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

The year 2021 was a turning point for the Limnology Center, due to the Director Prof. Wüest's retirement. In that respect, it meant the closing of the APHYS laboratory, which was a key actor of the Limnology Center throughout the years. The primary production project, that managed to bring together scientists from the three large binational lakes, also came to an end. Fortunately, the LIMNC Center is successfully secured until the end of the LéXPLORE platform.

Since September, the LIMNC Center has therefore started a new phase with Tom Battin as the Director ad Interim, and Natacha Tofield-Pasche as the Operational Director. Sébastien Lavanchy and Guillaume Cunillera will continue to ensure the technical operations on the LéXPLORE platform, while Lara Dubois will remain for the administration.

After the COVID crisis, the operations on LéXPLORE have come back to normal, and six peered-reviewed articles highlighting the research on LéXPLORE were published. By end of 2021, we have reached 37 projects. We also published a peered-review article describing the LéXPLORE platform and the multiple research opportunities, that will help to better position LéXPLORE internationally.

I would like to warmly thank Johny Wüest for his commitment, talents, and visions in developing the Limnology Center into an attractive hub for researchers. By leading the establishment of LéXPLORE, he left us with the best freshwater research platform in the world. In decades, limnologists will still remember this unique facility, what a legacy!

N. Tofield-Pasche, Op. Dir LIMNC

Prof. Wüest and scientists ending a training on turbulences measurements, June 2021

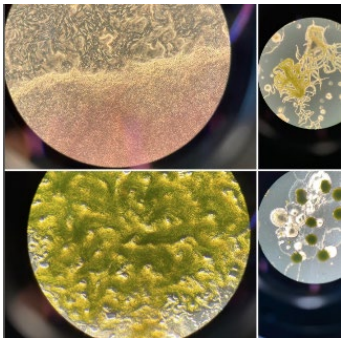
Call for interdisciplinary projects (3rd call)

On 15th October, the Limnology Center launched a call for interdisciplinary projects on LéXPLORE projects open to all partners. A total of 6 proposals were submitted. The Center funded the following three projects to a total amount of 110'000 CHF.

Dr. Tercier-Waeber Mary-Lou, and Prof. Ibelings Bastiaan	Synergic interaction between arsenic species and microorganisms in freshwater contrasting dynamic conditions (SyBam)
Dr. Carratalà Ripollès Anna, Prof. Ibelings Bastiaan, Dr. Daniel Odermatt, and Dr. Janssen Elisabeth	Remote sensing and risk assessement of toxic Cyanobacteria in Lake Geneva (CYANOSENSE)
Dr. Bouffard Damien, Prof. Perga Marie-Elodie, and James Runnals	REPRODUCE - léxploRE PRODUct ACcESs

The project **SyBam** will use the innovative analytical tool developed by the Bakker Group at UNIGE. This tool can measure in-situ the bioavailable fraction of arsenic, which is potentially toxic for algae. The goal is to study the dynamic behaviour of the arsenic species and the algal-bacterial species, in order to investigate their feedback interactions in contrasting dynamic conditions.

The project **REPRODUCE** aims at improving the DATALAKES dataportal, by applying a robust method to ensure a good quality check for the environmental data, and by implementing higher level products of data. A LéXPLOR'hathon will also be organized, where diverse scientists will work collaboratively on the core dataset over 3 days.

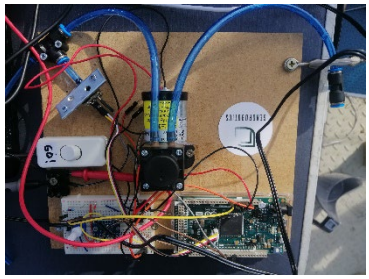


Bringing together scientists from the three Swiss partners, the project **CYANOSENSE** propose to develop for the first-time a risk assessment of the toxic cyanobacteria species and the toxins they produce in Lake Geneva. The goal is also to develop a remote sensing-based method to rapidly detect and follow the formation of blooms and mats of toxic cyanobacteria in the lake.

