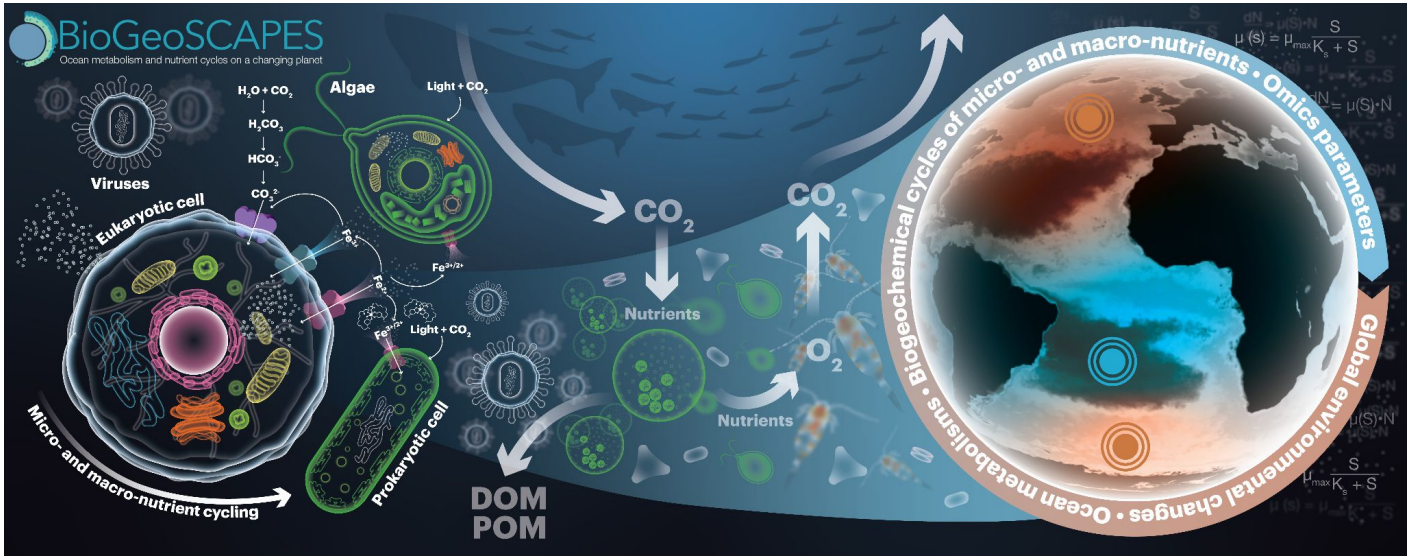
BioGeoSCAPES Program Development Update

BioGeoSCAPES
Ocean metabolism and nutrient cycles on a changing planet

NSF

Ocean Metabolism – at the heart of our planetary system

BioGeoSCAPES
Ocean metabolism and nutrient cycles on a changing planet



Vision: to understand how the collective microbial biochemical reactions and processes shape biogeochemical cycles, as well as influence and response to unprecedented rates of complex global change

Why? To constrain biological and chemical feedbacks on a changing planet

What is BioGeoSCAPES?

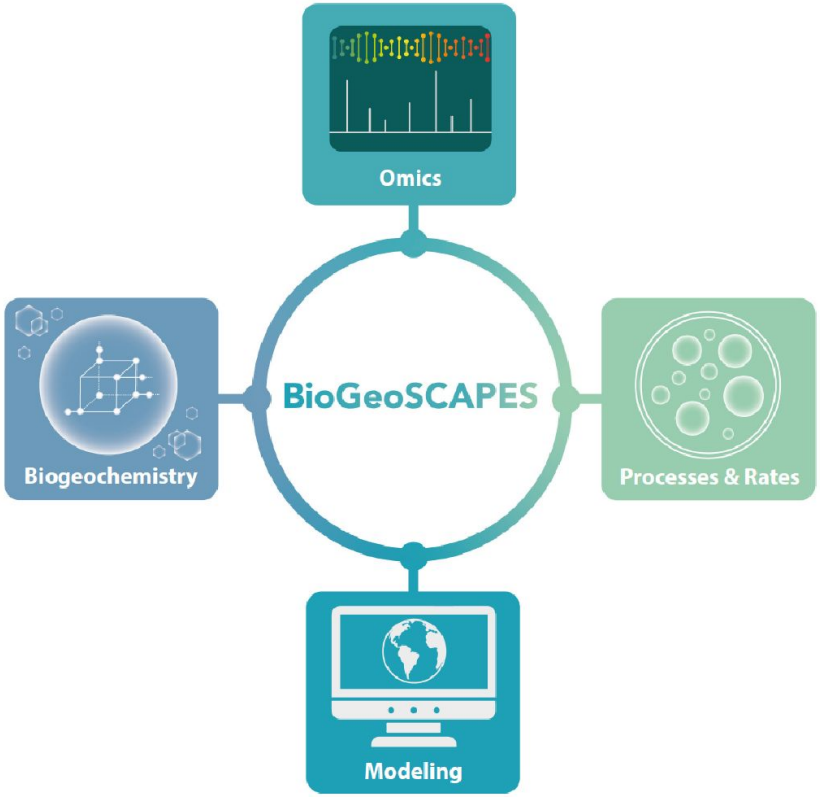
A global-scale research program: future SCOR Large-Scale Research Program

Combine interdisciplinary (bio)-analytical capabilities, physiology, biogeochemistry & computational biology and ocean biogeochemical modeling

Multiple scales of investigation: Including regional process studies, ocean basin-scale transects, time-series, laboratory and computational studies

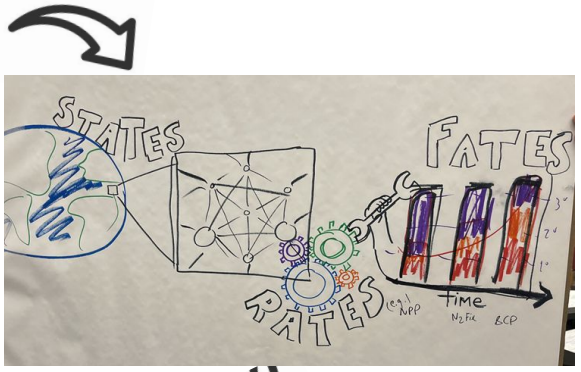
Underpinned by intercalibration efforts and interoperable data standards to create an international interoperable data system

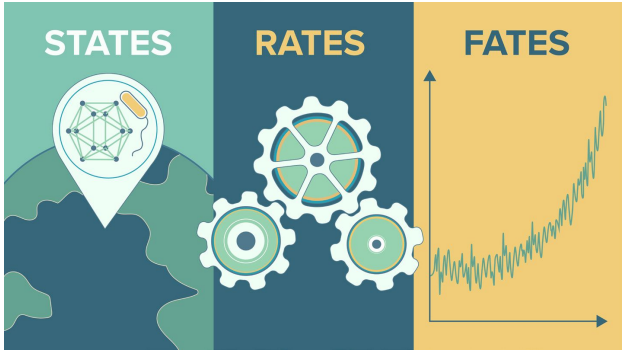
Open Community: Self-identifying and encourage bottom-up initiatives and engagement



