Aquat Sci (2014) 76 (Suppl 1):S1–S6
DOI 10.1007/s00027-014-0353-8

Aquatic Sciences

EDITORIAL - BASED ON MIR INVESTIGATIONS IN LAKE GENEVA

Into the abyss of Lake Geneva: the elemo interdisciplinary field investigation using the MIR submersibles

Alfred Wüest · Flavio S. Anselmetti · J. Samuel Arey · Bastiaan W. Ibelings · Jean-Luc Loizeau · Torsten Vennemann · Ulrich Lemmin

Published online: 24 May 2014

Abstract In summer 2011, the two Russian MIR submersibles were brought to Switzerland to perform deep water dives in Lake Geneva. Research teams from several environmental science institutes, both national and international, participated in this interdisciplinary effort to investigate the deeper parts of Lake Geneva. Using the MIRs allowed the scientists to see and precisely select the sites where they could extract specific sediment cores and carry out detailed in situ measurements at the sediment–water boundary. One focus site was the surrounding of the outlet of the wastewater treatment plant of the City of Lausanne, which discharges into the Vidy Bay. The investigations concentrated on the pollution of the local sediments, pollution-related ecotoxicological risks, microbial activity and spreading and removal of the effluents from the bay to the open waters of the lake. The other focus site was the Rhône River delta and its subaquatic canyons, which formed as a result of the long-term interplay of the deposition of river-borne sediments and flood-triggered canyon erosion events.

Keywords Elemo · Lake Geneva · MIR submersible · Micropollutants · Rhône River delta · Vidy Bay

A. Wüest (✉) · J. S. Arey · U. Lemmin
Faculté de l'Environnement Naturel, Architectural et Construit (ENAC), Ecole Polytechnique Fédérale de Lausanne (EPFL), 1015 Lausanne, Switzerland
e-mail: alfred.wueest@eawag.ch

A. Wüest · U. Lemmin
Limnology Center, Ecole Polytechnique Fédérale de Lausanne (EPFL), 1015 Lausanne, Switzerland

A. Wüest · F. S. Anselmetti · J. S. Arey
Eawag (Swiss Federal Institute of Aquatic Science and Technology), 6047 Kastanienbaum, Switzerland

F. S. Anselmetti
Institute of Geological Sciences and Oeschger Centre for Climate Change Research, University of Bern, Bern, Switzerland

B. W. Ibelings · J.-L. Loizeau
Institut F-A Forel, University of Geneva, 10 Route de Suisse, 1290 Versoix, Switzerland

T. Vennemann
Institute of Earth Surface Dynamics (IDYST), University of Lausanne, 1015 Lausanne, Switzerland

Introduction

A fundamental challenge for oceanographic and limnological research is the more or less "blind" and inflexible method of sampling in the field. At present, profiling with CTDs, lowering sediment corers and anchoring instrumented moorings are still the most common techniques for collecting data, and are performed most of the time with little knowledge of the surrounding. Even the most advanced cabled underwater observatories (Cowles et al. 2010; Bouffard and Lemmin 2013a) can only provide a spatially limited view of the underwater environment. Within the water column, an important first step to expand data acquisition to lateral information was made by using horizontally towed arrays of sensors (Osborn and Lueck 1985), multibeam sonars for sediment mapping, and autonomous underwater vehicles (Doble et al. 2009), such as gliders that can perform fine-scale scans of the water column (Eriksen et al. 2001).

Techniques for taking underwater pictures, such as in situ particle image velocimetry (Bertuccioli et al. 1999), where turbulent water movements are retrieved, give some "sight" of the underwater world. However, such landers permit only a limited view of the sediment surface and their location is often quite undefined. Investigating the lake bottom boundary in a systematic manner over an extended area became possible with the development of remotely operated underwater vehicles (ROVs). They can provide online images or videos of visually inspected natural features or man-made objects (Marks et al. 1995). However, these videos cannot entirely replace a person's 3-D visual ability to interpret and assess what is being seen within a lake. The dream of many scientists working in the field, therefore, is to use a submersible in order to actually see the "corpus delicti" of their research. In Lake Geneva, over a decade ago, the team of Ulrich Lemmin used the submersible F-A Forel that carried a turbulence package to measure temperature, velocity, and shear at the micro-scale, in order to study mixing in boundary layers over lateral slopes (Fer et al. 2002) and in the near-surface mixed layers (Ozen et al. 2006).

