The mission of the LIMNOLOGY Center is to provide socially-relevant and multi-disciplinary research to ensure the sustainable use and conservation of natural water resources, both on national and international levels.

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LIMNOLOGY Center

Ecole Polytechnique Fédérale de Lausanne

EDITORIAL

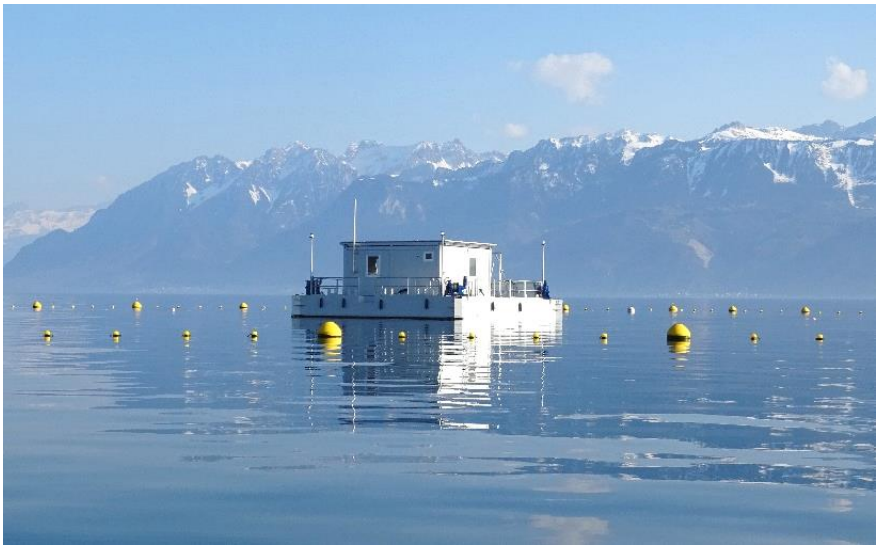
In 2019, our most exceptional and memorable achievement was on 19th of February, when finally - after several years of planning, negotiations and construction - the LéXPLORE platform was pulled from its assembly station in Le Bouveret to its anchoring location off Pully, where Lake Leman is 110 m deep.

The following months, various safety, technical and scientific equipment were installed under the supervision of Natacha Pasche and Sébastien Lavanchy, LéXPLORE Chief Technical Officer. In parallel, the first two SNF projects on Primary Production (by A. Wüest, EPFL) and on Leman Carbon Budget (by M-E. Perga, UniL) were both initiated on LéXPLORE. With a Call for EPFL Projects, funded by the Limnology Center, the access of the platform was granted to four EPFL projects. By the end of 2019, a total of 16 projects from the five partners institutions (EPFL, Eawag, CARRTEL, UniGE and UniL) applied to use LéXPLORE.

In the coming years, the challenges will be to implement successfully the current and future additional projects, as well as to ensure a safe and well-maintained operation of LéXPLORE.

Another highlight in summer 2019 was the publication of the special issue on the "*Life under Ice on Lake Onego*", which formed the natural conclusion of the FEEL-Foundation supported collaboration with our Russian colleagues in Karelia.

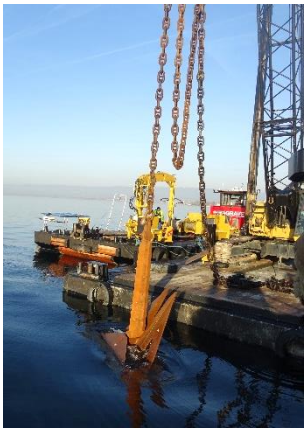
We thank all our colleagues, who worked with the Limnology Center in 2019, for their collaborative and supportive attitudes.



29th March 2019: LéXPLORE Platform is in use

LÉXPLORE platform is operational

On 19th February 2019, the platform was successfully launched on Lake Leman near Pully above a water depth of 110 m. ASN International GmbH, Sagrave SA and Rampini & Cie collaborated to perform this delicate anchoring operation. This event was meticulously covered by national news (RTS Téléjournal de 19h30, RTS radio La matinale, Une île flottante ancrée à Pully, SRF Tagesschau, Swiss administration, …)