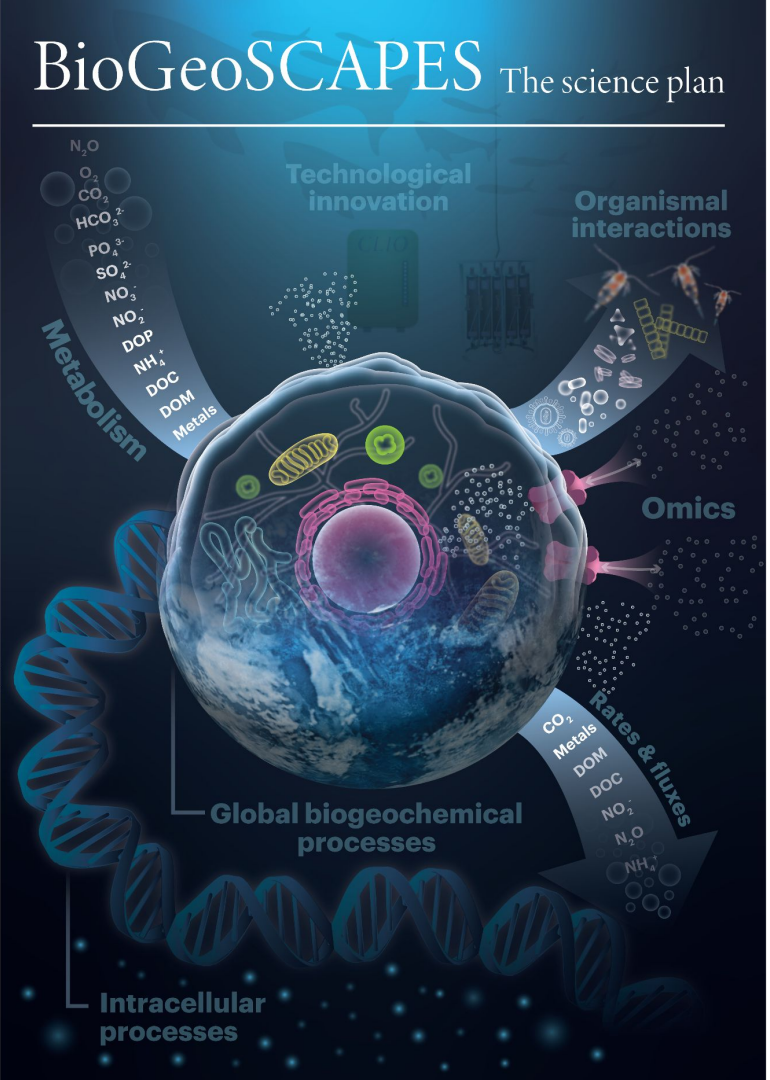
Interdisciplinary by definition

International Science Planning Workshop November 2023





November 2023: 72 in-person and 90 virtual participants brainstormed their visions for BioGeoSCAPES and developed the States, Rates and Fates framework during the three-day workshop



The Science Plan

- 56 authors from 17 countries
- Opportunities for feedback extended to 225+ researchers
- Six sections:
  - Executive Summary
  - Introduction
  - Research Themes 1-3 (States, Rates, Fates); 12 authors each
  - Implementation (Authored by 21-person International Implementation Committee)
- Audience: primarily for scientific community to learn how to engage and collaborate in project

Science Plan Research Themes

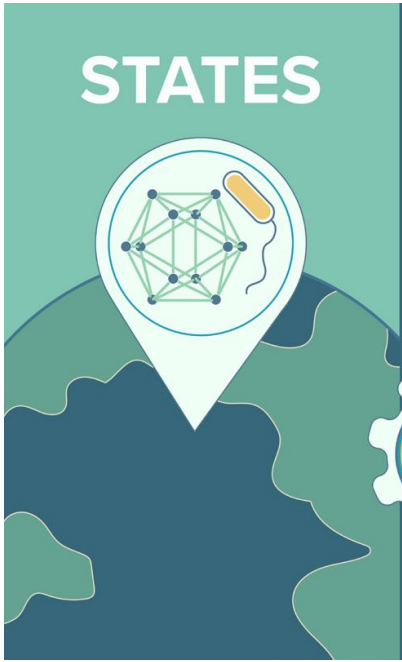
Theme 1: States

Ocean Environments: coastal environments, euphotic zone, mesopelagic and deep ocean, time dimension

The Chemical Environment: Macronutrients, micronutrients, carbon: inorganic, DOC, and metabolites

Key Organismal Environments - Taxonomic and Functional Classifications: Phototrophic microbes, Heterotrophic microbes, Diazotrophs, Chemoautotrophic microbes, Eukaryotic mixoplankton, Nano/microzooplankton and Metazoans, Viruses, Microbial interactions

Convert organismal knowledge into trait-based knowledge to biogeochemical relevant tracers



Science Plan Research Themes

Theme 2: Rates

Primary Productivity

Macronutrient Cycles and Microbes

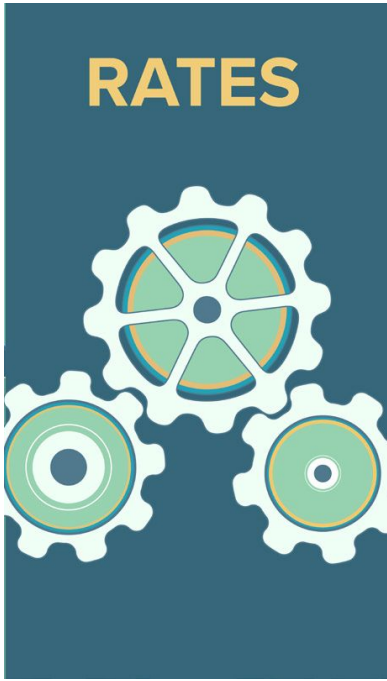
Trace Metal Cycles and Microbes

Connecting the global ocean oxygen inventory to microbial activity

Connecting organic geochemistry to biological processes

Using enzymes to quantify microbial processes in the ocean

Modeling microbial metabolisms and biogeochemical connections



Science Plan Research Themes

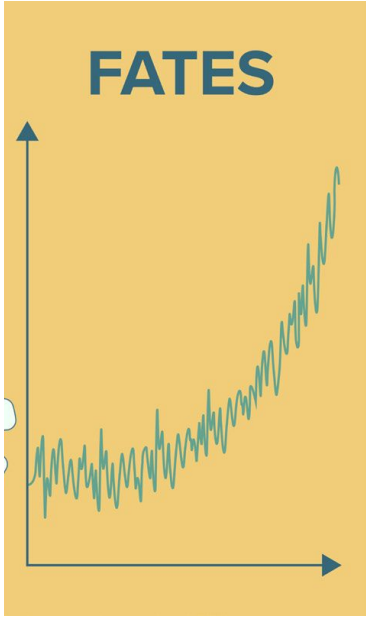
Theme 3: Fates

Numerical modeling approaches for assessing the fate of key ocean metabolisms in response to global change

Mechanisms of microbial acclimation and adaptation to global change

Role of functional and biological diversity in the face of global change

Implications of microbial and biogeochemical system changes and feedbacks



The Science Plan Review Process

- Cross-review of chapters by Theme and Implementation authors (April 2025)
- Feedback from participants of 2023 Science Plan workshop (~150 people), National Ambassadors, and others incorporated (October 2025)
- Full plan draft submitted to SCOR in October of 2025; 6 reviews and co-chair summary received in January 2026
- Plan in revision for final approval, publication this spring.

