Emerging *Vibrio harveyi* and *Vibrio campbellii* Pathogens in Georgia Waters: Presence, Distribution, and Concentrations

Cameron Brown*, Alex Rosa-Calix, Dr. Andrei L. Barkovskii

Climate Change

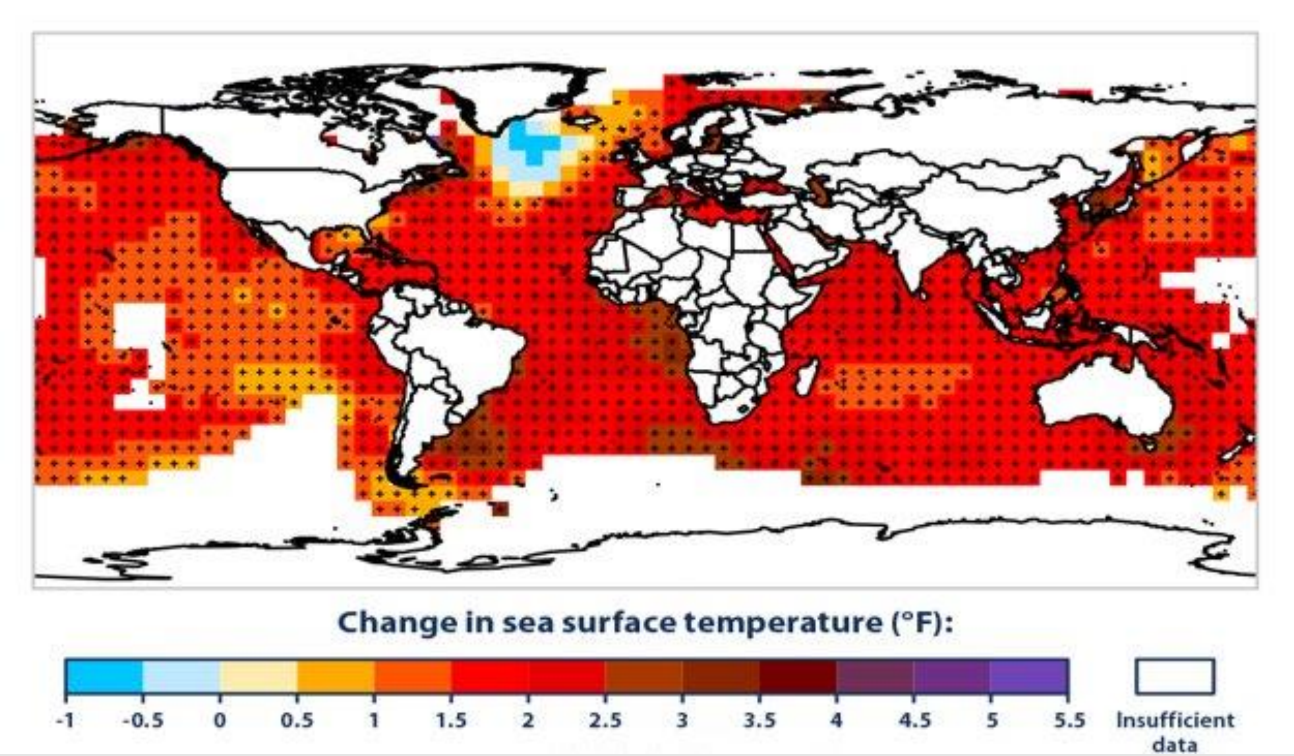
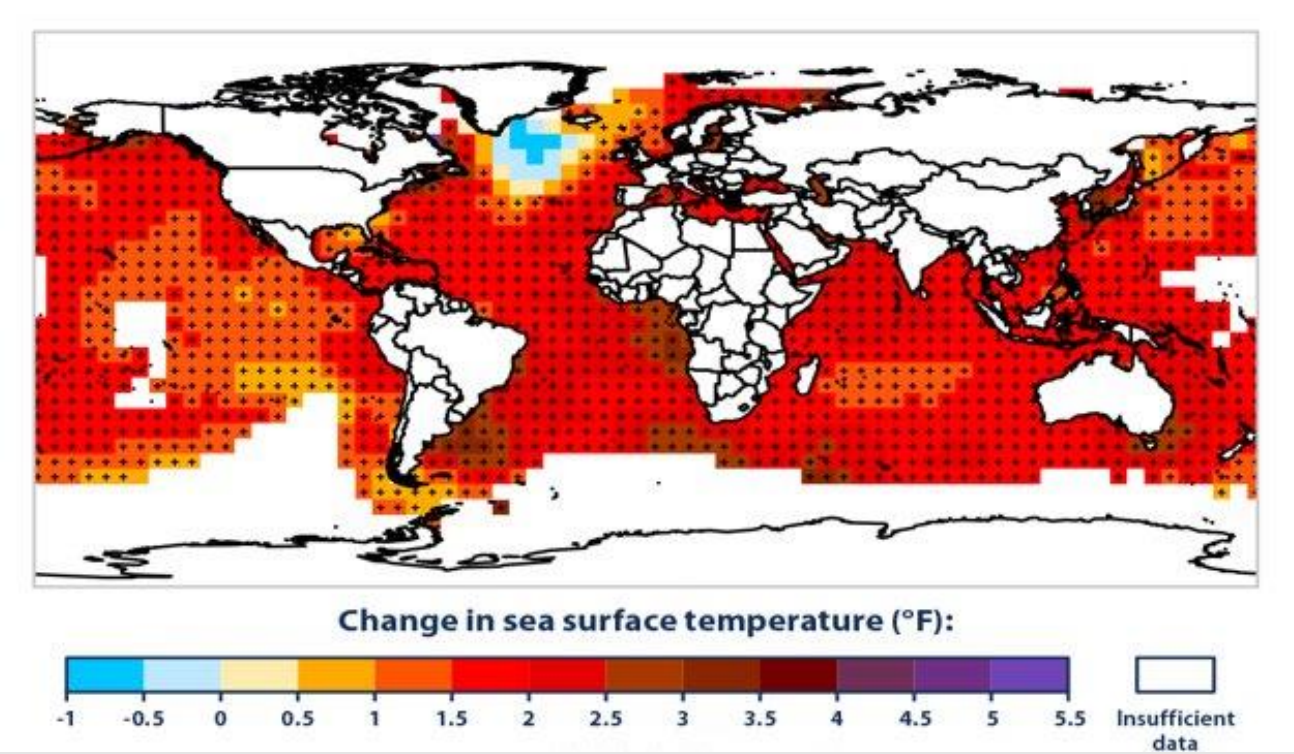


Figure 1. Change in sea surface temperature, 1901-2020 (EPA)

Climate Change



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Scientists' warning to humanity: microorganisms and climate change

Ricardo Cavicchioli, ... Matthew Baylis, Michael J. Behrenfeld, Antje Boetius, Philip W. Boyd, Aimée T. Classen, Thomas W. Crowther, Roberto Danovaro, Christine M. Foreman, Jef Huisman, David A. Hutchins, Janet K. Jansson, David M. Karl, Britt Koskella, David B. Mark Welch, Jennifer B. H. Martiny, Mary Ann Moran, Victoria J. Orphan, David S. Reay, Justin V. Remais, ... Nicole S. Webster + Show authors

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Abstract

In the Anthropocene, in which we now live, climate change is impacting most life on Earth. Microorganisms support the existence of all higher trophic life forms. To understand how humans and other life forms on Earth ... anthropogenic climate change, it is vital to ... majority'. We must learn not just how micro... production and consumption of greenhous... climate change and other human activities. ... role and global importance of microorgani... humanity on notice that the impact of clim... microorganisms, which are essential for ac...