EPFL projects on LéXPLORE (2nd call)

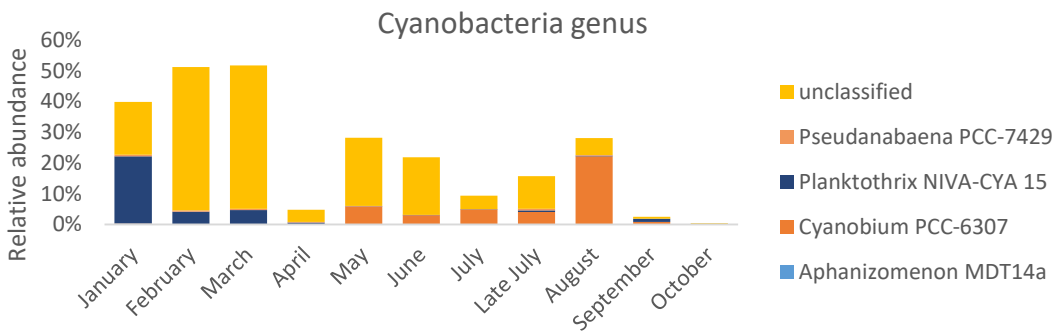
Bernier-Latmani, Maerkl et al: GenoRobotics – CoWaS (Continuous Water Sampling)

In 2021, the GenoRobotics prototype was tested on LéXPLORE platform. It successfully pumped water from a fixed depth, and pushed 2 liters through a 0.22 µm filter. The DNA extraction and the amplification of the 16S gene were still performed in the lab, but these processes will soon be included in the prototype. Such an automatic robot will be valuable to understand the dynamic of bacterial communities.



GenoRobotics prototype tested on LéXPLORE

Carratalà et al: Unravelling the diversity, functioning and toxin production of cyanobacteria populations in Lake Geneva (CYANOFUN)

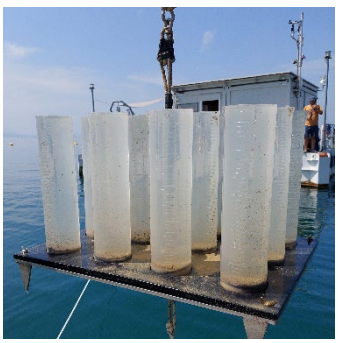


Relative abundance of cyanobacteria genus in 2021

In 2021, the different genus of cyanobacteria were analyzed in 140 water samples. Planktothrix and Cyanobium were observed at different time of the year. A peak in microcystins linked to Cyanobium was measured in September, but remained far from the WHO guidelines values. However, tests in the laboratory at the peak concentration prevented the growth of a protist specie. The proliferation of toxic cyanobacteria might therefore influence the ecosystem functioning.

Ferrari et al: Effects of lake suspended matter quality on growth, emergence and molecular endpoints in *Chironomus riparius*

Settling particulate matter was collected twice during 4 months at LéXPLORE. Bentic larvaes of chironomids were exposed to this material in the laboratory, to analyze the potential toxicity. Surprisingly, a high larvae mortality was observed during summer/fall 2021, which corresponded to the Rhône peak discharge. The quality of the particulate matter will be further investigated, to better interpret these results.

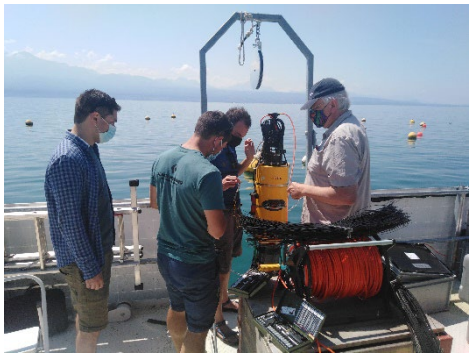


Science

The first scientific articles on LéXPLORE were published in 2021, related to the primary production and carbon cycling projects. A peered-review publication described the LéXPLORE platform and the diverse research opportunities offered by this unique infrastructure. The first full-year study of turbulent mixing in Lake Geneva was advertised in EPFL and Eawag news.

