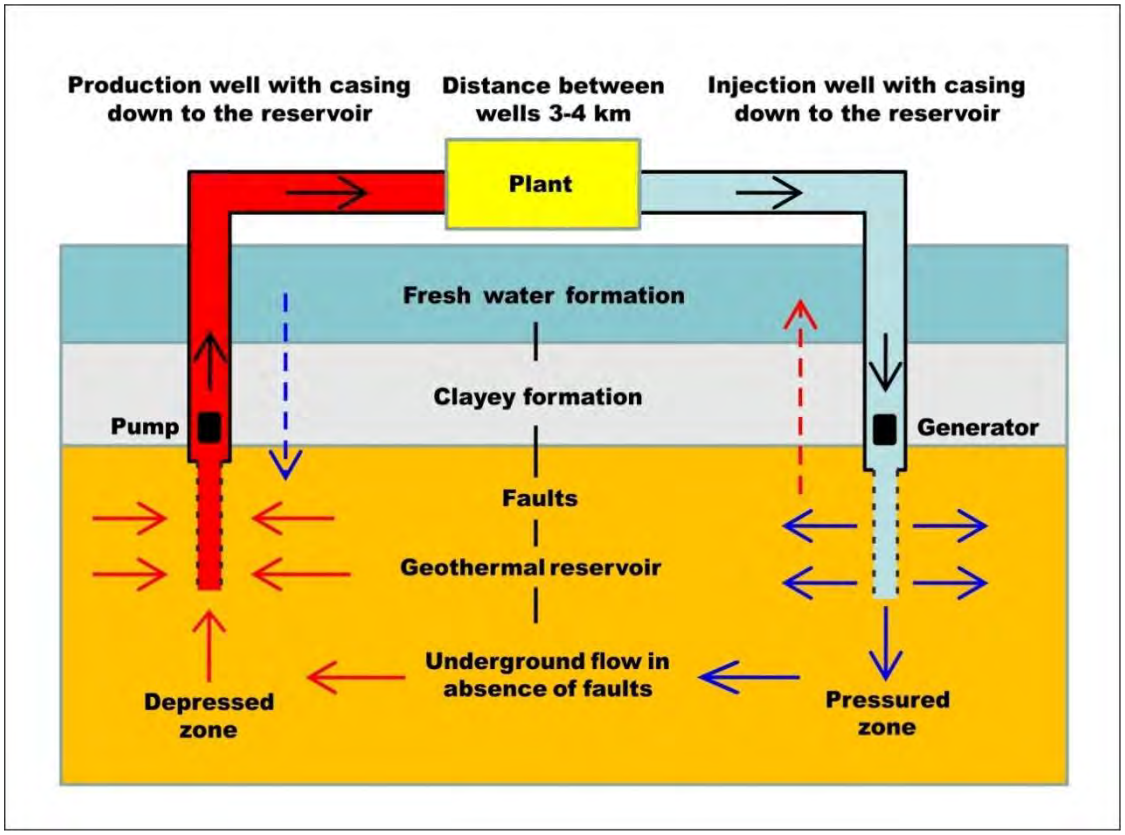
Geothermal energy is a form of potentially exploitable energy that can be obtained from the hot fluids which are present in the subsoil. To supply enough temperature for heating houses or greenhouses, shallow wells are sufficient.

Instead, the production of electrical energy requires a much higher fluid temperature. This can be reached by drilling deep wells, of “medium” and “high enthalpy”, to be connected to a geothermal plant, where enthalpy is a way to indicate the potential energy of a system. In the case of geothermal fluids, the energy is mainly related to the temperature and to the pressure of the fluid. It is obviously convenient to locate the plants in areas where high temperature fluid is present at depths that can easily be reached. The areas of volcanic origin, like that of the Bolsena territory, are the preferred ones.

Generally, the “low enthalpy” plants use probes, consisting of two concentric tubes inside which a service fluid circulates, thus transporting the heat subtracted from the subsoil to the surface. They are not invasive and do not produce harmful effects for the environment. The “medium and high enthalpy” plants move a huge quantity of underground hot fluids to the surface and return them back after subtracting heat. They have an impact on the environment that must be carefully evaluated.