Consequently, the opportunity of a lifetime was presented when the Consulat Honoraire de la Fédération de Russie, proposed to the Ecole Polytechnique Fédérale de Lausanne (EPFL) to bring the two world's most famous MIR submersibles to Lake Geneva (Fig. 1). The PP Shirshov Institute of Oceanography in Moscow, owner of the MIRs and the Fondation pour l'Etude des Eaux du Léman (FEEL) in Lausanne, agreed that the MIRs would make a total of 60 scientific dives in Lake Geneva from 14 June to 24 August 2011. The generous sponsoring by the Consulat Honoraire de la Fédération de Russie and the FEEL foundation allowed initiating and supporting the project elemo (http://www.elemo.ch) in order to take advantage of this unique opportunity. The emphasis was put on studies

Fig. 1 MIR submersible from the PP Shirshov Institute of Oceanography, Moscow, of the Russian Academy of Sciences, ready to be launched in Vidy Bay, Lake Geneva, Switzerland. The submersible is driven by the large *black* propeller (*left*) and its 3-D trajectory is controlled by two small *white* propellers (*center* one on each side). Details of the equipment visible in front of the submersible (*right*) are given in Fig. 3. Photo by J. Samuel Arey, MIR team

that are difficult or impossible to carry out by other means. This was the first time that scientists from so many different branches of environmental sciences collaborated in an interdisciplinary project in Lake Geneva in such a short time window. This special issue of Aquatic Sciences reports on the results from those dives.

Lake Geneva: an ideal site for interdisciplinary submersible studies

Lake Geneva is an ideal site for submersible-based research. With its surface area, maximum depth and volume of 580 km^2, 310 m and $\sim$89 km^3, respectively, Lake Geneva is one of the largest freshwater reservoirs in Europe and as such, the lake is of great economic and ecological interest and value. With its contiguous two-basin structure and the substantial exposure to wind arising from the channelling effect of the parallel mountain ranges, the water body experiences basin-scale gyres, strong internal seiches, and especially, large-amplitude Kelvin waves (Bouffard and Lemmin 2013b). Other special features are the spectacular surrounding mountains and an underwater topography that in certain areas is enriched by the underwater canyons (Sastre et al. 2010), shaped by erosion and deposition dynamics of the particle-rich discharge of the Rhône River (Girardclos et al. 2012), which is strongly affected by the upstream hydropower operations (Loizeau and Dominik 2000).

Lake Geneva is also exposed to substantial anthropogenic pressures, due to an increasing population density along its entire lakeshore, strongly modified shorelines, increasing extraction of thermal energy from the lake water, and macro- as well as micro-pollutants (Noars and Bourg 2013; Loizeau et al. 2013) that originate from industry and wastewater in the drainage area (Bonvin et al. 2011). Furthermore, the climate-induced increase in water temperature by $\sim$1 °C during recent decades (Lemmin and Amouroux 2013), increased water column stability, and changing river inflow dynamics have been observed. Similar changes have been found in most medium-to-large sized lakes in Europe (Fink et al. 2014).

The research carried out within the elemo project followed the concept "from source-to sink", i.e., the trajectories of waters entering the lake and the fate of their constituents, such as pollutants, are tracked through the lake. Therefore, detailed field studies were performed in the "source" areas of the Rhône River delta and Vidy Bay (Fig. 2), where allochthonous material and anthropogenic pollutants are brought into the lake. In particular, the MIR submersibles permitted an unprecedented opportunity to study the complex subaqueous canyon structures of the Rhône River delta, including sedimentation, erosion, and

