WSU's 2021 Dreissenid Mussel Early Detection Monitoring in the Columbia River

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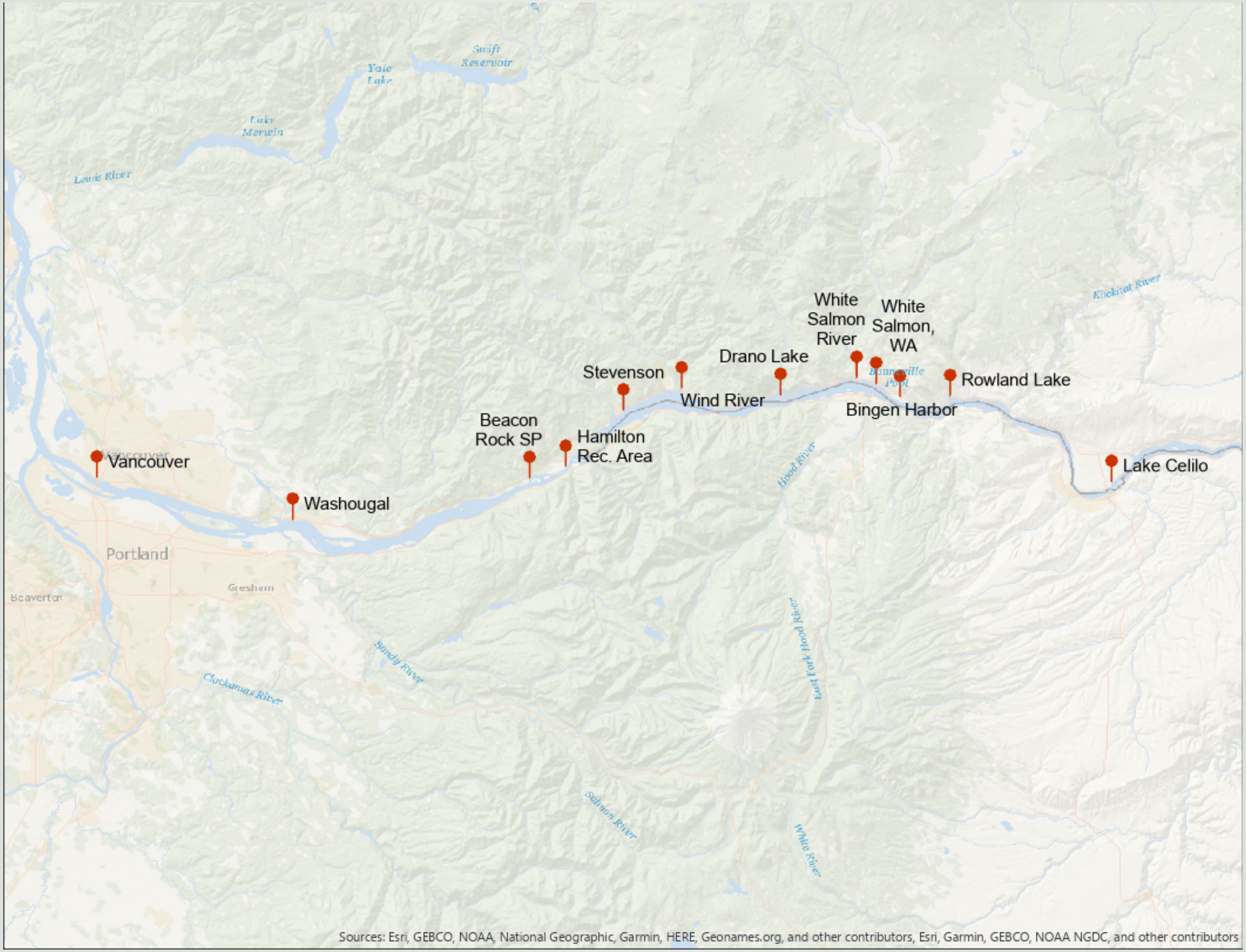
Location and number of samples to be collected in 2021 (Bi-weekly, May through October)