The production of electricity by geothermal plants would be an economic disaster if it were not supported by generous State incentives, granted with the aim of reducing atmospheric pollution. The incentives are so generous that the entrepreneurs, who intend to benefit from them, have multiplied. The cost of incentives is charged to citizens through electricity bills and amounts to over 12 billion euros a year. Lake Bolsena, being in an area of volcanic origin, with high temperatures at modest depth, is literally surrounded by applications for geothermal research. For first-generation plants, called “flash” plants (practically all the existing ones), incentives are not justified because the air pollution they produce is comparable to that of a modern gas power plant. And in fact, in December 2018 a government decree was issued that abolishes incentives to flash plants. The decree is disputed by the Tuscany Region because of job losses.



Second generation plants, called "pilot" plants (submitted for ministerial authorization, but none has been authorized so far), have no emissions into the atmosphere, but like "flash" plants, they move huge amounts of underground hot fluids to the surface and then return them back to the subsoil after subtracting heat.

They can cause negative effects such as pollution of the superficial aquifers used to feed the drinking network and also increase the seismic risk. Third generation plants are made up of probes that do not move underground fluids and have no emissions. They are still under study. The first "pilot" plan close to authorization, is located in Castel Giorgio in Umbria, but it has heavy negative consequences in Lazio.

On September 8th 2015 the Ministry of Economic Development convened a Conference for the final approval of the Castel Giorgio project; however, consent from the Umbria Region was lacking because of popular opposition, therefore the authorization process was left on a dead track for years. Following a complaint by the Geothermal Company, the Civil Court of Umbria, on April 9, 2018, decided to transfer the final decision to the Council of Ministers of the Italian State.

Their Department for Administrative Coordination, with a procedure concluded on September 10th 2018, collected the requests of the numerous stakeholders and transmitted them to the Council of Ministers. The representatives for Lazio were the Mayors of Montefiascone, Bolsena and Acquapendente, those for Umbria were the Mayors of Castel Giorgio, Orvieto and Castel Viscardo. They presented a joint report of 200 pages contrary to the plant.

Representing the Lazio Region was the Secretary Dr. Luca Ferrante who promised a careful examination of the documentation produced by the above mentioned six Mayors. No representative of the Ministry for the Environment was present, but an official sent a note reiterating his position favorable to the plant. We do not know which official signed it.

Following this, Mr. Ferrante asked the Environment Department of the Lazio Region for a technical opinion about the documentation presented by the six Mayor.

On October 16th, 2018, the Environmental Director, after examining the papers, promptly expressed a technical opinion contrary to the Castel Giorgio plant, concluding "there could possibly be a negative impact on the drinking water withdrawal areas, within the Lake Bolsena basin".

We sent a letter to the Minister of the Environment to inform him that, probably without his knowledge, an Official of his Ministry reaffirmed the “favorable evaluation” for the Castel Giorgio plant, whose environmental compatibility (EIA) had been approved four years earlier (on October 31st 2014), by the previous Minister.

The favorable evaluation, reaffirmed by the Commission, is not surprising because its members were appointed by the previous government on 07/19/2011 with a three-year mandate. The same members are actually still in charge after seven years of their appointment by the previous Government.

We then suggested to the Minister to review the situation and eventually cancel the favorable evaluation of the Commission, mainly because it contrasts with the recent opinion of the Lazio Environment Directorate, here below transcribed (freely translated from Italian into English).

Object: Procedure pursuant to art. 14 of Law 241/1990 - Search permits for geothermal resources related to a pilot plant called "Castel Giorgio" – Proposer: ITW-LKW GEOTERMIA ITALIA SpA

Reference is made to protocol N. 550052 dated 12/09/2018, relating to the subject in question, requesting the undersigned to evaluate the documentation attached to the aforementioned note, which includes technical reports and memoirs produced by the bodies and administrations participating in the preliminary coordination table set up by the Presidency of the Council of Ministers, on the hydrogeological problems connected to the construction of the plant. The results are as follows:

<u>1. Concerning the functioning of the Castel Giorgio pilot plant</u>

- the proponent ITW-LKW GEOTERMIA ITALI SpA is planning to build 5 wells that produce geothermal fluid, and, further south, at a distance of a few kilometers, 4 wells for the re-injection of the same cooled fluid.