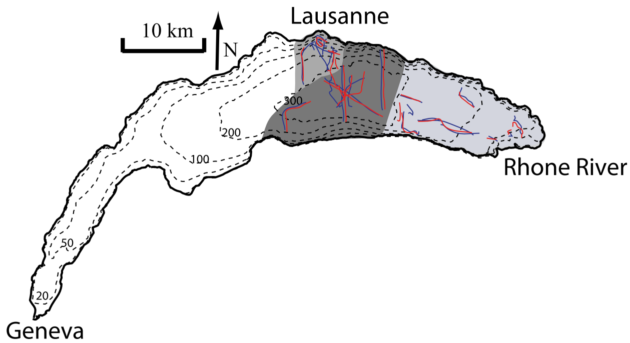

Fig. 2 Summary of the dives that were carried out by the two MIRs from 14th June to 24th August 2011 in three regions of the main basin of Lake Geneva: the *Rhône River* delta and its canyons (to the east; *light grey*), Vidy Bay (to the north; *grey*) and the deep-water regions (south; *dark grey*). The colours *blue* and *red* refer to the different trajectories of the two MIRs

delta stability. Complementary studies were carried out in the deeper zones that characterize the "sink" areas, in order to determine the fate of particles and pollutants in the lake (Fig. 2). The MIR activities in Lake Geneva mainly investigated sediment properties, the dynamics of the overlying water boundary layer, the water–sediment interaction, and the extraction of sediment cores taken by direct sight.

The bottom-up approach of the project elemo resulted in a fruitful collaboration of an interdisciplinary group of scientists coming from a wide range of environmental science and engineering backgrounds. Teams from the Swiss Universities of Basel, Geneva, Lausanne, Neuchâtel, and Zurich, from the two Federal Institutes of Technology in Lausanne and Zurich and Eawag, as well as colleagues from abroad (USA, France, Great Britain, Australia, Spain, Germany) participated in 16 different projects. This issue contains eight publications with a focus on the Rhône River delta and Vidy Bay. Additional papers have already been or will soon be published.

The MIR submersibles in Lake Geneva

The Russian academy of science has traditionally used manned submersibles for deep water research. In December 1987, the PP Shirshov Institute of Oceanography tested for the first time two identically built submersibles, MIR-1 and MIR-2 in the open ocean, and in February 1988, their first scientific expedition to a hydrothermal site in the Atlantic took place (Sagalevitch 2012). Since then, numerous dives have been made in the Pacific, Indian, Atlantic and Polar oceans (including a dive below the geographic North Pole), as well as in Lake Baikal (Sagalevitch 2012). During those missions, the Russian scientists

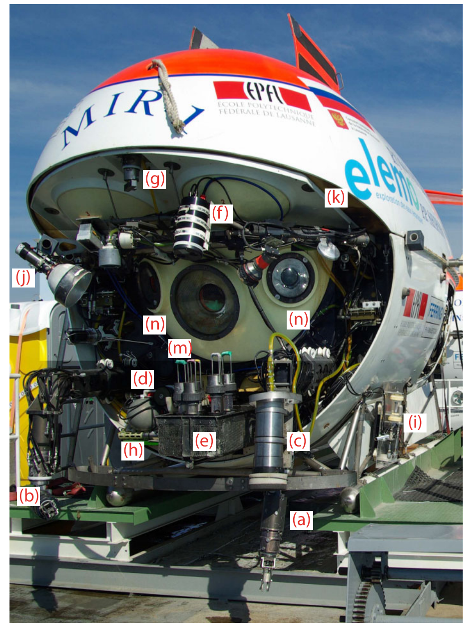

Fig. 3 Front view of the MIR 1 submersible. The following equipment and instrumentation was typically used during dives in Lake Geneva: *a*, *b* robotic arms, *c* high-resolution video camera (fixed to the robotic arm), *d* in situ mass spectrometer, *e* sliding basket holding bottom corers for sediment short cores, *f* stereo camera, *g* horizontal acoustic echo sounder, *h* sea-bird conductivity sensor, *i* pump for micro-pollutant filtering, *j* flood-light illumination for the video camera, *k* LED light for stereo camera, *m* main window for the pilot and *n* two side windows for the scientists. Photo by Tonya DelSontro, MIR team

acquired extensive expertise and took a leading position in scientific submersible-based deep-sea research. It was therefore a great honour for the Lake Geneva research community to be able to use those famous submersibles.