Sampling Location	Number of Net Samples	Number of eDNA Samples
Lake Celilo, WA	40	12
Rowland Lake	40	12
Bingen Harbor	40	12
White Salmon	40	12
White Salmon River at Underwood CUR	40	12
Drano Lake	40	12
Wind River	42	12
Stevenson	41	12
Near Bonneville Lock, Hamilton Recreation area	41	12
Beacon Rock SP	37	12
Washougal Marina	41	12
Vancouver, near I-5 bridge	45	12
Total	**487**	**144**

Location of samples collected in 2021



Risk assessment data used to direct sampling

Table 21. Water bodies in Washington that have a high to medium relative risk of dreissenid mussel establishment and/or introduction. Risk categories were formulated using best professional judgment. The amount of data used to assign risk categories varied for each water body. Data is summarized in Appendix 1 and II, and risk categories based on one or two data points are flagged with an asterisk. Dreissenids can also establish in areas identified with low to very low risk of establishment.

Water Body Name	$[Ca^{2+}]$ mg/L	pH	Relative Risk Establishment	Relative Risk Introduction[#]
Moses Lake	30.5	8.18	High	High
Potholes Reservoir outflow	28.3	8.14	High	High
Pend Oreille River	20.1		Medium	High
Lake Washington, inflow	18.8	7.77	Medium	High
Banks Lake	17.8	7.90	Medium	High
Columbia River, Lake Celilo	16.8		Medium	High
Columbia River, Lake Bonneville	16.5	8.11	Medium	High
Clear Lake	16.4	8.47	Medium	High
Williams Lake	20.5	7.39	Medium	Medium
Columbia River, Lake Wanapum	18.1	8.02	Medium	Medium
Lake Cresent	15.9	6.94	Medium	Medium
Nooksack River	12.0	7.57	Low	Medium
Silver Lake	10.4	7.49	Very Low	High
Deer Lake	9.3	7.50	Very Low	High
Cowlitz River	8.1	7.47	Very Low	High
Lake Cushman	11.6	7.55	Very Low	Medium
Diamond Lake	7.5	7.90	Very Low	Medium
Mineral Lake, outflow	5.8	7.64	Very Low	Medium
Alder Lake	5.1	7.45	Very Low	Medium
Cle Elum Reservoir	4.7	7.08	Very Low	Medium
Bumping Reservoir	3.8	7.55	Very Low	Medium

[#] When there were multiple measures of boater use, the measure with the highest risk category was used.

Wells et al. (2011)

In 2017, with generous support from the M.J. Murdock Charitable Trust, WSU Vancouver established the Water Chemistry Facility, a state-of-the-art water chemistry laboratory equipped with an Agilent 7900 ICP MS, a DIONEX Ion Chromatograph, and a Hach Dissolved Organic Carbon and Total Nitrogen Analyzer. Together, these instruments can be used to detect and quantify a broad range of elements and ions. In addition to its own research, the facility also offers its services to researchers, governmental users, and the private sector.

Analytical Capabilities

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List of analytes by instrument

ICPMS Major Elements	Na, Mg, Al, Si, P, K, Ca, Ti, Mn, Fe
ICPMS Trace Elements	Ag, As, Au, B, Ba, Be, Cd, Ce, Co, Cr, Cu, Dy, Er, Eu, Gd, Ge, Hf, Ho, Ir, La, Lu, Mn, Mo, Nb, Nd, Ni, P, Pb, Pd, Pr, Pt, Re, Rh, Ru, S, Sc, Sb, Se, Si, Sm, Sn, Ta, Tb, Te, Th, Ti, Tl, Tm, U, V, W, Y, Yb, Zn, Zr
Ion Chromatograph Anions	Fluoride, Chloride, Nitrite, Bromide, Sulfate, Phosphate
Ion Chromatograph Cations	Na+, NH4+, K+, Mg2+, Ca2+
Dissolved Organic Carbon and Total Nitrogen Analyzer	Total organic carbon, dissolved organic carbon, dissolved inorganic carbon, total nitrogen, total dissolved nitrogen