The role of changing temperature in microbial metabolic processes during permafrost thaw

Published: April 30, 2020

Article | Authors | Metrics | Comments | Media Coverage

Abstract

Climate Change and Infections on the Move in North America

Infect Drug Resist. 2021; 14: 5711–5723.
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PMCID: PMC8722568
PMID: 35002262

Naomi Hauser,[1,2] Kathryn C Conlon,[2,3,4] Angel Desai,[1] and Leda N Kobziar[5]

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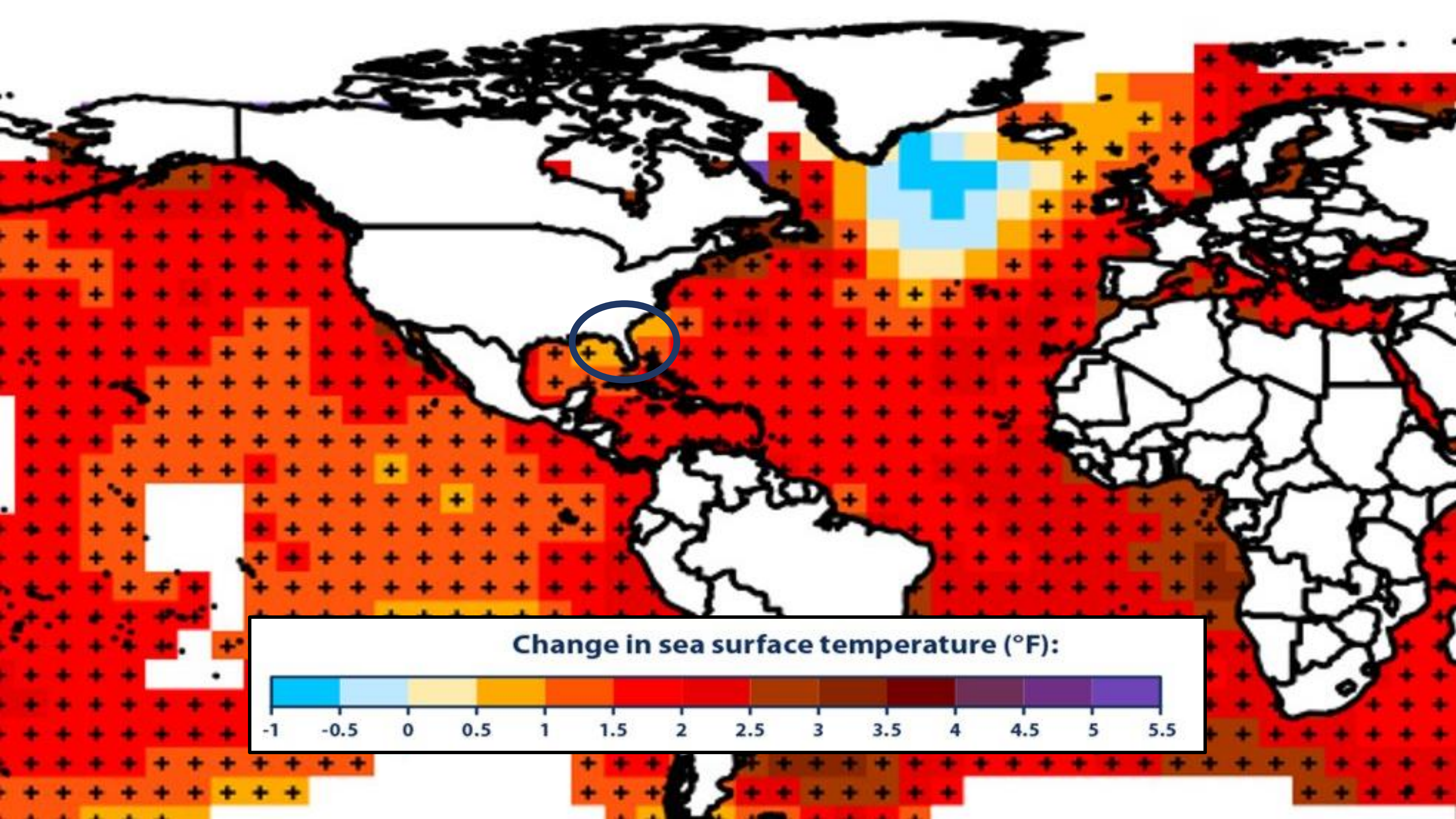
Abstract

Climate change is increasingly recognized for its impacts on human health, including how biotic and abiotic factors are driving shifts in infectious disease. Changes in ecological conditions and processes due to temperature and precipitation fluctuations and intensified disturbance regimes are affecting infectious pathogen transmission, habitat, hosts, and the characteristics of pathogens themselves. Understanding the relationships between climate change and infectious diseases can help clinicians broaden the scope of differential diagnoses when interviewing, diagnosing, and treating patients presenting with infections lacking obvious agents or transmission pathways. Here, we highlight key examples of how the mechanisms of climate change affect infectious diseases associated with water, fire, land, insects, and human transmission pathways in the hope of expanding the analytical framework for infectious disease diagnoses. Increased awareness of these relationships can help prepare both clinical physicians and epidemiologists for continued impacts of climate change on infectious disease in the future.

Keywords: climate change, global warming, infectious disease, environment


Change in sea surface temperature (°F):
-1
-0.5
0
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2
2.5
3
3.5
4
4.5
5
5.5

Figure 2. Oyster cages (NOAA)

Figure 4. Oyster cages (NOAA)

Figure 3. Wild oyster mounds (NOAA)

Oysters, clams, shrimp, red drum, almaco jack, spotted seatrout, summer flounder, snook, pompano, black seabass, and algae[1]

Vibrio harveyi and *Vibrio campbellii*

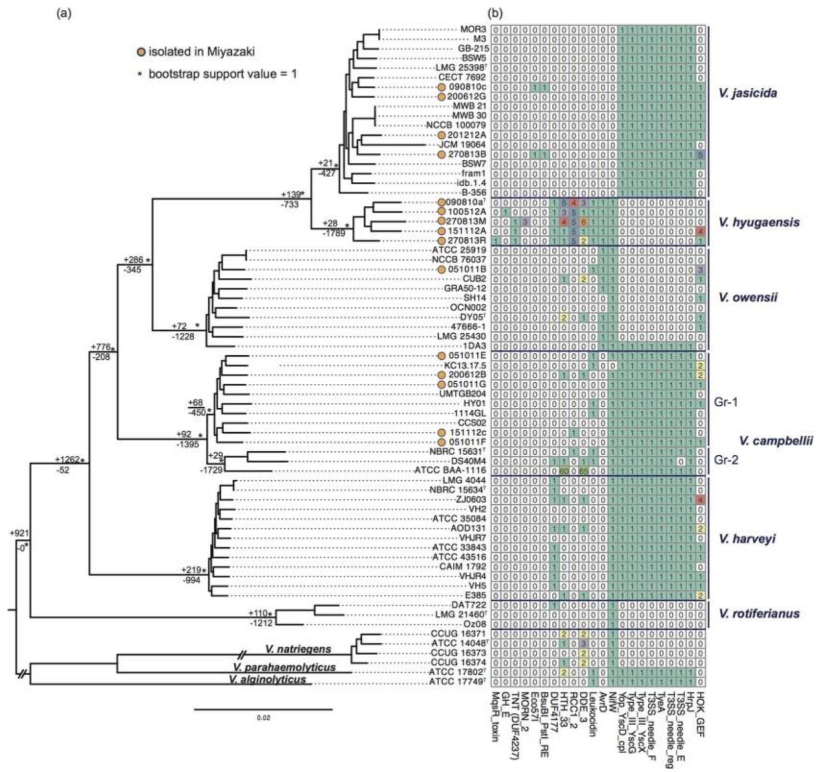

Figure 5. Phylogenetic tree of Harveyi clade (Ke *et al.*)

Figure 6. Muscle necrosis with *V. harveyi* infection

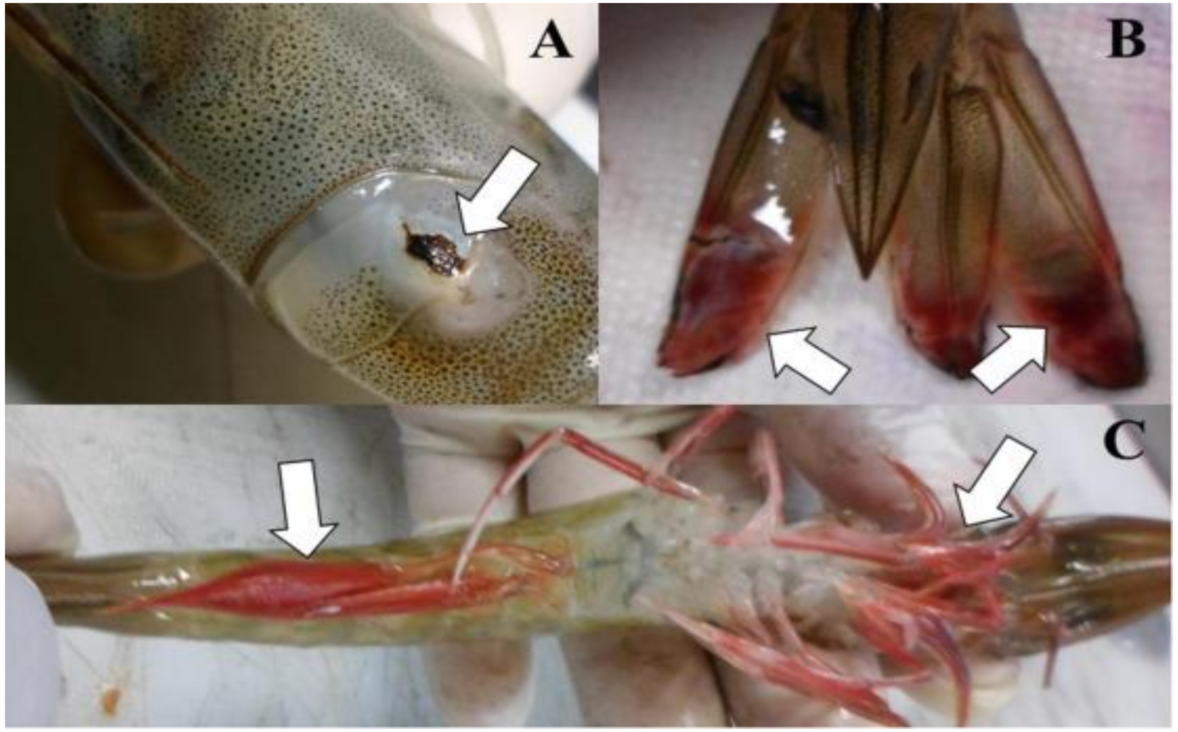

Figure 7. *V. harveyi* infection in shrimp (CDN)