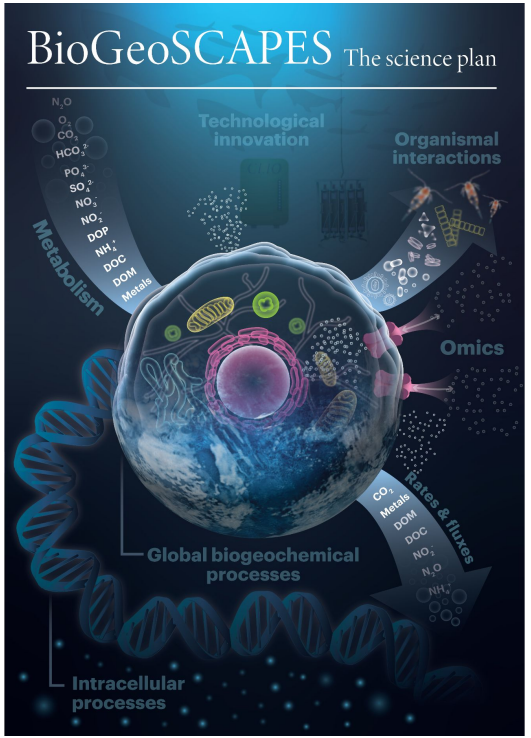
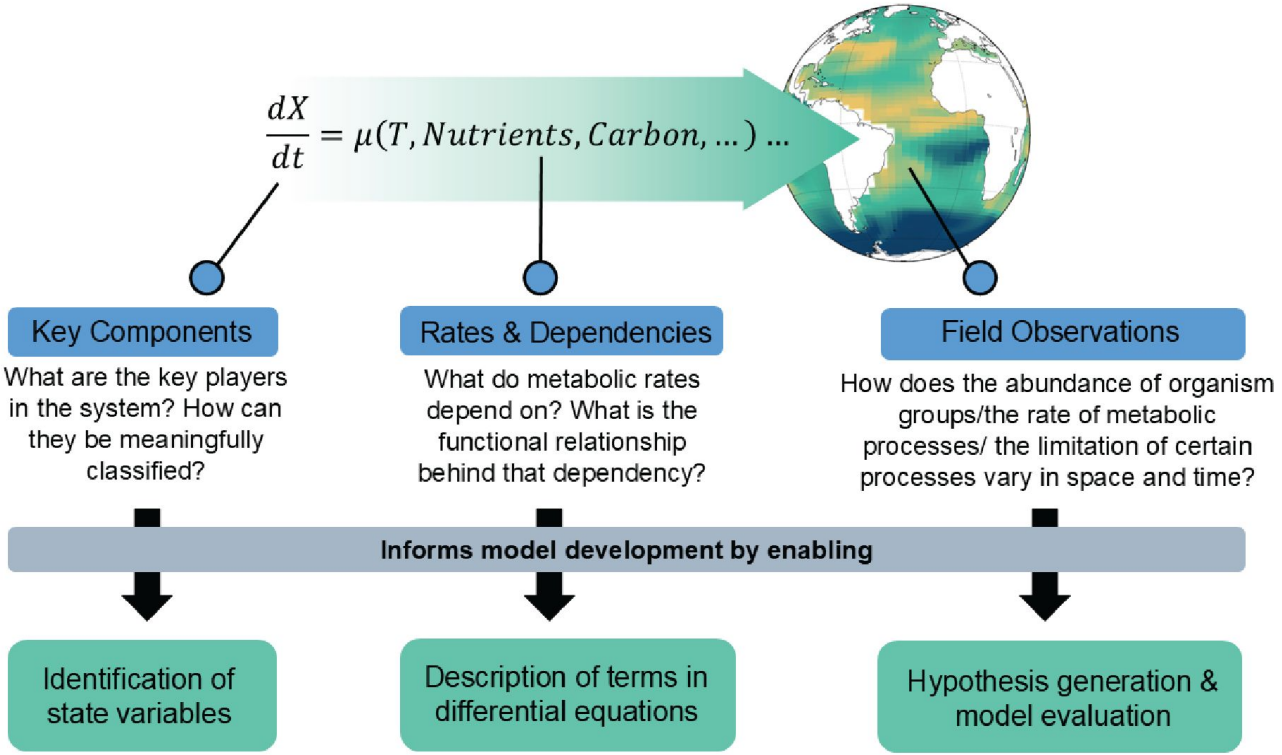


Image credit: Ichiko Sugiyama

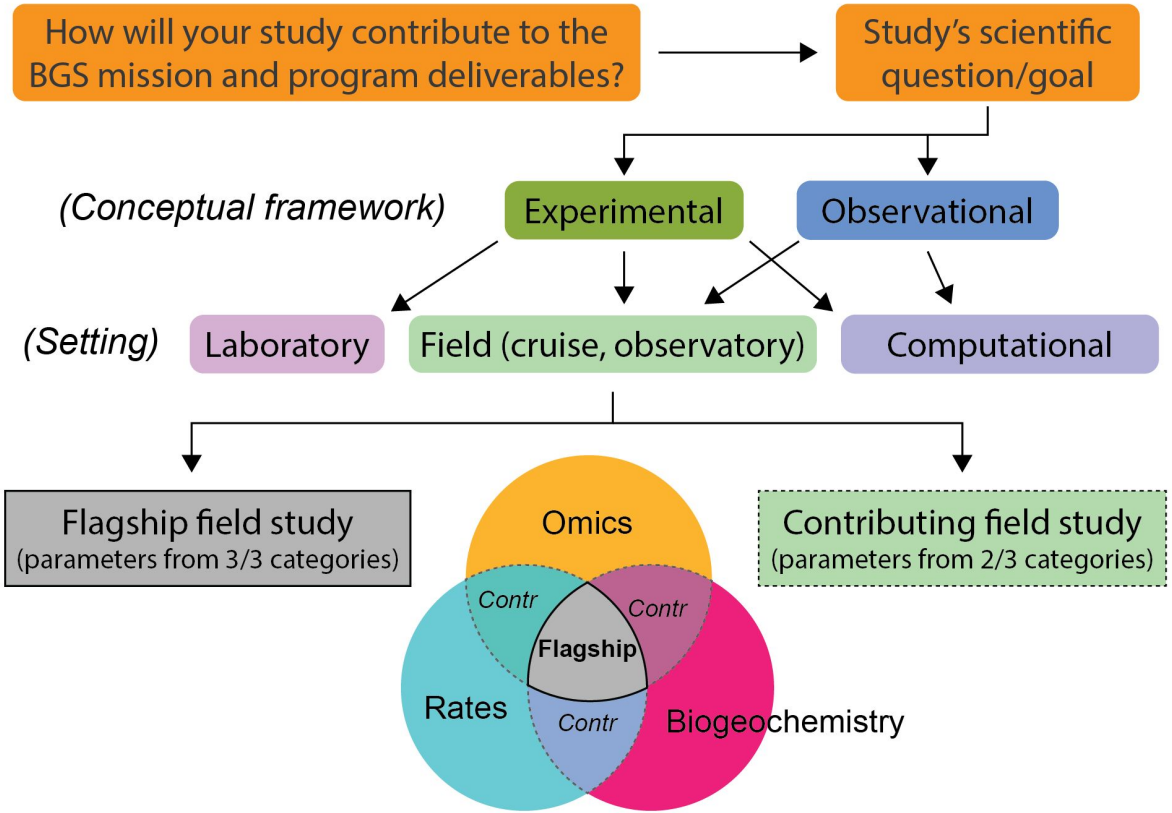
Conceptual BiogeoSCAPES Framework

Field and lab-based experiments and observations (omics, biogeochemical & physical) inform Earth system model developments for synthesis & prediction



Science Plan - Chapter 5: Implementation, Figure credit: Sinikka Lennartz

BioGeoSCAPES Flagship and Contributing Studies



Science Plan - Chapter 5: Implementation, Figure Credit: Shane Hogle

BioGeoSCAPES Major Deliverables & Legacy

Major deliverables

- Improved understanding & modelling of biogeochemical cycles
- 4D maps of key microbial metabolisms and their drivers
  - assess rates of change across different scales
  - contribute to global ocean monitoring co-design frameworks
- Risk and vulnerability assessments
  - directly informing international climate and biodiversity policies
  - supporting the design and implementation of climate-smart MPAs

Legacy

- New generation of interdisciplinary scientists
- Intercalibration studies and production of analytical standards
- International interoperable informatics and data management capabilities
- Example of how diverse scientific fields and researchers can collaborate to address complex challenges