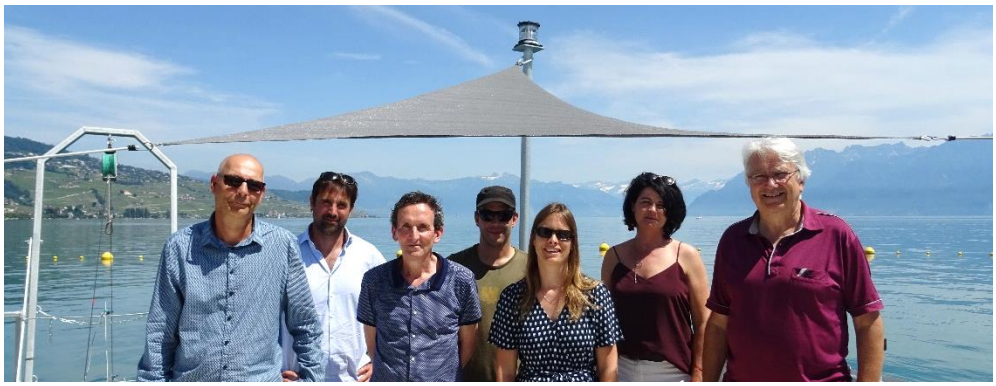


Setting a gravity anchor

The three companies collaborated on different vessels

LéXPLORE is a unique partnership between four Swiss academic institutions Eawag, EPFL, Unil, and UniGE. It became international when CARRTEL in Thonon-les-Bains, a mixed unit between INRA and Université Savoie - Mont-Blanc, joined the consortium in April 2019.

The Limnology Center is responsible for the day to day management of the platform. In that respect, this intense year was dedicated to setting up its exploitation. First, LéXPLORE technical committee installed the safety equipment and the scientific instruments that will provide a minimum dataset to all researchers and partly to the public. The platform was inaugurated on 24th June with the officials from the academic institutions, the city of Pully, the Federal Office for Environment and the cantonal authorities for water quality.



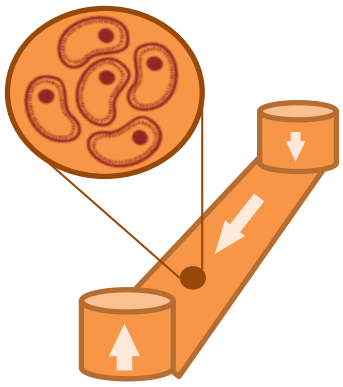
24 June 2019: the steering committee prepares LéXPLORE baptism

Call for EPFL projects

On 31st May, the Limnology Center organized a call for LéXPLORE projects targeted for EPFL researchers. The four submitted projects were all of excellent quality, promoting new technologies on LéXPLORE and collaborating with the other partner institutions. The Limnology Center therefore funded the following projects to a total amount of 174'820 CHF.

○ Prof. Kirstin Schirmer	$RAINBOW_{FLOW}$ $CHIP_{ONLINE}$: Fish cell biosensor for automated water quality testing
○ Dr. Stephane Joost	Local Adaptation of freshwater bacteria Communites to environmental conditions (LAC)
○ Dr. Florian Breider	MicroSed project – Deposition and Accumulation of Microplastics in Lake Sediment
○ Dr. Yves Bellouard	All-glass sensors for DCM algae population monitoring

$RAINBOW_{FLOW}CHIP$

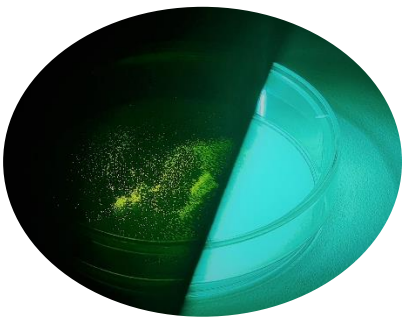


Courtesy from K. Schirmer

LAC – underwater vehicle

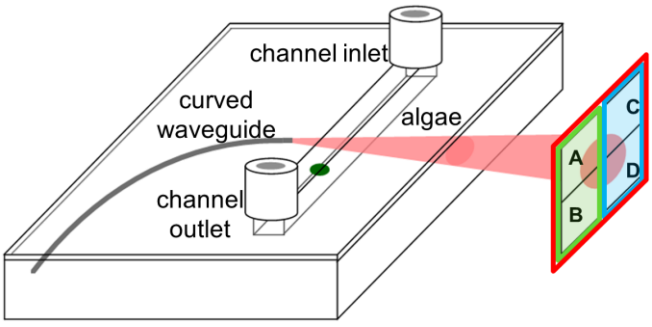
Courtesy from A. Martinoli

MicroSed project



Courtesy from F. Breider

All-glass sensor



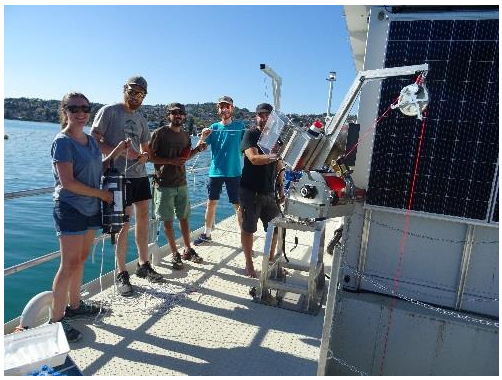
Courtesy from Y. Bellouard

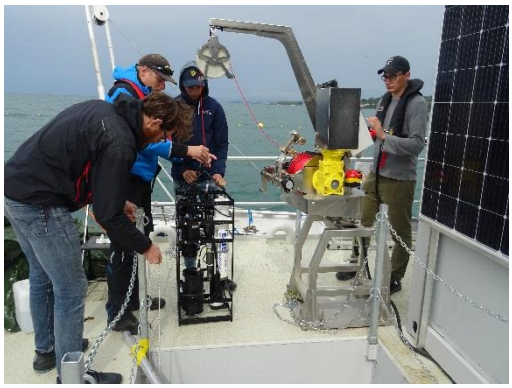
Science

In 2019, the steering committee validated 16 different projects with a broad diversity, showing the great interest from researchers for this innovative infrastructure. The different projects will investigate (complete list on www.lexplore.ch) :

