Benoît Pasquier

Current affiliation

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Research Interests

My research focuses on addressing fundamental questions in oceanography using cutting-edge scientific tools.

I spend most of my time thinking about mechanisms and developing models of global marine biogeochemical cycles. In order to build useful and efficient models of these cycles, my collaborators and I must leverage advanced scientific tools and engage with diverse fields including biology, geology, physics, and, surely, mathematics and computational science. Being originally instructed as a mathematician, I strive for precision in our oceanographic enquiries and thoroughly enjoy applying mathematics to the field. For instance, past works included linear algebra, differential equations, Green functions, nonlinear phenomena, statistics, and optimization, to mention a few.

My PhD was spent deconstructing the global marine biological pump by creating accurate phosphorus-, silicon-, and iron-cycle models that were amenable to novel Green-function diagnostics. The importance of understanding the biological pump cannot be overstated because it relates directly to the amount of carbon sequestered by the ocean and thus to anthropogenic global warming. My first postdoc was dedicated to more general biogeochemistry modelling and optimization targeted at the remineralization of carbon and silicon in the ocean. During that time I became more supportive of open science and developed several open-source packages written in the Julia language that provide oceanographers with simple yet efficient new modelling tools. My current postdoc took a slight turn towards trace elements and their isotopes, including iron, cadmium, nickel, and neodymium, which provide complementary constraints and shed light on unresolved questions about the past, current, and future of the oceans.

I am fascinated by the complex interplay between ocean circulation, biology, and our climate. The unrelenting resolve of our fellow oceanographers to pursue and collect new data through large international collaborative projects has been and will be instrumental in advancing our understanding of the Earth system. The current global warming crisis makes these endeavours critical. As a mathematically inclined oceanographer, I seek to work in parallel to bring about the new concepts and mathematics that will strengthen both the science and its communication. Such progress depends on the development of new, open-source, and user-friendly scientific software that is scalable from the simplest 0-dimensional models to complex high-resolution simulations. Key to the success of these tools is composability. Combining classical simulations with state-of-the-art software for, e.g., data assimilation, parameter optimization, uncertainty analysis, Bayesian inference, and machine learning will bring about impactful breakthroughs. I hope that I can contribute to such efforts in my future appointments.

Education

2013—2017 **PhD in Applied Mathematics** University of New South Wales, Sydney, Australia

Supervisor: **Mark Holzer**. Modelling and diagnosing ocean biogeochemical cycles.
Thesis title: *The Ocean's Global Iron, Phosphorus, and Silicon Cycles: Inverse Modelling and Novel Diagnostics.*

- Global Biogeochemical Cycles, Global Biological Pump
- Ecosystem Modelling & Biogenic Transport Modelling
- Green Functions Techniques (Path Densities, Flow Rates, Time Scales)
- Nonlinear Systems, Parameter Optimization/Inverse Modelling
- Iron Control on the Global Biological Pump
- Southern Ocean Nutrient Trapping

2010 **MSc in Environmental Science** University of New South Wales, Sydney, Australia

Study of the nature of environmental problems and the methodology of their evaluation and management.

- Geophysical Fluid Dynamics (taught by **Mark Holzer**)
- Oceanography (Katrin Meissner)
- Project Management, Environmental Risk Management

2007—2008 **MSc in Finance Mathematics** Paris Dauphine + ENSAE ParisTech, Paris, France

MASEF (Mathematics of Insurance, Economics and Finance), Finance specialty.

- Stochastic Calculus, Levy Processes with Jumps
- Stochastic Differential Equations
- Numerical Methods (Monte Carlo)

2004—2007 **MSc in Mathematics & Engineering** École Polytechnique, Palaiseau, France

Pure mathematics specialization.

- Algebra, Arithmetics, Numerical Methods
- Differential Topology, Relativity
- Physics, Biology

2001—2004 **Preparatory Classes** Lycée Masséna, Nice, France

French Preparatory Classes, mathematics specialty.

- Linear Algebra, Topology, Numerical Methods
- Mechanics, Electromagnetism, Thermodynamics

Other Skills

Scientific Programming

Julia / MATLAB	**Advanced**
Python	**Competent**
R	**Casual use**
Fortran / C++ / Ruby	**Out of practice**
Java / OCaml / Pascal	**Out of practice**

Languages

French	**First language**
English	**Fluent**
Italian	**Intermediate**
Japanese	**Novice**

Professional Experience

Nov 19—Present **Postdoctoral Researcher** University of Southern California, Los Angeles, CA, USA
Global marine trace metals and isotopes modelling with **Seth John**.

