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BIBLIOGRAPHIC CITATION

COVER IMAGE
Credit: GO-BGC

WORKSHOP WEBSITE & TALK RECORDINGS
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Overview

The Global Ocean Biogeochemistry (GO-BGC) array is a 5-year effort funded by the US National Science Foundation to produce and deploy 500 profiling floats equipped with biogeochemical sensors in the world ocean. Deployments began in the first quarter of 2021. To inform and engage a broad oceanographic user community, the Ocean Carbon & Biogeochemistry (OCB) and the US Climate Variability and Predictability (CLIVAR) Programs worked with GO-BGC leadership to host a virtual GO-BGC Scientific Workshop from June 28-30, 2021.

The objectives of the workshop were to:

• Introduce the GO-BGC plan to the global scientific community
• Discuss and innovate on scientific applications of GO-BGC data
• Provide background information on the flow of data and archiving
• Deliver hands-on tutorials and computer code for accessing GO-BGC data

Presentations and discussions were scheduled for 3-4 hours on each day using the Zoom platform. Some pre-recorded presentations were available online prior to each day’s events, so that participants could consider discussion items before the meeting. A Slack channel was also created prior to the meeting so that participants could communicate with organizers, presenters, and other attendees during the event.

Scientific Organizing Committee

Steve Riser (UW)               Alison Gray (UW)
Andrea Fassbender (NOAA/PMEL) Yui Takeshita (MBARI)
Ken Johnson (MBARI)           David (Roo) Nicholson (WHOI)
Jorge Sarmiento (Princeton)   Sarah Purkey (SIO)
Lynne Talley (SIO)            Todd Martz (SIO)
Susan Wijffels (WHOI)         George Matsumoto (MBARI)
Roberta Hotinski (Princeton)  Heidi Cullen (MBARI)
# Workshop Agenda

**Monday, June 28, 2021; Day 1 Theme: What is GO-BGC: Outline and Plans**  
**Chair: Sarah Purkey, Scripps Inst. Oceanography**

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:00 am PT</td>
<td>Welcome</td>
</tr>
<tr>
<td>10:05</td>
<td><strong>Keynote</strong> (Ken Johnson, MBARI)</td>
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<tr>
<td>10:35</td>
<td><strong>Basic questions about GO-BGC</strong> (based on curated, pre-recorded talks)</td>
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<td></td>
<td>(a) Float technology (Steve Riser, UW)</td>
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<tr>
<td>11:30</td>
<td><strong>Panel Discussion</strong></td>
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<tr>
<td>12:00</td>
<td>Break</td>
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<tr>
<td>12:15-1:15</td>
<td><strong>Science applications</strong> (15 mins. each, curated)</td>
</tr>
<tr>
<td></td>
<td>(a) O2/nutrients/pH/Chl (Lionel Arteaga, NASA GSFC)</td>
</tr>
<tr>
<td>10:00 am PT</td>
<td><strong>Introduction</strong></td>
</tr>
<tr>
<td>10:05</td>
<td><strong>Short talks from prospective national GO-BGC users</strong></td>
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<tr>
<td></td>
<td>Nathan Briggs (UK)</td>
</tr>
<tr>
<td></td>
<td>Marti Gali (Spain)</td>
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<tr>
<td></td>
<td>Mariana Bif (Brazil/US)</td>
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<tr>
<td></td>
<td>Fei Chai (China)</td>
</tr>
<tr>
<td></td>
<td>Emily Osborne (US)</td>
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<tr>
<td></td>
<td>Christina Schallenberg (Australia)</td>
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<tr>
<td></td>
<td>Miguel Piecho-Santos (Portugal)</td>
</tr>
</tbody>
</table>
Wednesday, June 30, 2021; Day 3 Theme: GO-BGC and Community Interaction
Chair: Todd Martz, Scripps Inst. Oceanography

10:00 am PT  Introduction

10:05  Outreach (George Matsumoto, MBARI)

10:30  Data tutorials: Matlab, Python, and R (Lead: Alison Gray, UW)
MATLAB, R, and Python code developed for BGC Argo data access tutorials on the GO-BGC GitHub page: https://github.com/go-bgc

11:45 Break

11:45  Break

12:00  Engagement with other programs
Pete Strutton (Australia)
Katja Fennel (Canada)
Hedy Edmonds (US/NSF)
Emily Smith (US/NOAA)

12:30-1:15  Meeting summary, questions, final discussion
Participation

The workshop was promoted by OCB, US CLIVAR, and GO-BGC and online registration was high at 380 participants (breakdown below). Registrants included representatives from academia, government, and industry with a diverse mix of gender, race/ethnicity, and career stages (see Table 1 below). Over 60% of registrants had zero to novice-level experience with BGC float data.

