

Luca Carraro

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Current position

University of Zurich – Zurich, Switzerland

July 2022 – present Scientist (SNF Ambizione Fellow)

Unit: Department of Evolutionary Biology and Environmental Studies (IEU)

Hosted at: Department of Aquatic Ecology (ECO), Eawag, Dübendorf, Switzerland

Previous positions

University of Zurich – Zurich, Switzerland

Oct 2019 – Jun 2022 Postdoctoral Fellow

Advisor: Prof. Dr. Florian Altermatt

Unit: Department of Evolutionary Biology and Environmental Studies (IEU)

Hosted at: Department of Aquatic Ecology (ECO), Eawag, Dübendorf, Switzerland

Swiss Federal Institute of Aquatic Science and Technology (Eawag) – Dübendorf, Switzerland

Oct 2018 – Sep 2019 Postdoctoral Fellow

Advisors: Prof. Dr. Jukka Jokela, Prof. Dr. Florian Altermatt

Unit: Department of Aquatic Ecology (ECO)

École Polytechnique Fédérale de Lausanne (EPFL) – Lausanne, Switzerland

May 2018 – Sep 2018 Postdoctoral Fellow

Advisor: Prof. Dr. Andrea Rinaldo

Unit: Laboratory of Ecohydrology (ECHO)

Education

École Polytechnique Fédérale de Lausanne (EPFL) – Lausanne, Switzerland

Apr 2014 – May 2018 Ph.D., Doctoral Program in Civil and Environmental Engineering

Thesis title: *Ecohydrological and Metacommunity Studies of Proliferative Kidney Disease Spread in Freshwater Salmonid Fish (awarded with EPFL Outstanding PhD Thesis Distinction)*

Advisors: Prof. Dr. Andrea Rinaldo, Prof. Dr. Enrico Bertuzzo

Unit: Laboratory of Ecohydrology (ECHO)

University of Padua – Padua, Italy

Jan 2012 – Apr 2014 M.Sc., Civil Engineering - specialization in Hydraulics (Grade: 108/110)

Sep 2008 – Nov 2011 B.Sc., Civil Engineering (Grade: 110/110)

Publication record

Total articles: 20

Total citations: 1206*

h-index: 11*

Publications

Peer-reviewed articles

- [A20] **Carraro, L.**, Altermatt, F. (2024). eDITH: An R-package to spatially project eDNA-based biodiversity across river networks with minimal prior information. *Methods in Ecology and Evolution*. doi:10.1111/2041-210X.14317.
- [A19] **Carraro, L.** (2023). Technical note: Seamless Extraction and Analysis of River Networks in R. *Hydrology and Earth System Sciences*. doi:10.5194/hess-27-3733-2023.
- [A18] Boschman, L., **Carraro, L.**, Cassemiro, F. A. S., de Vries, J., Altermatt, F., Hagen, O., Hoorn, C., Pellissier, L., (2023). South American freshwater fish diversity shaped by Andean uplift since the Late Cretaceous. *Nature Ecology and Evolution*. doi:10.1038/s41559-023-02220-8.
- [A17] Ho, H.-C.[†], Altermatt, F., **Carraro, L.**[†] (2023). Coupled biological and hydrological processes shape spatial food-web structures in riverine metacommunities. *Frontiers in Ecology and Evolution*, 11, 1147834. doi:10.3389/fevo.2023.1147834.
- [A16] **Carraro, L.**, Blackman, R. C., Altermatt, F. (2023). Modelling eDNA transport in river networks reveals highly resolved spatio-temporal patterns of freshwater biodiversity. *Scientific Reports*, 13, 8854. doi:10.1038/s41598-023-35614-6.
- [A15] Altermatt, F., **Carraro, L.**, Antonetti, M., Albouy, C., Zhang, Y., Lyet, A., Zhang, X., Pellissier, L. (2023). Quantifying biodiversity using eDNA from water bodies: general principles and recommendations for sampling design. *Environmental DNA*. doi:10.1002/edn3.430.
- [A14] Jacquet, C.[†], **Carraro, L.**[†], Altermatt, F. (2022). Meta-ecosystem dynamics drive the spatial distribution of functional groups in river networks. *Oikos*, 2022(11), e09372. doi:10.1111/oik.09372.
- [A13] **Carraro, L.**, Altermatt, F. (2022) Optimal Channel Networks accurately model ecologically-relevant geomorphological features of branching river networks. *Communications Earth & Environment* 3, 125. doi:10.1038/s43247-022-00454-1.
- [A12] **Carraro, L.**, Stauffer, J. B., Altermatt, F. (2021). How to design optimal eDNA sampling strategies for biomonitoring in river networks. *Environmental DNA*, 3(1), 157-172. doi:10.1002/edn3.137.
- [A11] **Carraro, L.**, Mächler, E., Wüthrich, R., Altermatt, F. (2020). Environmental DNA allows upscaling spatial patterns of biodiversity in freshwater ecosystems. *Nature Communications*, 11(1), 3585. doi:10.1038/s41467-020-17337-8.
- [A10] **Carraro, L.**, Bertuzzo, E., Fronhofer, E. A., Furrer, R., Gounand, I., Rinaldo, A., Altermatt, F. (2020). Generation and application of river network analogues for use in ecology and evolution. *Ecology and Evolution*, 10(14), 7537-7550. doi:10.1002/ece3.6479.