Intercomparisons & Bringing communities together

- **OCB Ocean nucleic acids 'omics intercalibration and standardization workshop**
  https://www.us-ocb.org/ocean-nucleic-acids-omics-workshop/

- **DOM Intercomparison**
  https://pubs.acs.org/doi/10.1021/acs.est.5c12691

BIOGEOCHEMICAL CYCLING | February 6, 2026

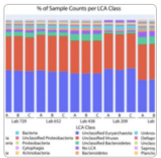
Comparability of Liquid Chromatography Tandem Mass Spectrometry Analysis of Dissolved Organic Matter across Laboratories

Jarmo-Charles Kalinski, Bruno Ruiz Brandão da Costa, Tilman Schramm, Lance R. Buckett, Laura T. Carlson, Nicole R. Coffey, Tito Damiani, Elias Dechent,

- **OCB Ocean metaproteomic intercomparison study**
  https://www.us-ocb.org/intercomparison-and-intercalibration-metaproteomics/

Research article | 08 Nov 2024

Results from a multi-laboratory ocean metaproteomic intercomparison: effects of LC-MS acquisition and data analysis procedures

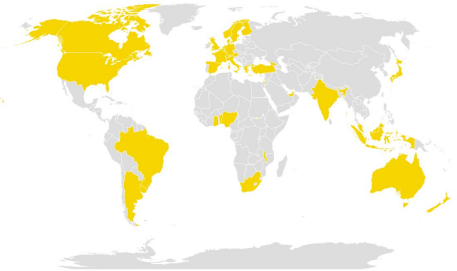


Mak A. Saito, Jaclyn K. Saunders, Matthew R. McIlvin, Erin M. Bertrand, John A. Breier,
Margaret Mars Brisbin, Sophie M. Colston, Jaimee R. Compton, Tim J. Griffin, W. Judson Hervey,

Modeling Working Group

May 2025 Webinar Series

- 450 live participants representing 30 nations



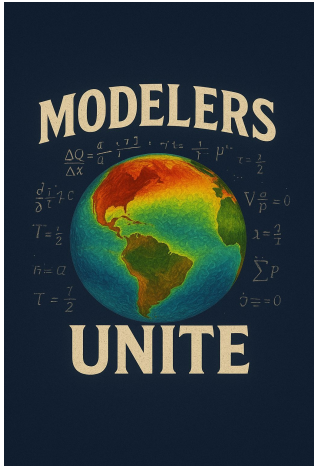
THREE-PART MODELING WEBINAR SERIES

Biogeochemical Models
Presenters: Pearse Buchanan, Sinikka Lennartz
Moderators: Al Tagliabue, Charlotte Laufkötter

Network and Statistical Approaches
Presenters: Corday Selden, Lionel Guidi
Moderators: Sophie Clayton, Christoph Volker

Cellular Scales
Presenters: Daniel Segre, Suzana Leles
Moderators: Damien Eveillard, Naomi Levine

Watch the Recordings Now on YouTube



September 2025 In-Person Workshop

- Multi-scale Model Integration
- Perspective Manuscript

News from our PRIMO SCOR Working Group Collaborators

Physiology and Rates in Microbial Oceanography

PRIMO SCOR WG

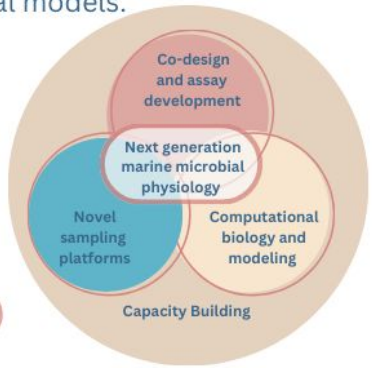
Help us improve our inventory of oceanographic physiological assays

Our goal: Develop a framework to co-design physiological metrics to link 'omics and biogeochemistry. You can read more about us here: www.primoscorwg.org

Our first step: Compile an inventory of metrics used in biological oceanography to determine physiological rates and their potential readiness to be used in biogeochemical models.

Our ask: Your input and expertise is greatly appreciated to identify where information is incomplete or could be improved!

Scan the QR code to share your feedback!

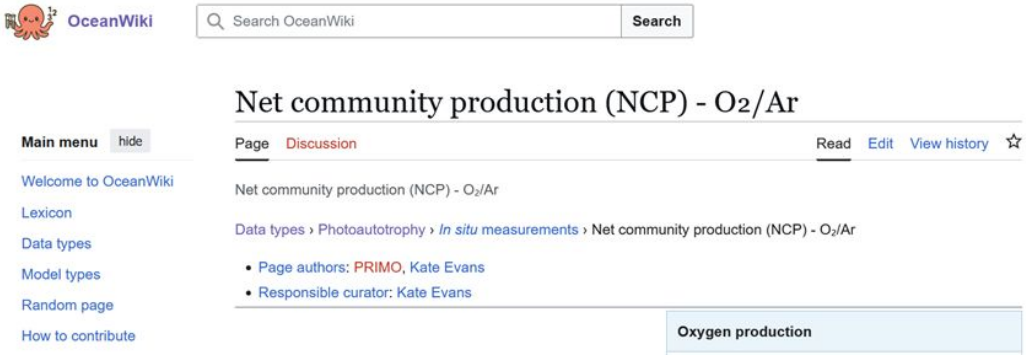


OceanWiki

- Lexicon to overcome barriers created by jargon
- Methods & protocols — written by users & curated by experts
- Models & code — explained and put in context by developers
- Giving credit where credit is due to authors & curators

Kate Evans

Hagen Buck-Wiese



Join us

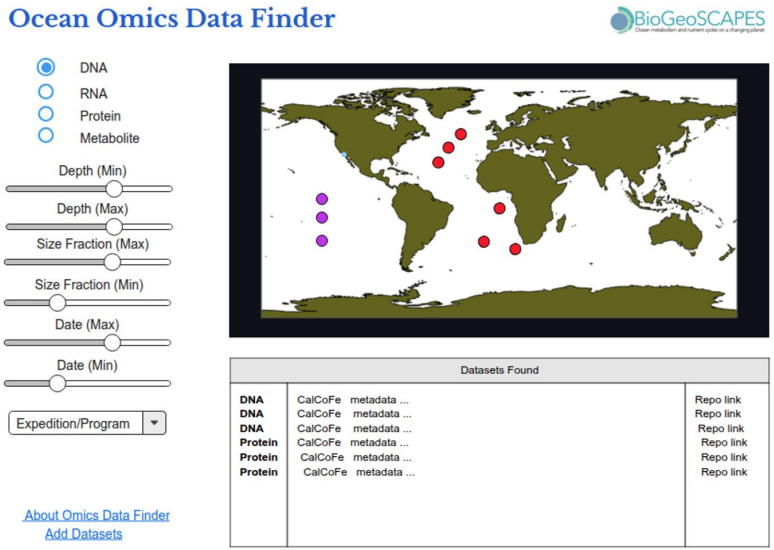
biogeoscapes.net/wiki
or oceanwiki.org

Informatics & Data Management Efforts

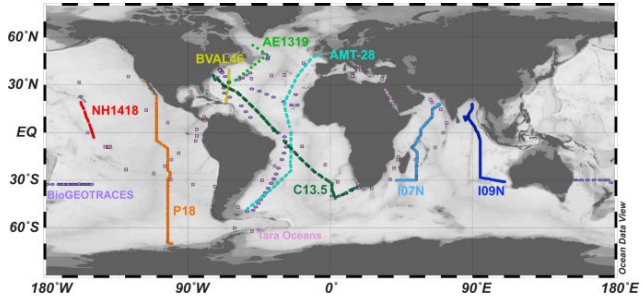
- Informatics is a key part of BioGeoSCAPES research
- We want to encourage and leverage community efforts
- Informatics Workshop Planned for 2027
- New Biogeoscapes.Net “Sandbox” for informatics project sharing and hosting