### WORKSHOP REGISTRATION BREAKDOWN

<table>
<thead>
<tr>
<th>Category</th>
<th>Count</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government Scientist</td>
<td>33</td>
<td>8.7%</td>
</tr>
<tr>
<td>Graduate Student (1-2 years)</td>
<td>45</td>
<td>11.8%</td>
</tr>
<tr>
<td>Graduate Student (3+ years)</td>
<td>47</td>
<td>12.4%</td>
</tr>
<tr>
<td>Postdoc</td>
<td>55</td>
<td>14.5%</td>
</tr>
<tr>
<td>Early-career Faculty (pre-tenure, e.g., assistant professor)</td>
<td>27</td>
<td>7.1%</td>
</tr>
<tr>
<td>Mid-Career Faculty (tenured associate professor)</td>
<td>8</td>
<td>2.1%</td>
</tr>
<tr>
<td>Senior Faculty (full professor or emeritus)</td>
<td>19</td>
<td>5.0%</td>
</tr>
<tr>
<td>Researcher</td>
<td>86</td>
<td>22.6%</td>
</tr>
<tr>
<td>Technician</td>
<td>15</td>
<td>3.9%</td>
</tr>
<tr>
<td>Private Industry</td>
<td>12</td>
<td>3.2%</td>
</tr>
<tr>
<td>Other</td>
<td>33</td>
<td>8.7%</td>
</tr>
<tr>
<td><strong>Total Registrations</strong></td>
<td><strong>380</strong></td>
<td></td>
</tr>
</tbody>
</table>

Gender identity

380 responses

- Female (176)
- Male (194)
- Non-binary (1)
- Prefer not to say (8)
- Woman (1)
Actual participation in the meeting was smaller but still robust at 150-190 participants per day, with the greatest participation in the early sessions of the meeting. Most participants were from the US and Canada, with representation from countries including Argentina, Australia, Bangladesh, Germany, France, India, Ireland, Italy, Japan, Mexico, New Zealand, Norway, Portugal, Spain, South Korea, Sweden, Switzerland, and the UK.
Major Sessions

Basic questions about GO-BGC & Panel Discussion
This session provided an overview of the GO-BGC program, including float and sensor technology, cruise plans, and data management. The 10-25 minute talks were supplemented by longer pre-recorded videos on each topic available online for viewing before and after the meeting.

The panel discussion provided a forum for questions. Topics included:

- Sensor accuracy and QC procedures
- Cycling times for BGC floats and their impact on float longevity
- Uncertainties in derived products
- Vertical sampling resolution
- Types of vessels used for deployment cruises

Scientific applications
In this session, experienced users gave overviews on their research using BGC data and derived products to study phytoplankton blooms and productivity, fisheries and fisheries management, and the ocean carbon cycle. Assimilation of BGC data into models for forecasting was also discussed.

Participants in this session expressed an interest in having access to a short document that outlines data uncertainties and basic information users should know about using BGC variables and products. An update to the GO-BGC website, as an FAQ, now provides much of this information.

Short talks from prospective national GO-BGC users
Registrants were encouraged to provide short abstracts on existing research or proposed applications for BGC data. Topics included were:

- Tracking large particles with BGC-Argo (Briggs)
- Particulate organic carbon (POC) estimation and comparison with model estimates (Gali)
- Estimating net primary productivity with oxygen measurements (Bif)
- Upper ocean phytoplankton response to extreme weather events in the Northwest Pacific (Chai)
- BGC-Argo initiatives at NOAA (Osborne)
- Variability in the fluorescence/Chl ratio in the Southern Ocean (Schallenberg)
- Studying the Mediterranean outflow with BGC-floats (Piecho-Santos)
Breakout rooms
Attendees were able to choose a Zoom breakout room to participate in one of the following participant-driven discussions:

**Biological carbon pump** - This group discussed methods and the issue of temporal and spatial scales that floats measure. Particular areas of focus were quantifying carbon flux with bio-optics and/or BGC sensors, quantifying particle density, and quantifying sinking flux. There was agreement that bringing multiple datasets (float, shipboard, satellite, and glider) together would help produce better estimates of BGC processes.