Vibrio harveyi & *Vibrio campbellii*

Acute Hepatopancreatic Necrosis Disease (AHPND) and Early Mortality Syndrome (EMS)[2]

Blindness, Gastroenteritis, Vasculitis, Scale loss, Muscle necrosis, Tail rot, Anorexia, Lethargy, Kidney damage, and Brain swelling

Project Goals & Methods

1

2

3

DEVELOPMENT

Develop molecular tools to screen for environmental *Vibrio harveyi/campbellii*

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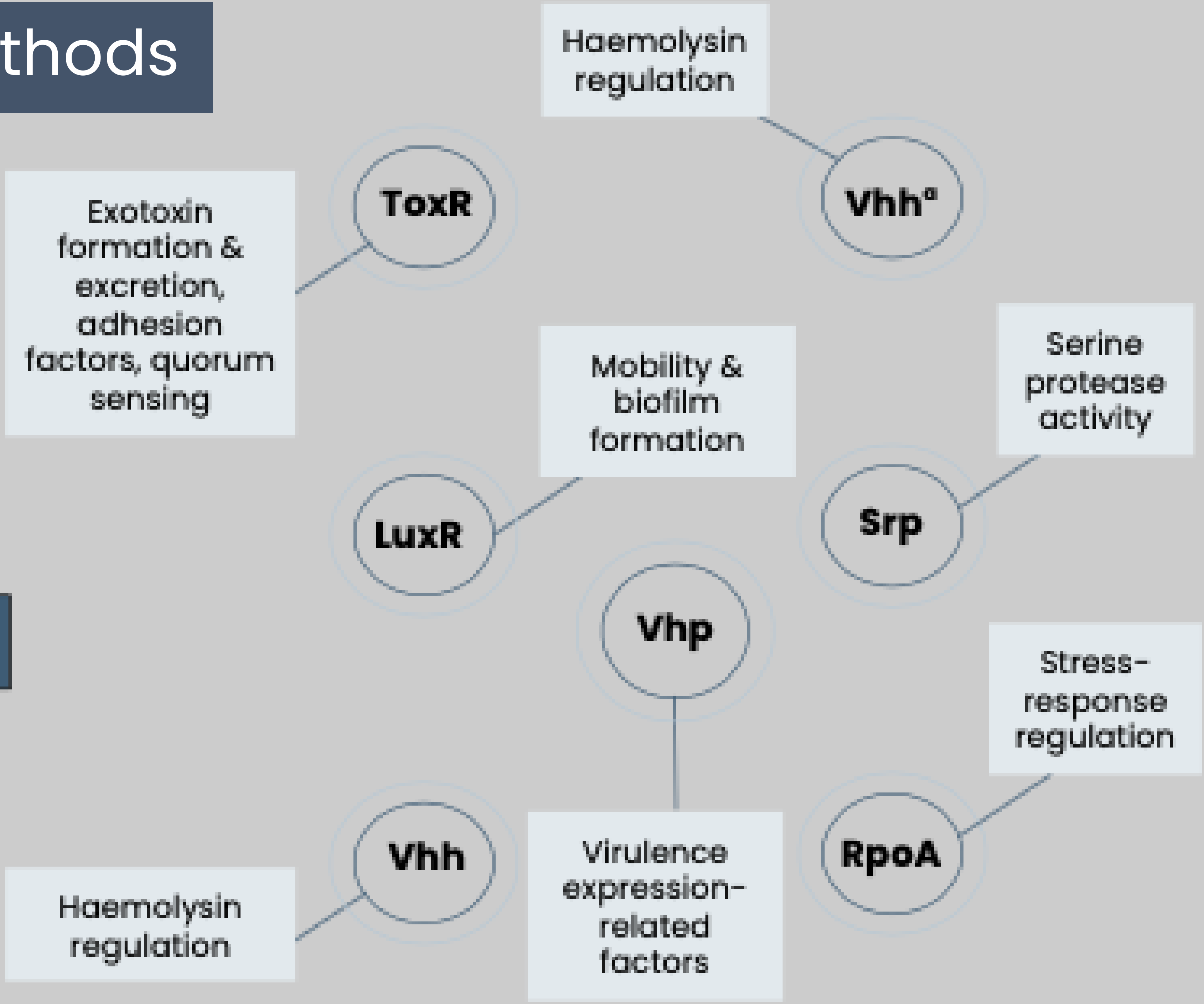

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Determine the presence of *Vibrio harveyi* and *Vibrio campbellii* in environmental water and sediment samples from Townsend, GA

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Project Goals & Methods

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DETECTION

Determine the presence of *Vibrio harveyi* and *Vibrio campbellii* in environmental water and sediment samples from Townsend, GA

Figure 8. Horiba water parameter meter (Horiba)

Figure 10. Clam beds

Figure 9. Map of Townsend and Sapelo Island, GA (Etsy)

QIAGEN

Figure 11. Thermocycler (Bio-rad)

Project Goals & Methods

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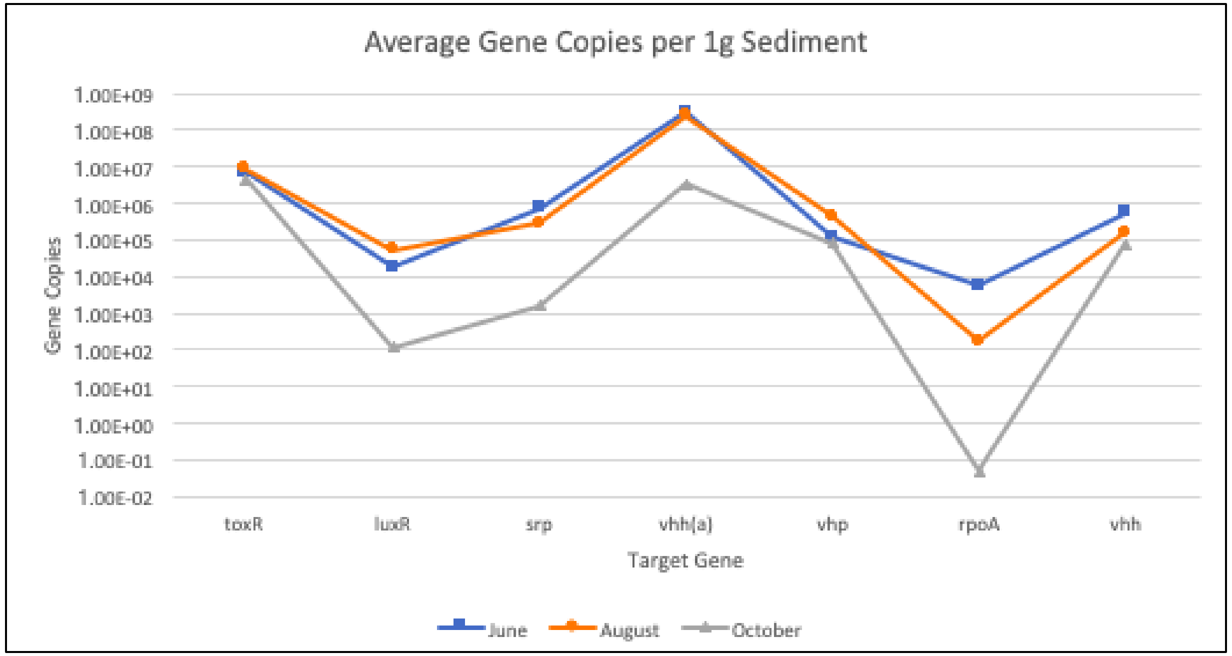
3