- the ecosystem functioning from bacterial, mussels, phytoplankton and fishes.
- The physical, biological and biogeochemical processes at high resolution.
- the lake spatial variability with remote sensing and spatial ground truthing.
- new technologies such as underwater vehicles, a biosensor and an all-glass sensor.
- The project Datalakes will provide a web interface for LéXPLORE data

An advantage from the platform is to allow safe night time measurements, which were often neglected and thus baized the analyses. In 2019, 24h samplings were performed on 13-14th June, 27-28th August, 20-21st September, and 30-31st October.





Researchers from EPFL, Unil and Eawag strongly collaborated on 13th and 14th June 2019

Scientific event

On 13th November, the first scientific workshop on LéXPLORE brought together over 50 researchers in UniL's geopolis building. The Steering Committee never expected to reach such a number in less than one year of operation !

Participants in LéXPLORE Workshop on 13th November 2019

Communication and events

The Limnology Center also organised many events and work on diverse communication means, in collaboration with LéXPLORE steering committee:

- Common communication strategy for LéXPLORE with the four initial institutions.
- A hashtag defined as **#Leman_explore**
- a 6.10 min film about LéXPLORE construction, that was produced by the audiovisual service (SAVE) at EPFL, is available here.
- an information panel was installed near Pully harbor on 28th June 2019.
- Presentations and visits were organized upon request from different associations. The public visits on 2nd October, where 140 guests registered, had to be cancelled.
- Media visits resulting in over 17 articles in newspapers, including 24heures, Le Temps, Die Neue Zürcher Zeitung.

Un laboratoire flottant pour récolter un «big data du Léman»

LIMNOLOGIE La plateforme lacustre LéXPLORE a commencé sa moisson de données. Physique, chimie, biologie, rien n'échappe aux instruments des scientifiques qui espèrent simuler numériquement le plus grand lac d'Europe

FABIEN GOUBET
@fabiengoubet

Même sous un ciel sombre et pluvieux, on peut apercevoir le petit labo au fil de l'eau. A environ 500 mètres au large du port de Pully, la plateforme scientifique LéXPLORE flotte paisiblement sur les eaux du Léman. Un trajet de quelques minutes en bateau, ponctué de considérations sur les matériaux rendant les cordages plus résistants, suffit à y accoster et à rejoindre les équipes de scientifiques qui travaillent sur ce carré métallique de dix mètres de côté et au centre duquel se dresse une cabine flanquée d'ordinateurs et

La plateforme LéXPLORE, au large de Pully (VD). (SANDRA HILDEBRANDT/KEYSTONE)

Example of LéXPLORE article in Le Temps on 22nd August 2019

As responsible for LéXPLORE construction, the Limnology Center organized an event on 9th October to thank for the stakeholders that help during this 5 years-long process. 35 participants could join this event.

LéXPLORE team on 9th October

Different stakeholders participated

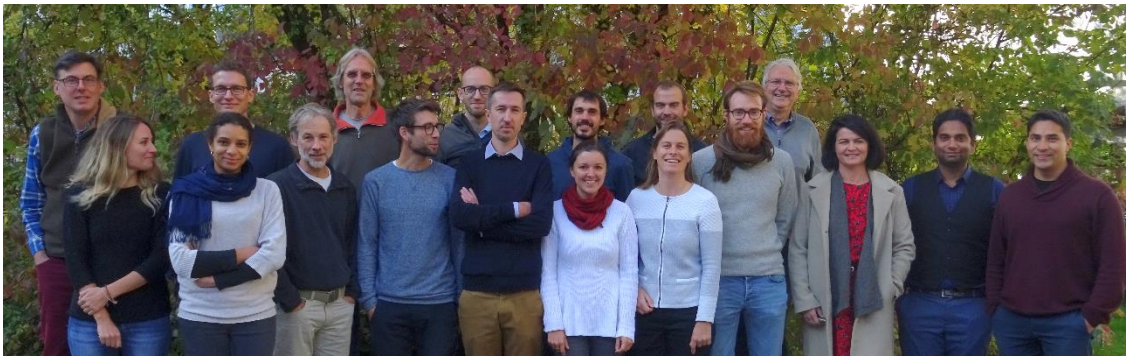
PRIMARY PRODUCTIVITY IN SWISS LAKES

This multidisciplinary project, launched in 2018, is led by a consortium from EPFL, University of Lausanne, University of Geneva, University of Applied Sciences and Arts of Southern Switzerland, and Eawag. The goal is to better understand the changes in primary production following the reduction of nutrients inputs in large lakes. To reach this goal, the Limnology Center organized two workshops in 2019.