**Climate change impacts** - This group discussed the need for sustained funding to carry out a comprehensive program for observing climate, and the importance of communicating that need to the science community and funding agencies. Other topics were ocean geoengineering and its impacts and encouraging the use of BGC float data to validate CMIP6 models.

**Cruise planning** - No participants, but the discussion moderator emphasized the importance of observing system design and encouraged participants to help in identifying priority fields to sample.

**Data management and access** - Participants discussed the importance of having a BGC Data Assembly Center (DAC) with sustained funding, as well as possible data products that could be produced for the community.

**Float technology** - The group addressed challenges with battery life and biofouling and discussed new technologies for floats, including transmissometers, active acoustics, and wet chemistry. Participants also stressed the need for improvements of existing sensors and importance of sensor uniformity for a global BGC-Argo program.

**Marine food webs** - Participants discussed data resolution and the types of data needed to resolve higher trophic levels, including backscatter, acoustic backscatter, underwater vision profilers (UVPs), multispectral FLBBs, and genomics on floats.

**Models** - This group discussed Observing System Simulation Experiments (OSSEs) and use of BGC data to evaluate and validate models, improve model parameterizations, and produce more realistic models through data assimilation. Participants also indentified the need for better information about covariance between BGC and physical variables.

Data Tutorials
After an overview by Alison Gray (UW) that covered where to find BGC float data, data file formats, and data visualization tools, users joined separate hour-long data access tutorials for Matlab, Python, and R programming languages.
For Matlab and R tutorials, tutorial code (including required toolboxes) was developed and made available for download from the GO-BGC GitHub workshop repositories, while the Python tutorial was carried out using the Google Collab platform. For each programming language there were help desks and tutorial channels on Slack where participants could ask for help from the organizers and/or interact with organizers and other participants during the tutorial. These (and additional GO-BGC Workshop) Slack channels remained accessible after the workshop, allowing continued discussion of BGC Argo and data access.

Development of the interactive tutorials and software tools was a major effort that required a multi-institutional team. Members of the data tutorial committee are listed below:

**Organizing Comm.**
- Andrea Fassbender
- Roo Nicholson
- Steve Riser
- Yui Takeshita

**Python**
- Ryan Anderson
- Ethan Campbell
- Katy Christensen

**Matlab**
- Hartmut Frenzel
- Tanya Maurer
- Josh Plant
- Jon Sharp

**R**
- Yibin Huang
- Marin Cornec
- Raphaëlle Sauzede
- Catherine Schmechtig
- Quentin Jutard

**Engagement with other programs**

Peter Strutton (Australia) and Katja Fennel (Canada) provided overviews of BGC-Argo research activities and float deployment plans in their national programs. Dr. Hedy Edmonds (National Science Foundation) spoke about funding available for research using BGC float data, encouraging participants to write proposals to use the GO-BGC data. She also mentioned that NSF would continue to consider proposals for additional targeted deployments of BGC floats to address specific science questions. Finally, Emily Smith presented information on NOAA’s past and current investments in BGC-Argo efforts, including support for pilot arrays in different regions, data centers, modeling, and improving sensors. Dr. Smith also mentioned the potential for future competitive research funding opportunities in FY23, as well as plans to expand the Argo Scientific Educational Resources and Experience Associated with the Deployment of Argo profiling floats in the South Pacific Ocean (SERead) and Adopt-a-Float activities.

**Summary**

The final open session elicited participant questions and feedback on topics of wide interest that had arisen throughout the workshop. Themes included:

- The importance of international collaboration in float deployment planning
- A desire from the community for gridded products and datasets that combine float, satellite, and shipboard data
- The importance of sustained funding for array and sensor development
- The wide range of BGC data already available, particularly the global oxygen dataset
- Integrating BGC sensors on Deep Argo floats
- Entraining scientists whose countries don’t deploy BGC floats to engage with the dataset
- The collection and availability of float data in Exclusive Economic Zones (EEZs)
Resources
Digital resources from the meeting were organized on a dedicated page in the workshop section of the GO-BGC website: https://www.go-bgc.org/workshops/building-a-community-of-biogeochemistry-float-data-users-workshop

These resources include:
- Pre-recorded videos on float and sensor technology, science applications for BGC data, deployment planning and data QC and management
- Recordings of live sessions - available on this YouTube Playlist
- Software tools and on-demand video tutorials for data access and visualization https://www.go-bgc.org/data/data-faq

In addition, a “Getting Started with GO-BGC Data” page featuring these resources and others was added under the “Data” tab of the GO-BGC website to facilitate new user access to the float data.