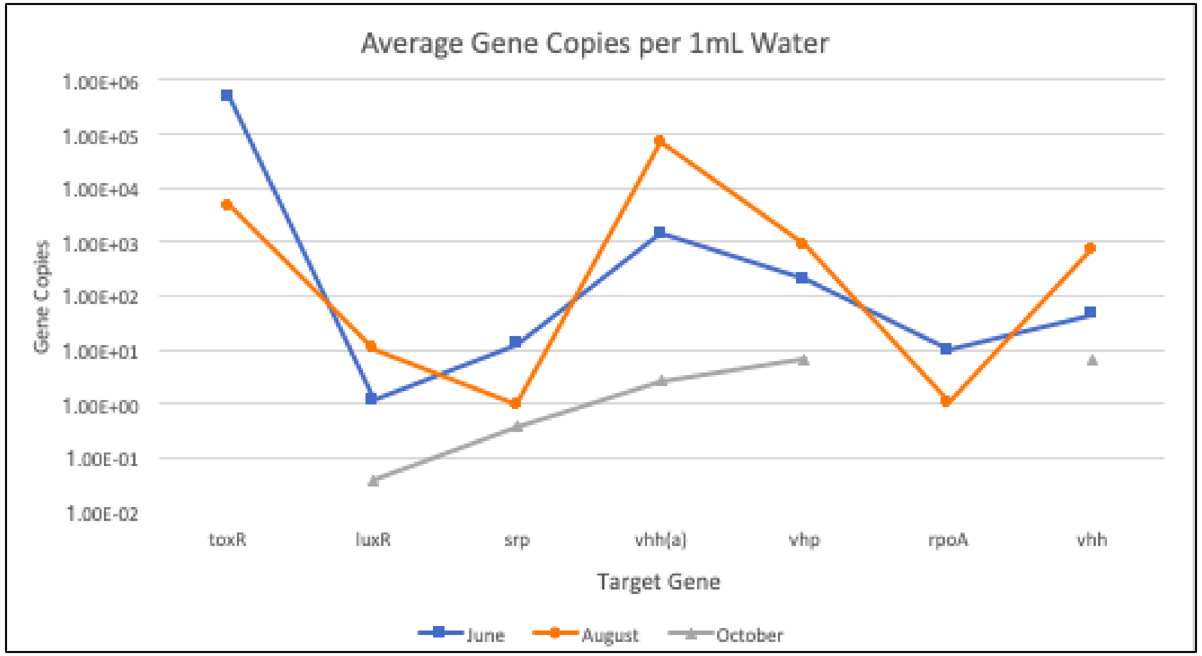
PREVALENCE

Report the dynamics in distribution and concentration of 7 virulence genes in environmental samples over time

Results & Conclusions

- Average gene copy number ranged from **0 to 10^5 in water samples** and **10^{-2} to 10^8 in sediment samples**
- *toxR* and *rpoA* were **not detected** in water samples in October
- *luxR*, *srp*, and *vhp* occurred in the **highest concentrations** in both water and sediment in **August**





*Please note difference in y-axis scale

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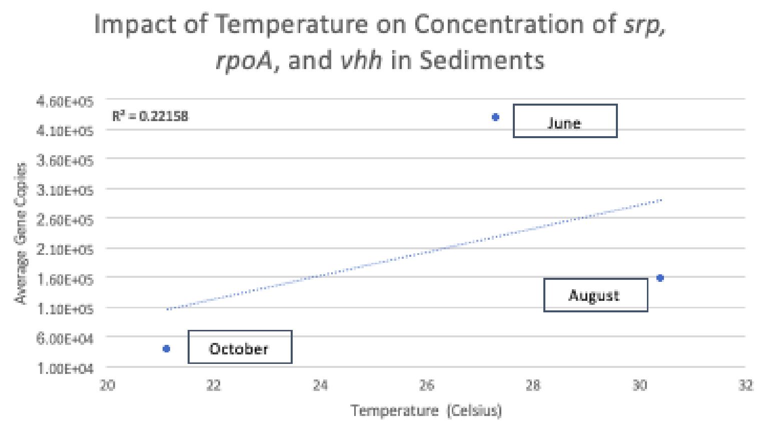
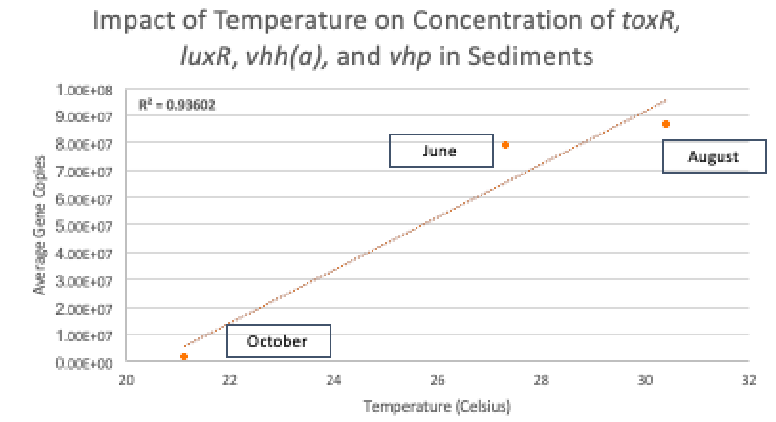
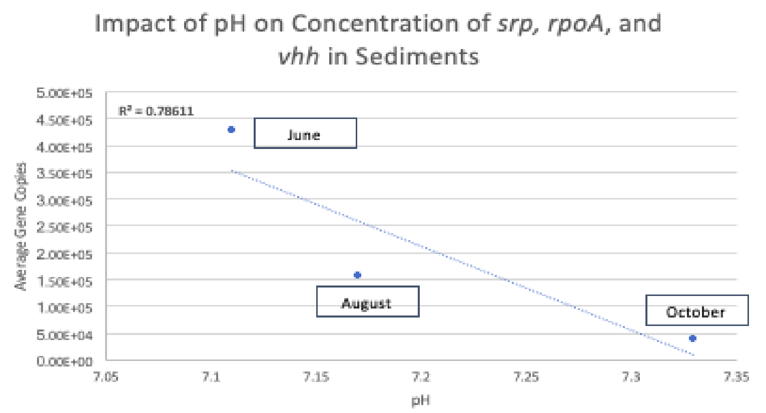
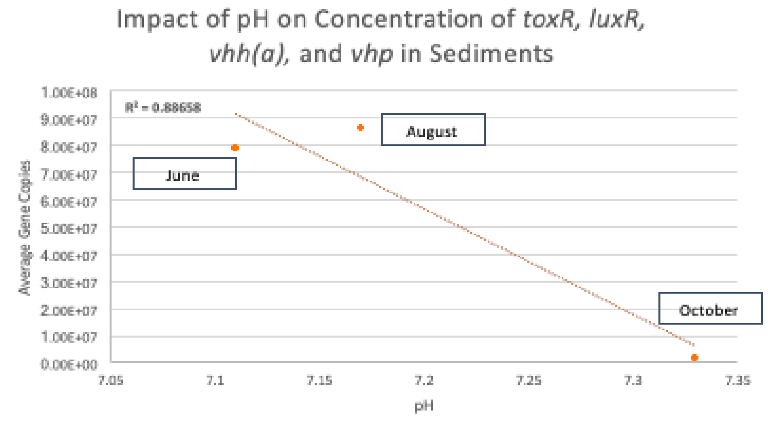
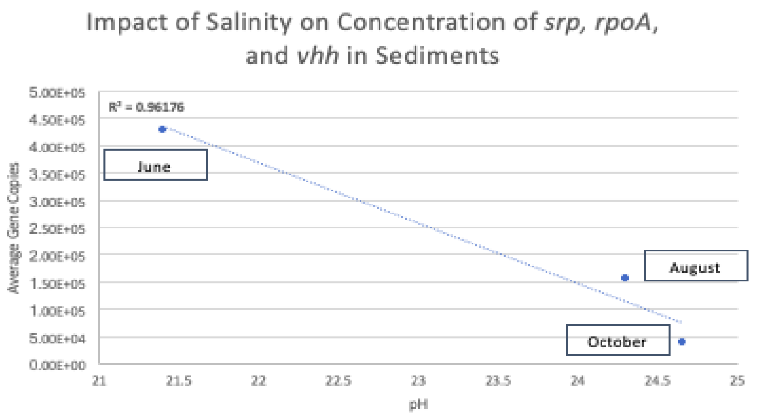
Gene/Parameter	pH	Temperature (Celsius)	Salinity (ppt)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Conductivity (mS/cm)	TDS (g/L)	Potential Water Density
toxR	-0.758719	0.994005	-0.182694	-0.434791	-0.892259	-0.074187	-0.314036	-0.598426
luxR	-0.567118	0.933085	0.074547	-0.650428	-0.747295	0.183049	-0.061060	-0.373884
srp	-0.933443	0.567939	-0.952115	0.586352	-0.820860	-0.913013	-0.984726	-0.989201
vhh(a)	-0.997854	0.860594	-0.736341	0.192898	-0.984648	-0.658012	-0.821115	-0.959566
vhp	-0.341404	0.812427	0.323294	-0.820760	-0.555853	0.424744	0.192289	-0.128246
rpoA	-0.729208	0.215565	-0.997112	0.848571	-0.544829	-0.999440	-0.977669	-0.860868
vhh	-0.822943	0.358516	-0.997308	0.760362	-0.663579	-0.983327	-0.998059	-0.927018
All gene averages	-0.931753	0.974051	-0.498261	-0.111706	-0.991483	-0.400554	-0.610987	-0.830164