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SHORT COMMUNICATION

WILEY

Calcium concentrations in the lower Columbia River, USA, are generally sufficient to support invasive bivalve spread

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Abstract

Dissolved calcium concentration [Ca^{2+}] is thought to be a major factor limiting the establishment and thus the spread of invasive bivalves such as zebra (*Dreissena polymorpha*) and quagga (*Dreissena bugensis*) mussels. We measured [Ca^{2+}] in 168 water samples collected along ~100 river-km of the lower Columbia River, USA, between June 2018 and March 2020. We found [Ca^{2+}] to range from 13 to 18 mg L^{-1} during summer/fall and 5 to 22 mg L^{-1} during the winter/spring. Previous research indicates that [Ca^{2+}] < 12 mg L^{-1} are likely to limit the establishment and spread of invasive bivalves. Thus, our results indicate that there is sufficient Ca^{2+} in most locations in the lower Columbia River to support the establishment of invasive dreissenid mussels, which could join the already widespread and abundant Asian clam (*Corbicula fluminea*) as the newest invader to an already heavily invaded Columbia River ecosystem. These new data provide important measurements from a heretofore under-sampled region of the Columbia River and have important implications for the spread of invasive bivalves and, by extension, the conservation and management of native species and ecosystems.

KEYWORDS
Asian clam *Corbicula fluminea*, cation concentration, dreissenid mussels, shell formation, water chemistry