Sep 17—Sep 19 **Postdoctoral Research Scholar** University of California, Irvine, CA, USA
Developed new tools for improving global biogeochemistry models with **J. Keith Moore** and **François Primeau**.

Mar 17—Aug 17 **Casual Research Assistant** University of New South Wales, Sydney, Australia
Continuing PhD work with **Mark Holzer**.

Jun 16—Dec 16 **Mathematics Tutor** University of New South Wales, Sydney, Australia
Numerical Methods and Statistics, 2nd year.

May 11—Aug 12 **Proposal Engineer** Degrémont, Suez Environnement, Sydney, Australia
Managed tendering projects for Design, Construction, Maintenance and Operation contracts. Participated in business development, liaising with potential clients, advertising on company capabilities.

Jul 08—Jun 09 **Currency Trader Assistant** Société Générale Investment Banking, Paris, France
MASEF Internship, researched new detection and calculation techniques for high frequency data used in automated arbitrage. In particular, developed algorithms to evaluate unbiased stochastic moments in real-time.

Apr 07—Jul 07 **Mathematics Research Intern** École Polytechnique, Palaiseau, France
École Polytechnique Specialty (Mathematics) Internship at the Laurent Schwartz Mathematics Center under the direction of **Jean Lannes**. Calculated the Witt ring of quadratic forms defined on number fields, on the field of p-adic numbers, and on Dedekind rings such as the integers.

Sep 04—Feb 05 **IT Intern** Bioforce, Lyon, France
Bioforce provides training and careers advice in aid programmes and logistics. Developed an Access database to improve communication and management.

References

Seth John
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François Primeau
Department of Earth System Science
University of California, Irvine
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J. Keith Moore
Department of Earth System Science
University of California, Irvine
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Publications

[1] Microbial controls on the marine cadmium cycle
Seth John, Benoît Pasquier
in preparation *(2021)*

[2] Disentangling the marine neodymium cycle: insights from a data-driven modeling approach
Sophie Hines, Benoît Pasquier, Hengdi Liang, Yingzhe Wu, Seth John, Steven Goldstein
in preparation *(2021)*

[3] AIBECS.jl: The ideal tool for exploring global marine biogeochemical cycles
Benoît Pasquier, François Primeau
in preparation *(2021)*

[4] The F-1 algorithm for efficient computation of the Hessian matrix of an objective function defined implicitly by the solution of a steady-state problem
Benoît Pasquier, François Primeau
in preparation *(2021)*

[5] A new metric of the biological carbon pump: number of pump passages and its control on atmospheric pCO_2
Mark Holzer Eun Young Kwon, Benoit Pasquier
Global Biogeochemical Cycles, under review *(2021)*

[6] Evaluating the benefits of Bayesian hierarchical methods for analyzing heterogeneous environmental datasets: a case study of marine organic carbon fluxes
Gregory L. Britten, Yara Mohajerani, Louis Primeau, Murat Aydin, Catherine Garcia, Wei-Lei Wang, Benoît Pasquier, B. B. Cael, François W. Primeau
Frontiers in Environmental Science *9 (2021) p. 28* DOI: 10.3389/fenvs.2021.491636

[7] Perspective on identifying and characterizing the processes controlling iron speciation and residence time at the atmosphere-ocean interface
Nicholas Meskhidze, Christoph Völker, Hind A. Al-Abadleh, Katherine Barbeau, Matthieu Bressac, Clifton Buck, Randelle M. Bundy, Peter Croot, Yan Feng, Akinori Ito, Anne M. Johansen, William M. Landing, Jingqiu Mao, Stelios Myriokefalitakis, Daniel Ohnemus, Benoît Pasquier, Ying Ye
Marine Chemistry *217 (2019) p. 103704* DOI: 10.1016/j.marchem.2019.103704

[8] Diatom Physiology Controls Silicic Acid Leakage in Response to Iron Fertilization
Mark Holzer, Benoit Pasquier, Timothy DeVries, Mark Brzezinski
Global Biogeochemical Cycles *33.12 (2019) pp. 1631–1653* DOI: 10.1029/2019GB006460