In 2021, 13 new projects were validated including the six projects financed from the last two calls from the Limnology Center. The other projects investigated the infectivity of virus, analysed organic contaminants with passive samplers, tested a new ADCP, measured the degradability of a novel biopolyester, recorded the sounds below the platform, will test in-situ an active chlorophyll fluorometer to measure primary production, and will develop a low cost automated chamber for gas emissions. By end 2021, LéXPLORE reached a total of 37 projects. We welcomed the first international project with Chelsea Technologies from UK, and are delighted by the growing interests to use LéXPLORE by researchers from diverse fields.

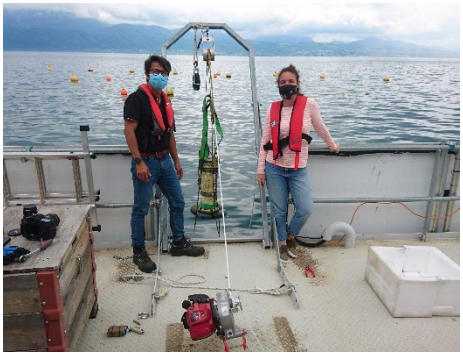
Mid-July 2021, the first scientific report on LéXPLORE gave an overview of the results from the 23 current projects and the achievements from 5 closed projects. It is available on https://lexplore.info/scientific-report/



Training on diverse instruments to measure turbulences

Deployment of the Contros HydroC™ methane sensor

First tests in-situ for the biosensor $RAINBOW_{Flow}$ $CHIP_{online}$



Test of a new ADCP for a future deployment in the lake deepest point

LéXPLORE platform

The following outreach activities took place in 2021:

- 31st October : Public presentations « *La plateforme LéXPLORE: un outil de pointe pour comprendre les changements environnementaux dans le Léman* » by Natacha Tofield-Pasche during Scientastic, the EPFL Science Festival
- 10th August: photo-reportage on La plateforme in the ocean newsletter
- 21st August, Eawag: LéXPLORE brings together researchers from different disciplines – that's fantastic"
- 10th August: Tribune de Genève: Le lac Léman, notre poumon bleu, risque de manquer d'oxygène
- 9th August: 24 heures, Avec le réchauffement, notre poumon bleu risque de manquer d'air
- 9th June: Rockland news, Swiss Limnologists Benefit from Swift Support & Loaner MicroCTD
- 9th and 16th June: Filming sessions for the EPFL Science Outreach Department
- 22-27th June: exhibition of LéXPLORE at the ASLO virtual meeting
- 19th May : RTS 36.9°: Microplastics – quels dangers pour la santé? 24 min on TV
- 22nd April: RTS on va vers le beau, Rhône, Léman et écologie (4/5) – Un labo flottant pour comprendre les processus climatiques, 30 min on radio
- 1st April: ZDF, plan B: Wärme dank Hanf und Hightech, Neue Wege zur Energiewende
- 4th April: RTS Téléjournal 19h30, La pollution des eaux par les résidus de pneus affecte aussi les poissons
- 25th March: SRF Einstein, Introduction to Tauchen im Mittelmeer: Leben und forschen auf dem Meeresgrund | 2
- 18th March: SRF Einstein, Introduction to Tauchen im Mittelmeer: Leben und forschen auf dem Meeresgrund | 1
- 16th March: Filming session from the Geneva Water Hub for the World Water Day 2021: Valuing Water for Peace

19th Swiss Geoscience Meeting

This annual conference took place online on 20th and 21st November. Through the Swiss Society for Hydrology and Limnology, Damien Bouffard, Natacha Tofield-Pasche, Dorothea Hug Peter, and Michael Döring organized the session on Limnology in Switzerland for the second time. In total, 12 talks presented their results, including five related to LéXPLORE platform. Four of the 10 poster pitches were based on LéXPLORE.