WSU Calcium Data from 2018-2020

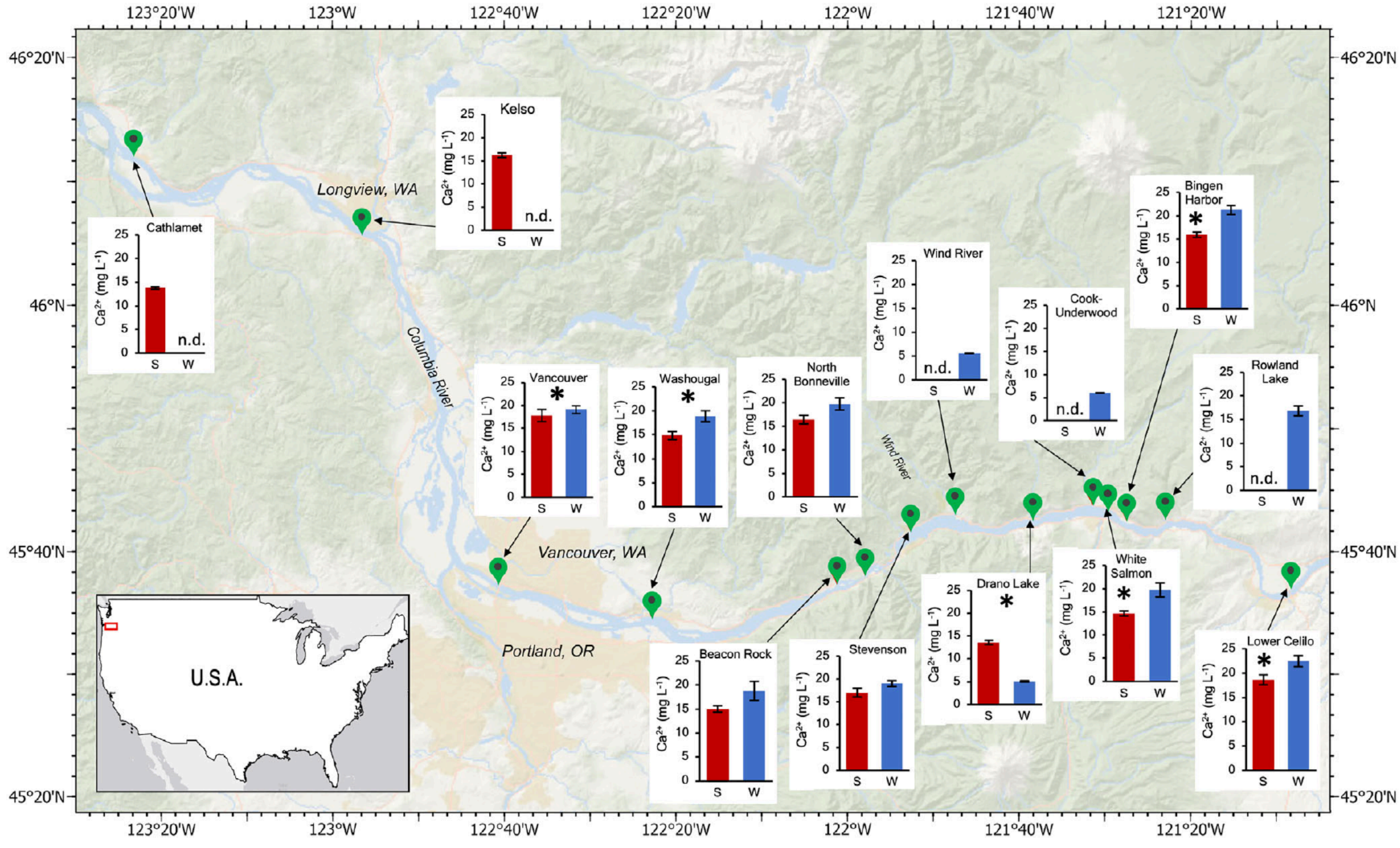

FIGURE 1 Mean [Ca^{2+}] during summer/fall 2018 (red bars) and winter/spring 2020 (blue bars) in the lower Columbia River, USA. Significant (two-tailed Welch's *t*-tests; $p < 0.05$) seasonal differences denoted by (*); "n.d." indicates no data were collected during that season; error bars represent 1 SE [Color figure can be viewed at wileyonlinelibrary.com]