Workshop Working Group: Harriet Alexander, Mak Saito, Chris Bowler, Arianna Krinos, Paula Huber, Stephane Pesant

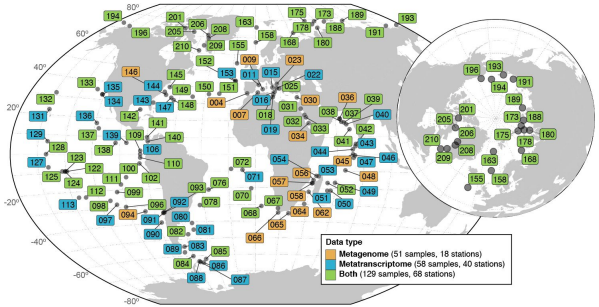
Mockup of Omics Data Registration tool



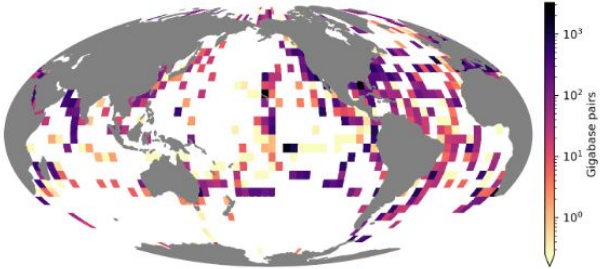
Meta-omics becoming standard practice in biological oceanography



Larkin et al., 2021



Salazar et al., 2019



Levine et al. 2025

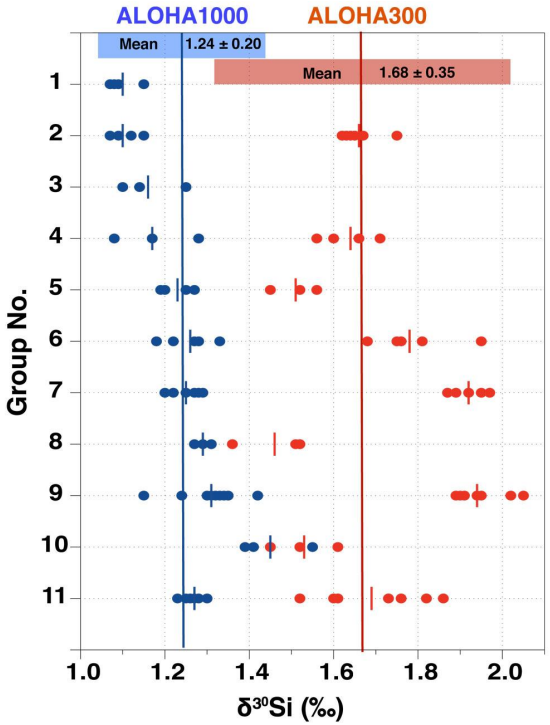
BIO GO-SHIP

TARA OCEANS

AtlantECO
Atlantic ECOsystems Assessment, Forecasting & Sustainability

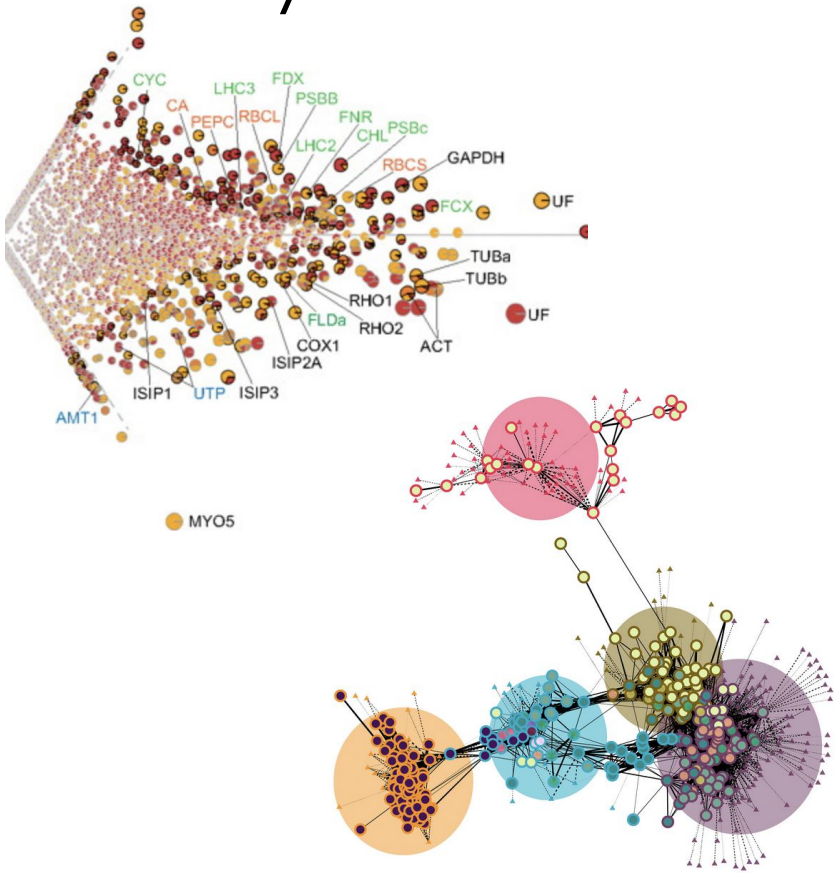
… etc.

Data from –omics rarely can be synthesized to a single number…



Grasse et al. 2017

vs.



Marchetti et al. 2012; Alexander et al. 2023

Momentum towards ‘omic intercomparisons

OCB Ocean nucleic acids ‘omics intercalibration and standardization workshop

https://www.us-ocb.org/ocean-nucleic-acids-omics-workshop/

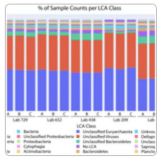
OCB Oce

https://www.u

Eukaryotic Metatranscriptomics!

Research article | 08 Nov 2024

Results from a multi-laboratory ocean metaproteomic intercomparison: effects of LC-MS acquisition and data analysis procedures



Mak A. Saito, Jaclyn K. Saunders, Matthew R. McIlvin, Erin M. Bertrand, John A. Breier, Margaret Mars Brisbin, Sophie M. Colston, Jaimee R. Compton, Tim J. Griffin, W. Judson Hervey, Robert L. Hettich, Pratik D. Jagtap, Michael Janech, Rod Johnson, Rick Keil, Hugo Kleikamp, Dagmar Leary, Lennart Martens, J. Scott P. McCain, Eli Moore, Subina Mehta, Dawn M. Moran, Jaqui Neibauer, Benjamin A. Neely, Michael V. Jakuba, Jim Johnson, Megan Duffy, Gerhard J. Herndl, Richard Giannone, Ryan Mueller, Brook L. Nunn, Martin Pabst, Samantha Peters, Andrew Rajczewski, Elden Rowland, Brian Searle, Tim Van Den Bossche, Gary J. Vora, Jacob R. Waldbauer, Haiyan Zheng, and Zihao Zhao

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Physical sample processing

Step 1. Sample collection:
Filtration mechanism, duration, filter type, preservation

Step 2. RNA extraction:
Sample handling, extraction kit, physical disruptions, DNA removal