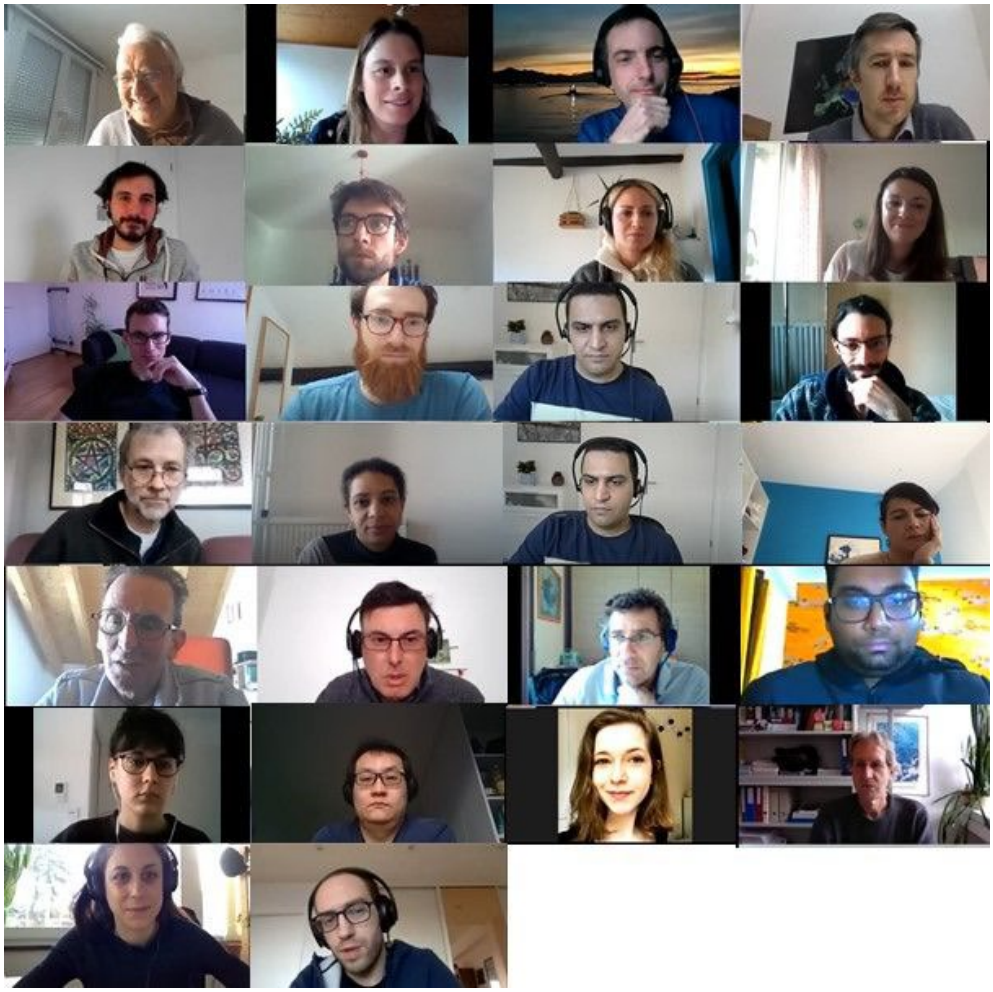
We were pleased with this session, as the limnology was promoted in Switzerland and results from the LéXPLORE platform were presented to a wider community.

PRIMARY PRODUCTIVITY IN SWISS LAKES

This multidisciplinary project, launched in 2018, is a joint effort by a consortium from EPFL, University of Lausanne, University of Geneva, University of Applied Sciences and Arts of Southern Switzerland, Eawag and University of Constance. The goal is to better understand the changes in primary production following the reduction of nutrients inputs in Lakes Geneva, Constance and Lugano.

Workshop

The annual workshop took place virtually on 26th January 2021. We had 14 presentations followed by discussions showing the progress of the different projects. This workshop gave a good overview of the current state of the results, and the planned publications. Most of the publications are expected later this year.