The MIRs (Fig. 1) weigh 18.6 tons and have a length, width and height of 7.8, 3.8 and 3.0 m, respectively. The submersibles can take a crew of three as deep as 6,000 m, and with an energy storage of 100 kWh (NiCd batteries), they can maintain operation for 246 person-hours. The human-occupied sphere of 2.1 m diameter is made of nickel steel. With a maximum payload of 290 kg, the MIR can carry diverse scientific instrumentation, as shown in Figs. 1 and 3. The navigation relies on hydro-acoustic seabed beacons, an inertial navigation gyro compass and a bottom-tracking Doppler velocity meter (Sagalevitch 2012). The vehicles are equipped with devices for sampling and with two manipulator arms having five degrees of freedom (Fig. 3). The MIRs also carry modern photographic equipment for digital video and photo recording. This solid research platform thus allowed the mounting of various scientific equipment provided by the research teams—depending on the objective of the dives—such as CTDs, a Niskin-bottle rosetta, a penetrometer (Stark et al. 2013), sediment corers, the TETHYS in situ mass spectrometer (Camilli et al. 2010), stereo-imaging photogrammetry (Henderson et al. 2013), a submersible voltammetric probe for in situ monitoring of bioavailable trace metals (Tercier-Waeber and Taillefert 2008), a dissolved oxygen sensor, a turbidity and pH meter, chlorophyll and phycocyanin detectors, pump-driven water filters, and pump-driven samplers for hydrophobic organic pollutants (Fig. 3).

Results and summary

The first set of papers in this special issue of Aquatic Sciences focuses on studies made in Vidy Bay, which is the receiving water body of the main waste water treatment plant (WWTP) outlet of the City of Lausanne and the largest wastewater outfall in Lake Geneva. Hoerger et al. (2014) demonstrated that wastewater-derived micropollutants, generally in the low ng/L range, can be detected throughout a ~ 1 km^2 area surrounding the WWTP outlet. The concentration of detected pharmaceuticals was found to decrease with increasing distance from the WWTP outlet. An assessment based on the cumulative risk exerted by all measured substances indicated that the wastewater caused a zone of potential ecotoxicological risk that extended well into the deep lake and also in the direction of the St. Sulpice drinking water intake of the City of Lausanne (Hoerger et al. 2014, Razmi et al. 2014, Bonvin et al. 2013). This unique survey was possible because during the dives, the scientists inside the MIR submersibles observed in real time proxy wastewater indicators, such as conductivity and could guide the MIRs along the wastewater plume trajectory.

Gascon Diez et al. (2014) used MIR dives to determine the influence of the WWTP effluent on mercury contamination in the visibly polluted sediment near the Vidy Bay outfall. The total mercury concentrations in 14 sediment cores ranged from 0.3 to 10 mg/kg and increased towards the WWTP outlet. The monomethylmercury concentration in pore waters of surface sediments was almost half of the total mercury concentration, which was subject to biogeochemical processes. The scientists' ability to visually and precisely select coring sites at close range was pivotal to the success of these field measurements.

Sauvain et al. (2014) used DNA recovery techniques and found large quantities of bacterial groups, identified as those typical for activated sludge in sediments near the WWTP outlet. Trace-metal analysis and speciation were performed at the sediment–water interface within Vidy Bay. Differences in trace-metal speciation in the sediment and overlying water were found to have a higher correlation with bacterial community, abundance, type, and activity rather than with the distance from the WWTP sewage outlet (Masson and Tercier-Waeber 2014). Their results highlight the potential role of endospore-forming Firmicutes for the transport and sediment deposition of trace metals released from effluents (Sauvain et al. 2014). Observed increases in dissolved metal concentrations in the interstitial water were attributed to organic matter mineralization. The Vidy Bay sediments are significantly contaminated, especially with the trace metals Cu and Hg.

