DOE FINAL REPORT

I. COVER PAGE

a. Recipient Award Identification Number: **DE-SC0019382**
b. Federal Agency and Organization Element to Which Report is Submitted: **Department of Energy, BER Program: SBR**
c. Federal Grant or Other Identifying Number Assigned by Agency UEI: **NNFQH1JAPEP3**
d. Project Title: **The Influence of Microbial Priming Effects on the Hydro-bio-geochemistry of Large River Reservoirs**
e. PD/PI Name, Title and Contact Information (e-mail address and phone number): **Thomas S. Bianchi; e-mail-tbianchi@ufl.edu; phone-352-392-6138**
f. Name of Submitting Official, Title, and Contact Information (e-mail address and phone number), if other than PD/PI: **University of Florida, Division of Sponsored Programs, Stephanie Gray, ufawards@ufl.edu, (352)392-9267**
g. Submission Date: **01/26/2022**
h. DUNS Number: **969663814**
i. Recipient Organization (Name and Address): **University of Florida, Gainesville FL**
j. Project/Grant Period (Start Date, End Date): **09/15/2018 - 09/14/2020**
k. Reporting Period End Date: **end of award 09/14/2020**
l. Report Term or Frequency (annual, semi-annual, quarterly, final, other): **Annually and final report**

II. ACCOMPLISHMENTS: Mandatory

1) Rationale and major goals

Rationale: River-tributary confluences, where diverse organic matter (OM) sources mix, are considered aquatic critical zones of biogeochemical cycling. The sources of OM to the Columbia River watershed vary considerably with inputs from agriculture and natural forests across a steep hydrologic gradient.

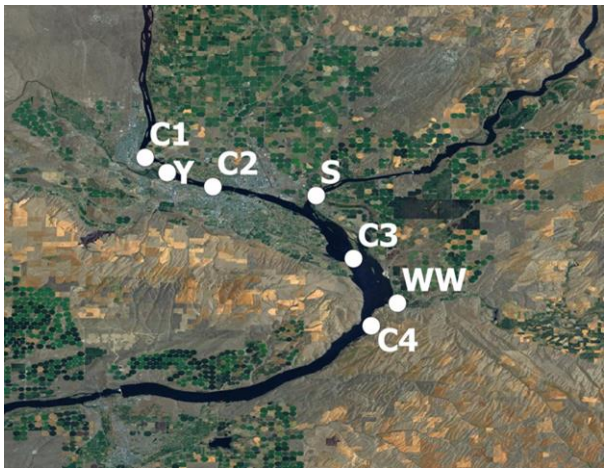
Working Hypothesis: Microbial priming effects directly regulate the amount of organic matter (OM) that is removed from or stored in terrestrial-aquatic ecosystems. The efficiency and expression of priming effects are linked to the hydrology and physical structure of a system and are greatest in settings characterized by high water residence times and low suspended sediment loads (i.e. hydroelectric reservoirs), which support high algal productivity and provide ample time for OM decomposition prior to export.

Goal 1: Determine if there are “hotspots” in dissolved OM (DOM) processing across mainstem and tributary confluences.

Goal 2: Determine if priming effects play a differential role on microbial processing of terrestrially-derived OM (TDOm) in aquatic systems across wet vs. dry climatic regions, and are amplified in impounded rivers relative to naturally-flowing tributaries due to a higher abundance of algal-derived priming substrates, changes in the bacterioplankton community, and enhanced connectivity between surface and subsurface flows and nutrient dynamics.

2) Objectives and major activities;

Obj. 1.: Sample waters along the mainstem of the Columbia River (C1 – C5) and four of its tributaries (Yakima (Y), Snake (S), Walla Walla (WW), and Wind (WD) rivers) sample along these two reaches and associated tributary confluences, at high and low flow periods. Perform incubation experiments to evaluate what happens when these tributaries mix with the mainstem.



Obj. 1 Activity: The eastern samples were collected in both August 2018 and April 2019, while the western samples were only collected in April 2019. Therefore, the discussion below will be focused on those samples collected during both years. However, we will include the April 2019 western samples in the publication that is close to submission, see below.

Obj. 2: Assess the watershed characteristics that control TDOM), algal dissolved OM (ADOM), and particulate OM (POM) production, mobilization.