*Verified on Scopus on Apr 9, 2024.

[†]Equally contributing authors.

- [A9] Gatto, M., Bertuzzo, E., Mari, L., Miccoli, S., **Carraro, L.**, Casagrandi, R., Rinaldo, A. (2020). Spread and dynamics of the COVID-19 epidemic in Italy: Effects of emergency containment measures. *Proceedings of the National Academy of the United States of America*, 117(19), 10484-10491. doi:10.1073/pnas.2004978117.
- [A8] **Carraro, L.**, Toffolon, M., Rinaldo, A., Bertuzzo, E. (2020). SESTET: a spatially explicit stream temperature model based on equilibrium temperature. *Hydrological Processes*, 34(2), 355-369. doi:10.1002/hyp.13591.
- [A7] González-Ferreras, A.M., Bertuzzo, E., Barquín, J., **Carraro, L.**, Alonso, C., Rinaldo, A. (2019). Effects of altered river network connectivity on the distribution of *Salmo trutta*: Insights from a metapopulation model. *Freshwater Biology*, 64(11), 1877-1895. doi:10.1111/fwb.13379.
- [A6] **Carraro, L.**, Hartikainen, H., Jokela, J., Bertuzzo, E., Rinaldo, A. (2018). Estimating species distribution and abundance in river networks using environmental DNA. *Proceedings of the National Academy of Sciences of the United States of America*, 115(46), 11724-11729. doi:10.1073/pnas.1813843115.
- [A5] **Carraro, L.**, Mari, L., Gatto, M., Rinaldo, A., Bertuzzo, E. (2018). Spread of proliferative kidney disease in fish along stream networks: A spatial metacommunity framework. *Freshwater Biology*, 63(1), 114-127. doi:10.1111/fwb.12939.
- [A4] **Carraro, L.**, Bertuzzo, E., Mari, L., Fontes, I., Hartikainen, H., Strepparava, N., Schmidt-Posthaus, H., Wahli, T., Jokela, J., Gatto, M., Rinaldo, A. (2017). Integrated field, laboratory, and theoretical study of PKD spread in a Swiss prealpine river. *Proceedings of the National Academy of Sciences of the United States of America*, 114(45), 11992-11997. doi:10.1073/pnas.1713691114.
- [A3] **Carraro, L.**, Mari, L., Hartikainen, H., Strepparava, N., Wahli, T., Jokela, J., Gatto, M., Rinaldo, A., Bertuzzo, E. (2016). An epidemiological model for proliferative kidney disease in salmonid populations. *Parasites and Vectors*, 9(1), 487. doi:10.1186/s13071-016-1759-z.
- [A2] Queloz, P.[†], **Carraro, L.**[†], Benettin, P., Botter, G., Rinaldo, A., Bertuzzo, E. (2015). Transport of fluorobenzoate tracers in a vegetated hydrologic control volume: 2. Theoretical inferences and modeling. *Water Resources Research*, 51(4), 2793-2806. doi:10.1002/2014WR016508.
- [A1] Queloz, P., Bertuzzo, E., **Carraro, L.**, Botter, G., Miglietta, F., Rao, P. S. C., Rinaldo, A. (2015). Transport of fluorobenzoate tracers in a vegetated hydrologic control volume: 1. Experimental results. *Water Resources Research*, 51(4), 2773-2792. doi:10.1002/2014WR016433.