Feedback
A survey was sent out after the workshop to solicit feedback on various aspects of the workshop (results attached as Appendix). Participants rated the overall content of live and pre-recorded presentations highly, and had positive comments about the data tutorials (aside from technical difficulties that were resolved with the help of OCB staff). A common critique was that there were too few opportunities for communication among participants, and that participants would have appreciated opportunities for informal networking and more effective use of the Slack platform. Though participants were complimentary of the pre-recorded talks, most had time to view only a few, if any, of these videos. Finally, the timing of the meeting was challenging for some participants outside of the U.S., though that issue was partially addressed by the pre-recorded talks and workshop videos posted after the meeting.

Moving forward, the majority of participants suggested that alternating in-person and virtual meetings would be the optimal format for future GO-BGC science workshops.

Acknowledgments
The workshop was supported as part of GO-BGC’s outreach program, which is funded by National Science Foundation Mid-scale Research Infrastructure-2 program (Award No. CHE-1946578). The organizing committee would like to thank the OCB (funding sources: NSF, NASA) and US CLIVAR Project Offices (funding sources: NASA, NOAA, NSF, DOE) and Mariah Salisbury (MBARI) for help in workshop development and logistics.

Special thanks are due to the tutorial teams that worked on a very short timeline to develop invaluable software tools and content for the interactive sessions and for future use by GO-BGC data users.
Appendix: Post workshop survey

What is your current position? (18 responses)

- Researcher: 38.9%
- Private Industry: 11.1%
- Graduate Student (1 year): 11.1%
- Graduate Student (3 years): 5.6%
- Government Scientist: 11.1%
- Early-career Faculty: 5.6%
- Program Manager (federated component): 5.6%
- Postdoc: 11.1%
- None: 0 (0%)

Which plenary sessions did you attend? (select all that apply) (18 responses)

- Keynote by Ken Johnson (June 28): 16 (88)
- Basic Questions (June 28): 14 (77.8)
- Science Applications (June 28): 15 (83.3)
- Short talks from potential new data users: 14 (77.8)
- Outreach (June 30): 10 (55.6)
- Data Tutorials (June 30): 14 (77.8)
- Engagement with other programs: 7 (38.9)
- None: 0 (0%)
If you are an early career scientist, please share your feedback on the following elements of the workshop.

![Bar chart showing feedback on networking space, slack channel, and virtual aspect]

Please share ideas you have to improve early career support and engagement during GO-BGC activities [comments are verbatim from survey input]

- These things are difficult to do virtually. But perhaps it would work to join up early career scientists with mid-career and senior scientists to co-organize activities
- Training activities
  - Of course in-person would have been great, but failing that perhaps some breakout room chats by interest would have been helpful.
- Involve ECR more strongly in the organization of the event
- Early career slack channel? I really liked having some early career scientists involved in leading events (ex: Ethan and Katy leading the Python workshop). That felt much more accessible as an early career scientist myself
- Having some discussion sessions limited to early career scientists/grad students
- Ask people during registration if they want to participate in assigned breakout groups so that they feel committed to attending and investing.
- Early career breakout time would be useful (I don't remember any)
- For young researchers it is easier if there are more detailed sessions for data handling from BGC-Argos and also methods for quality control. That was a gap in this meeting.
- Re-advertise the recorded portions of the workshop, to attract new attendees (but no need to reproduce all of the material or wrangle so many trans-hemisphere presentations) and (somehow) draw folks into the Slack channel. I know it is difficult to get enough momentum to get the balls rolling themselves...
- Focus a session on this topic
- The workshop on using the data was very useful
Please share your thoughts on the sessions:

Did you make valuable new connections at this workshop? If so, where and when? If not, what were the barriers?