Obj. 2 Activity: EXO2 Sonde measurements were made in the field (e.g., temperature, Conductivity, Turbidity, etc.), along with water oxygen isotopes ($\delta^{18}O$), CO_2 concentrations, dissolved organic matter, bulk dissolved organic carbon (DOC) and total dissolved nitrogen (TDN), chemical biomarker (e.g., lignin and amino acids), and chemodiversity - using ultrahigh resolution mass spectrometry (FT-ICR MS). In particular, the number of samples analyzed (in parentheses) for the following parameters collected at these sites and during incubations in two different seasons are as follows: DOC/TDN (n = 138); FT-ICR MS (n = 138); lignin (n = 129); amino acids (n = 136); CO_2 and CH_4 (n = 74); water isotopes (n = 16); DOM (n = 82).

3) Significant results and conclusions:

a. Results

1. The Exo2 Sonde data collected for water temperature and specific conductance show evidence of confluence becomes well mixed by the next downriver station during low flow in August 2018. However, the data collected in April 2019 (high flow) showed that these two water sources were stratified for several kilometers downriver.

2. Based on a 2-endmember mixing models, using $\delta^{18}O$ values of mainstem and tributary waters, the $\delta^{18}O$ mixing model results agreed with the discharge data in August showing low contributions of the tributaries, except for the Snake River. In April 2019, Based on the discharge data, we used the Snake River and Columbia 2 $\delta^{18}O$ values as endmembers further downstream in mainstem stations (Columbia 3 and Columbia 4).

3. Using a bootstrapping method, coupled to the $\delta^{18}O$ mixing model, modeled DOC

concentrations approximated the measured concentrations except for the most downstream station (Columbia 4) in April 2019. This suggests a significant loss of DOC during the mixing of the Snake and Columbia rivers. This same pattern of loss was also found for TDN and lignin concentrations at Columbia 4 in April 2019.

4. Unlike DOC, and TDN, the total hydrolyzable amino acids increase in concentration compared to what's expected via conservative mixing at C4. Much of the TDN is likely from DIN, which is being assimilated by primary producers into PON, which is then leading to increases in dissolved amino acids from PON degradation (i.e., sloppy feeding). Moreover, a more degraded amino acid biomarker indices were found in the Yakima in August 2018 and the Snake River in April 2019. The degraded signal from the Snake River is almost completely lost by Columbia 4.

b. Conclusions

1. It is essential to understand the hydrology and mixing dynamics of river-tributary confluence prior to interpreting their biogeochemical data.

2. The influence of a tributary on the biogeochemistry of the mainstem was only evident after mixing with a tributary of similar scale to the mainstem (i.e., Snake River and Columbia River).

3. The diagenetic state of the amino acids can change rapidly and in an unexpected direction downriver, and in this case this "fresh" production likely led to possible priming of TDOM as indicated by the concurrent decrease in total DOC and lignin. However, further work is need to more effectively test for priming at site Columbia 4.

4) Unexpected negative and positive changes to with goals and outcomes:

a. Negative outcome – Because the budget did not allow graduate students funds for Co-PIs Butman and Ward, all field sampling was performed with undergraduate students. Unfortunately, numerous students on the project left for better fellowship offers, which left D. Butman with limited resources for the planned sampling resolution. Nevertheless, we successfully sampled during the two most hydrologically distinct periods that allowed us to best assess priming effects given budget and time limitations.

b. Positive outcome - Fortunately, this work led to conversations with PIs on this project and other scientists in the community, working on similar question across river networks and the coastal ocean; this unexpectedly led to the following special issue on this topic: *Bianchi, T.S. and Ward, N.D. (2019) Editorial: The Role of Priming in Terrestrial and Aquatic Ecosystems. Frontiers in Earth Science. 7 (321). https://doi.org/10.3389/feart.2019.00321.*

5) Training and professional development:

Bianchi was able to support a graduate student, Michael Shields, for a limited period of time, that did allow for training in chemical biomarker analyses at the Bianchi lab at University of Florida. The lignin and amino acids analyses required the use of state-of-the-art techniques in UHPLC/MS/MS and GC/MS/MS. Michael Shields has since been hired in the Dept. of Oceanography and GERG Research Center, at Texas A&M University, where he leads organic and geochemical analyses on many research projects, the training form this grant was invaluable in part, for the necessary experience needed to perform his currents job duties. Likewise, Ward supported an undergraduate

intern Julia Indivero to carry out incubation experiments. Julia has since started doctoral studies at the University of Washington.