- in order to draw fluid from the surrounding reservoir rock, the project assumes that a depressed area is formed around the bottom of the production wells, while around the reinjection wells a pressure zone is formed for the dispersion of the fluid into the reservoir. Underground, the re-injected fluid should theoretically migrate from the reinjection area towards the production area, warming up again along the underground flow;

- in short, the correct functioning of the power plant is based on two hypotheses:

1. that the geothermal fluid can freely flow underground from the reinjection area to the production area. Otherwise, instead of recirculation, there would be a permanent transfer of fluid from one area to another, creating dangerous pressure and thermal imbalances, precursors of seismic risks;

2. that the clay formation, known as covering rock, interposed between the geothermal reservoir and the overlying aquifer formation, is actually waterproof. This would prevent a fluid exchange between the surface aquifer and the geothermal reservoir. Otherwise, the surface aquifer, above the area of reinjection, would be polluted by the geothermal fluid, while there would be a loss of water from the surface aquifer down.

2. Concerning the hydrogeological problems highlighted by the technical documentation

- the plant, on the whole, is more extensive than appears at ground level, as the wells will be deviated, therefore a larger volume of rock is involved in the production and in the reinjection of the fluid. Furthermore, the reinjection enters the hydrogeological basin of Lake Bolsena;

- from the examination of the hydrogeological map, it appears that the plant of Castel Giorgio is located within the hydrogeological basin of Lake Bolsena. In particular, the bottom of the injection wells is located under the basin of Lake Bolsena. Therefore, the plant takes geothermal fluid from under the Tiber basin and discharges the cooled geothermal fluid under the basin of Lake Bolsena;

- the above is confirmed by the Proposer who, in the technical documentation, highlights: ".... Only the final section of the reinjection wells is located in the area where the underground drainage of the volcanic aquifer is directed towards Lake Bolsena. While the production wells are located in the area where the drainage is in the opposite direction, towards the Paglia and the Tiber rivers...;

- concerning the free circulation of geothermal fluids within the carbonate reservoir: from the examination of studies, reported in authoritative international scientific publications, the existence of fault lines is documented within the aforementioned carbonate reservoir that determine the "Compartmentalization" of carbonate rocks. The faults, while hindering the passage of fluids in a horizontal direction (hypothesized by the proposer), favor the passage of fluids through vertical paths towards the surface formations;

- geological maps of the area evidence the presence around lake Bolsena of numerous faults, due to the collapse of the caldera that formed the basin of the lake;

- the clayey formation (defined as impermeable by the proposer), interposed between the deep geothermal reservoir and the overlying volcanic aquifer, is not actually impermeable (aquiclude) being formed by Pliocene clayey sediments and marly clayey deposits of a liguriannature, characterized by a low degree of permeability;

- this type of formation would not therefore be able to prevent exchanges of geothermal fluids between the surface rock and the deep rock, with consequent pollution of the surface aquifer above the area of the reinjection wells and the consumption of good water in the area above the production wells;

- that reported in the previous point is demonstrated by the presence of numerous manifestations of superficial thermalism which feed the many entrepreneurial activities in the area;

- the reinjection pressure could possible cause an increase in the rising of geothermal fluid towards the surface aquifer, by passing through the not completely waterproof covering rock. The geothermal fluid contains high percentages of arsenic and other toxic carcinogenic elements. Therefore, it could possibly pollute the drinking water withdrawal areas.

Regarding the aforementioned and in compliance with the precautionary principle with respect to the issues dealt with, it is not possible to exclude negative impacts on the drinking water withdrawal areas, deriving from the realization of the project under discussion.