- I already know the community quite well so did not make new connections
- I sent emails after the meeting to some researchers to know the schedule of deployment of the BGC-Argo.
- My aim was to figure out how to create outreach programs around Adopt-a-Float, and it didn’t seem that there was anyone else there with that goal. But I feel comfortable wading into the data. Also had to miss some of it because of teaching commitments.
- No
- No, because I could not attend as many sessions as I planned, and I already knew many participants
- No, connecting in a virtual space still feels very difficult
- No, the small group discussion I joined was largely dominated by senior scientists, so it was harder for me to make connections.
- No, virtual setting not conducive to getting to know people
- No. Slack Channel wasn't utilized much.
- Not really. I did email with some of the speakers though with questions I had. Virtual meetings are different than in person meetings. Harder to 'meet' and 'chat' with someone outside meeting sessions
- The time of the workshop for Indian participants were very late and therefore inconvenient for attending the entire meeting.
- The workshop was a way for me to be exposed to a community that I have tangential associations to. I learned a lot about the research community as it is and where it could go (i.e. early & mid-career scientists & their institutions) and got a sense of 'who is who', in terms of the most established researchers and institutes. I didn't walk away with new connections, but I did re-connect with two of my former PhD advisors, whom I hadn't reached out to in too
long. I'll keep an eye out and am confident that I will cross paths with attendees in the future.

- There were no opportunities but there were not any barriers
- Yes
- Yes, but with a limited group of people. There were several folks I didn't have time to engage with but would have liked to have more.

Please share any feedback you have on the GO-BGC content and format

- I did not like the format of having people come together to brainstorm applications. Why would people want to give away their best ideas, especially early career scientists? This is a publicly available dataset and there is bound to be competition already.
- I did not like the prerecorded format. It felt like it took the spontaneity out of the QA
- I just started with BGC data already, I figured most of it out by myself, but it was nice to get confirmation of what I was doing. Plus I learned some new stuff.

Please comment on the following aspects of the GO-BGC 2021 workshop.

Please share any ideas you have for future GO-BGC session topics

- Examples of their use in oceanographic models (localized or global); model output is the most likely way that my research would benefit, given my current skillset
- Getting involved as an early career scientist
- The coding tutorials were super useful but the code was rudimentary and has lots of room for
improvement before it will actually be useful for science. I think a hackathon would be even more useful so the community can converge around one set of tools that we all contribute to.

What are the TOP THREE reasons you attended the GO-BGC workshop? If this was your first OCB workshop, would you wish to attend a future OCB workshop (in person or virtual)?

- Data tutorials, info about data quality/where to find data
- I am starting to work with BGC Argo floats; I would like to attend the tutorials; I would like to know about sensors
- I am working on biogeochemical response of ocean to Tropical cyclones therefore this workshop was of use to me. I want to attend this workshop in the coming years as well. I would love to attend in person.
- It was accessible (no cost to attend), I'm starting a project using BGC floats, getting to know the BGC community. I would really like to attend a future OCB workshop.
- Learn on how to use BGC data
- Learning, discussing, showing own work
- Main reason was the data tutorial, and also speaker presentations. Yes, I would attend future workshops!
- To learn enough to be able to write some K-12/general public materials; to meet potential collaborators; might attend depending on schedule.
- Vital to our business, networking with scientists, learning about technical/program requirements

What do you think is the optimal format for future GO-BGC workshops?

17 responses

- In person only (at University of Washington, Seattle, USA)
- In person only (consider alternating venues, including minority serving institutions)
- Hybrid (combined in-person and virtual)
- Alternate between in-person and virtual summer workshops
What formats and activities would you like to see for GO-BGC 2023 topics (e.g. breakout discussions, informal networking opportunities, early career support, JEDI, etc.)?

- Informal networking specifically with peers
- More informal networking opportunities (like coffee hours or happy hours centered around something fun because we are human!)
- More outreach community-building.
- Not sure, I enjoyed the talks and didn’t think the breakout sessions were that useful. I didn’t get much out of it. Maybe because of the virtual format.

Is there additional feedback in general that you’d like to share?

- I was incredibly impressed by this workshop, both content and making an effective and engaging virtual conference. A huge thank you to the organizers!
- It would have been good if there was C programming material. I could follow the Python materials but it isn't my native language. :-(
- Thank you for the workshop.