6) How have the results been disseminated to communities of interest?
Results have been disseminated at various conferences and are in preparation for a peer-reviewed manuscript.

7) What do you plan to do during the next reporting period to accomplish the goals and objectives?
N/A and "Nothing to Report."

III. PRODUCTS:

1) Presentations and Publications:
a. T.S. Bianchi presented a poster on this work at the annual DOE meeting in Potomac, MD entitled: **The Hydro-bio-geochemistry of the Columbia River - Tributary Confluences** by: *Thomas Bianchi, David Butman, Nicholas Ward, Michael Shields, Evan Arntzen, James Stegen, Julia Indivero, Yulia Farris, Albert Rivas-Ubach, Nikola Tolic, and Rosalie Chu.*

b. M. Shields presented a talk at the Ions@Work 2020: A Symposium Organized by the TAMU's Mass Spectrometry Core Febriary 2020 at Texas A&M University, entitled: The **Hydro-bio-geochemistry of the Columbia River - Tributary Confluences**, with acknowledgments of funding and the following collaborators: *Thomas Bianchi, David Butman, Nicholas Ward, Michael Shields, Evan Arntzen, James Stegen, Julia Indivero, Yulia Farris, Albert Rivas-Ubach, Nikola Tolic, and Rosalie Chu*

c. T.S. Bianchi presented a talk remotely at the American Geophysical Union meeting, December 2021 entitled: **Dissolved Organic Matter Transformations along the Columbia River and its Tributaries,** by *Michael Shields, Thomas Bianchi, David Butman, Nicholas Ward, Albert Rivas-Ubach, and Rosalie Chu.*

d. T.S. Bianchi and Ward, N.D. (2019) Editorial: The Role of Priming in Terrestrial and Aquatic Ecosystems. *Frontiers in Earth Science.* 7 (321). https://doi.org/10.3389/feart.2019.00321.

IV. PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS: MANDATORY

Who has been involved?
Agencies need to know who has worked on the project to gauge and report performance in promoting partnerships and collaborations. The following information on participants and other collaborating organizations during this reporting period must be provided:

1. **Participants**

Individuals that have worked on the project
(1) Project director (Thomas S. Bianchi) Project Principal investigator, Nicholas Ward (Co-PI), David Butman (Co-PI), Michael Shields (Ph.D student), Julia Indivero (post-bachelor- research associate), and

(2) each person who has worked, and was funded by the project, at least one person month per year on the project during the reporting period, regardless of the source of

compensation (a person month equals approximately 160 hours of effort). Please note that such reporting does not constitute a formal institutional report of effort on the project, but rather is used by agency program staff to evaluate the progress of the project during a given reporting period.

Provide the name and identify the role the person played in the project. Do NOT include any other identifying information on individuals. Indicate the nearest whole person month (Calendar, Academic, Summer) that the individual worked on the project. Show the most senior role in which the person has worked on the project for any significant length of time. For example, if an undergraduate student graduates, enters graduate school, and continues to work on the project, show that person as a graduate student, preferably explaining the change in involvement. Describe how this person contributed to the project and with what funding support. If information is unchanged from a previous submission, provide the name only and indicate “no change”.

1) **Name:** Thomas S. Bianchi
2) **Project Role**: Project PI
3) **Nearest person month worked:** summer 0.25 mo.
4) **Contribution to Project:** Mentoring of Mike Shields, coordination of project logistics (sampling and lab work) and lead in writing proposal.
5) **Funding Support:** N/A
6) **Collaborated with individual in foreign country:** No
7) **Country(ies) of foreign collaborator:** No
8) **Travelled to foreign country:** No
9) **If traveled to foreign country(ies), duration of stay**: N/A