[9] The number of past and future regenerations of iron in the ocean and its intrinsic fertilization efficiency
Benoît Pasquier, Mark Holzer
Biogeosciences *15.23 (2018) pp. 7177–7203* DOI: 10.5194/bg-15-7177-2018

[10] Inverse-model estimates of the ocean's coupled phosphorus, silicon, and iron cycles
Benoît Pasquier, Mark Holzer
Biogeosciences *14.18 (2017) pp. 4125–4159* DOI: 10.5194/bg-14-4125-2017

[11] The age of iron and iron source attribution in the ocean
Mark Holzer, Marina Frants, Benoît Pasquier
Global Biogeochemical Cycles *30.10 (2016) pp. 1454–1474* DOI: 10.1002/2016GB005418

[12] The plumbing of the global biological pump: Efficiency control through leaks, pathways, and time scales
Benoît Pasquier, Mark Holzer
Journal of Geophysical Research: Oceans *121.8 (2016) pp. 6367–6388* DOI: 10.1002/2016JC011821

Talks and Posters

[1] AIBECS.jl: the ideal tool for marine biogeochemistry modelling
Benoît Pasquier, François Primeau
Ocean Sciences Meeting, 2020, San Diego Convention Center, San Diego, California, USA

[2] F-1 algorithm: Efficient differentiation through large steady-state problems
Benoî Pasquier, François Primeau
Applied Maths Seminar, 2019, School of Mathematics and Statistics, UNSW, Australia

[3] Introducing AIBECS.jl, a Julia package for creating global marine biogeochemistry models
Benoî Pasquier, François Primeau, J. Keith Moore
Applied Maths Seminar, 2019, Climate Change Research Centre (CCRC), UNSW, Australia

[4] The number of past and future regenerations of iron in the ocean and its intrinsic fertilization efficiency
Benoît Pasquier, Mark Holzer
Michael Follows Group Meeting, 2019, MIT, USA

[5] Developing a new, open-source, user-friendly, fast, modular, global marine biogeochemistry model (in Julia)
Benoît Pasquier
Sack-lunch seminar, 2019, MIT, USA

[6] Offline parameter optimization for global marine biogeochemical models
Benoît Pasquier
François Primeau Group Meeting, 2018, University of California, Irvine, USA

[7] Inverse-model estimates of the ocean's coupled phosphorus, silicon, and iron cycles.
Benoît Pasquier, Mark Holzer
Ocean Sciences Meeting, 2018, Portland, Oregon, USA

[8] The efficiency of different iron sources in supporting the ocean's global biological pump
Benoît Pasquier, Mark Holzer
Half-baked seminar, Department of Earth System Science, 2017, University of California, Irvine, USA

[9] Response of the biological pump to perturbations in the iron supply: Global teleconnections diagnosed using an inverse model of the coupled phosphorus-silicon-iron nutrient cycles
Benoît Pasquier, Mark Holzer
AMOS National Conference, 2017, Canberra, Australia

[10] Exploring iron control on global productivity: "FePSi", an inverse model of the ocean's coupled phosphate, silicon and iron cycles
Benoît Pasquier, Mark Holzer
Postgrad Conference, 2016, Sydney, Australia

[11] Iron control on global productivity: an efficient inverse model of the ocean's coupled phosphate, silicon, and iron cycles
Benoît Pasquier, Mark Holzer

Ocean Sciences Meeting, 2016, New Orleans, Louisiana, USA

[12] The plumbing of the global biological pump
Benoît Pasquier, Mark Holzer
AMOS National Conference, 2015, Brisbane, Australia

[13] An efficient inverse model of the ocean's coupled nutrient cycles
Benoît Pasquier, Mark Holzer
Postgrad Conference, 2015, Sydney, Australia

[14] Plumbing of the biological pump
Benoît Pasquier, Mark Holzer
Postgrad Conference, 2014, Sydney, Australia

Honors and Awards

2015 **Scholarship** — Cuomo Foundation, Monaco

2014 **Scholarship** — Frères Louis et Max Principale Foundation, Monaco

2014 - 2016 **Scholarship** — Monaco Government, Monaco
Higher studies scholarship

2013 **Scholarship** — Monaco Government, Monaco
H.S.H. The Prince Albert II Exceptional Scholarship

2013 - 2016 **Scholarship** — Monaco Scientific Centre, Monaco

2013 - 2016 **Tuition Fee Scholarship** — Graduate Research Shcool, UNSW, Sydney, Australia

2004 - 2008 **Scholarship** — Monaco Government, Monaco
Higher studies scholarship

Open-source scientific software packages

Owner **AIBECS.jl** https://github.com/JuliaOcean/AIBECS.jl
The ideal tool for exploring global marine biogeochemical cycles.