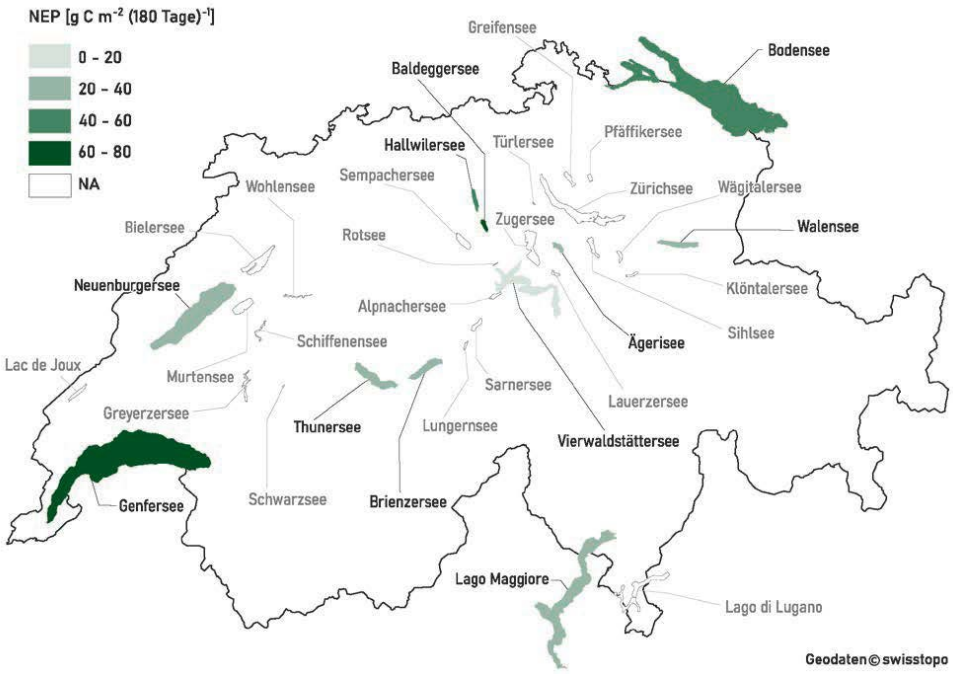


Participants of the workshop in January 2021

PRIMARY PRODUCTION IN SWISS LAKES

Project with the Federal Office for the Environment

A method was developed to estimate the net ecosystem production (NEP) in Swiss lakes, using the available monitoring data. The method is based on the following four components: the oxygen consumption in the water column, the oxygen consumption in the sediment, the oxidation of the reduced substances, and the net sedimentation. Using these components, the NEP was calculated differently depending on the specificity of the lake. The method is explained in details on: https://www.dora.lib4ri.ch/eawag/islandora/object/eawag%3A21995



The estimates of the net ecosystem production (NEP) for the larger Swiss lakes

Seed projects for the Primary Production

The three seed projects were completed in September with the following outcomes:

- Odermatt et al: managed to develop an algorithm that detects whitening events in lakes using remote sensing, and maps are accessible within DATALAKES webportal.
- Peeters et al: estimated metabolic rates using the oxygen diel pattern combined with the isotopic composition of oxygen. The application in Lake Constance were perturbed by physical processes interfering with the signature from the primary production, but the concept was confirmed within a mesocosm experiment.
- Ibelings et al: showed that the quality of the food impacted the growth and survival of Daphnia in a laboratory experiment. Further experiments are still ongoing to assess the combined effects of varying food quantity and quantity.

WITHIN THE LIMNOLOGY CENTER

Johny Wüest retired on 30th August 2021. We cannot thank him enough for his vision, commitment, and for the LéXPLORE platform. We will miss him enormously!

It is a success that the EPFL/ENAC have accepted to renew his position, and the process to hire a new professor will start in 2022.

Johny Wüest on LéXPLORE

Steering Committee on 29th June 2021

During the transition, Tom Battin has accepted to act as the Director ad Interim of the Limnology Center.

He already took part in the LéXPLORE Steering Committee in June 2021.