1) **Name:** Nicholas Ward
2) **Project Role**: Co-PI
3) **Nearest person month worked:** 0.75 mo.
4) **Contribution to Project:** Field sampling, water extractions, mentored Julia Indivero, and data interpretation
5) **Funding Support:** N/A
6) **Collaborated with individual in foreign country:** No
7) **Country(ies) of foreign collaborator:** No
8) **Travelled to foreign country:** No
9) **If traveled to foreign country(ies), duration of stay**:N/A

1) **Name:** David Butman
2) **Project Role**: Co-PI
3) **Nearest person month worked:** 0.75 mo.
4) **Contribution to Project:** Field sampling, trace gas and water quality measurements in field, organizing all field sampling events, data interpretation, and mentoring undergraduate students.
5) **Funding Support:** N/A
6) **Collaborated with individual in foreign country:** No
7) **Country(ies) of foreign collaborator:** No
8) **Travelled to foreign country:** No
9) **If traveled to foreign country(ies), duration of stay**:N/A

1) **Name:** Michael Shields
2) **Project Role:** Graduate Student
3) **Nearest person month worked:**1.0 mo.
4) **Contribution to Project:** Michael Shields conducted all biomarkers analyses on the project; he has also been responsible for analyzing and synthesizing the data for presentations at meeting and the manuscript currently in preparation.
5) **Funding Support:** N/A
6) **Collaborated with individual in foreign country:** No
7) **Country(ies) of foreign collaborator:** No
8) **Travelled to foreign country:** No
9) **If traveled to foreign country(ies), duration of stay**: N/A

1) **Name:** Julia Indivero
2) **Project Role:** Post-bachelor Research Associate
3) **Nearest person month worked:** 0.5 mo.
4) **Contribution to Project:** Julia aided in sample processing (e.g., filtration, solid phase extraction) and performed incubation experiments.
5) **Funding Support:** N/A (Complete only if the funding provided from other than this award.)
6) **Collaborated with individual in foreign country:** No
7) **Country(ies) of foreign collaborator:** N/A
8) **Travelled to foreign country:** N/A
9) **If traveled to foreign country(ies), duration of stay:** N/A

1) N**ame:** Claudia Davis
2) **Project Role:** undergraduate worker
3) **Nearest person month worked:** 0.25 mo.
4) **Contribution to Project:** Claudia aided in field sampling, and sample processing (e.g., filtration).
5) **Funding Support:** N/A (Complete only if the funding provided from other than this award.)
6) **Collaborated with individual in foreign country:** No
7) **Country(ies) of foreign collaborator:** N/A
8) **Travelled to foreign country:** N/A
9) **If traveled to foreign country(ies), duration of stay:** N/A

2. **Partners**

What other organizations have been involved as partners?
"Nothing to Report."

3. **Other Collaborators**
Have other collaborators or contacts been involved?
"Nothing to Report."

V. IMPACT:

1) Impact of the project

a. What was the impact on the development of the principal discipline(s) of the project?

Results from this study definitively showed that priming effects play an important role in the processing of carbon at river confluences. Our results are among the first molecular level evidence of aquatic priming effects, which have been notoriously difficult to detect/interpret based on bulk measurements that have been more widely deployed by the community. Likewise, the suite of quantitative biomarkers and ultra-high resolution DOM characterization techniques enabled unprecedented characterization of hydro-biogeochemical processes occurring along river corridors. Results from this study highlight that interactive effects on DOM decomposition are an important gap in biogeochemical models not only in river systems, but ecosystems across the land-ocean continuum.

b. What was the impact on other disciplines?

The novel application of both quantitative and untargeted molecular analyses to evaluate organic matter cycling mechanisms has broad relevance across terrestrial, aquatic, and marine science domains. The techniques that were deployed are specifically designed to evaluate the fate and transformation of carbon as it moves from soils, into inland waters, to the sea. Likewise, priming effects are likely a universal phenomenon to terrestrial, aquatic, coastal, and marine settings under different scenarios. Thus, constraining the magnitude and mechanism of priming across diverse terrestrial-aquatic interfaces in paramount to accurately portraying the carbon cycle in Earth system models.

c. What was the impact on the development of human resources?

As described earlier, this work allowed for a graduate student at the time, Michael Shields, to obtain analytical instrument training that was critical for his current job duties at Texas A&M University. Julia Indivero, after working as an undergraduate on the project with Nick Ward, was accepted as a Ph.D student in the Aquatic and Fisheries Sciences at University of Washington..

d. What was the impact on physical, institutional, and information resources that form infrastructure?