Numerical simulations by Razmi et al. (2014) with the hydrodynamic model Delft3D-FLOW allowed to estimate the flushing dynamics of the water in Vidy Bay under different meteorological conditions. It was observed that for a given wind velocity, the main factor influencing water residence time in the bay is the angle of the wind. Significantly different residence times, one for cases with gyre formation within the bay (long residence time of order a week) and one for longshore currents (short residence time of order days) were made evident. The most problematic meteorological situation is a "Bise" wind (from Northeast) with a longshore component, since it results in westward parallel-to-shore currents that transport WWTP discharge water in the direction of the Lausanne drinking water intake.

The second set of papers focuses on investigations in the Rhône River delta and its downstream canyons. Corella et al. (2014) dove with the MIRs into the subaquatic Rhône canyons and investigated their sediments. The analysis of the sediment cores revealed that erosion processes control the sediment dynamics in the proximal canyon floor while sedimentation dominates on the levees. Sedimentation rates progressively decrease down-channel along the levee structures. The rapid sediment loading, slope undercutting and over-steepening, and high sediment methane concentrations control the long-term slope instability of the canyon walls (Girardclos et al. 2012). This specific sedimentation scheme determines the spatial distribution of the sediment-born methane that originates from the riverine organic matter deposited and decomposed in the Rhône River delta (Sollberger et al. 2014). Due to the large variability of the Rhône River discharge, deposited and decomposed delta sediments are episodically resuspended and transported down the canyons. As a result, the highest methane production and release was found at intermediate distances from the river mouth, where the organic carbon accumulation is still appreciable, but the removal rate is already low. In addition, more methane is produced on the canyon levees, due to enhanced sedimentation. These findings are consistent with the concept that regions with high sedimentation of riverine allochthonous organic material in river deltas are hot spots of methanogenesis (Sollberger et al. 2014). Once again, by working from inside the MIR submersibles, the researchers were able to selectively sample both horizontal and vertical features at close visual range. This created unparalleled research opportunities in this extremely complex subaquatic terrain.

In order to document the anthropogenic influences on the trophic status of the lake during the last century, a sediment core covering the past 90 years was retrieved from the Rhône River delta (Wunderlin et al. 2014). Endospore-forming bacteria extracted from the core sediments are persistent in the sediment layers and are therefore useful as proxies to reconstruct the ecological history of the lake. The diversity of this group of bacteria changed significantly, however, reflecting the change in the eutrophication level of the lake from 1960 to 1990 and specifically, the time variability of the oxygen concentration in Lake Geneva. This study shows that the abundance and diversity of endospore-forming bacteria can be used in paleoecology (Wunderlin et al. 2014).

Last, but not least—the elemo project was a great experience in interdisciplinary collaboration with unusual tools and unusual sights into the abyss of Lake Geneva.

Acknowledgments The eight publications in this special issue of aquatic sciences entitled, "elemo-investigations using the MIR submersibles in Lake Geneva" resulted from the international, interdisciplinary research project elemo (http://www.elemo.ch) whose objective was to investigate the deep-waters of Lake Geneva using the two Russian MIR submersibles. Funding for this study was provided by the Fondation pour l'Etude des Eaux du Léman (FEEL), and the Consulat Honoraire de la Fédération de Russie, Lausanne. Some of the work described in those papers received additional funding from Eawag, ETHZ, and the Swiss National Science Foundation SNSF ProDoc project Nr 123048 (Léman-21). We are grateful for the support. We thank the Russian MIR crew members (http://www.elemo.ch/mir-team) for their excellent performance and the SAGRAVE team who provided and operated the platform from which the dives were carried out. We also thank Jean-Denis Bourquin for project coordination and administration. The assistance of Mikhail Krasnoperov (Consulat Honoraire de la Fédération de Russie) as liaison is greatly appreciated. Finally, we thank the many researchers and their collaborators, as well as the reviewers for their valuable time and effort. Thank you all for the great commitment to this project!

