# Benoît Pasquier

## Current affiliation

Research Associate
School of Mathematics and Statistics
The University of New South Wales
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## Contact

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# Research Interests

My work sits at the forefront of ocean sciences using cutting-edge mathematical and numerical tools.

I spend most of my time thinking about the fascinating mechanisms that drive the cycles of carbon, nutrients, and oxygen in the global ocean. To improve our understanding, I build numerical models of tracers in the ocean. This requires engaging with a diverse range of research fields including biology, geology, chemistry, and physics, and deep knowledge of advanced mathematical and computational tools rooted in linear algebra, differential equations, Green functions, nonlinear phenomena, statistics, and optimisation, to mention a few. My education as a mathematician and engineer helps me to develop new ideas and methods to tackle challenging questions in ocean sciences.

My PhD at UNSW was spent studying the global marine cycles of nutrients and iron, which control the ocean's fertility and the "biological pump". This is a critically important area of research as these nutrients sustain all life in the ocean and their cycles are predicted to respond dramatically to climate change. My first postdoc at UCI expanded on this research and was dedicated to biogeochemistry modelling and optimisation. During that time I also developed several open-source packages that provide researchers and students with effective tools for investigating global marine biogeochemical cycles. For my second postdoc, I focused on trace elements and their isotopes, such as nickel, neodymium, cadmium, and iron, which provide complementary constraints and shed light on unresolved questions about the past, current, and future of the oceans. In my current position at UNSW, I have been working on the response of the biological pump and the response of the oxygen cycle to climate change. Understanding the oxygen cycle is another critical issue because the warming climate is driving the ocean to lose its oxygen, which is essential for most marine life, with direct impacts for global food security.

I firmly believe that scientists have a duty to make sure we understand our environment well enough to prepare for its abrupt change and prevent the worst outcomes. I commend my fellow sea-going oceanographers, who play a crucial role in this pursuit by providing us with an ever-growing set of observational data. As a mathematically inclined oceanographer, I am committed to contribute to that endeavour by putting all my energy towards answering the critical science questions posed by our changing environment and towards educating the next generation of scientists that will eventually take over. Despite my expertise, which continuously exposes me to the grim outlook of climate change, I am regularly amazed by the scientific discoveries that we make and the positive outcomes that we can achieve. I remain scientifically fascinated by the complex interplay between the ocean, biology, and climate, and I look forward to making a difference by working alongside wonderful collaborators.

# Education

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

Thesis title: *The Ocean's Global Iron, Phosphorus, and Silicon Cycles: Inverse Modelling and Novel Diagnostics.*

Supervisor: A/Prof. Mark Holzer.

- Global Biogeochemical Cycles, Global Biological Pump
- Ecosystem Modelling & Biogenic Transport Modelling
- Green Functions Techniques (Path Densities, Flow Rates, Time Scales)
- Nonlinear Systems, Parameter Optimisation/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
- Oceanography
- 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 speciality.

Supervisor: Prof. Bruno Bouchard.

- 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 specialisation.

- Algebra, Arithmetic, Numerical Methods, Computer Science
- Differential Topology, Relativity
- Physics, Biology

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

French Preparatory Classes, mathematics speciality.

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

# Professional Experience

**Oct 21—Present** **Research Associate** University of New South Wales, Sydney, Australia
Response of the ocean's carbon and oxygen cycles to climate change.
Supervisor: A/Prof. Mark Holzer.

**Nov 19—Oct 21** **Postdoctoral Researcher** University of Southern California, Los Angeles, CA, USA
Global marine trace metals and isotopes modelling.
Supervisor: A/Prof. Seth John.

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

**Mar 17—Aug 17** **Casual Research Assistant** University of New South Wales, Sydney, Australia
Continuing PhD work.
Supervisor: A/Prof. Mark Holzer.

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

**May 11—Aug 12** **Proposal Engineer** Degrémont, Suez Environnement, Sydney, Australia
Tendering project management for design, construction, maintenance, and operational contracts. Business development, liaison with clients, advertising on company capabilities.

**Jul 08—Jun 09** **Forex Trader Assistant** Société Générale Investment Banking, Paris, France
MASEF Internship in foreign exchange market (Forex). Research into new detection and calculation techniques for high frequency data used in automated arbitrage. Development of algorithms for evaluating unbiased stochastic moments in real-time.
Supervisors: Prof. Bruno Bouchard and Dr. Nicolas Boitout.

