Growth and condition of the invasive Asian clam, *Corbicula fluminea,* in the Columbia River Estuary, USA

Summer Henricksen[1], Stephen Bollens[1], Gretchen Rollwagen-Bollens[1], and Julie Zimmerman[1]

[1]Washington State University Vancouver, Aquatic Ecology Lab

INTRODUCTION

The Asian clam, *Corbicula fluminea*, invaded the Columbia River in the 1930's and has since become very abundant. *C. fluminea* can potentially outcompete native, less prolific clams as well as clog industrial infrastructure with its mucoid larval stage.

The overall goal of this research is to better understand the population ecology of *C. fluminea* and to aid in its control. *C. fluminea*, may be a model for understanding and preparing for the likely invasion of zebra/quagga mussels, which are rapidly approaching the Columbia River.

The specific objective of this research project is to understand how the growth and abundance of *C. fluminea* vary seasonally, spatially, and interannually.

METHODS

Sampling:

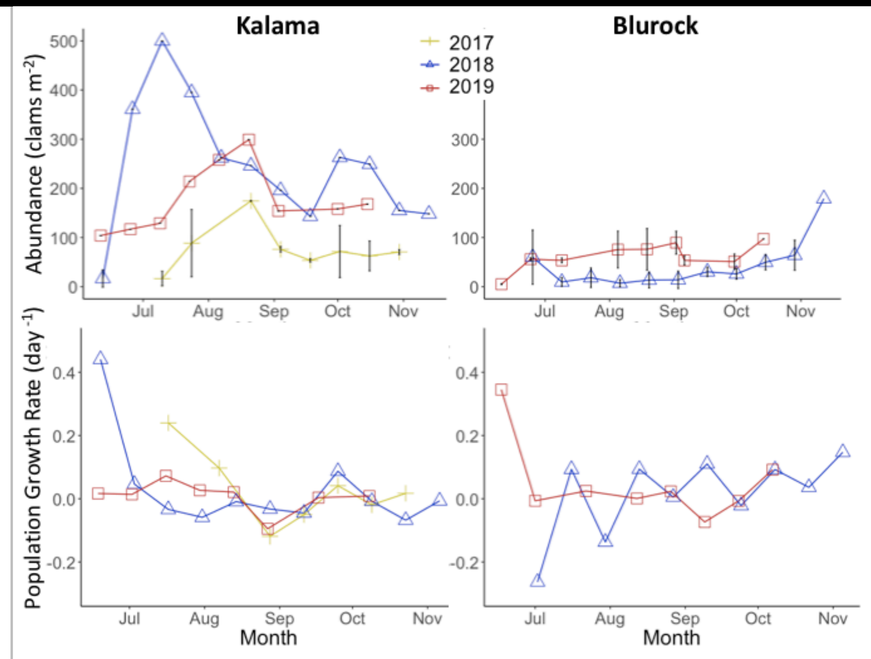
Samples were collected biweekly at Blurock in Vancouver, WA in 2018 and 2019 and at Kalama, WA in 2017, 2018 and 2019. On each date, samples were collected by sieving the contents within a 1m x 1m quadrant at randomly chosen stations on a transect. Clams were taken back to the lab where length, weight, height. and ring count were measured for each sampling unit.

Data Analysis:

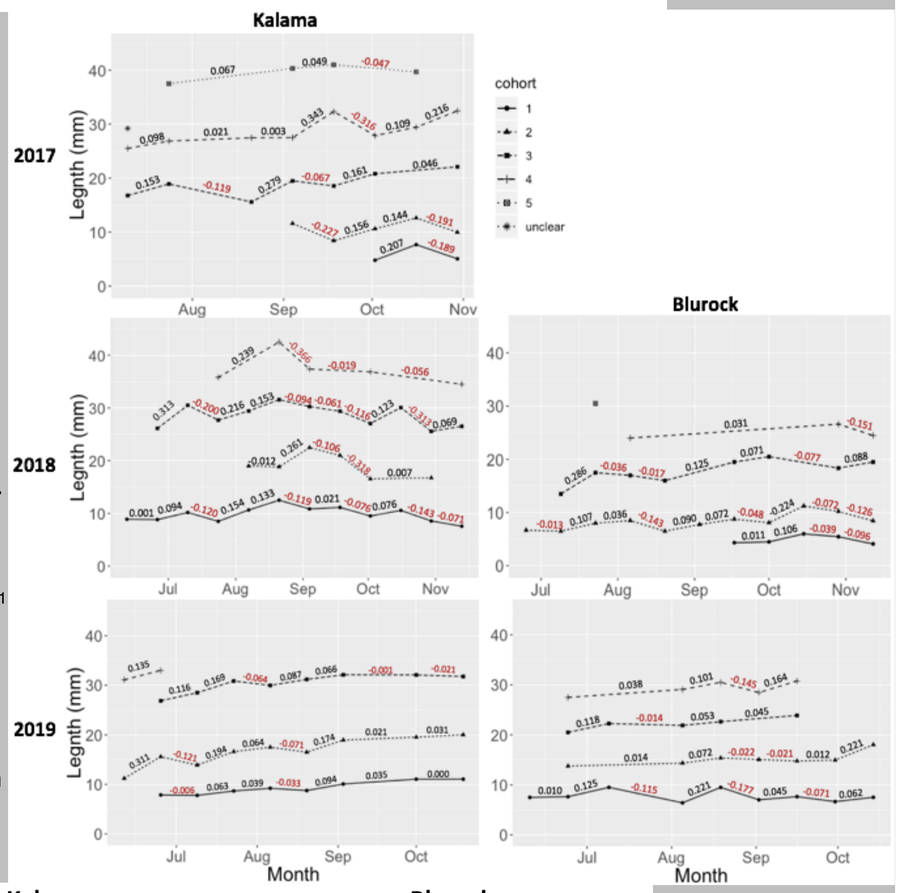
Growth was measured in terms of the increase in shell length. Data was grouped into length-frequency bins and plotted into histograms. Growth rates (mm/day) were calculated using modal progression analysis (U.N Food and Agriculture Organization's FiSAT software.).