From Bollens et al., 2021, River Res. Appl., https://doi.org/10.1002/rra.3804

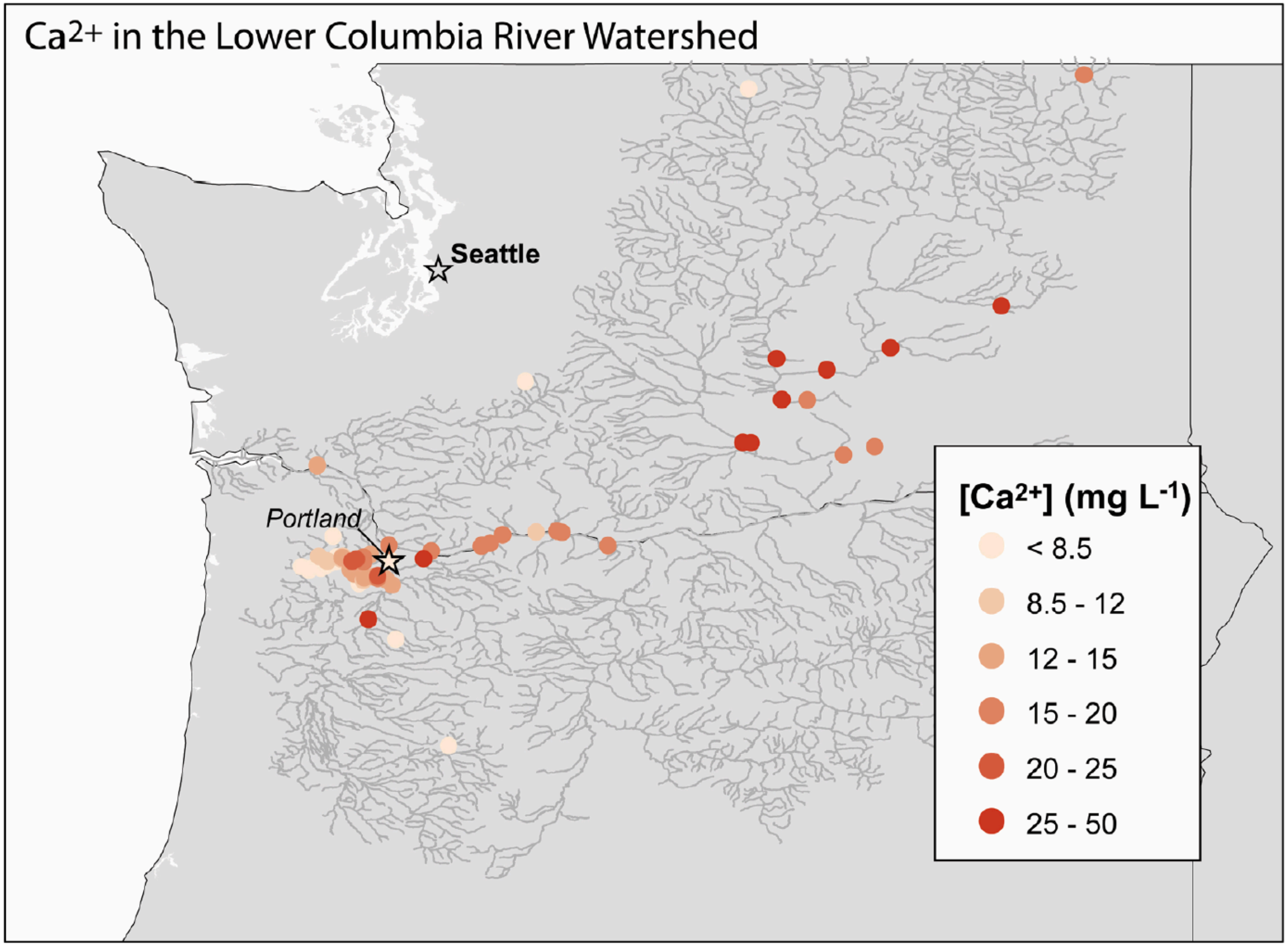

FIGURE 2 Mean [Ca^{2+}] in the lower Columbia River Basin using data from the USGS NWIS (2,132 data points collected from 54 sites between 2000 and 2019), and this study (142 data points from nine sites collected in 2018 and 2020) for which both winter/spring and summer/fall measurements were available [Color figure can be viewed at wileyonlinelibrary.com]

From Bollens et al., 2021, River Res. Appl., https://doi.org/10.1002/rra.3804

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Risk of Introduction	**Risk of Establishment**
High	Medium

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Risk of Introduction	Risk of Establishment	Potential Economic Impacts
High	Medium	Extremely High

Given our (WSU's) sampling locations, which range from Lake Celilo (most upstream) to Vancouver (most downstream), our risk assessment is as follows:

Risk of Introduction	Risk of Establishment	Potential Economic Impacts	Potential Ecological Impacts
High	Medium	Extremely High	Extremely High

Allocation of samples by sampling method

FIELD COLLECTION METHOD	LABORATORY ANALYSIS METHOD	WATER BODY			TOTAL
		THE DALLES RESERVOIR	BONNEVILLE RESERVOIR	"LOWER" COLUMBIA	
Plankton tow	CPLM Microscopy	40	283	164	487
Water sample	eDNA	12	84	48	144
Plankton tow	FlowCam	12	24	12	48

Results of 2021 Surveys: Dreissenid Veligers

The Good News!
(Based on May samples only)

FIELD COLLECTION METHOD	LABORATORY ANALYSIS METHOD	WATER BODY			TOTAL
		THE DALLES RESERVOIR	BONNEVILLE RESERVOIR	"LOWER" COLUMBIA	
Plankton tow	CPLM Microscopy	0	0	0	0
Water sample	eDNA	TBD	TBD	TBD	TBD
Plankton tow	FlowCam	TBD	TBD	TBD	TBD

Ingestion rate of the Asian clam, *Corbicula fluminea*, as a function of food concentration