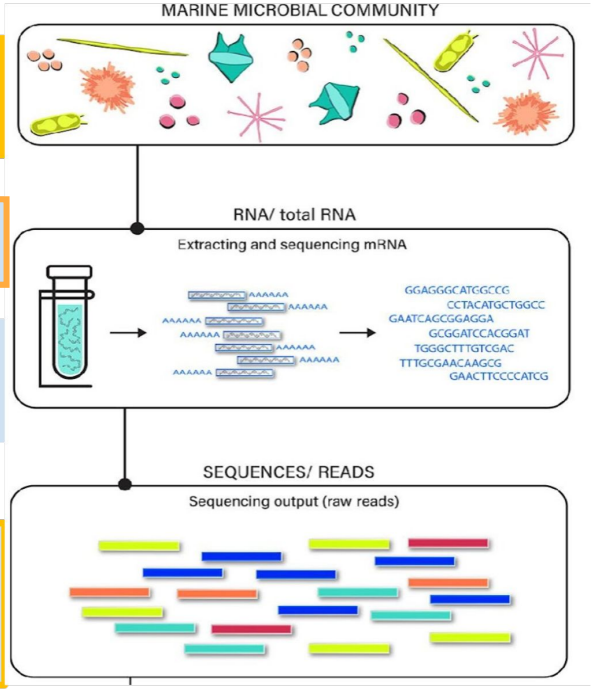
Step 3. Sequence prep:
Library preparation, rRNA removal

Step 4. Sequencing:
Sequence facility, platform and throughput

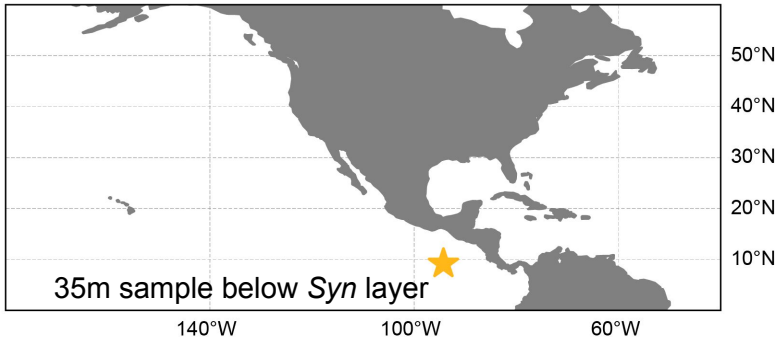
Bioinformatics

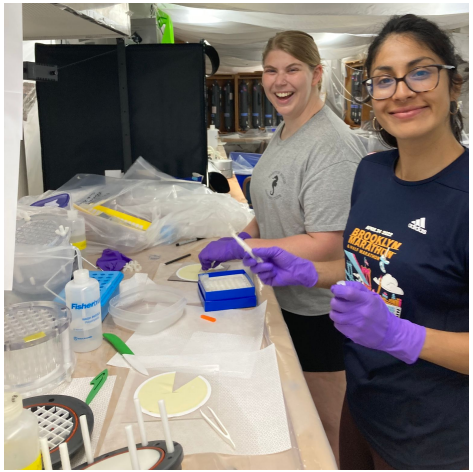
Step 5. Assembly:
contaminant removal, trimming, assembly vs. direct mapping, assembler choice

Step 6: Annotation:
Ortholog clustering, taxonomic database, functional database, alignment method

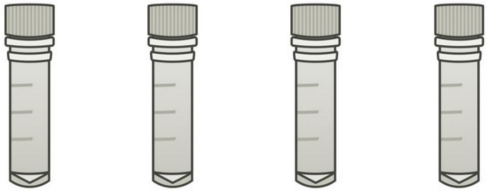


2023 Dome Upwelling cruise (Saito Lab)





McLane Pump: 0.2 – 51 µm filter; 100-140L filtered
1/8th slices □ 32 filters □ -80C