"Nothing to Report."

e. What was the impact on technology transfer?

"Nothing to Report."

f. What was the impact on society beyond science and technology?

"Nothing to Report."

g. What percentage of the award's budget was spent in foreign country(ies)?

zero

VI. CHANGES/PROBLEMS:

a. Changes in approach and reasons for change

Describe any changes in approach during the reporting period and reasons for these changes. Remember that significant changes in objectives and scope require prior approval of the Contracting Officer.

None to report

b. Actual or anticipated problems or delays and actions or plans to resolve them
Describe problems or delays encountered during the reporting period and actions or plans to resolve them.
None to report

c. Changes that have a significant impact on expenditures
None to report

d. Significant changes in use or care of human subjects, vertebrate animals, biohazards, and/or select agents
N/A

e. Change of primary performance site location from that originally proposed
N/A

f. Carryover Amount
N/A

VII. DEMOGRAPHIC INFORMATION:

Thomas S. Bianchi – email: tbianchi@ufl.edu

Gender: **Male**
Female
Do not wish to provide
Ethnicity: Hispanic or Latina/o
Not-Hispanic or not-Latina/o
Do not wish to provide
Race (select one or more):
American Indian or Alaska Native
Asian , Black or African American
Native Hawaiian or other Pacific Islander
White
Do not wish to provide
Disability Status:
Yes (check yes if any of the following apply to you)
Deaf or serious difficulty hearing
Blind or serious difficulty seeing even when wearing glasses
Serious difficulty walking or climbing stairs
Other serious disability related to a physical, mental, or emotional condition.
No
Do not wish to provide

David Butman – email:dbutman@uw.edu

Gender: **Male**
Female

Do not wish to provide
Ethnicity: Hispanic or Latina/o
Not-Hispanic or not-Latina/o
Do not wish to provide
Race (select one or more):
American Indian or Alaska Native
Asian , Black or African American
Native Hawaiian or other Pacific Islander
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Deaf or serious difficulty hearing
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Other serious disability related to a physical, mental, or emotional condition.
No
Do not wish to provide

Michael Shields – email: mshields@tamu.edu
Gender: **Male**
Female
Do not wish to provide
Ethnicity: Hispanic or Latina/o
Not-Hispanic or not-Latina/o
Do not wish to provide
Race (select one or more):
American Indian or Alaska Native
Asian , Black or African American
Native Hawaiian or other Pacific Islander
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Do not wish to provide
Disability Status:
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Blind or serious difficulty seeing even when wearing glasses
Serious difficulty walking or climbing stairs
Other serious disability related to a physical, mental, or emotional condition.
No
Do not wish to provide

Nicholas Ward – email: nicholas.ward@pnnl.gov
Gender: **male**

Female
Do not wish to provide
Ethnicity: Hispanic or Latina/o
Not-Hispanic or not-Latina/o
Do not wish to provide
Race (select one or more):
American Indian or Alaska Native
Asian, Black or African American
Native Hawaiian or other Pacific Islander
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Blind or serious difficulty seeing even when wearing glasses
Serious difficulty walking or climbing stairs
Other serious disability related to a physical, mental, or emotional condition.
No

Julia Indivero – email: jindiv@uw.edu
Gender: Male
Female
Do not wish to provide
Ethnicity: Hispanic or Latina/o
Not-Hispanic or not-Latina/o
Do not wish to provide
Race (select one or more):
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Serious difficulty walking or climbing stairs
Other serious disability related to a physical, mental, or emotional condition.
No
Do not wish to provide

Claudia Davis – email: megan.davis269@gmail.com
Gender: Male

Female
Do not wish to provide
Ethnicity: Hispanic or Latina/o
Not-Hispanic or not-Latina/o
Do not wish to provide
Race (select one or more):
American Indian or Alaska Native
Asian, Black or African American
Native Hawaiian or other Pacific Islander
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Do not wish to provide
Disability Status:
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Serious difficulty walking or climbing stairs
Other serious disability related to a physical, mental, or emotional condition.
No
Do not wish to provide

VIII. SPECIAL REPORTING REQUIREMENTS:

N/A