Accepted articles

- [B2] Blackman, R. C., **Carraro, L.**, Keck, F., Altermatt, F. (2024). Measuring the state of aquatic environments using eDNA—Upscaling spatial resolution of biotic indices. *Philosophical Transactions of the Royal Society B: Biological Sciences*, in press. doi:10.1098/rstb.2023.0121.
- [B1] Blackman R. C., Couton, M., Keck, F., Kirschner, D., **Carraro, L.**, Cereghetti, E., Perrelet, K., Bossart, R., Brantschen, J., Zhang, Y., Altermatt, F. (2024). Environmental DNA: the next chapter. *Molecular Ecology*, in press. doi:10.1111/mec.17355.

[†]Equally contributing authors.

Software

- [C4] **Carraro, L.**, Altermatt F. (2023) eDITH - Model Transport of Environmental DNA in River Networks. *R Package*. Hosted on CRAN: <https://cran.r-project.org/web/packages/eDITH/index.html>.
- [C3] **Carraro, L.** (2023) rivnet - Extract and Analyze Rivers from Elevation Data. *R Package*. Hosted on CRAN: <https://cran.r-project.org/web/packages/rivnet/index.html>.
- [C2] **Carraro, L.**, Salmon, M., Sadek, W., Müller, K. (2022) traudem - Use TauDEM. *R Package*. Hosted on CRAN: <https://cran.r-project.org/web/packages/traudem/index.html>.
- [C1] **Carraro, L.**, Altermatt, F., Fronhofer, E. A., Furrer, R., Gounand, I., Rinaldo, A., Bertuzzo, R. (2019). OCNet - Generate and analyze Optimal Channel Networks. *R Package*. Hosted on CRAN: <https://cran.r-project.org/web/packages/OCNet/index.html>.

Invited seminars and talks

- [D10] **Carraro, L.** (Aug 2023). *Integrating hydrology and environmental DNA to advance monitoring of aquatic biodiversity*. eDNA4Hydro workshop, University of Bern, Switzerland.
- [D9] **Carraro, L.** (Aug 2023). *Integrating hydrology and environmental DNA to advance monitoring of aquatic biodiversity* (virtual). Molecular Ecology & Evolution Colloquium, University of Duisburg-Essen, Germany.
- [D8] **Carraro, L.** (Mar 2023). *Spatial processes shape biodiversity patterns in river networks*. IBP Seminar Series, ETH Zurich, Switzerland.
- [D7] **Carraro, L.** (Mar 2022). *Spatial processes shape biodiversity patterns in river networks*. Environmental Engineering Seminar Series, EPFL, Lausanne, Switzerland.
- [D6] **Carraro, L.** (Dec 2021). *Integrating hydrology and environmental DNA to advance monitoring of freshwater biodiversity*. (virtual) SEBES Seminar Series, University of Zurich, Switzerland.
- [D5] **Carraro, L.** (Dec 2021). *Using environmental DNA as a tracer to advance hydrological research* (virtual, invited e-poster). AGU Fall Meeting, New Orleans, USA.
- [D4] **Carraro, L.** (Mar 2021). *Spread of a disease lethal to salmonids: intertwined roles of water, vegetation and climate* (virtual talk, in Italian). XX Giornata Mondiale dell'Acqua – Acqua, vegetazione, clima: l'avvento dell'ecoidrologia. Accademia dei Lincei, Rome, Italy.
- [D3] **Carraro, L.** (May 2020). *Generating synthetic river networks and perspectives in freshwater biodiversity assessment* (webinar). Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), Birmensdorf, Switzerland.
- [D2] **Carraro, L.** (Oct 2019). *eDNA as a tool to reconstruct biodiversity patterns in river networks*. BEEES Seminar Series, University of Zurich, Zurich, Switzerland.
- [D1] **Carraro, L.** (May 2018). *Using environmental DNA to study species distributions in river networks*. Eawag, Dübendorf, Switzerland.