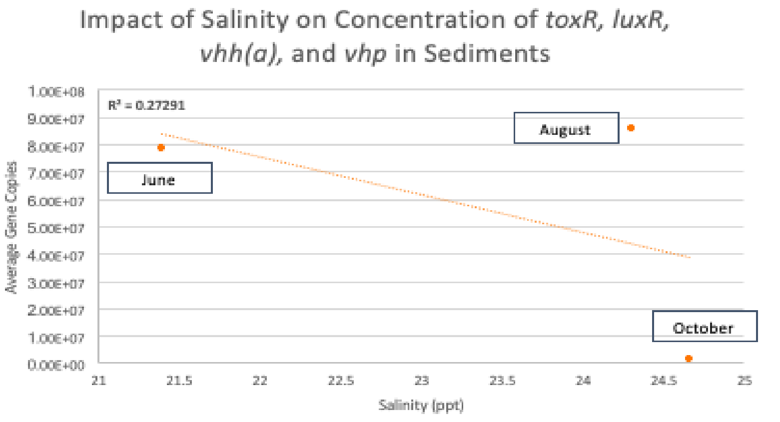












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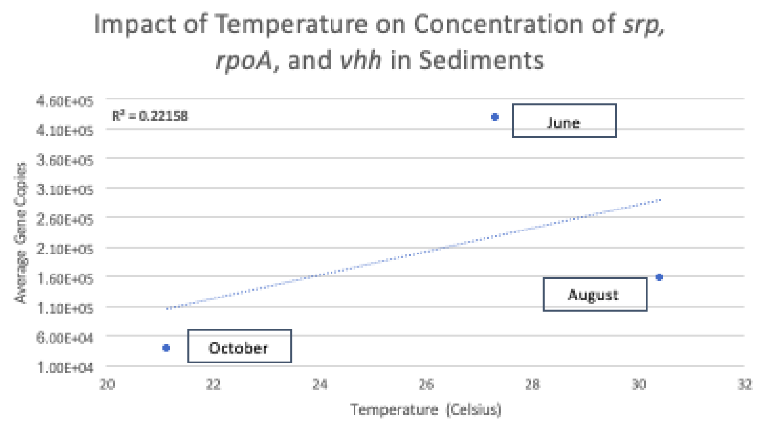

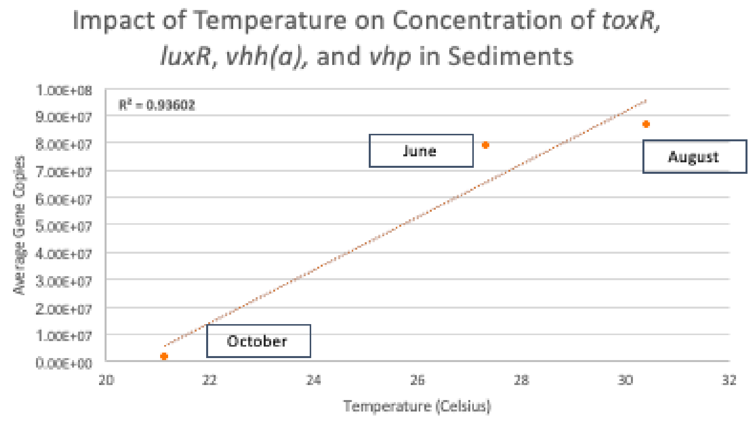

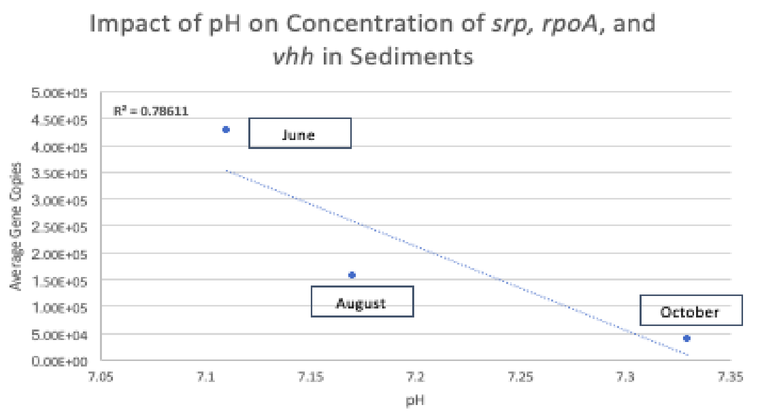

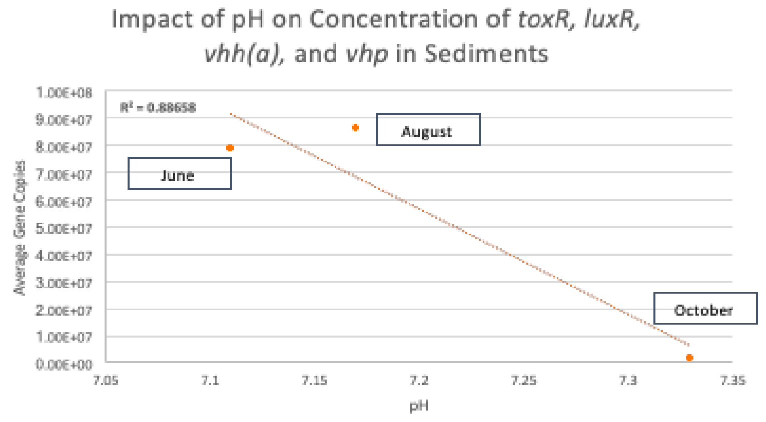

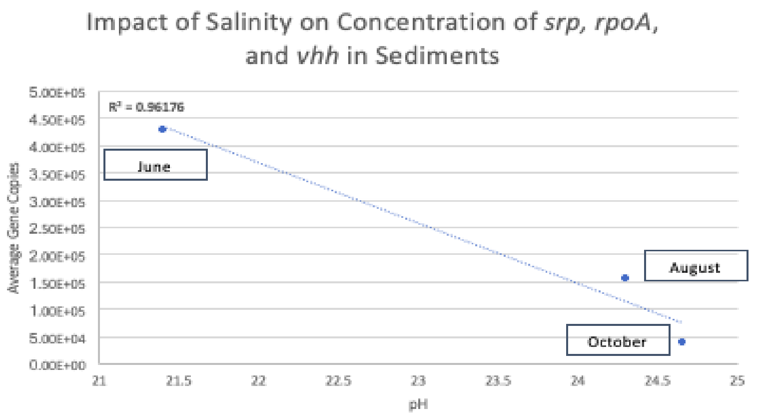

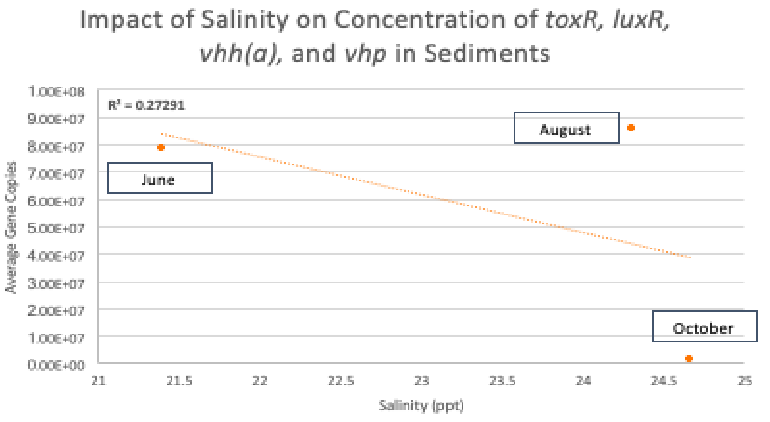

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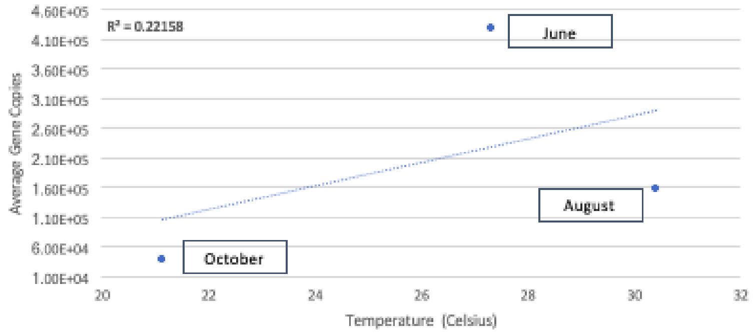
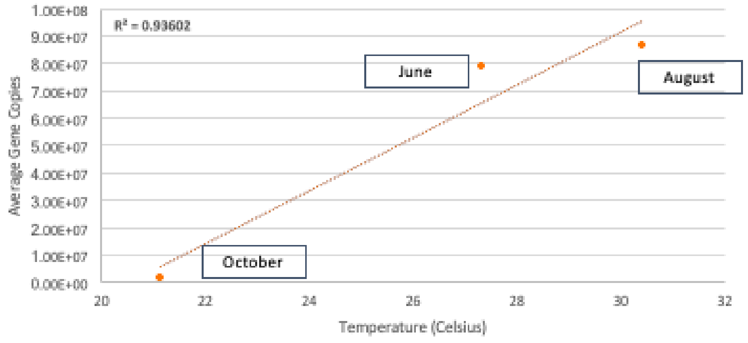
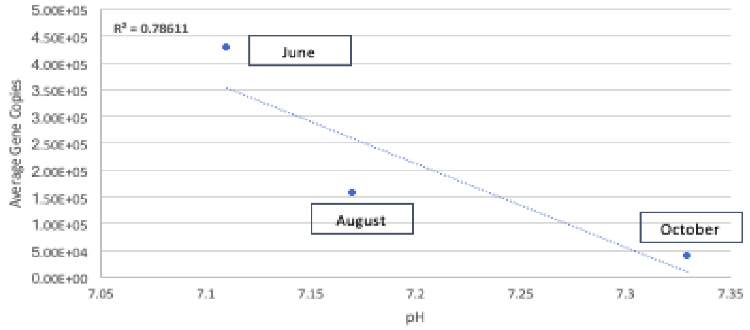
Impact of Temperature on Concentration of *srp*, *rpoA*, and *vhh* in Sediments