The Limnology Center's Team

Natacha Tofield-Pasche

Lara Dubois Sébastien Lavanchy

Guillaume Cunillera

Since September 2021, Natacha Tofield-Pasche has become the Operational Director of the Center. We manage to maintain the former employees Sébastien Lavanchy, Guillaume Cunillera (80%) and Lara Dubois (20%). We would like to thankt the team members for their dedicated work throughout 2021.

LéXPLORE

PARTNERS

In Europe

CARRTEL, France: Dr. Jean Guillard, Dr. Viet Tran-Khac, Philippe Quétin, Dr. Serena Rasconi, Dr. Isabelle Domaizon, Dr. Orlane Anneville, Dr. Chloé Goulon, Dr. Didier Jézéquel, Clément Rautureau

Marine Research Institute (IIM-CSIC), Spain: Dr. Miguel Gil Coto

In Switzerland

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

University of Geneva: Prof. Bastiaan Ibelings, Dr. Jean-Luc Loizeau, Roxane Fillion, Julio Alegre Stelzer, Jorrit Mesman, Dr. Mridul Thomas, Ena Suarez Bolanos, Matthieu Devanthery, Sebastien de Loes, Andrea Gallorini, Philippe Arpagaus

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, Simon Bloem, Christian Ebi, René Schönenberger, Michael Plüss, James Runnalls, Dr. Thomas Steinberger, Tomy Doda, Dr. Jonas Sukys, Dr. Artur Safin, Dr. Abofazel Irani Rahaghi, Dr. Janssen Elisabeth, Annita Schlatter, Remika Gupana

Federal Office for Environment: Rémy Estoppey, Dr. Manuel Kunz

Swiss Data Science Center: Fotis Georgatos, Bouillet Eric, Perez Cruz Fernando

Swiss Center for Applied Ecotoxicology: Dr. Benoît Ferrari**,** Dr. Rébecca Beauvais, Dr. Carmen Casado-Martinez, Christina Thiemann

ETH Zürich: Dr. Julie Lattaud, Prof. Timothy Eglinton, Lissie de Groot, Beata Zborowski, Marco Bolandini

Hydromea: Dr. Alexander Bahr, Dr. Felix Schill

The technical team during a health and safety training on LéXPLORE, on 16th November 2021

PARTNERS

LéXPLORE

Within EPFL

APHYS-Margaretha Kamprad Chair: Prof. Johny Wüest, Dr. Hannah Chmiel, Dr. Bieito Fernandez Castro, Dr. Shubham Krishna, Dr. Camille Minaudo, Dr. Natacha Tofield-Pasche, Dr. Hugo Ulloa, Dr. Sebastiano Piccolroaz, Sebastien Lavanchy, Guillaume Cunillera, Isabel Kiefer, Lucas Serra Moncadas

Central Environmental Laboratory: Dr. Florian Breider, Karine Vernez, Sylvain Coudret

Environmental Chemistry Laboratory: Prof. Tamar Kohn, Dr. Anna Carratalà, Odile Larivé, Chaojie Li.

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

Laboratory of Environmental Toxicology: Prof. Kristin Schirmer

The Ecological Engineering Laboratory: Prof. Andrew Barry, Mehrshad Foroughan Benjamin Graf, Htet Kyi Wynn, Dr. Violaine Pitton, Rafael Reiss

Wind Engineering and Renewable Energy Laboratory: Prof. Fernando Porté-Agel

Environmental Microbiology Laboratory: Prof. Rizlan Bernier-Latmani

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

Microsystems Laboratory 4: Prof. Philippe Renaud

Laboratory of Biological Network Characterization: Jonathan Selz, Adam Nicolas, Prof. Sebastian Maerkl

Laboratory of Sustainable and Catalytic Processing: Prof. Luterbacher Jeremy, Lorenz Manker, Maxime Hedou