Conference presentations

- [E7] **Carraro, L.**, Altermatt, F., Ho, H-C. (Jun 2023). Coupled biological and hydrological processes shape spatial food-web structures in riverine metacommunities. *Biodiversity Convention - From Science to Implementation*, Ascona (Monte Verità), Switzerland.
- [E6] **Carraro, L.**, Altermatt, F., Ho, H-C. (Jun 2023). Coupled biological and hydrological processes shape spatial food-web structures in riverine metacommunities. *ASLO Aquatic Sciences Meeting*, Palma de Mallorca, Spain.
- [E5] **Carraro, L.**, Jacquet, C., Altermatt, F. (Jun 2022). Meta-ecosystem dynamics drive spatial distribution of functional groups in rivers. *World Biodiversity Forum*, Davos, Switzerland.
- [E4] **Carraro, L.**, Mächler, E., Wüthrich, R., Altermatt, F. (May 2021). Modelling environmental DNA transport and decay allows upscaling spatial patterns of biodiversity in riverine ecosystems. *Society for Freshwater Science Annual Meeting* (virtual).
- [E3] **Carraro, L.**, Hartikainen, H., Jokela, J., Rinaldo, A., Bertuzzo, E., Mächler, E., Little, C. J., Wüthrich, R., Altermatt, F. (Apr 2019). Reconstructing species distribution and abundance patterns in rivers with environmental DNA. *EGU General Assembly*, Vienna, Austria.
- [E2] **Carraro, L.**, Rinaldo, A., Toffolon, M., Bertuzzo, E. (Jun 2018). A spatially-explicit stream temperature model for ecohydrological applications. *5th IAHR Europe Congress - New Challenges in Hydraulic Research and Engineering*, Trento, Italy.
- [E1] **Carraro, L.**, Hartikainen, H., Jokela, J., Bertuzzo, E., Rinaldo, A., (Apr 2018). Using environmental DNA to study species distributions in river networks. *EGU General Assembly*, Vienna, Austria.

Conference posters

- [F7] **Carraro, L.**, Blackman, R., Altermatt, F. (Jan 2024). Coupling environmental DNA and hydrology-based modelling to advance monitoring of freshwater ecosystems. *Biology24*, Zurich, Switzerland.
- [F6] **Carraro, L.**, Blackman, R., Altermatt, F. (Jun 2022). Modelling eDNA transport in rivers reveals spatiotemporal biodiversity patterns. *World Biodiversity Forum*, Davos, Switzerland.
- [F5] **Carraro, L.**, Blackman, R., Altermatt, F. (Oct 2021). Modelling environmental DNA transport and decay reveals spatiotemporal patterns of freshwater biodiversity. *URPP Fall Symposium*, University of Zurich, Switzerland.
- [F4] **Carraro, L.**, Mächler, E., Wüthrich, R., Altermatt, F. (Feb 2020). Environmental DNA allows upscaling of spatial patterns of biodiversity in freshwater ecosystems. *World Biodiversity Forum*, Davos.
- [F3] **Carraro, L.**, Bertuzzo, E., Toffolon, M., Rinaldo, A. (Apr 2018). A spatially-explicit stream temperature model for ecohydrological applications. *EGU General Assembly*, Vienna, Austria.
- [F2] **Carraro, L.**, Bertuzzo, E., Mari, L., Gatto M., Rinaldo, A. (May 2017). A metacommunity model for the spread of proliferative kidney disease in stream networks. *Impact of Environmental Changes on Infectious Diseases*, Trieste, Italy.
- [F1] **Carraro, L.**, Bertuzzo, E., Mari, L., Gatto, M., Strepparava, N., Hartikainen, H., Rinaldo, A. (Apr 2015). An epidemic model for the interactions between thermal regime of rivers and transmission of proliferative kidney disease in salmonid fish. *EGU General Assembly*, Vienna, Austria.

Outreach

- [G4] **Carraro, L.**, (2022) The structure of dendritic river networks shapes ecological dynamics (blog post). Nature Portfolio Earth & Environment Community. <https://tinyurl.com/36yds9xr>
- [G3] **Carraro, L.**, (2020) Predicting the biodiversity of rivers (blog post). Nature Portfolio Ecology & Evolution Community. <https://tinyurl.com/3wbk5f9d>
- [G2] **Carraro, L.**, Altermatt, F., Blackman R. C. (2020) Environmental DNA reveals hidden diversity in riverine ecosystems. *Hotspot* (magazine of the Forum Biodiversität Schweiz).
- [G1] **Carraro, L.**, Mariani, D. (2020). In Italy, 200'000 hospitalizations averted thanks to lockdown. Interview with the Swiss Italian television (in Italian). <https://tinyurl.com/ybtdcsgj>.

Teaching activities

University of Zurich – Zurich, Switzerland

- 2022 – present Freshwater Environmental and Ecosystem Modelling (3 ECTS - B.Sc. in Biology)
 Role: Module leader and lecturer
- Spring 2022 Ecological Theories 2 (Course for Ph.D. students in Ecology)
 Role: Lecture on freshwater ecosystem modelling
- 2020 – 2021 Field Course in Biodiversity Assessment and Monitoring (M.Sc. in Quantitative Environmental Sciences)
 Role: Teaching assistant (support in data analysis)
- Fall 2020 Block Course in Aquatic Ecology (B.Sc. in Biology)
 Role: Teaching assistant (supervision of student project)