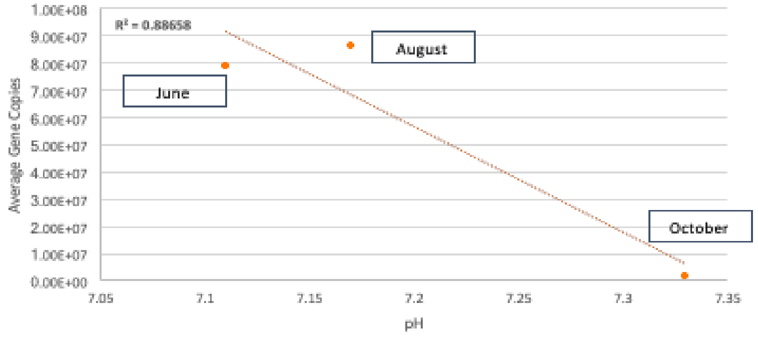
Impact of Temperature on Concentration of *toxR*, *luxR*, *vhh(a)*, and *vhp* in Sediments



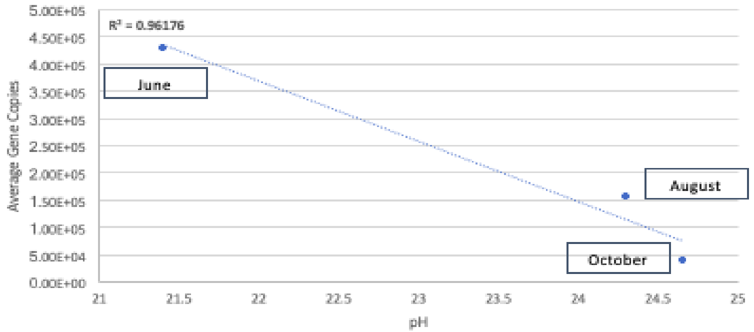
Impact of pH on Concentration of *srp*, *rpoA*, and *vhh* in Sediments



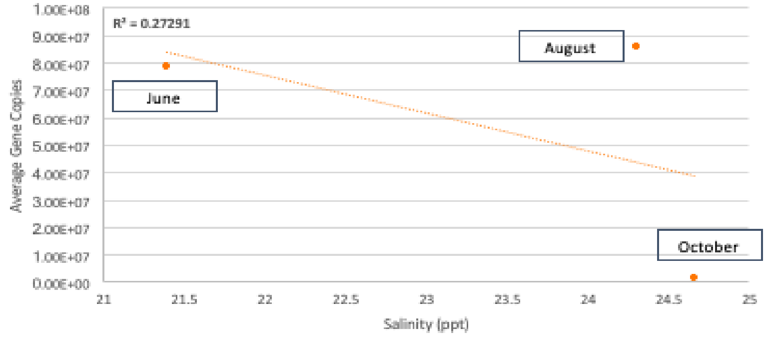
Impact of pH on Concentration of *toxR*, *luxR*, *vhh(a)*, and *vhp* in Sediments



Impact of Salinity on Concentration of *srp*, *rpoA*, and *vhh* in Sediments



Impact of Salinity on Concentration of *toxR*, *luxR*, *vhh(a)*, and *vhp* in Sediments



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srp	-0.738192	0.228456	-0.998029	0.841502	-0.555868	-0.998911	-0.980362	-0.867520
vhh(a)	-0.271061	0.767152	0.392293	-0.860706	-0.492948	0.490440	0.264233	-0.054659
vhp	-0.452515	0.876950	0.206537	-0.745688	-0.652261	0.312198	0.072257	-0.247186
rpoA	-0.774680	0.282419	-0.999976	0.810048	-0.601382	-0.994751	-0.989838	-0.893921
vhh	-0.300860	0.786726	0.363502	-0.844460	-0.519763	0.463105	0.234117	-0.085680
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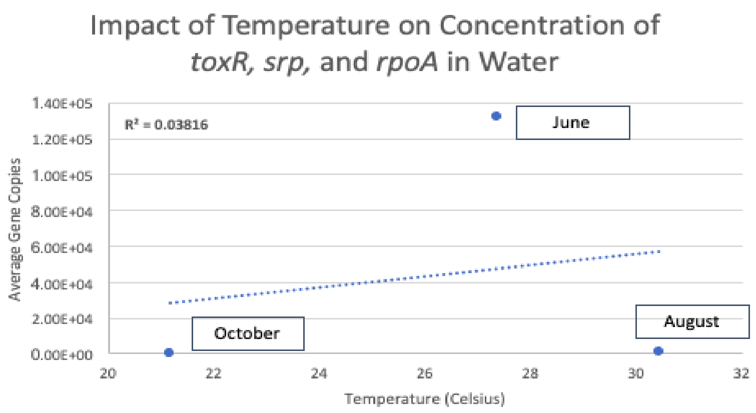