**Apr 07—Jul 07** **Mathematics Research Intern** École Polytechnique, Palaiseau, France
École Polytechnique Speciality (Mathematics) Internship at the Laurent Schwartz Mathematics Centre (CMLS). 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.
Supervisor: Prof. Jean Lannes.

**Sep 04—Feb 05** **IT Intern** Bioforce, Lyon, France
Development of an ACCESS database to improve communication and management of Bioforce, which provides training and career advice in aid programs and logistics.

**Jul 06—Jul 06** **Assembly Line Worker (Internship)** Mecaplast, Monaco
École Polytechnique Industrial Placement.

# References

## Supervisors

**A/Prof. Mark Holzer**
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Department of Applied Mathematics
School of Mathematics and Statistics
University of New South Wales
NSW, 2035, Australia

**A/Prof. Seth G. John**
sethjohn@usc.edu
Department of Earth Sciences
University of Southern California
Los Angeles, California, USA

**Prof. François W. Primeau**
fprimeau@uci.edu
Department of Earth System Science
University of California, Irvine
Irvine, California, USA

**Prof. J. Keith Moore**
jkmoore@uci.edu
Department of Earth System Science
University of California, Irvine
Irvine, California, USA

## Collaborators

**Dr. Richard J. Matear**
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Climate Science Centre, Environment
CSIRO
Hobart, Tasmania, Australia

**Dr. Matthew A. Chamberlain**
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Environment
CSIRO
Hobart, Tasmania, Australia

**Dr. Sophie K. V. Hines**
shines@whoi.edu
Marine Chemistry and Geochemistry
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts, USA

**Dr. Gregory L. Britten**
gregory.britten@whoi.edu
Population and Ecosystem Modelling Lab
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts, USA

# Publications

[1] Deoxygenation and its drivers analyzed in steady state for perpetually slower and warmer oceans
**Benoît Pasquier**, Mark Holzer, Matthew A. Chamberlain, Richard J. Matear, Nathaniel L. Bindoff
Journal of Geophysical Research: Oceans *(under review)*

[2] The biological and preformed carbon pumps in perpetually slower and warmer oceans
**Benoît Pasquier**, Mark Holzer, Matthew A. Chamberlain
Biogeosciences *(in press)*                                    DOI: 10.5194/egusphere-2023-2525

[3] Biogeochemical Fluxes of Nickel in the Global Oceans Inferred From a Diagnostic Model
Seth G. John, Hengdi Liang, **Benoît Pasquier**, Mark Holzer, Sam Silva
Global Biogeochemical Cycles *38.5 (2024) e2023GB008018*         DOI: 10.1029/2023GB008018

[4] Atmospheric pCO2 Response to Stimulated Organic Carbon Export: Sensitivity Patterns and Timescales
Mark Holzer, Tim DeVries, **Benoît Pasquier**
Geophysical Research Letters *51.12 (2024) e2024GL108462*        DOI: 10.1029/2024GL108462

[5] Optimal Parameters for the Ocean's Nutrient, Carbon, and Oxygen Cycles Compensate for Circulation Biases but Replumb the Biological Pump
**Benoît Pasquier**, Mark Holzer, Matthew A. Chamberlain, Richard J. Matear, Nathaniel. L. Bindoff, François. W. Primeau
Biogeosciences *20.14 (2023) pp. 2985–3009*                                        DOI: 10.5194/bg-20-2985-2023

[6] The Biogeochemical Balance of Oceanic Nickel Cycling
Seth G. John, Rachel L. Kelly, Xiaopeng Bian, Feixue Fu, M. Isabel Smith, Nathan T. Lanning, Hengdi Liang, **Benoît Pasquier**, Emily A. Seelen, Mark Holzer, Laura Wasylenki, Tim M. Conway, Jessica N. Fitzsimmons, David A. Hutchins, Shun-Chung Yang
Nature Geoscience *15.11 (2022) pp. 906–912. Nature Publishing Group*            DOI: 10.1038/s41561-022-01045-7

[7] AIBECS.Jl: A Tool for Exploring Global Marine Biogeochemical Cycles.
**Benoît Pasquier**, François W. Primeau, Seth G. John
Journal of Open Source Software *7.69 (2022) p. 3814*                              DOI: 10.21105/joss.03814

[8] GNOM v1.0: An Optimized Steady-State Model of the Modern Marine Neodymium Cycle
**Benoît Pasquier**, Sophia K. V. Hines, Hengdi Liang, Yingzhe Wu, Steven L. Goldstein, Seth G. John
Geoscientific Model Development *15.11 (2022) pp. 4625–4656*                       DOI: 10.5194/gmd-15-4625-2022