Two workshops:

On 24th and 25th January, the goals of the workshop were to identify gaps and interfaces between the different partners, as well as to sharpen the research questions. The 21 participants discussed about 6 different themes in groups and then in plenum. The participants managed to establish links, and to define a clear way forward for the future collaborations within this large project.

On 12th November, the 2nd workshop was dedicated to the current results of the different groups. Among the 23 participants, 12 speakers presented their preliminary results, that were followed by open discussions. These promising results gave new insights on the primary productivity of three larges lakes in Switzerland.



Participants on Primary Production Workshop on 12th November 2019

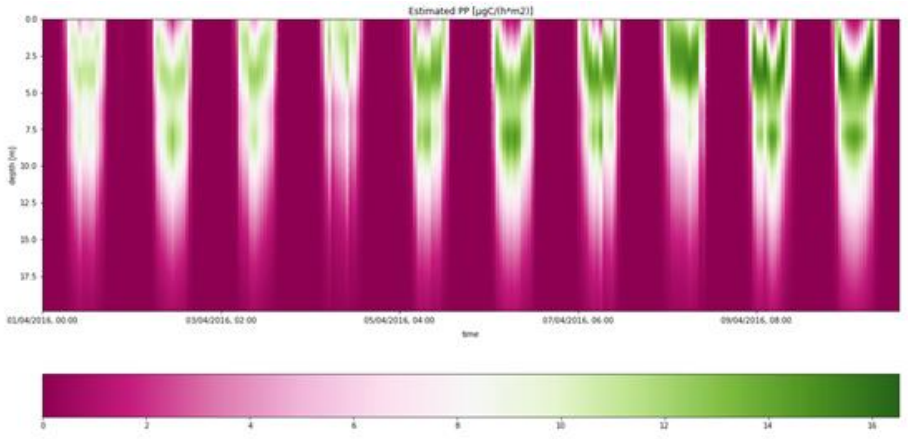
A successful proposal:

On 28th November, the Center successfully signed a contract with the Federal Office for the Environment for a total of 372'000 CHF. The goal is to propose an estimate of primary production for practitioners based on routine monitoring dataset. This project will largely benefit from the results from the primary production project. Part of this new funding is dedicated to LéXPLORE platform, and will allow to fully cover the construction overcosts.

SEED PROJECTS FOR PRIMARY PRODUCTION

Software for lake productivity

The goal of SOFTLAKE is to produce a user-friendly, open-source software that automates the calculation of primary production from monitoring data. The software will permit a time-efficient analysis of the data. M. Cannata, F. Lepori, C. Capelli from SUPSI delivered a beta version of the software that will be further tested in 2020.



Graphic output: hourly primary production rates integrated in time and across 0-20m

Primary productivity of different phytoplankton groups in Lake Constance

In 2019, Frank Peeters and his group organized an intensive data collection in Lake Constance, where moorings with chains of O_2-optodes were installed in three different basins during three time periods. The preliminary analysis of the O_2 data revealed, that in this very oligotrophic lake the impact of physical transport on surface concentration of dissolved oxygen causes large uncertainties in the metabolic rates determined with the diel O_2-technique. Peeters et al. (2019) therefore investigated if the recently proposed $^{16/18}$O-technique could be an alternative to the diel O_2-technique. The detailed analysis of the large data set is in progress and will be the major task in 2020.

Peeters, F., H. Hofmann, and J. Encinas Fernandez. (2019). **On the calculation of lake metabolic rates: Diel O_2 and $^{18/16}$O technique.** Water Research 165: 114990, doi:10.1016/j.watres.2019.114990.

SEED PROJECTS FOR PRIMARY PRODUCTION

Stoichiometric bottlenecks in the foodweb of Lake Leman under impact of reoligotrophication

The goal of this experimental project, led by Bastiaan Ibelings from UniGE, is to evaluate the effects of decreasing food quality for zooplankton. Roxane Fillion managed to grow 20 clones of Daphnia in the laboratory. She also obtained variable green algal food quality, with C:P ratio ranging from 30 to 500. The next steps are planned for 2020.

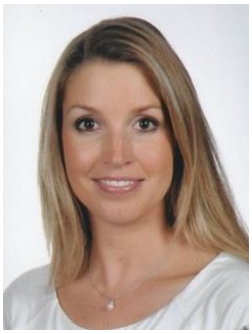
Green algae of different food quality (courtesy of B. Ibelings)

Whitening detection and optical characterization

Daniel Odermatt from Eawag developed a processing chain to detect whiting event from satellite images. As an alert-based, the processed images were sent to partners. Two field campaigns took place on 11th-14th June, and on 4th July, when the optical properties were measured during a large whiting event. A publication is expected in collaboration with Nicolas Escoffier from UniL.

Lake Leman whiting seen by Sentinel-2A MSI, 29th June 2019 (courtesy of ESA).