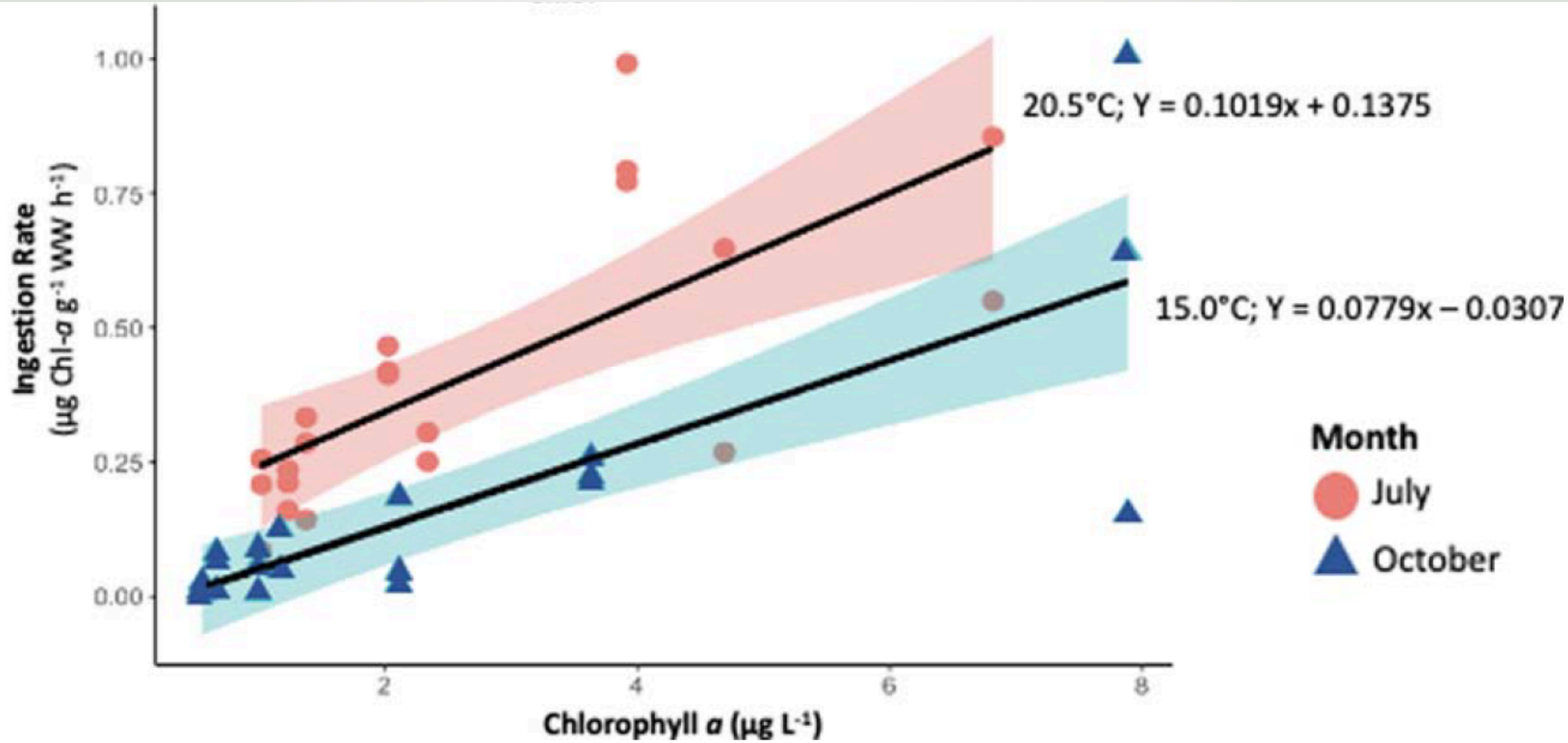
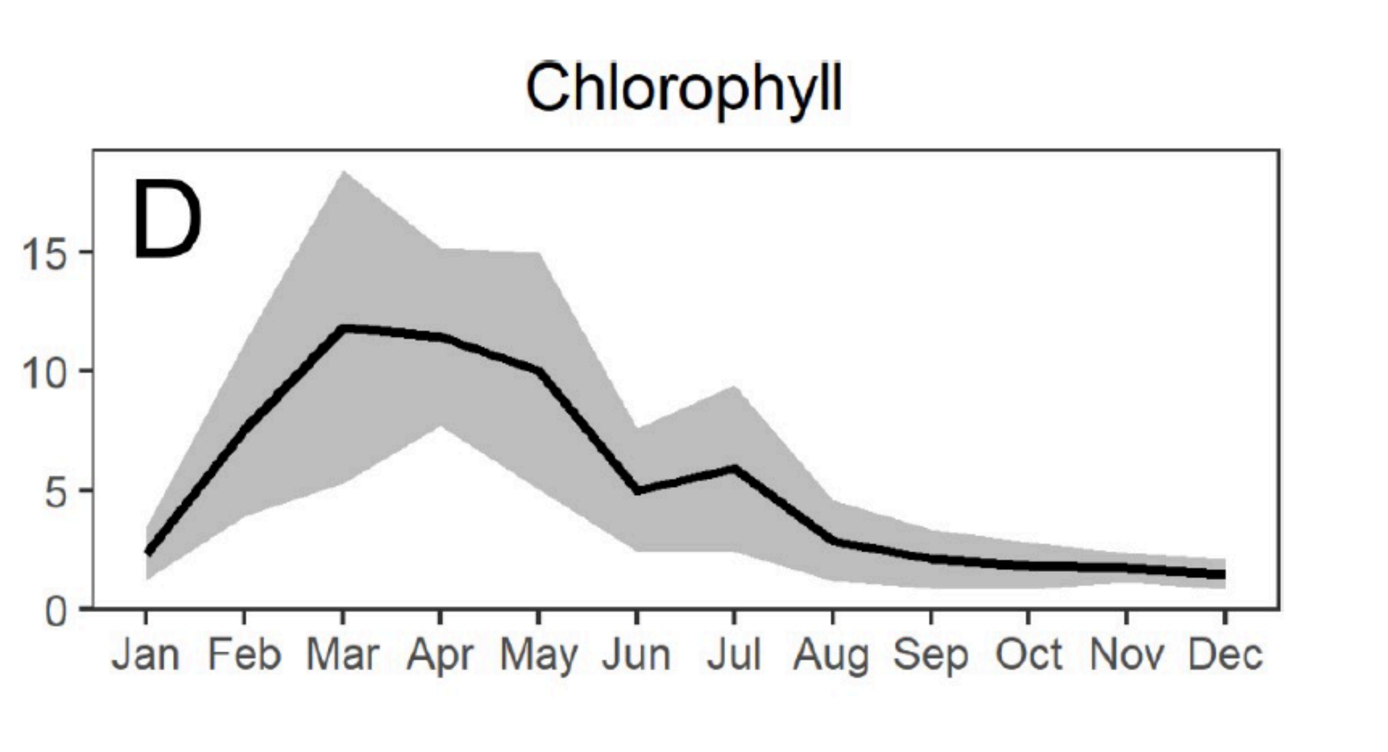


Figure 1. Experimentally determined (a) clearance rates and (b) Chl-*a* ingestion rates of adult *C. fluminea* as a function of food density (Chl-*a* concentration of natural microplankton collected from the Columbia River during July and October 2016). Solid lines are results of linear regressions; shaded areas are 95% confidence intervals. Both regression lines in panel (b) had slopes significantly different from zero ($p < 0.001$).

From Rollwagen-Bollens et al., 2021, *Inland Waters*, https://doi.org/10.1080/20442041.2020.1843933

Chlorophyll *a* concentration (ug/L) in the lower Columbia River (Vancouver Dock, 2005-2016)



From Dexter et al., 2020, PLoS ONE 15(12): e0243002
https://doi.org/10.1371/journal.pone.0243002

What went well and what posed difficulties?

Everything continues to go "as smooth as silk" – WSU has been doing this for many years now, so we are a "well-oiled machine."

COVID slowed down the processing of the 2020 samples by several weeks, but is no longer significantly affecting our work.