Owner **F1Method.jl** https://github.com/briochemc/F1Method.jl
Efficient quasi-auto-differentiation of an objective function defined implicitly by the solution of a steady-state problem.

Collaborator **UnitfulRecipes.jl** https://github.com/briochemc/UnitfulRecipes.jl
Plotting data with units seamlessly in Julia.

Owner **Inpaintings.jl** https://github.com/briochemc/Inpaintings.jl
Julia version of MATLAB's `inpaint_nans`.

Owner **WorldOceanAtlasTools.jl** https://github.com/briochemc/WorldOceanAtlasTools.jl
Downloading and using data from the World Ocean Atlas (WOA) database.

Owner **OceanographyCruises.jl** https://github.com/briochemc/OceanographyCruises.jl
An interface for dealing with oceanographic cruises data.

Contributor **GeoStats.jl** https://github.com/JuliaEarth/GeoStats.jl
Comprehensive framework for geostatistics (or spatial statistics).

Owner **OceanGrids.jl** https://github.com/briochemc/OceanGrids.jl
Standard format of grids for AIBECS.

Owner **OceanBasins.jl** https://github.com/briochemc/OceanBasins.jl
Programmatically determine which ocean basin a (lat,lon) coordinate is in.

Owner **GEOTRACES.jl** https://github.com/briochemc/GEOTRACES.jl
A package for reading and using GEOTRACES data in Julia.

Collaborator **HyperDualNumbers.jl** https://github.com/JuliaDiff/HyperDualNumbers.jl
Julia implementation of HyperDualNumbers.

Owner **DualMatrixTools.jl** https://github.com/briochemc/DualMatrixTools.jl
Efficiently solve dual-valued linear systems.

Owner **HyperDualMatrixTools.jl** https://github.com/briochemc/HyperDualMatrixTools.jl
Efficiently solve hyperdual-valued linear systems.

Owner **BlockDiagonalFactors.jl** https://github.com/briochemc/BlockDiagonalFactors.jl
Efficiently solve linear block-diagonal systems with repeated blocks.

Contributor **Plots.jl** https://github.com/JuliaPlots/Plots.jl
Powerful convenience for Julia visualizations and data analysis.

Contributor **Unitful.jl** https://github.com/PainterQubits/Unitful.jl
Julia package for physical units.

Contributor **UnitfulMoles.jl** https://github.com/briochemc/UnitfulMoles.jl
A set of predefined conventional elemental mol units.

Contributor **Distributions.jl** https://github.com/JuliaStats/Distributions.jl
A Julia package for probability distributions and associated functions.

Contributor **DiffEqBase.jl** https://github.com/SciML/DiffEqBase.jl
DiffEqBase.jl is a component package in the DiffEq ecosystem.

Contributor **SciMLBase.jl** https://github.com/SciML/SciMLBase.jl
The Base interface of the SciML ecosystem.

Contributor **DiffEqOperators.jl** https://github.com/SciML/DiffEqOperators.jl
Linear operators for discretizations of differential equations and scientific machine learning (SciML).

Contributor	**Interpolations.jl**	https://github.com/JuliaMath/Interpolations.jl
	Fast, continuous interpolation of discrete datasets in Julia.	
Contributor	**RecipesBase.jl**	https://github.com/JuliaPlots/RecipesBase.jl
	Base package for defining transformation recipes on user types for Plots.jl	
Contributor	**CMAP.jl**	https://github.com/simonscmap/CMAP.jl
	Simons CMAP Julia client.	
Contributor	**InverseDistanceWeighting.jl**	https://github.com/juliohm/InverseDistanceWeighting.jl
	Inverse distance estimation solver for the GeoStats.jl framework.	
Owner	**Earth2014.jl**	https://github.com/briochemc/Earth2014.jl
	Download topographic data for the globe.	