Generalized linear mixed models (GLMM) were then created in R with population growth rate and individual growth rate as dependent variables and pH, DO, temperature, and Chlorophyll-a concentration as potential explanatory variables.

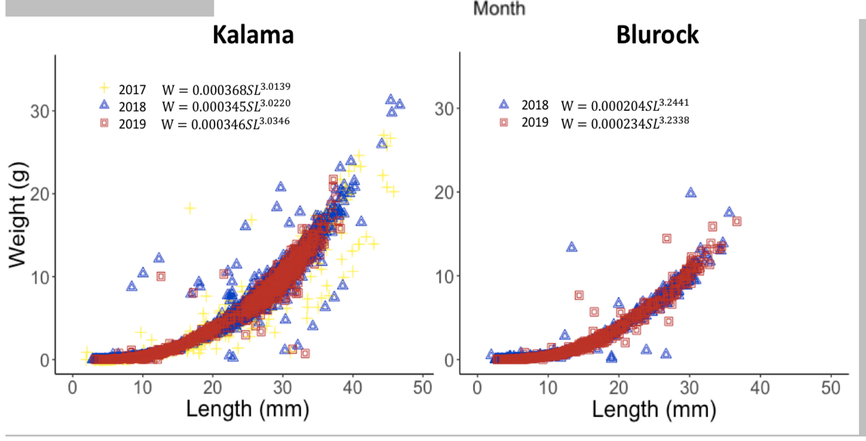
RESULTS



Abundance (clams m^{-2}) and population growth rate (day^{-1}) at Kalama in 2017 (yellow), 2018 (blue) and 2019 (red), and at Blurock in 2018 (blue) and 2019 (red).



Results of modal progression analysis with FiSAT software Each point represents the mean length of a cohort and the individual growth rate is calculated as the change in the mean length of that cohort between two consecutive sampling periods. Positive slopes indicate positive individual growth rates, in mm day^{-1} (numbers in black), and negative slopes indicate negative individual growth rates (numbers in red).



Relationship between wet weight (g) and length (mm) of *Corbicula fluminea.* Data from Kalama in 2017 (yellow cross), 2018 (blue triangle) and 2019 (red square), and from Blurock in 2018 (blue triangle) and 2019 (red square).

DISCUSSION

We observed marked differences in the population biology of *C. fluminea* at our two sites in the lower CR (Kalama and Blurock), as well as some differences between seasons and years.

Two patterns in the seasonal abundance of *C. fluminea* were observed. At Kalama, abundance followed the pattern previously observed in North and South America and which we hypothesized for the CR – highest abundance in the summer, with a secondary peak in fall. At Blurock, however, abundance was lower during the summer and only peaked in the fall. Modal progression analyses indicated a life span of 2-3 years for *C. fluminea* in the CR, with new young-of-the-year recruits (< 15 mm), one-year old (13-25 mm), two-year old (20-33mm), and three-year old (30-43mm) clams present.

The population growth rate of *C. fluminea* was predicted best by chl-*a* and temperature at Kalama, with DO and pH being additional explanatory variables at Blurock. Individual growth rate of *C. fluminea* increased significantly with temperature, but only when data from our two sites were combined, and in any event this explained little of the overall variation in individual growth rate.

Finally, the morphological condition of *C. fluminea* varied significantly between our two sites (higher at Blurock), suggesting important differences in environmental factors (e.g., dissolved oxygen and temperature). However, other environmental variables not measured by us, such as dissolved calcium, benthic algae, sediment characteristics and food quality, should be included in future studies of growth and condition of *C. fluminea*. Overall, this study emphasizes that the population biology of *C. fluminea* in the CR is similar in many regards to other populations studied in temperate regions of North America, South America and Europe, but that important spatial differences in population biology can occur between sites separated by 60 km within the same river system.

REFERENCES

Sousa, R., C. Antunes, and L. Guilhermino. 2008. Ecology of the invasive Asian clam Corbicula fluminea (Müller, 1774) in aquatic ecosystems: an overview. Annales de Limnologie – International Journal of Limnology 44:85–94.

AKNOWLEDGEMENTS

Many thanks to Steve Waste, Tim Counihan and Craig Haskell of USGS for providing resources vital to the completion of this project. Also, many thanks to all of the members of the Aquatic Ecology Lab for support in data collection and data analysis.

A special thanks to Salvador Rob-Chavez for countless hours of help in the field.