Signed by the Director
Dr. FlaminiaTosini

The Italian Ferrero Hazelnut Project

The Italian Ferrero Hazelnut Project proposes a five-year increase of 20,000 hectares of hazelnut growing in Italy, equal to 12,000,000 new plants. Ferrero offers the producers a contract for the supply of hazelnuts according to favorable conditions. To access the contract the minimum departing threshold is 100 hectares and 500 within the next 5 years, with even more producers coordinated by Coldiretti.

The lake is a protected area (SCI/ZSP) therefore an environmental impact assessment is required for every project that may affect the lake.

The section and the map of the hydrogeological basin are illustrated on pages 9 and 10. The section clearly shows the importance of the percolation of the rain, that transports the substances diffused on agricultural soil to the underlying aquifer.Upon reaching the water table, the above-mentioned substances migrate through the subsoil towards the lake and the emissary.

The rain, which is not percolating, washes the polluting substances of agricultural origin downinto the lake. Hazelnut groves, within the hydrogeological basin, or in neighboring areas, before being authorized, should be examined in the following aspects.

Water consumption - The annual irrigation requirement is concentrated in the dry summer periods when the flow of the emissary is at or near the minimum Vital Flow (DVD). An increase in water consumption is not compatible with the present quantitative water emergency, highlighted on page 10.

Phosphorus supply - Fertilizers are essential for the productivity of hazelnuts, and phosphorus is an important component. The phosphorus load that currently reaches the lake has caused the ongoing process of eutrophication, so much so that the quality of the lake has been degraded from “good” to “sufficient”. Any activity that involves an increase in phosphorus is not compatible with Lake Bolsena. The phosphorus load must be reduced.

Herbicides – Herbicides are considered carcinogenic to humans. The water that feeds the public water supply is the same polluted by agricultural activity. Furthermore, the natural destination of Lake Bolsena is not only eco-friendly tourism and agriculture, but also professional fishing. The greatest danger to aquatic flora and fauna comes from herbicides, and among them glyphosate.

In conclusion, the proposal of alternative methods, compatible with the lake ecosystem, should be examined and evaluated in the three aspects indicated above. This does not mean being opposed to hazelnut treesin general; the perplexity is limited to the hydrogeological basin of Lake Bolsena. This in order to protect the underlying aquifer that feeds our drinking network. Subsequent updates on this topic will be available on the "Environmental Observatory of Lake Bolsena" site.

The appeal to the European Environment Commission

The reason for the appeal to the European Commission originated in 2009, when the Province of Viterbo approved the Lake Bolsena Management Plan (called PdG), which was not implemented or discussed by the Lazio Region. The Plan, financed by the European Community, consists of 328 pages and contains a long list of conservation measures. The title is: *"Management Plan and Conservation Measures of the SIC IT 6010055 Lake Bolsena including both Bisentina and Martana Islands*"

The Plan is part of the third Integrative Agreement of the Framework Program Agreement "Sensitive Areas: parks and reserves (APQ7)", elaborated by the Province of Viterbo with the collaboration of the University of Tuscia - DAF and the Soc. Lynx Nature and Environment. The PdG was associated to the "Model for the management of the upper outflows of the Marta river". This model consists of 134 pages, studied by the University of Roma on behalf of the Regional Basin Authority. Therefore, there are a total of 462 pages prepared by experts of the Lake Bolsena environment.

Here are the authors of the PdG.

Activities Coordinator: Dr. Mario Busatto of the Province of Viterbo.

Responsible for the Procedure: Dr. Lucia Modenesi.

Technical Staff Responsible for the scientific coordination of the Conservation Measures: Dr. Enrico Calvario, Prof. Antonio Leone, Dr. Francois Salomone.

With technical collaboration and advice from the following experts:
Mr. Fedele Aversa, Ing. Piero Bruni, Prof. Enio Campiglia, Prof. Gabriele Dono, Mr. Nicola Goffredo, Dr. Mario Iberite, Dr. Graziano Mazzapicchio PhD, Prof. Roberto Minervini, Dr. Raffaele Pelorosso PhD, Dr. Alba Pietromarchi, Dr. Carlo Maria Rossi PhD, Prof. Alessandro Ruiggeri, Dr. Silvia Sebasti, Dr. Anna Rita Taddei.