Distribute ~2 filter slices across 14 participating labs

Consistent sequencing center + library prep

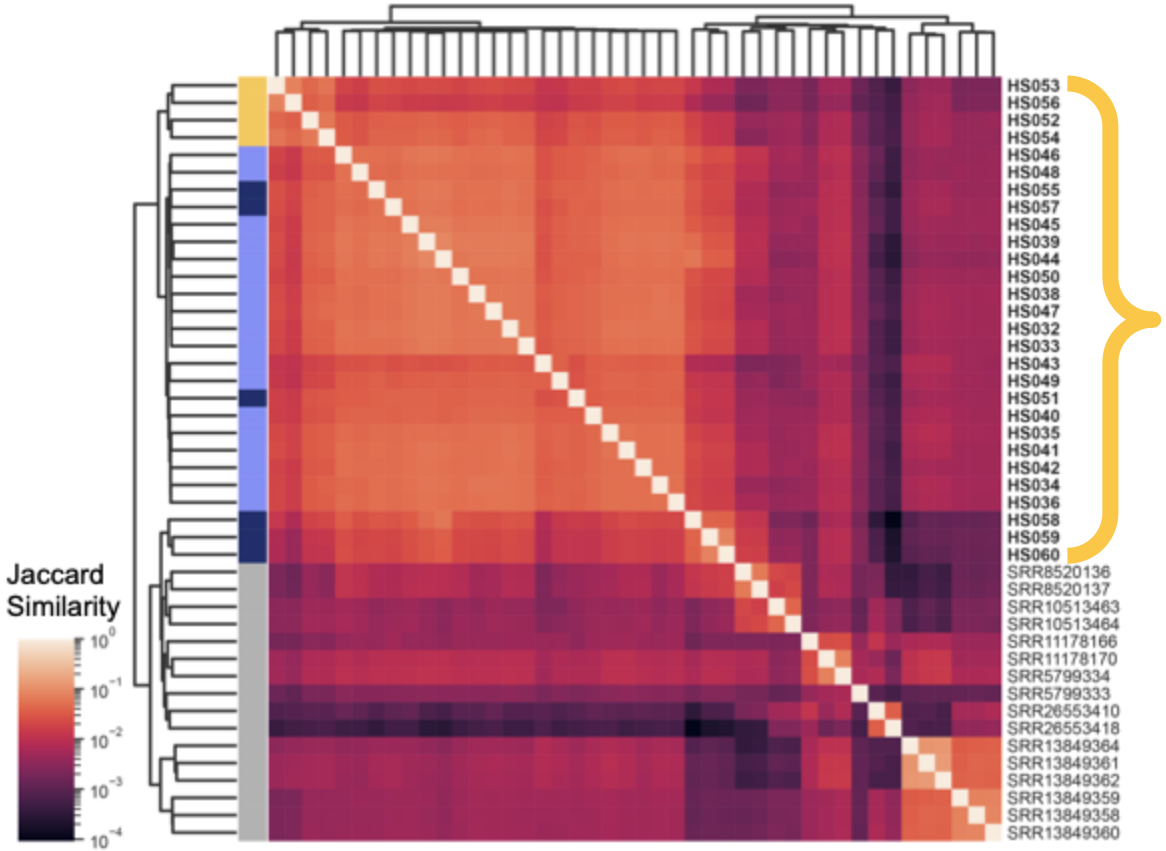
Poly-A selected 100bp PE

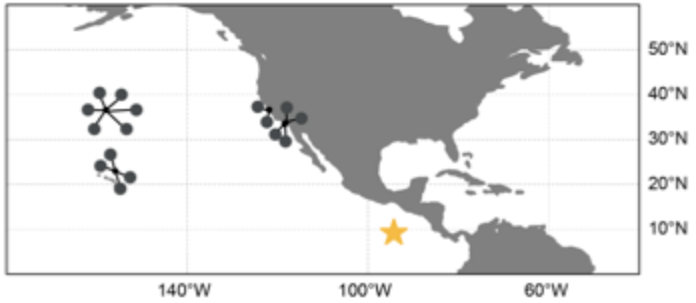
Lab choice

Poly-A selected 150bp PE

rRNA depleted 150bp PE

Intercomparison samples **distinct** from other metaT samples from the Pacific





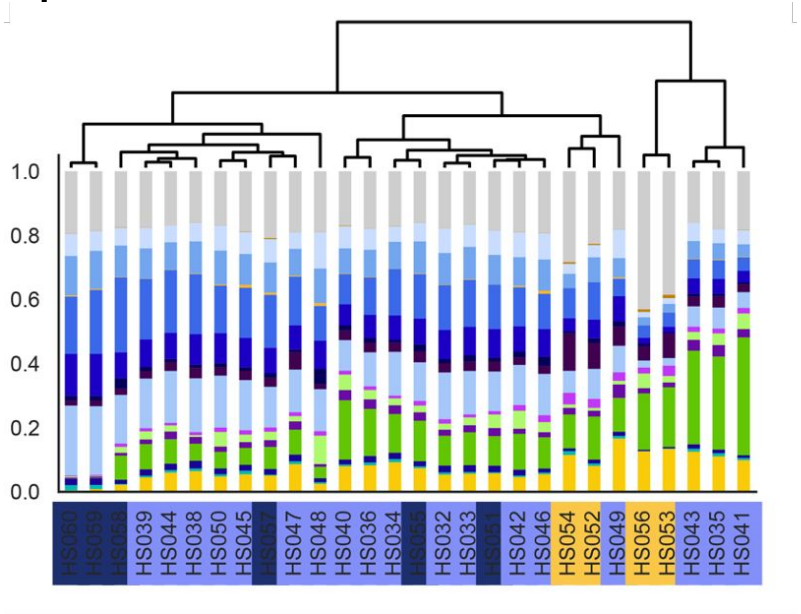
Poly-A 100bp

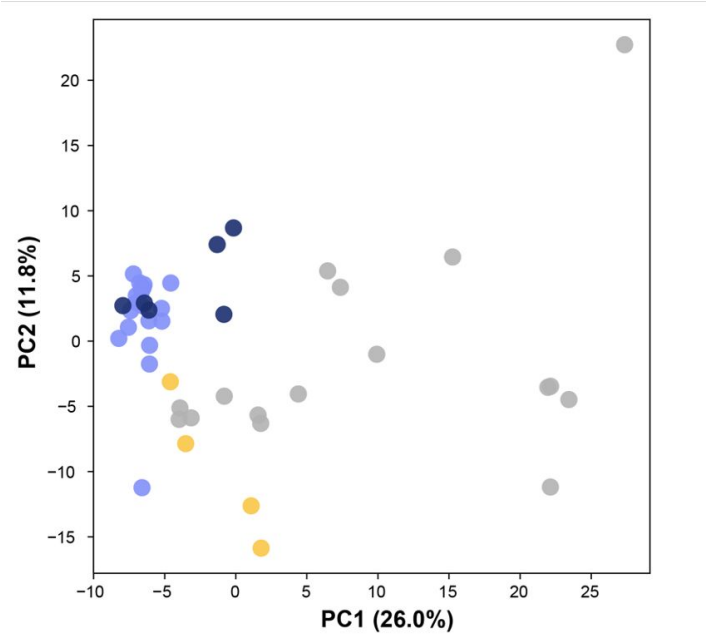
Poly-A 150bp

rRNA depleted 150bp

Sourmash k=31; rRNA content removed

Taxonomic breakdown largely **coherent** across samples





Eukaryota;Stramenopiles;Ochrophyta;Pelagophyceae;Pelagomonadales
Eukaryota;Stramenopiles;Stramenopiles;Stramenopiles;Stramenopiles
Eukaryota;Stramenopiles;Ochrophyta;Bacillariophyta;Thalassiosirales
Eukaryota;Alveolata;Dinoflagellata;Dinophyceae;Prorocentrales
Eukaryota;Alveolata;Dinoflagellata;Oxyrrhea;Oxyrrhinales
Eukaryota;Alveolata;Dinoflagellata;Dinophyceae;Gonyaulacales
Eukaryota;Alveolata;Dinoflagellata;Dinophyceae
Eukaryota;Alveolata;Dinoflagellata;Dinophyceae;Peridiniales
Eukaryota;Alveolata;Dinoflagellata;Dinophyceae;Gymnodiniales
Eukaryota;Alveolata;Dinoflagellata;Dinophyceae;Suessiales
Eukaryota;Alveolata;Ciliophora;Spirotrichea;Choreotrichida
Eukaryota;Archaeplastida;Chlorophyta;Mamiellophyceae;Mamiellales
Eukaryota;Archaeplastida;Chlorophyta;Chloropicophyceae;Chloropicales
Eukaryota;Hacrobia;Haptophyta;Prymnesiophyceae;Prymnesiales
Eukaryota;Hacrobia;Haptophyta;Prymnesiophyceae;Phaeocystales
Eukaryota;Hacrobia;Haptophyta;Prymnesiophyceae;Isochrysidales
Prokaryote
Other

Meta-EukOmic Hackathon (October 2024)

Want to learn more?
Don't miss the
Molecular / Omics
S&I Power Hour

OCB Booth (#45)
10:00-13:00 on
Thursday, Feb. 26

halexander@whoi.edu and amarchetti@unc.edu

SIMONS FOUNDATION

OCB
Ocean Carbon & Biogeochemistry

AccelNet BioGeoSCAPES Intercalibration Efforts

Encourage new and follow-up intercalibrations (Seeking “Heroes”) and standards materials

Future Workshop (late 26’ or early 27’):

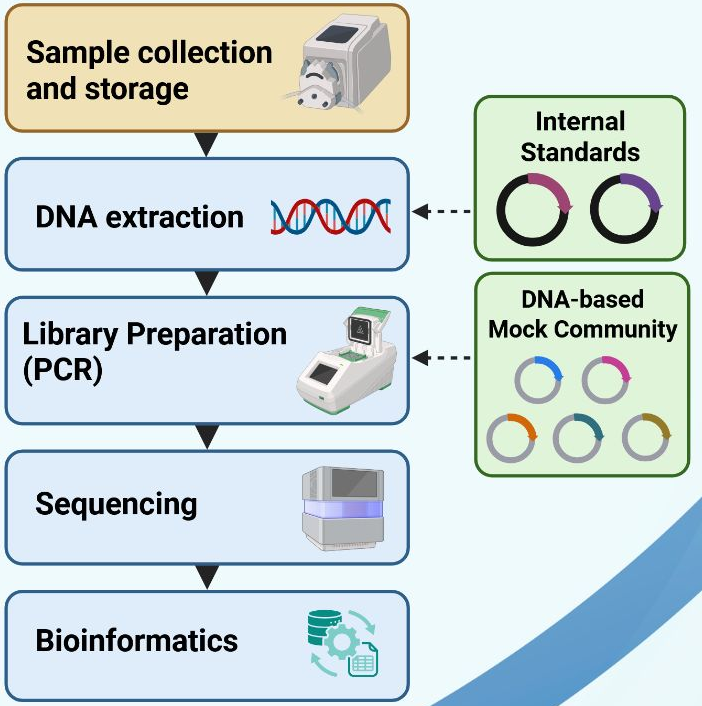
- Focus on Technical *and Scientific* Interoperability

Workshop Organizing Committee:
Adrian Marchetti, Mark Moore, Mak Saito, Raquel Flynn (Fellow), Katie Roche (Fellow)
Heather Benway, Randie Bundy

Intercalibration working group: DNA metabarcoding of marine microbial communities

- **Goal**: identify sources of variability and develop best practices for lab procedures and data analysis
- U.S. & international labs encouraged to apply for participation, including an in-person workshop in early 2027
- Bi-monthly webinars and training opportunities