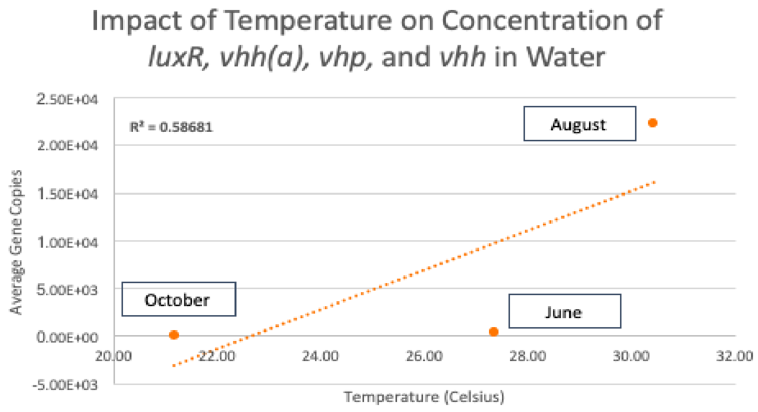

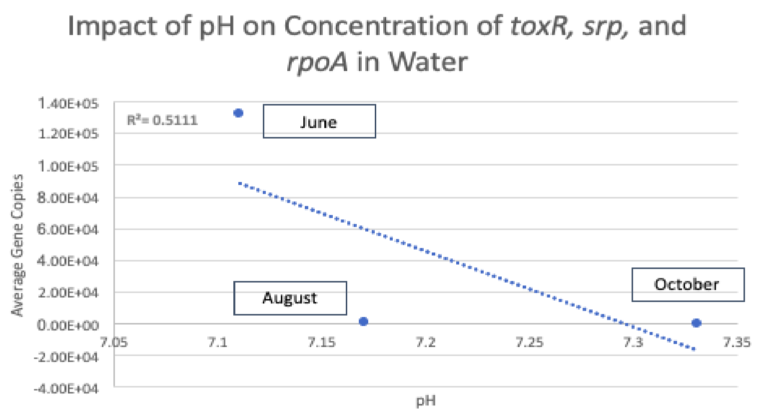

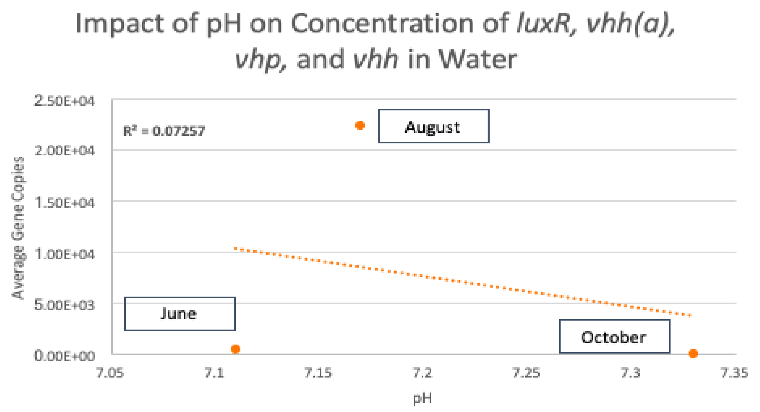

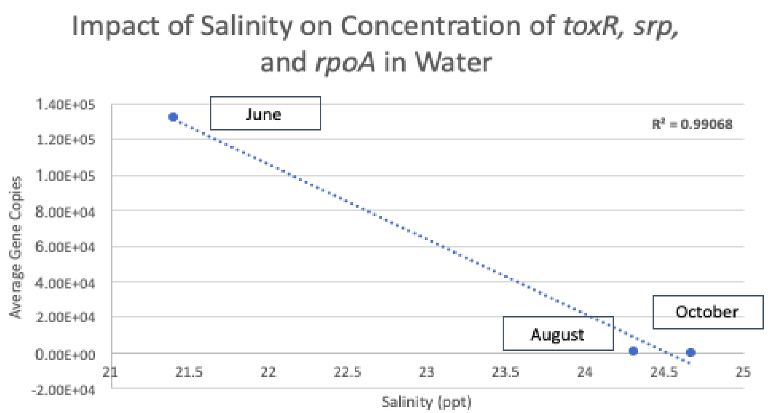

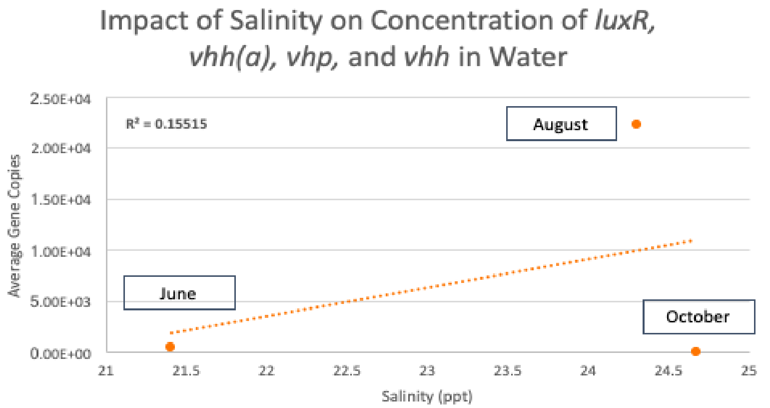

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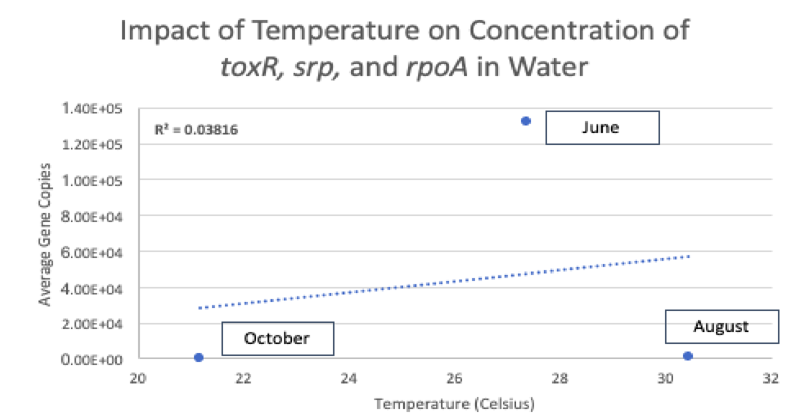
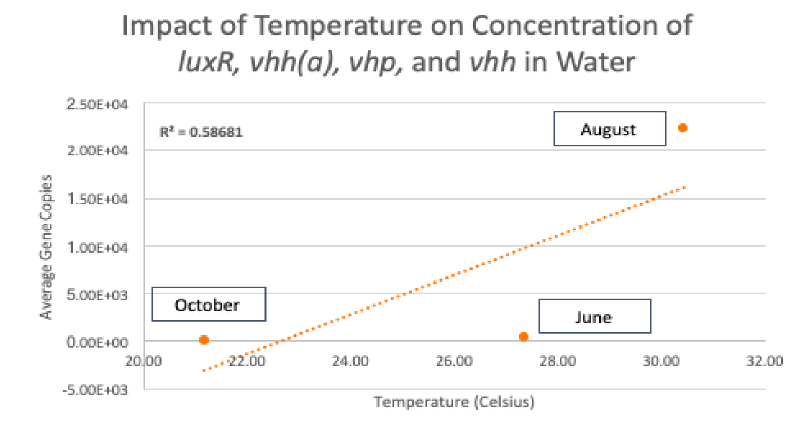
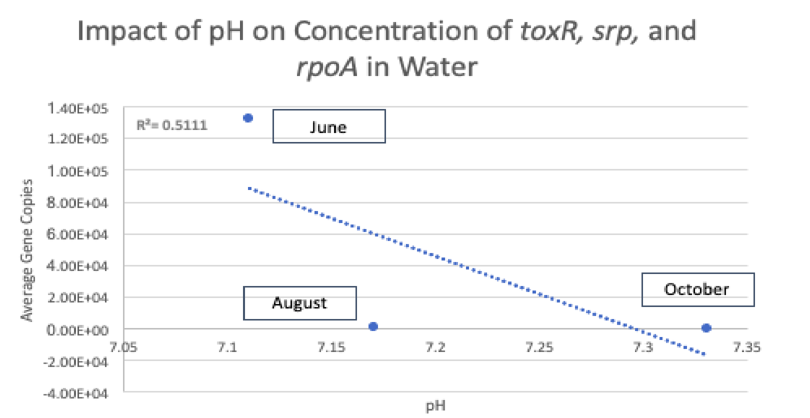
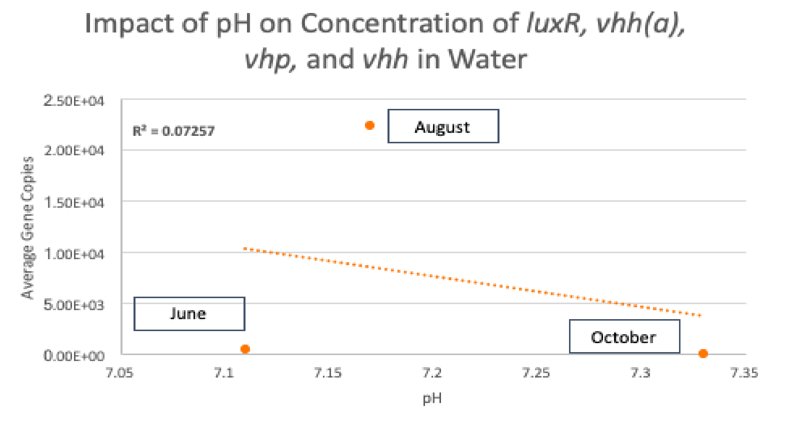
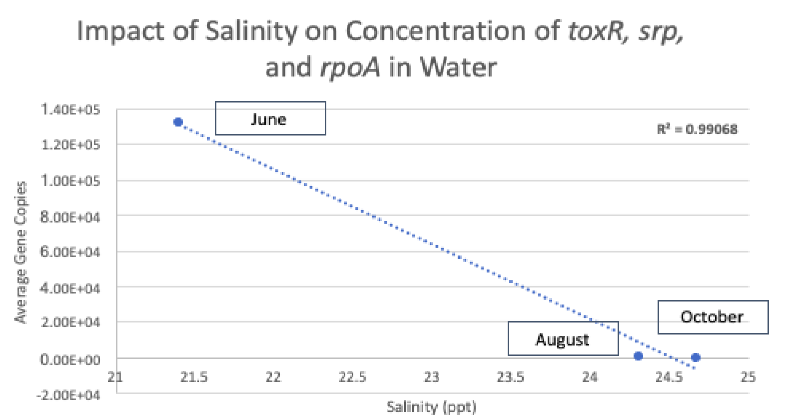
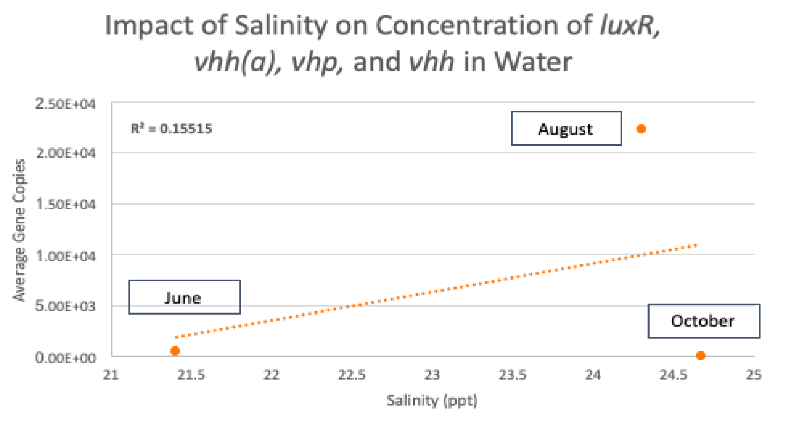