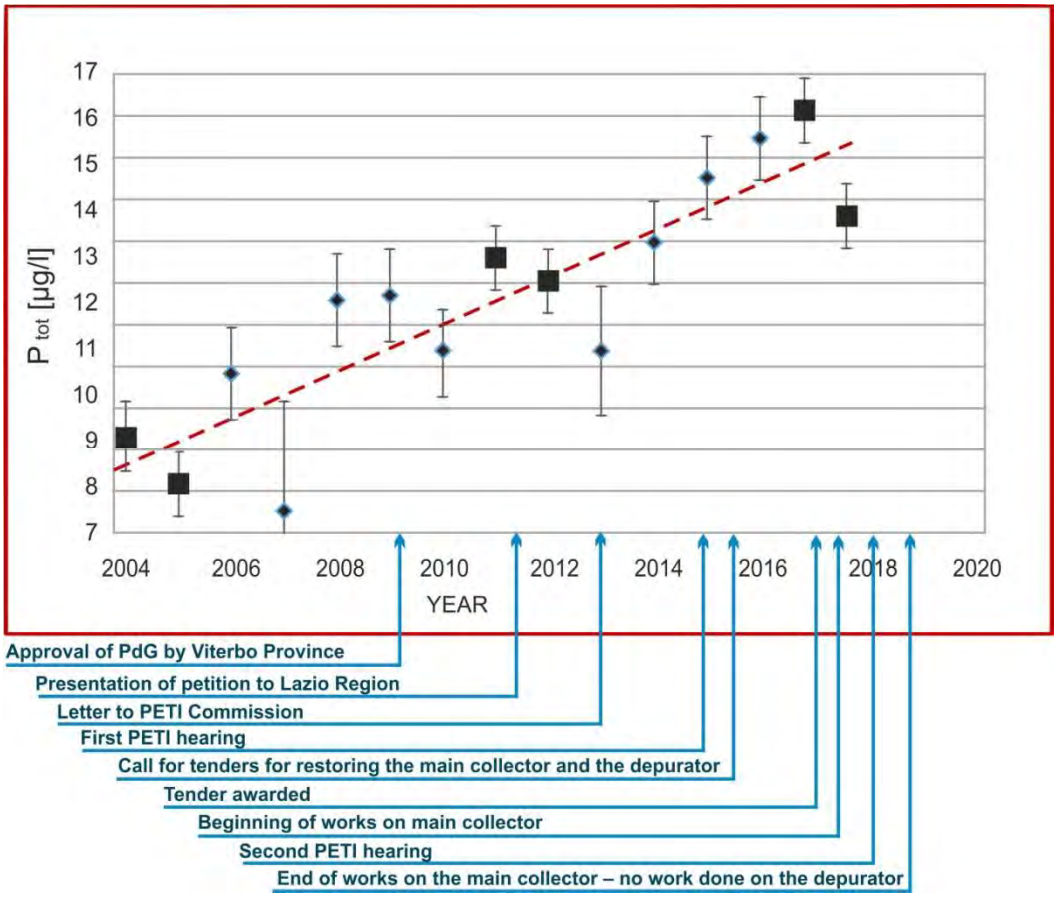
Ten years have passed since the presentation of the PdG, during which no conservation measures indicated in it have been applied, nor have subsequent ones of other origins, aimed at containing the build-up of phosphorus in the lake. The degradation is now clear for all to see.

The PdG is still valid and should be seriously discussed and updated as the eutrophication process has worsened in the last 10 years of abandonment and new activities could threaten the environment.

In fact, the ecological status has officially changed from "good" to "sufficient", as the increase in phosphorus concentration has been well documented. Furthermore, requests for high enthalpy geothermal plants, inside the hydrogeological basin, have been submitted and incentives for large hazelnut groves have been approved.