WITHIN THE LIMNOLOGY CENTER



Lara Dubois

Since February 2019, Lara Dubois has worked as a secretary at 10% for the Limnology Center. She helped to organize many events related to LéXPLORE platform. We are happy to welcome her in our team!

The core group of the Limnology Center were pleased that LéXPLORE became operational. It took more than 5 years, since this project was launched.

Sébastien Lavanchy, Natacha Tofield-Pasche and Johny Wüest at LéXPLORE baptism

Sébastien Lavanchy and Michael Plüss installing the weather station

Sebastien Lavanchy has acted as Chief Technical Officer for LéXPLORE. We would like to thank him for his flexibility, his commitment, and his capacity to find technical solutions. LéXPLORE is a unique infrastructure, that is more complex to run than we anticipated.

LéXPLORE

PARTNERS

In France

CARRTEL: Jean Guillard, Viet Tran-Khac, Philippe Quétin, Serena Rasconi, Isabelle Domaizon, Orlane Anneville

In Switzerland

University of Lausanne: Prof. Marie-Elodie Perga, Prof. Torsten Vennemann, Dr. Nicolas Escoffier, Dr. Thibault Lambert, Aurélien Ballu, Gabriel Cotte, Pascal Perolo

University of Geneva: Prof. Bastiaan Ibelings, Prof. Daniel McGinnis, Prof. Vera Slaveyskova, Dr. Tonya Del Sontro, Dr. Jean-Luc Loizeau, Thibaud Cossart, Roxane Fillion, João Santos, Ena Suarez Bolanos

Eawag: Prof. Kristin Schirmer, Prof. Piet Spaak, Dr. Damien Bouffard, Dr. Stuart Dennis, Dr. Carolin Drieschner, Dr. Peter Isles, Dr. Daniel Odermatt, Dr. Beat Müller, Dr. Francesco Pomati, Linda Haltiner, Patrick Kathriner, Jenny Maner, Michael Plüss

Natural History Museum: Dr. Isabel Blasco-Costa

Ecotoxicology Center: Dr. Benoit Ferrari

University of Applied Sciences and Arts of Southern Switzerland: Dr. Massimiliano Cannata, Dr. Camilla Capelli, Dr. Fabio Lepori, Daniele Strigaro

Federal Office for Environment: Rémy Estoppey

Within EPFL

APHYS-Margaretha Kamprad Chair: Prof. Johny Wüest, Dr. Hannah Chmiel, Dr. Bieito Fernandez, Dr. Shubham Krishna, Dr. Camille Minaudo, Dr. Natacha Tofield-Pasche, Dr. Hugo Ulloa, Sebastien Lavanchy

Central Environmental Laboratory: Dr. Florian Breider

Environmental Chemistry Laboratory: Prof. Tamar Kohn, Dr. Anna Carratalà, Coralie Chappelier

Laboratory of Geographic Information Systems: Dr. Stéphane Joost, Dr. Elia Vajana, Annie Guillaume

Distributed Intelligent Systems and Algorithms Laboratory: Prof. Martinoli Alcherio, Anwar Quraishi

Laboratory of Environmental Toxicology: Prof. Kristin Schirmer

Galatea Laboratory: Prof. Yves Bellouard, Dr. Manon Tardif, Ivo Arabadzhiev, Sebastiano Ribi

Microsystems Laboratory 4: Prof. Philippe Renaud

PARTNERS: PRIMARY PRODUCTION

In Germany

University of Constance: Prof. Frank Peeters, Dr. Hilmar Hofmann

In France

INRA-Thonon-les-Bains: Dr. Orlane Anneville

In Switzerland

University of Geneva: Prof. Bastiaan W. Ibelings, Dr. Evanthia Mantzouki, Ena Suarez Bolanos, Roxane Fillion

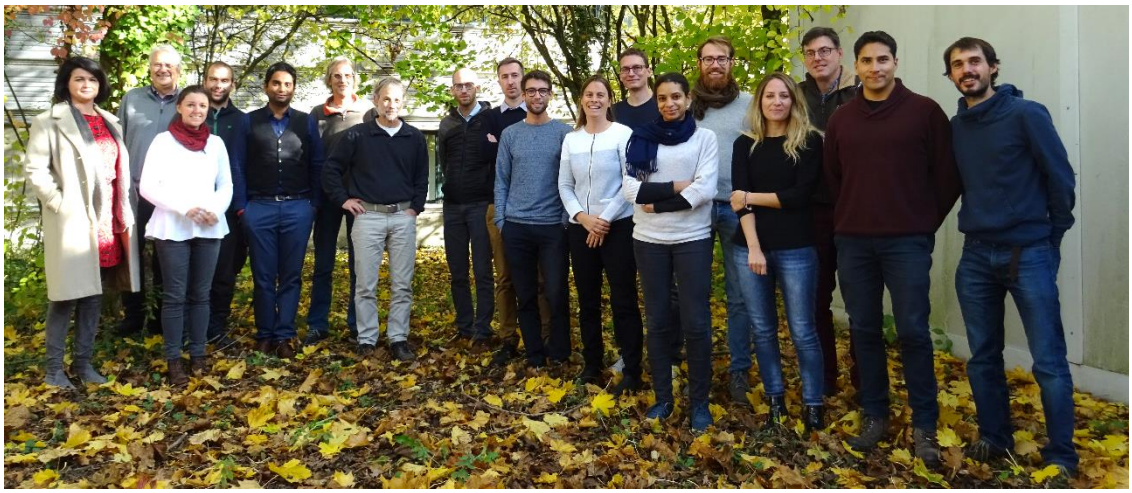
Eawag: Dr. Damien Bouffard, Dr. Beat Müller, Dr. Vincent Nouchi, Dr. Daniel Odermatt, Luca Brüderlin, Patrick Kathriner