References

Bertuccioli L, Roth GI, Katz J, Osborn TR (1999) A submersible particle image velocimetry system for turbulence measurements in the bottom boundary layer. J Atmos Ocean Technol 16(11):1635–1646. doi:10.1175/1520-0426(1999)016<1635:ASPIVS>2.0.CO;2

Bonvin F, Rutler R, Chèvre N, Halder J, Kohn T (2011) Spatial and temporal presence of a wastewater-derived micropollutant plume in Lake Geneva. Environ Sci Technol 45(11):4702–4709. doi:10.1021/es2003588

Bonvin F, Razmi AM, Barry DA, Kohn T (2013) Micropollutant dynamics in Vidy Bay—a coupled hydrodynamic-photolysis model to assess the spatial extent of ecotoxicological risk. Environ Sci Technol 47(16):9207–9216. doi:10.1021/es401294c

Bouffard D, Lemmin U (2013a) A new sensor platform for investigating turbulence in stratified coastal environments. J Atmos Ocean Technol 30(8):1789–1802

Bouffard D, Lemmin U (2013b) Kelvin waves in Lake Geneva. J Great Lakes Res 39(4):637–645. doi:10.1016/j.jglr.2013.09.005

Camilli R, Reddy CM, Yoerger DR, Van Mooy BAS, Jakuba MV, Kinsey JC, McIntyre CP, Sylva SP, Maloney JV (2010) Tracking hydrocarbon plume transport and biodegradation at deepwater horizon. Science 330(6001):201–204. doi:10.1126/science.1195223

Corella JP, Arantegui A, Loizeau JL, DelSontro T, Le Dantec N, Stark N, Anselmetti FS, Girardclos S (2014) Sediment dynamics in the subaquatic channel of the Rhone Delta (Lake Geneva, France/Switzerland). Aquat Sci 76(S1). doi:10.1007/s00027-013-0309-4

Cowles T, Delaney J, Orcutt J, Weller R (2010) The ocean observatories initiative: sustained ocean observing across a range of spatial scales. Mar Technol Soc J 44(6):54–64

Doble MJ, Forrest AL, Wadhams P et al (2009) Through-ice AUV deployment: operational and technical experience from two seasons of Arctic fieldwork. Cold Reg Sci Technol 56(2–3):90–97

Eriksen CC, Osse TJ, Light RD et al (2001) Seaglider: a long-range autonomous underwater vehicle for oceanographic research. IEEE J Ocean Eng 26(4):424–436

Fer I, Lemmin U, Thorpe SA (2002) Observations of mixing near the sides of a deep lake in winter. Limnol Oceanogr 47:535–544

Fink G, Schmid M, Wahl B, Wolf T, Wüest A (2014) Heat flux modifications related to climate-induced warming of large European lakes. Water Resour Res 50:2072–2085. doi:10.1002/2013WR014448

Gascon Diez E, Bravo AG, à Porta N, Masson M, Graham ND, Stoll S, Akhtman Y, Amouroux D, Loizeau JL (2014) Influence of a wastewater treatment plant on mercury contamination and sediment characteristics in Vidy Bay (Lake Geneva, Switzerland). Aquat Sci 76(S1). doi:10.1007/s00027-013-0325-4

Girardclos S, Hilbe M, Corella JP, Loizeau JL, Kremer K, DelSontro T, Arantegui A, Moscariello A, Arlaud F, Akhtman Y, Anselmetti FS, Lemmin U (2012) Searching the Rhone delta channel in Lake Geneva since François-Alphonse Forel. Arch Sci 65:103–118

Henderson J, Pizarro O, Johnson-Roberson M, Mahon I (2013) Mapping submerged archaeological sites using stereo-vision photogrammetry. Intern J Naut Archaeol 42(2):243–256. doi:10.1111/1095-9270.12016

Hoerger CC, Akhtman Y, Martelletti L, Rutler R, Bonvin F, Grange A, Arey JS, Kohn T (2014) Spatial extent and ecotoxicological risk assessment of a micropollutant-contaminated wastewater plume in Lake Geneva. Aquat Sci 76(S1). doi:10.1007/s00027-013-0315-6