For the reasons explained in the previous pages, total phosphorus (TP) is the main element that determines the eutrophication of the lake. The following graph shows the phosphorus trend, increasing from about 10 to 16 μg/l from 2004 to 2017. On the same graph the date of 2009 is indicated, when the Management Plan (PdG) was presented.

As can be seen, the total phosphorus in 2009 had already exceeded the threshold deemed compatible, with 8-10 μg/l. The following graph shows the various successive events, chronologically laid out, that could have reduced the arrival of phosphorus to the lake. Any delay or missed opportunity has resulted in a visible increase in phosphorus.



After the presentation of the PdG, as there were no interventions to stop the increase in phosphorus, a collection of signatures was organized, called SALVALAGO. In just a few days 13,892 signatures were collected along the shores, thanks also to the collaboration of some volunteers and numerous associations.

The signatures were delivered to the protocol of the Lazio Region on 12/12/2011. The photo shows Francesca Ferri with the package containing the signatures and Piero Bruni. Sandro Brenciaglia is not seen because he is busy taking the photograph.

The then President of the Region, Renata Polverini, added 2 million euros to the budget to restore the collector, but the financing was conditioned to the sale of properties, which never took place. As can be seen from the graph, at the time of the delivery of the signatures, phosphorus had exceeded the threshold of 12 µg /l.

Time passed without any corrective action. In 2013, when the phosphorus level had reached 13 µg/l, the "Lago di Bolsena Association" presented the European PETI Commission a report on the pollution of the lake.

It was the time of the European elections, so there were some problems awaiting the new Commission concerning the care of our lake. Finally, on May 5th, 2015, when the concentration of phosphorus had reached the level of 14.5 µg/l, Bruni was summoned to Brussels for a hearing.

Following the hearing, after the Commission had launched an investigation procedure, on 2/6/2015 the President Cecilia Wikström (Swedish) sent a letter to the Lazio Region asking for the adoption of an effective plan for repairing and completing the ring collector.

When the phosphorus concentration reached 15 µg/l the Region issued a call for tenders for the restoration of the existing collector. The tender was awarded late, when the phosphorus concentration had already reached 16 µg/l. There followed postponements before the start of the works and other delays in their execution.

On 21/3/2018 Bruni was again summoned to Brussels for an update. While our information was as truthful as possible, it did not match that communicated by Italy to the Commission. In fact, the internal communication of the Commission to their members reports the following:

"*Based on the information made available by the Member State concerned, the water body did not present significant risks of eutrophication and its status was good. The last report from Italy was transmitted in March 2017 and, based on official data reported, the ecological status and chemical status of Lake Bolsena were good under the water framework directive.* "

In 2018 we asked the European Commission to verify what we had declared and requested the application of the laws on water implemented by the Italian State. The Commission promptly confirmed that the information presented by us is currently being evaluated.

European Laws adopted by Italy
Bird Directive (79/409/CEE)
Habitat Directive (92/43/CEE)
Urban Waste Water Treatment Directive (91/271/CEE)
Water Framework Directive (2000/60/CE)

Italian Laws:
Consolidated Law D.lgs . 152 of 2006
Law 22 May 2015
(introduces crimes against the environment)

Fortunately, but only by pure chance, the Burian wind has temporarily reduced the concentration of phosphorus. It is necessary to take advantage of this unexpected advantage to contain the excessive arrival of more phosphorus from the basin. Given that the assessment of the state of the lake is made on a three-year basis, we will see what effects the repair of the collector will have had at the end of the three-year period. While waiting, we hope that the measures listed in the PTAR chapter will have been taken.

In conclusion, to the **quantitative emergency** and to the **qualitative emergency** (mentioned respectively on pages 10 and 17), we should add the **scarce interest of the central institutions** in the environmental protection of the SCI-ZSP Bolsena lake.