[9] A New Metric of the Biological Carbon Pump: Number of Pump Passages and Its Control on Atmospheric pCO2
Mark Holzer, Eun Young Kwon, **Benoît Pasquier**
Global Biogeochemical Cycles *35.6 (2021) e2020GB006863*                          DOI: 10.1029/2020GB006863

[10] 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

[11] 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

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

[13] 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

[14] 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

[15] The age of iron and iron source attribution in the ocean
Mark Holzer, Marina Frants, **Benoît Pasquier**

[16]  The plumbing of the global biological pump: Efficiency control through leaks, pathways, and time scales
**Benoît Pasquier**, Mark Holzer

# Talks and Posters

[1]  The Ocean's Carbon and Oxygen Cycles in Future Steady-State Climate Scenarios
**Benoît Pasquier**, Mark Holzer, Matthew A. Chamberlain, Richard J. Matear, Nathaniel L. Bindoff, François W. Primeau
*Ocean Sciences Meeting*, 2024, New Orleans, Louisiana, USA

[2]  Optimal parameters for the ocean's nutrient, carbon, and oxygen cycles compensate for circulation biases but replumb the biological pump
**Benoît Pasquier**, Mark Holzer, Matthew A. Chamberlain, Richard J. Matear, Nathaniel L. Bindoff, François W. Primeau
*AMOS National Conference*, 2024, Canberra, Australia

[3]  PCO2: A simple biogeochemistry model embedded in a simple ocean circulation model in matrix form
**Benoît Pasquier**
*UNSW Ocean Research Carnival*, 2023, UNSW, Sydney, Australia

[4]  Modeling Marine Ecosystems At Multiple Scales Using Julia
Gaël Forget, **Benoît Pasquier**, Zhen Wu
*JuliaCon*, 2021, Online

[5]  Julia users and tools for oceanography
Gaël Forget, **Benoît Pasquier**, Alexander Barth, Milan Klöwer, Ali Ramadan, Gregory L. Wagner, Constantinou Navid
*Ocean Sciences Meeting*, 2020, San Diego Convention Center, San Diego, California, USA

[6]  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

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

[8]  Introducing AIBECS.jl, a Julia package for creating global marine biogeochemistry models
**Benoît Pasquier**, François Primeau, J. Keith Moore
*CCRC Seminars*, 2019, Climate Change Research Centre (CCRC), UNSW, Australia

[9]  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

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

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

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

[13] 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

[14] 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

[15] 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

[16] 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

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

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

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

# Honors and Awards

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|---|---|---|
| 2021 | **Outstanding Review** | AGU Global Biogeochemical Cycles editors |
| | https://eos.org/agu-news/in-appreciation-of-agus-outstanding-reviewers-of-2021 | |
| 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 School, UNSW, Sydney, Australia |
| 2004 - 2008 | **Scholarship** | Monaco Government, Monaco |
| | Higher studies scholarship | |

# Skills

### Programming

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|---|---|
| Julia / MATLAB | Expert |
| Python / LaTeX | Advanced |
| HPC / Shell scripting / HTML | Competent |
| Mathematica / Maple / SageMath | Competent |
| FORTRAN / C++ / Ruby / R | Out of practice |

### Languages

| | |
|---|---|
| French / English | Fluent |
| Italian | Intermediate |
| Japanese | Novice |

# Open-source scientific software contributions

| Owner | AIBECS.jl | https://github.com/JuliaOcean/AIBECS.jl |
|---|---|---|
| | The ideal tool for exploring global marine biogeochemical cycles. | |
| Owner | GNOM | https://github.com/MTEL-USC/GNOM |
| | An optimized steady-state model of the modern global marine neodymium cycle. | |
| 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 | latexdiff | https://github.com/ftilmann/latexdiff |
| | Compares two latex files and marks up significant differences between them. | |

| | | |
|---|---|---|
| Contributor | **YAXArrays.jl** | https://github.com/JuliaDataCubes/YAXArrays.jl |
| | Yet Another XArray-like Julia package. | |
| Contributor | **cmap** | https://github.com/tsipkens/cmap |
| | Perceptually uniform colormaps for MATLAB, compiled from multiple sources. | |
| Contributor | **Makie.jl** | https://github.com/MakieOrg/Makie.jl |
| | Interactive data visualisations and plotting in Julia. | |
| Contributor | **offsetaxis-pkg** | https://github.com/kakearney/offsetaxis-pkg |
| | OFFSETAXIS Add an x- or y-axis offset from the plotted axis area (MATLAB). | |
| 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 visualisations 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.