University of Lausanne: Prof. Marie-Elodie Perga, Pascal Perolo, Dr. Thibault Lambert, Dr. Nicolas Escoffier, Gabriel Cotte, Matthieu Fallet

University of Applied Sciences and Arts of Southern Switzerland: Dr. Fabio Lepori, Dr. Massimiliano Cannata, Dr. Camilla Capelli, Daniele Strigaro

Within EPFL

APHYS-Margaretha Kamprad Chair: Prof. Alfred Wüest, Dr. Hannah Chmiel, Dr. Bieito Fernandez, Dr. Shubham Krishna, Dr. Camille Minaudo, Dr. Natacha Tofield-Pasche, Dr. Hugo Ulloa, Sebastien Lavanchy,



Primary Production Project: workshop participants on 12th November 2019

SPECIAL ISSUE – LIFE UNDER ICE

Inland Waters 2019, Volume 9, Issue 2: *Life under Ice in Lake Onego (Russia):* – an interdisciplinary winter limnology study:

Alfred Wüest, Natacha Pasche, Bastiaan Ibelings, Sapna Sharma, and Nikolay Filatov, **Life under ice in Lake Onego (Russia) – an interdisciplinary winter limnology study.** https://doi.org/10.1080/20442041.2019.1634450

Nikolai Filatov, Vyacheslav Baklagin, Tatyana Efremova, Larisa Nazarova, and Nikolay Palshin: **Climate changes on the watersheds of lakes Onego and Ladoga based on the remote sensing and in-situ data.** https://doi.org/10.1080/20442041.2018.1533355

Damien Bouffard, Galina Zdorovennova, Sergey Bogdanov, Tatyana Efremova, Sébastien Lavanchy, Nikolay Palshin, Arkady Terzhevik, Love Råman Vinnå, Sergey Volkov, Alfred Wüest, Roman Zdorovennov, and Hugo Ulloa: **Under-ice convection dynamics in a boreal lake**. https://doi.org/10.1080/20442041.2018.1533356

Natacha Pasche, Hilmar Hofmann, Damien Bouffard, Carsten Schubert, Petr Lozovik, and Sebastian Sobek: **Implications of river intrusion and convective mixing on the spatial and temporal variability of under-ice CO_2.** https://doi.org/10.1080/20442041.2019.1568073

Sergey Bogdanov, Galina Zdorovennova, Sergey Volkov, Roman Zdorovennov, Nikolai Palshin, Tatyana Efremova, Arkady Terzhevik, and Damien Bouffard: **Structure and dynamics of convective mixing in Lake Onego under ice-covered conditions.** https://doi.org/10.1080/20442041.2018.1551655

Ena Lucia Suarez, Marie-Caroline Tiffay, Nataliia Kalinkina, Tatjana Tchekryzheva, Andrey Sharov, Elena Tekanova, Maria Syarki, Roman Zdorovennov, Elena Makarova, Evanthia Mantzouki, Patrick Venail and Bastiaan Ibelings: **Diurnal variation in the convection-driven vertical distribution of phytoplankton under ice and after ice-off in large Lake Onego (Russia).** https://doi.org/10.1080/20442041.2018.1559582

Camille Thomas, Victor Frossard, Marie-Elodie Perga, Tofield-Pasche Natacha, Hilmar Hofmann, Nathalie Dubois, Natalia Belkina, Serge Robert and Emilie Lyautey: **Lateral variations and vertical structure of the microbial methane cycle in the sediment of Lake Onego (Russia).** https://doi.org/10.1080/20442041.2018.1500227

Tatyana Efremova, Albina Sabylina, Petr Lozovik, Vera Slaveykova, Mariya Zobkova, and Natacha Pasche: **Seasonal and spatial variation in hydrochemical parameters of Lake Onego (Russia): insights from 2016 field monitoring.** https://doi.org/10.1080/20442041.2019.1568097