Presumably this is due to the fact that the electoral basin of the municipalities around the lake represents only 0.3% of Lazio's voters. **It is for all these reasons that we have deemed it necessary to seek the support of the European Commission.**

Bolsena Lake Association

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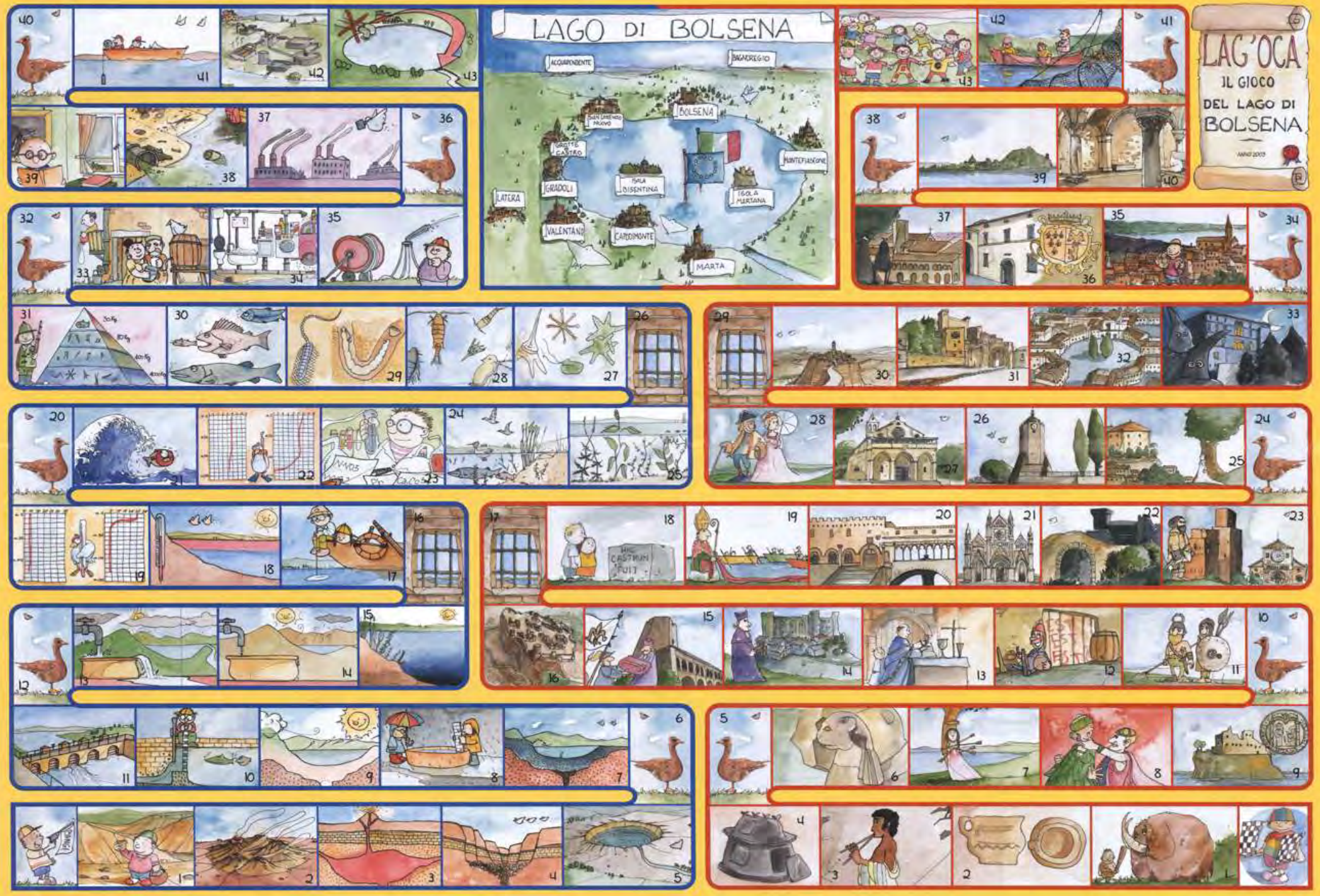
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CAPODIMONTE
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LAG'OCA
IL GIOCO DEL LAGO DI BOLSENA