PRIMARY PRODUCTION

University of Constance, Germany: Prof. Frank Peeters

INRAE-Thonon-les-Bains, France: Dr. Orlane Anneville, Dr. Serena Rasconi

In Switzerland

University of Geneva: Prof. Bastiaan Ibelings, Ena Suarez Bolanos, Roxane Fillion

Eawag: Dr. Beat Müller, Dr. Daniel Odermatt, James Runnals, Patrick Kathriner, Dr. Abofazel Irani Rahaghi

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

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 Castro, Dr. Shubham Krishna, Dr. Camille Minaudo, Dr. Natacha Tofield-Pasche, Dr. Hugo Ulloa, Sébastien Lavanchy, Dr. Sebastiano Picoolroaz, Guillaume Cunillera, Isabel Kiefer, Lucas Serra Moncadas

SCIENTIFIC PUBLICATIONS

PUBLICATIONS

Life under Ice project

Perga M-E, Syarki M, Spangenberg JE, Frossard V, Lyautet Emilie, Kalinkina N, and Bouffard D (2021): **Fasting or feeding: A planktonic food web under lake ice** *Freshwater Biology 66*(3): 570-581. https://doi.org/10.1111/fwb.13661

Primary Production project

Steinsberger T, Wüest A, Müller B (2021) **Net Ecosystem Production of Lakes Estimated From Hypolimnetic Organic Carbon Sinks**. Water Res 57 (5): 1-16. https://doi.org/10.1029/2020WR029473

Krishna S, Ulloa HN, Kerimoglu O, Minaudo C, Anneville O, Wüest A (2021) **Model-based data analysis of the effect of winter mixing on primary production in a lake under reoligotrophication.** Ecological Modelling 440:109401. https://doi.org/10.1016/j.ecolmodel.2020.109401

LéXPLORE platform

Wüest A, Bouffard D, Guillard J, Ibelings BW, Lavanchy S, Perga M-E, and Pasche N (2021) **LéXPLORE: A floating laboratory on Lake Geneva offering unique lake research opportunities.** WIREs Water 8:e1544. https://doi.org/10.1002/wat2.1544

Fernández Castro B, Chmiel HE, Minaudo C, Krishna S, Perolo P, Rasconi S and Wüest A (2021) **Primary and Net Ecosystem Production in a Large Lake Diagnosed From High-Resolution Oxygen Measurements**. Water Res 57:e2020WR029283. https://doi.org/10.1029/2020WR029283

Fernández Castro B, Bouffard D, Troy C, Ulloa HN, Piccolroaz S, Sepúlveda Steiner O, Chmiel HE, Moncadas LS, Lavanchy S, and Wüest A (2021) **Seasonality modulates wind-driven mixing pathways in a large lake.** Commun Earth Environ 2:215. https://doi.org/10.1038/s43247-021-00288-3

Minaudo C, Odermatt D, Bouffard D, Rahaghi AI, Lavanchy S and Wüest A (2021) **The Imprint of Primary Production on High-Frequency Profiles of Lake Optical Properties**. Environ Sci Technol 55:14234–14244. https://doi.org/10.1021/acs.est.1c02585

Perolo P, Fernández Castro B, Escoffier N, Lambert T, Bouffard D, and Perga M-E (2021) **Accounting for surface waves improves gas flux estimation at high wind speed in a large lake**. Earth System Dynamics 12:1169–1189. https://doi.org/10.5194/esd-12-1169-2021

Serafy GYHE, Schaeffer BA, Neely MB, Spinosa A, Odermatt D et al (2021) **Integrating inland and coastal water quality data for actionable knowledge**. Remote sensing 13:2899. https://doi.org/10.3390/rs13152899

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Rahaghi AI, Minaudo C, Damm A, Odermatt D (2021) **Optical Closure of Remote Sensing Reflectance Using Automated Hyperspectral Profiler Data**. In: 2021 IEEE International Geoscience and Remote Sensing Symposium IGARSS. pp 6832–6835.

Chmiel HE, Fernandez-Castro B, Minaudo C, Krishna S, Perolo P, Rasconi S, Wüest A, **Motion sick: How to estimate ecosystem metabolism in large and energetic lakes**. ASLO Summer meeting, June 2021 (Virtual).