Lemmin U, Amouroux A (2013) The influence of climate change on Lake Geneva. In: Goldman CR, Kumagai CR, Robarts RD (eds) Climatic change and global warming of inland waters: impacts and mitigation for ecosystems and societies. Wiley, New York

Loizeau JL, Dominik J (2000) Evolution of the upper Rhone River discharge and suspended sediment load during the last 80 years and some implications for Lake Geneva. Aquat Sci 62(1):54–67

Loizeau JL, Edder P, De Alencastro LF, Corvi C, Ramseier Gentile S (2013) La contamination du Léman par les micropollutants–revue de 40 ans d'études. Arch Sci 66:117–136

Marks RL, Rock SM, Lee MJ (1995) Real-time video mosaicking of the ocean-floor. IEEE J Ocean Eng 20(3):229–241

Masson M, Tercier-Waeber ML (2014) Trace metal speciation at the sediment-water interface of Vidy Bay: influence of contrasting sediment characteristics. Aquat Sci 76(S1). doi:10.1007/s00027-013-0323-6

Noars F, Bourg C (2013) Micropolluants dans les sédiments de la région Rhône-Alpes. Données cours d'eau et plans d'eau

2006-2011. Rapport, Service Ressources Energie Milieux et Prévention des Pollutions (REMIPP). DREAL Rhône -Alpes et REMIPP

Osborn TR, Lueck RG (1985) Turbulence measurements from a towed body. J Atmos Ocean Technol 2(4):517–527

Ozen B, Thorpe SA, Lemmin U, Osborn TR (2006) Cold-water events and dissipation in the mixed layer of a lake. J Phys Oceanogr 36(10):1928–1939. doi:10.1175/JPO2946.1

Razmi AM, Barry DA, Lemmin U, Bonvin F, Kohn T, Bakhtyar R (2014) Direct effects of dominant winds on residence and travel times in the wide and open lacustrine embayment: Vidy Bay (Lake Geneva, Switzerland). Aquat Sci 76(S1). doi:10.1007/s00027-013-0321-8

Sagalevitch AM (2012) 25th Anniversary of the deep manned submersibles Mir-1 and Mir-2. Oceanology 52(6):817–830

Sastre V, Loizeau JL, Greinert J, Naudts L, Arpagaus P, Anselmetti FS, Wildi W (2010) Morphology and recent history of the Rhone River delta in Lake Geneva (Switzerland). Swiss J Geosci 103:33–42

Sauvain L, Bueche M, Junier T, Masson M, Wunderlin T, Kohler-Milleret R, Gascon Diez E, Loizeau JL, Tercier-Waeber ML, Junier P (2014) Bacterial communities in trace metal contaminated lake sediments are dominated by endospore-forming bacteria. Aquat Sci 76(S1). doi:10.1007/s00027-013-0313-8

Sollberger S, Corella JP, Girardclos S, Randlett ME, Schubert CJ, Senn DB, Wehrli B, DelSontro T (2014) Spatial heterogeneity of benthic methane dynamics in the subaquatic canyons of the Rhone River delta (Lake Geneva). Aquat Sci 76(S1). doi:10.1007/s00027-013-0319-2

Stark N, Le Dantec N, Corella JP, Barry DA, Lemmin U, Giradclos S, Kopf A (2013) Deployment of a dynamic penetrometer from manned submersibles for fine-scale geomorphology studies. Limnol Oceanogr Methods 11:529–539

Tercier-Waeber M-L, Taillefert M (2008) Remote in situ voltammetric techniques to characterize the biogeochemical cycling of trace metals in aquatic systems. J Environ Monit 10:30–54

Wunderlin T, Corella JP, Junier T, Bueche M, Loizeau JL, Girardclos S, Junier P (2014) Endospore-forming bacteria as new proxies to assess impact of eutrophication in Lake Geneva (Switzerland-France). Aquat Sci 76(S1). doi:10.1007/s00027-013-0329-0