Apply by March 31



OCB Ocean Carbon & Biogeochemistry

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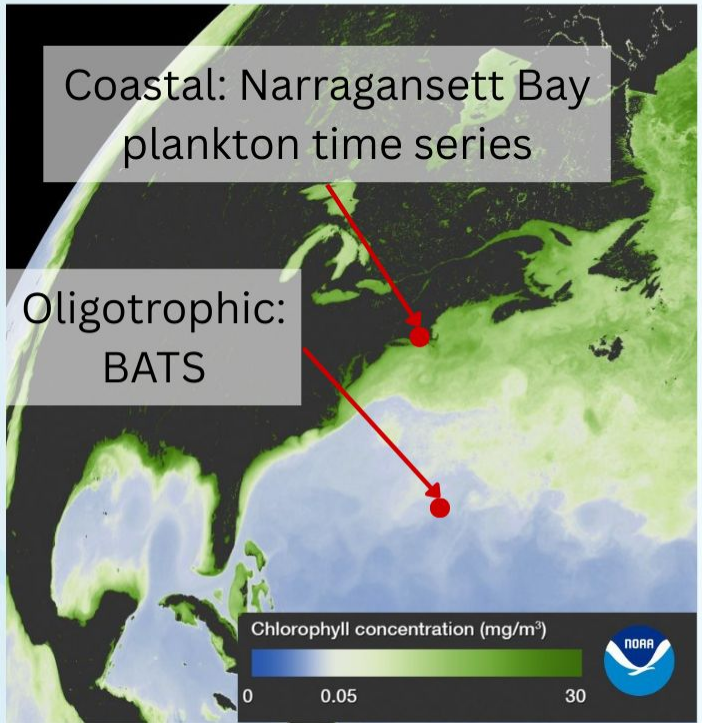
Intercalibration working group: DNA metabarcoding of marine microbial communities

Samples

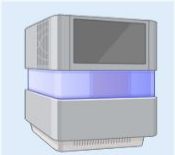


Participating labs

Extract DNA

PCR

Sequence



Central lab

Collective PCR & sequencing

Working group

Analyze for sources of variability and develop a set of DNA metabarcoding best practices

Early Career Fellows Program

- Two cohorts of Fellows (26 Fellows from 18 nations)
- Fill roles on committees and working groups
- Contributed as authors and reviewers of Science Plan
- Currently leading efforts related to BioGeoSCAPES Cookbooks, networking database, and capacity development in global south

BioGeoSCAPES Fellows in *Nature Microbiology*

Krinos, A.I., Muratore, D., Bittner, M.J. et al. A call for early-career teams in interdisciplinary microbiology research. *Nature Microbiology* 10, 2097–2099 (2025). **https://doi.org/10.1038/s41564-025-02097-2**

Capacity Development

Coastal Ocean Environment Summer School in Nigeria and Ghana (COESSING)

- Omics field, lab, and analytical training modules (2024 & 2025) - plans to continue in 2026!
- Demonstrates success of BioGeoSCAPES-supported training modules integrated with an established program.

Future BioGeoSCAPES Summer School in South America

- Leadership team assembled and planning underway led by Fellows and National Ambassadors from Argentina, Chile, Uruguay and Brazil.

Open cruise berth?
Share it with BioGeoSCAPES:
info@biogeoscapes.org

One berth
can make a difference

Help connect researchers from underrepresented regions with new collaborations at sea.

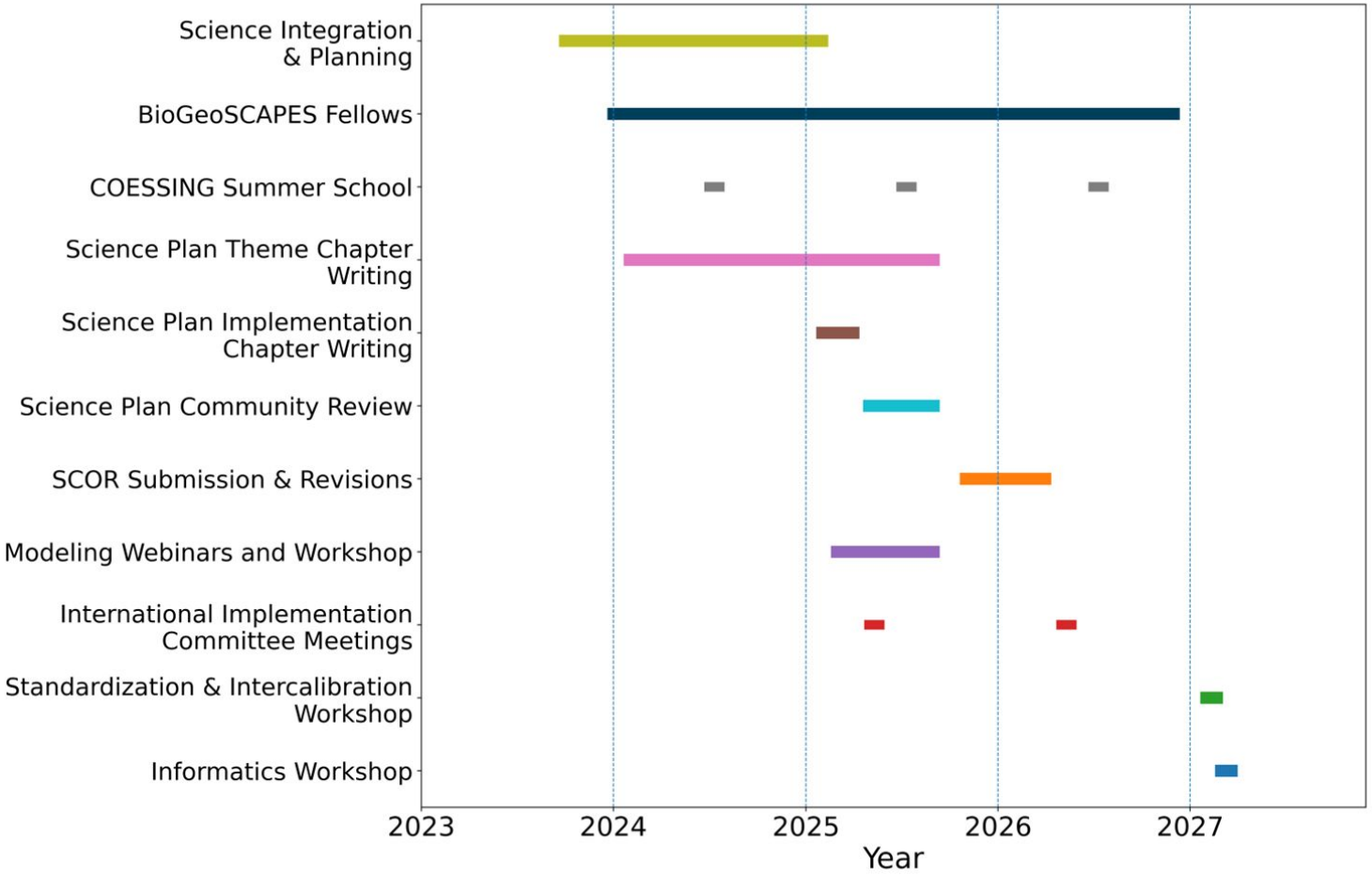
Incentives for scientists and nations to get involved in BioGeoSCAPES

- Bringing together scientists from around the world to advance our common goal of improving humanity's sustainable interactions with the ocean environment
- Advancing interdisciplinary and interoperable science with regards to microbial biogeochemistry
- Fostering careers of scientists through international recognition and collaborative opportunities
- Demonstrate value of integrative and interdisciplinary approach and critical importance of interdisciplinary ocean science and global cooperation

BioGeoSCAPES
Ocean metabolism and nutrient cycles on a changing planet

www.biogeoscapes.org

BioGeoSCAPES Timeline of Activities



Thank you!