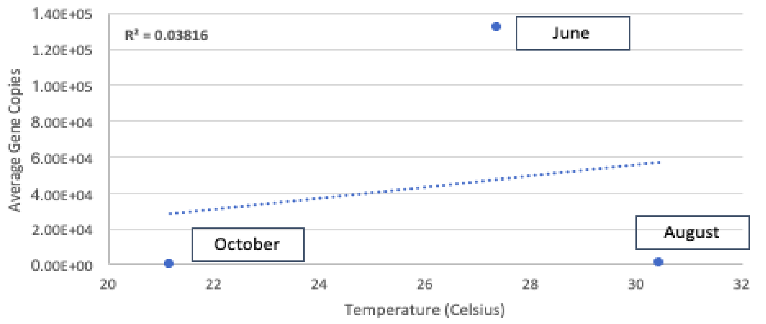




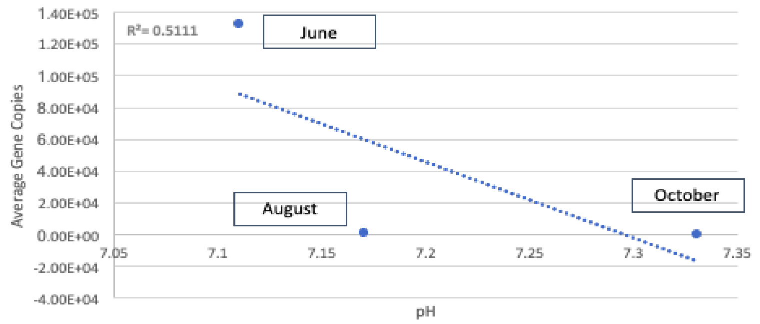
*Please note difference in y-axis scales

Gene/Parameter	pH	Temperature (Celsius)	Salinity (ppt)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Conductivity (mS/cm)	TDS (g/L)	Potential Water Density
toxR	-0.716556	0.197649	-0.995555	0.858116	-0.529383	-0.999885	-0.973657	-0.851407
luxR	-0.348787	0.816989	0.315840	-0.816241	-0.562375	0.417609	0.184563	-0.136044
srp	-0.738192	0.228456	-0.998029	0.841502	-0.555868	-0.998911	-0.980362	-0.867520
vhh(a)	-0.271061	0.767152	0.392293	-0.860706	-0.492948	0.490440	0.264233	-0.054659
vhp	-0.452515	0.876950	0.206537	-0.745688	-0.652261	0.312198	0.072257	-0.247186
rpoA	-0.774680	0.282419	-0.999976	0.810048	-0.601382	-0.994751	-0.989838	-0.893921
vhh	-0.300860	0.786726	0.363502	-0.844460	-0.519763	0.463105	0.234117	-0.085680
All gene averages	-0.948251	0.603424	-0.937819	0.550331	-0.845074	-0.894281	-0.976161	-0.994669

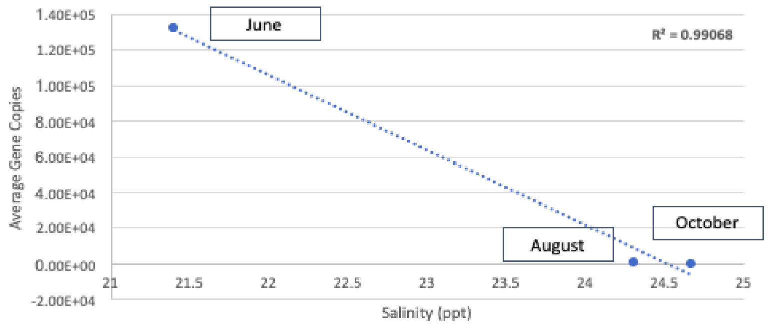
Impact of Temperature on Concentration of *toxR, srp,* and *rpoA* in Water



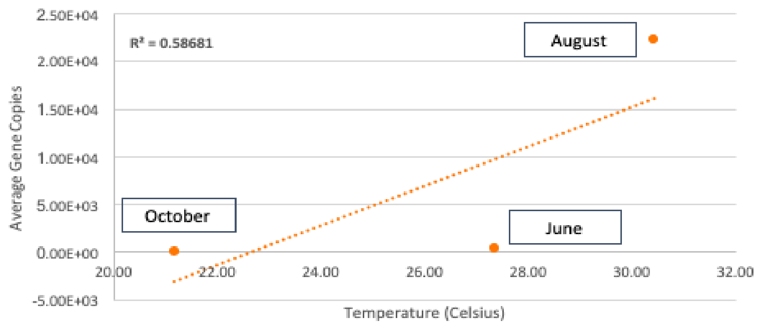
Impact of pH on Concentration of *toxR, srp,* and *rpoA* in Water



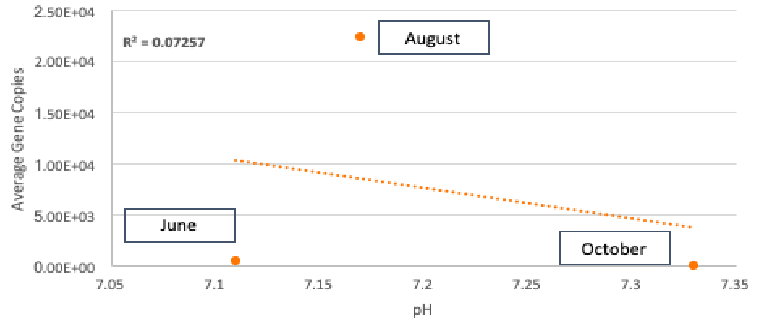
Impact of Salinity on Concentration of *toxR, srp,* and *rpoA* in Water



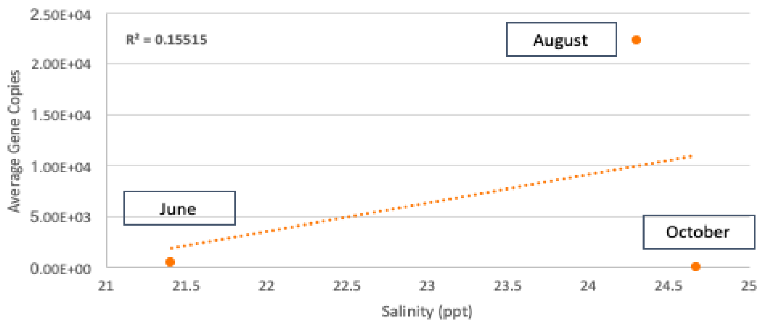
Impact of Temperature on Concentration of *luxR, vhh(a), vhp,* and *vhh* in Water



Impact of pH on Concentration of *luxR, vhh(a), vhp,* and *vhh* in Water



Impact of Salinity on Concentration of *luxR, vhh(a), vhp,* and *vhh* in Water



Summary

- Our findings indicate the **presence** of *Vibrio harveyi/campbellii* in Coastal Georgia waters for the first time
- All 7 genes were detected in each sampling event in **high concentrations**
- In general, there is a **positive correlation** between temperature and gene copy number
- Supplementary data in our lab has evidenced the presence of *V. harveyi/campbellii* in clams and oysters

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- A huge thank you to Dr. Andrei L. Barkovskii for entrusting, guiding, and supporting me throughout the course of this project

Questions?

(P.S. Yes, you can still eat seafood from Georgia. *Vibrio harveyi/campbellii* are not human pathogens….as of now)

References

1. National Oceanic and Atmospheric Administration (NOAA). 2022. Marine Aquaculture in NOAA Fisheries' Southeast Region. Available online at https://www.fisheries.noaa.gov/southeast/aquaculture/marine-aquaculture-noaa-fisheries-southeast-region Accessed 26 February 2023.
2. Kumar, V., S. Roy, B.K. Behera, P. Bossier, and B.K. Das. 2021. Acute hepatopancreatic necrosis disease (AHPND): Virulence, pathogenesis and mitigation strategies in shrimp aquaculture. Toxins. 23(8):524. doi: 10.3390/toxins13080524.
3. Figure 1. https://www.epa.gov/climate-indicators/climate-change-indicators-sea-surface-temperature
4. Figure 2-4. https://seagrant.noaa.gov/Portals/0/EasyGalleryImages/1/595/UGA%20Oysters015%5B3%5D.jpg
5. Figure 5. https://journals.asm.org/doi/10.1128/JB.00001-18
6. Figure 6-7. https://ars.els-cdn.com/content/image/1-s2.0-S002220111930120X-gr1.jpg
7. Figure 8. https://www.horiba.com/int/products/detail/action/show/Product/u-50-434/
8. Figure 9. https://www.etsy.com/market/sapelo_island_map
9. Figure 10. Produced by Cameron Brown
10. Figure 11. https://www.bio-rad.com/en-us/product/c1000-touch-thermal-cycler-for-classroom?ID=dcdab038-4e77-49a8-bcaa-f67e8648550d