PUBLICATIONS

SCIENTIFIC PUBLICATIONS

Life under Ice project

Sergey Volkov, Sergey Bogdanov, Roman Zdorovennov, Galina Zdorovennova, Arkady Terzhevik, Nicolay Palshin, Damien Bouffard, and Georgiy Kirillin (2018)**. Fine scale structure of convective mixed layer in ice-covered lake.** *Environmental Fluid Mechanics* 19(3): 751–764. https://doi.org/10.1007/s10652-018-9652-2

Vasily Ivanov, Nikolay Palshin, Yu. Manilyuk (2019): **Seiches in Petrozavodsk Bay, Lake Onega.** *Water Resources 46 (5):* 709–717. https://doi.org/10.1134/S0097807819050117

Kraig Winters, Hugo Ulloa, Alfred Wüest, and Damien Bouffard (2019). **Energetics of radiatively heated ice-covered lakes.** *Geophysical Research Letters 46(15)*: 8913 – 8925. https://doi.org/10.1029/2019GL084182

Hugo Ulloa, Kraig Winters, Alfred Wüest, and Damien Bouffard (2020). **Differential heating drives downslope flows that accelerate mixed-layer warming in ice-covered waters.** *Geophysical Research Letters 47.* https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2019GL085258

Marie-Elodie Perga, Maria Syarki, Nathalia Kalinkina, and Damien Bouffard (2019): **A rotiferan version of the punishment of Sisyphus?** *Ecology*. https://doi.org/10.1002/ecy.2934

Isabelle Worms, Hannah Chmiel, Jacqueline Traber, Natacha Tofield-Pasche and Vera Slaveykova (2019): **Dissolved organic matter and associated trace metal dynamics from river to lake, under ice-covered and ice-free conditions**. *Environmental Science & Technology* 53 (24): 14134-14143. https://doi.org/10.1021/acs.est.9b02184

Hannah Chmiel, Hilmar Hofmann, Sebastian Sobek, Tatyana Efremova, and Natacha Pasche (2019): **Where does the river end? Drivers of spatiotemporal variability in CO_2 concentration and flux in the inflow area of a large boreal lake.** *Limnology and Oceanography.* https://doi.org/10.1002/lno.11378

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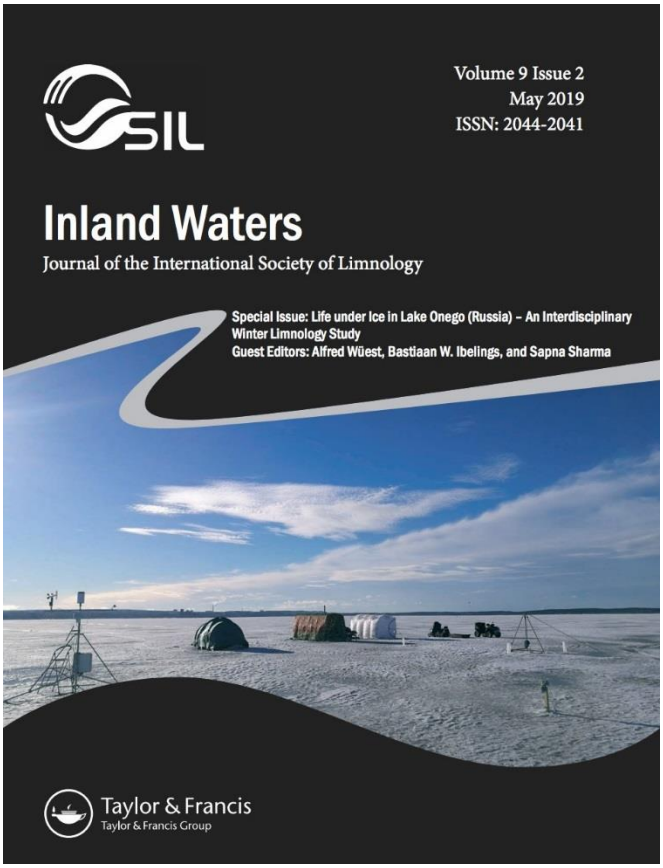
Life under ice project

Alexei Kouraev et al. **Ice cover and associated water dynamics of Eurasian lakes from satellite and in situ observations.** II International conference Lakes of Eurasia: Problems and solutions. Kazan, Russia, 19-24 May 2019. Proceeding, part I. p.280. ISBN 978-5-9690-0526-6

Hugo Ulloa, Kraig Winters, Alfred Wüest, Damien Bouffard. **Topographic effect on the rate of heating of radiatively-forced ice-covered waterbodies.** AGU, Ocean Science meeting 2019

Hugo Ulloa et al. **Circulation and energy distribution in radiatively-heated ice-covered waterbodies: the role of topography.** EGU General Assembly 2019: EGU2019-9397, 11 April 2019.