Minaudo C, Odermatt D, Fernandez-Castro B, Chmiel HE, Bouffard D, Rahaghi AI, Lavanchy S, Wüest A, **Primary production inferred from high-frequency water optical properties in a large lake**. ASLO Summer meeting, June 2021 (Virtual).

Gupana RS, Odermatt D, Rahaghi AI, Minaudo C, and Damm A. **Remote sensing of fluorescence in inland waters: improvements from using hyperspectral data.** SPIE Remote Sensing Symposium, September 2021.

Minaudo C, Capelli C, Cannata M, Lepori F, **What drives primary production phenology in large mesotrophic lakes?** AIOL Congress, 30 June – 2 July 2021 (Virtual).

Piccolroaz S, Fernández-Castro B, Chmiel HE, Perolo P, Wüest A. **CO2 fluxes in a large perialpine lake modulated by near-surface stratification, internal motions and biological processes.** AIOL Congress, 30 June – 2 July 2021 (Virtual).

Odermatt D, Rahaghi AI, Runnalls J, Minaudo C. **Primary productivity monitoring in Swiss lakes using Sentinel-3**. SEFS12, 25 - 30 July 2021 (Virtual).

Carratalà A, Chappelier C, Guillaume A, Vajana E, Kohn T, Joost S. **Spatiotemporal dynamics of bacteria communities in Lake Geneva by Next-Gen amplicon sequencing**. SEFS12, 25- 30 July 2021 (Virtual).

19TH SWISS GEOSCIENCE MEETING

Oral presentations linked to LéXPLORE

Carratalà et al.: Spatiotemporal dynamics of bacteria communities in Lake Geneva.

Escoffier et al.: Fine scale dynamics of calcite precipitation in a large hardwater lake unveiled from high-frequency sensor data

Forrest et al.: Submersible probe with in-line calibration and symmetrical reference element for long-term continuous measurements

Perolo et al.: Is gross primary production carbon-limited in Lake Geneva?

Piccolroaz et al.: Near-surface convection under the combined effect of cooling and radiative heating: the case of Lake Geneva

Posters linked to LéXPLORE

Ibelings et al.: Variation in Lake Geneva seston C:P as a function of phytoplankton species identity and P-levels

Maner et al.: RAINBOWflow CHIPonline: An impedance-based biosensor for water quality monitoring using permanent fish cell lines

Many et al.: Predicting CO2 dynamics in Lake Geneva using a deep learning approach (LSTM RNN)

Pasche et al.: Temporal and spatial variations in the composition and fluxes of settling particles in Lake Geneva

OUTLOOK

Improve the LéXPLORE core dataset

In 2022, the Limnology Center plans to better highlight the potential of the LéXPLORE core dataset. Within the last three years, the collected data have reached a promising quantity, and the seed project REPRODUCE will improve the quality checks and quality control for the real-time data streams. In addition, the LIMNC plans to hire a data scientist to exploit and to integrate the multidisciplinary data from the core dataset, in order to assess the impacts of global changes in Lake Geneva.

On the infrastructure level, the Center plans to submit grants to ENAC, to buy spare instruments for the core dataset. Having two-sets of instruments will allow to remove the data gaps, due to calibrations or reparations. Since November 2021, three buoys of the safety perimeter have broken and the Center has sent call for offers to repair them in an optimized manner.

Hard winter conditions for the LéXPLORE platform, on 12th February 2021

Ensuring the transition

In 2022, Tom Battin will act as the liaison to ENAC and support the Operational Director on strategic matters. Natacha Tofield-Pasche will take over the course in Limnology, previously taught by Johny Wüest. She will also be responsible to manage the LIMNC staff. Sébastien Lavanchy and Guillaume Cunillera will continue their excellent jobs to ensure the technical operations of LéXPLORE.

ENAC will launch the procedure to hire a new professor in aquatic physics, which might hopefully be filled by 2023.