École Polytechnique Fédérale de Lausanne (EPFL) – Lausanne, Switzerland

- 2014 – 2018 Water Resources Engineering (M.Sc. in Environmental Sciences and Engineering)
 Role: Teaching assistant
- Spring 2017 Mathématiques 2A, 2B (B.Sc., remedial classes on linear algebra and geometry)
 Role: Teaching assistant

Mentoring and supervision

University of Zurich – Zurich, Switzerland

- 2024 – present Eva Cereghetti, postdoctoral researcher: "Assessing temporal patterns of macroinvertebrate communities in a prealpine catchment with environmental DNA" (supervisor)
- 2024 – present Jesse van Leeuwen, M.Sc. thesis: "Analyzing optimal sampling intensity for environmental DNA samples with the eDITH model" (co-supervisor; hosted at TU Delft, Netherlands)

- 2023 – present Xhesida Ajvazi, M.Sc. thesis: "Analyzing community structure of aquatic insects and producing a metacommunity model at catchment scale" (co-supervisor)
- 2022 – 2023 Qing Fu, M.Sc. thesis: "Optimizing sampling strategies coupling environmental DNA and direct organism observation" (co-supervisor)
- 2022 – present Niklas Heinemann, Ph.D. candidate: "Delineating rivers' safe operating spaces for pelagic and benthic eutrophication under non-stationary stressors: Advancing a basin-scale model for competing algal dynamics" (co-supervisor; hosted at Helmholtz Centre for Environmental Research-UFZ, Magdeburg, Germany).

Swiss Federal Institute of Aquatic Science and Technology (Eawag) – Dübendorf, Switzerland

- Summer 2019 Julian Stauffer, B.Sc. summer project: "Assessing the effectiveness of environmental DNA sampling design strategies in river networks" (co-supervisor)

École Polytechnique Fédérale de Lausanne (EPFL) – Lausanne, Switzerland

- Spring 2022 Nathan Bonnet, M.Sc. Thesis: "Investigating temporary streamflow formation in a head-water catchment of the Swiss Mentue river" (external examiner)
- Spring 2019 Pascal Arbella, M.Sc. Thesis: "Patching large missing gaps of dissolved oxygen data in an intermittent stream: comparison of interpolation techniques, including machine learning models" (external examiner)
- Spring 2017 Mattia Petar, M.Sc. Thesis: "A spatially explicit water temperature model for the river Wigger" (co-supervisor)
- Fall 2016 Charlotte Burki, M.Sc. semester project: "Water temperature modelling in the river Wigger" (co-supervisor)
- Fall 2015 Yasmin Dressler, M.Sc. semester project: "Proliferative Kidney Disease in brown trout: modelling the disease evolution in fish" (co-supervisor)

Funding

- 2021 University of Zurich Forschungskredit postdoc grant (CHF 44,154)
- 2021 Swiss National Science Foundation Ambizione grant (CHF 845,183)

Awards

- 2019 EPFL Outstanding Ph.D. Thesis Distinction in Civil and Environmental Engineering

Academic service

- 2023 – present Associate Editor at *Royal Society Open Science* (section Ecology, Conservation, and Global Change Biology)
- 2023 – present Organizer of departmental seminar series at the Department of Aquatic Ecology, Eawag (Dübendorf, Switzerland)

- 2022 Convener of session "Integrating biodiversity and ecosystem functioning in aquatic and terrestrial systems across rivers", *World Biodiversity Forum*, Davos, Switzerland
- 2021 – present 3 reviews of research projects (BiodivERsA, NFDI4Earth, DFG)
- 2019 – present 56 reviews[‡] for journals *Acta Veterinaria Scandinavica*, *Advances in Water Resources*, *Aquatic Sciences*, *Biodiversity and Conservation*, *Diversity and Distributions*, *Earth and Space Science*, *Earth Surface Processes and Landforms*, *Ecosphere*, *Environmental DNA*, *Freshwater Biology*, *Frontiers in Ecology and Evolution*, *Frontiers in Environmental Science*, *Hydrological Processes*, *Hydrology and Earth System Sciences*, *International Journal of Digital Earth*, *Journal of Hydrology*, *Methods in Ecology and Evolution*, *Molecular Ecology*, *Molecular Ecology Resources*, *Oikos*, *PLOS ONE*, *PNAS*, *Rendiconti Lincei*, *Royal Society Open Science*, *Water Research*.

Languages

Italian (native), English (C1/C2), French (B2/C1), German (A2/B1)

[‡]Verified on Web of Science on Apr 9, 2024.