Vera Slaveykova, Elodie Moulin, Nicole Regier, Killian Kavanagh and Isabelle Worms "**Refractory components of dissolved organic matter from Lake Onega (Russia) protect phytoplankton from Hg**" 14th International Conference on Mercury as a Global Pollutant (ICMGP 2019) 7-13 September 2019, Krakow, Pologne



LéXPLORE

Articles in Newspapers

19.10 : Neue Zürcher Zeitung, Das Forschungfloss vom Genfersee

27.08 : RSI, Léxplore svela i misteri del Lemano

22.08: le Temps, un laboratoire flottant pour récolter un < big data du Léman >

28.07: Echo Magazine, une plateforme flottante ausculte le Léman

23.07 : Terre et Nature, un véritable laboratoire flottant pour percer les secrets du lac Léman

11.07 : Le Courrier de Lavaux-Oron : Un laboratoire de recherche flotte au large de Pully

04.07: 24 heures Les scientifiques au chevet du Léman

04.07 : **La plate-forme LéXPLORE opérationnelle au large de Pully (VD)**, published in, Swissinfo, RTN, la Liberté, TWnews, RFJ, Bluewin, Watson, with a 2.2 min film in 20 minutes, Tribune de Genève, Le Matin

20.02: **Une station de recherche flottante explore le lac Léman,** Bote, MyScience, Swiss administration, La Liberté, Zentralschweizertafelrunde, Nashagazeta, Agenparl

20.02: Press release "**Une station de recherche flottante explore le lac Léman** » by the academic institutions (Eawag, EPFL, UniGE, UniL)

20.02: 24 Heures – une île flottante ancrée au large de Pully pour huit ans

Radio

26.08: RTS CQFD, Un labo flottant pour comprendre le Léman, 21 min

20.02: RTS radio la Matinale, LéXPLORE, un laboratoire flottant pour étudier les changements climatiques, 2 min

27.08: RSI, Léxplore svela i misteri del Lemano, 3.2 min

Television

23.02: SRF Tagesschau 19h30, Ein schwimmendes Labor auf dem Genfersee

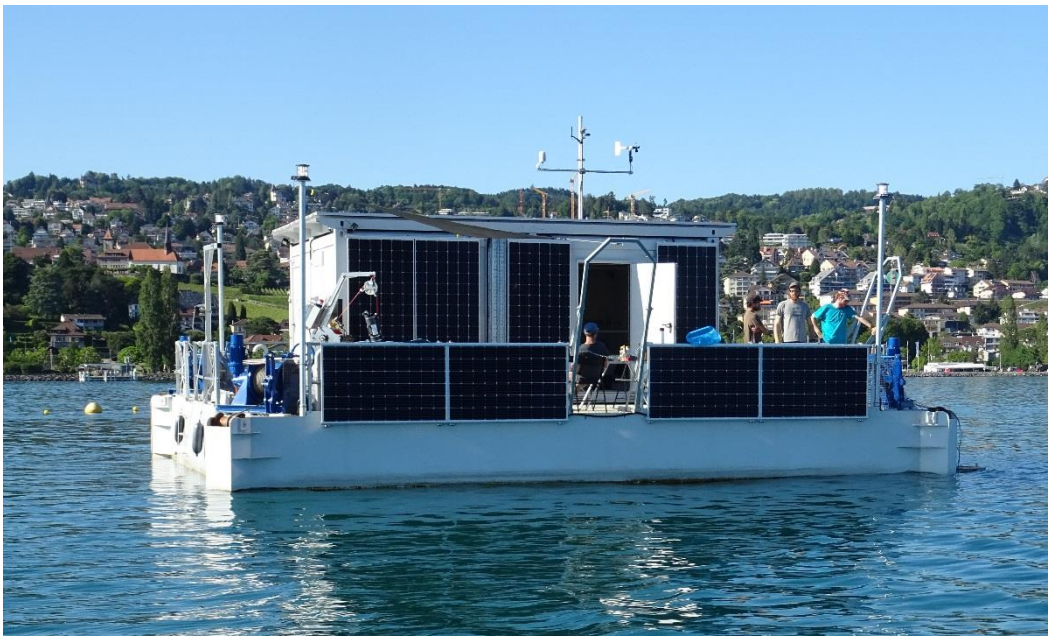
19.02: RTS Telejournal 19h30, Un laboratoire sur le Léman pour saisir les changements climatiques

Film

23.06: LéXPLORE (Lac Leman Exploration), 6.15 min, EPFL audiovisual service

Exploitation of LéXPLORE Platform

In 2020, the Limnology Center will focus on reaching an effective exploitation of LéXPLORE platform, with balanced financial records. We also aim at providing LéXPLORE data through a webportal within DATALAKES project. We will also continue to promote LéXPLORE use for researchers, education but also for the population.



Researchers working on LéXPLORE platform during a 24h experiment

Next year will be intense for LéXPLORE technical team with many new instruments to install for the upcoming projects. There are also a few technical issues that need to be fixed. Thus, the Limnology Center and APHYS laboratory will hire a technician to help Sébastien Lavanchy on LéXPLORE platform.

LéXPLORE technical team: Aurélien Ballu (UniL), Roxane Fillion (UniGE) , Sébastien Lavanchy (EPFL), Michael Plüss (Eawag), Philippe Quétin (CARRTEL - not on photo)