Data Final

Kaleb

2022-12-03

Introduction

Oysters are an important member of their ecosystems, but their population has been in major decline. Oyster reefs are sites that provide habitats for many organisms, where important nutrient cycles are managed, and many more beneficial processes occur.

Sadly, a catastrophic decline in New Hampshire oyster population has been recorded, with only 10% of the population being what it was in the 1980's. Decline has been attributed to major diseases, human harvest and anthropogenic impacts, decline in oyster shell substrate for larval settling, and low recruitment.

There have been restorative efforts in the local Great Bay Estuary (GBE) of New Hampshire. Oyster spat has been distributed in restoration sites in the GBE, with different sites having varying degrees of success. Restorative success depends on recruitment in wild populations of oysters, which can depend on many factors. The ocean absorbs CO_2 from the air. When air CO_2 concentrations increase, it causes the pH of the ocean to go down into a more acidic environment called ocean acidification which can affect shell growth in early larval stages.

Salinity stuff, temperature stuff.

By finding where oyster larvae are most abundant throughout the GBE, this study aims to find the best environmental conditions for oyster reproduction. This data will aid future restoration efforts by showing what factors and sites to focus on for optimal results.

Methods

All data was collected at the Great Bay Estuary in New Hampshire. Six sites in total were used in the study. Woodman's Point (WP), Nannie Island (NI), the Lamprey River (LR), and Squamscott River (SR) were collected in the 2018 and 2019 seasons. In the 2020 season WP and NI were used again, while Adams Point (AP) and an oyster farm (OF) were added. Collection of samples from the GBE and counting of D-hinge and Veliger larvae was completed by *Stasse et al.* (All techniques can be found in *insert here*). Physiochemical data was collected by the Oceanic and Atmospheric Administration's (NOAA) National Estuarine Research Reserve System (NERRS) data buoy for each sampling day.

An analysis of variance (ANOVA) test was performed to test for differences of D-hinge and veliger counts among years. A Tukey's honnestly significant difference (HSD) was performed *post-hoc* among sampling years for D-hinge annd veliger counts. Regression models were performed for pH, temperature, and salinity as independent variables, and D-hinge and veliger counts as dependent variables. Stats were all performed using R

Results

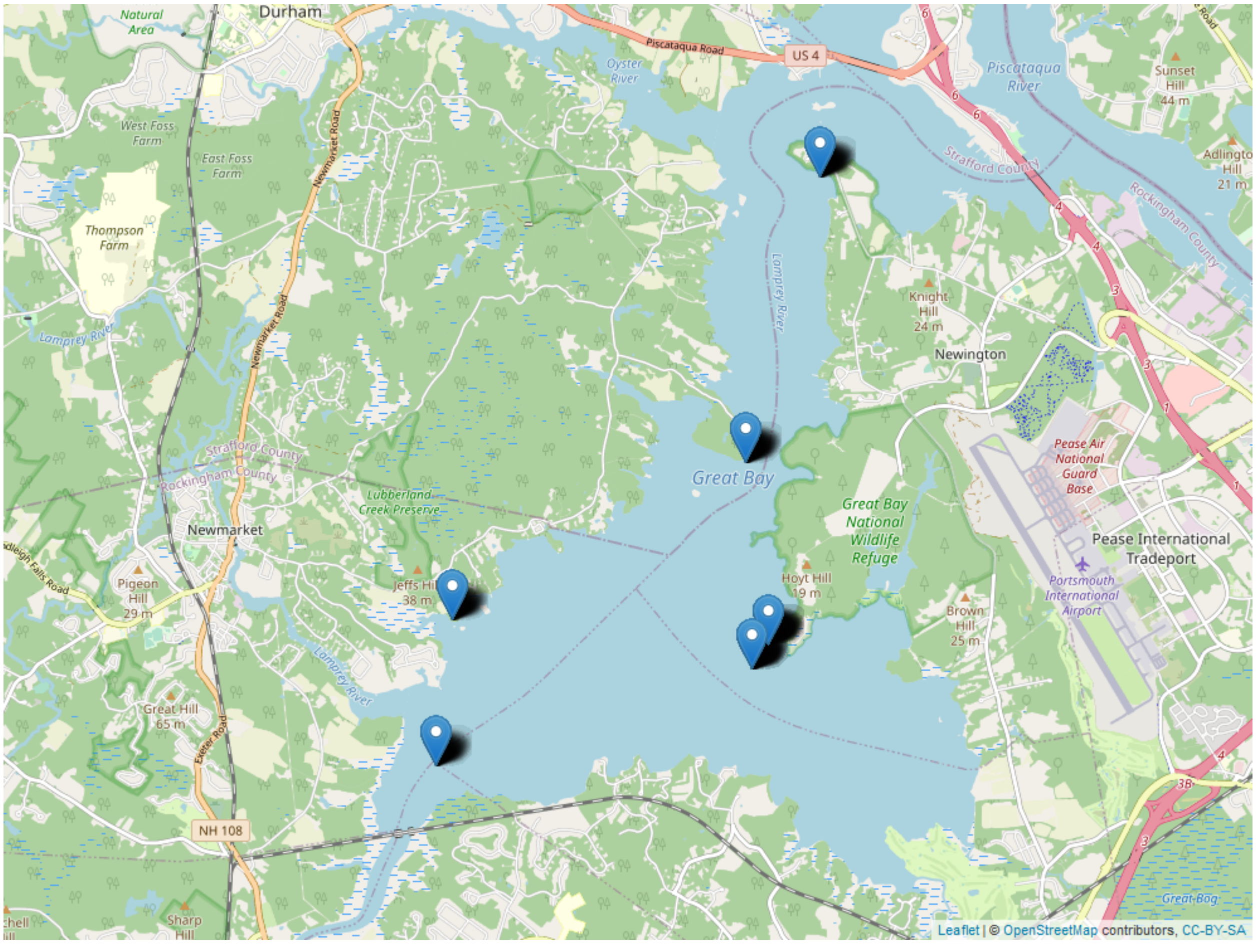
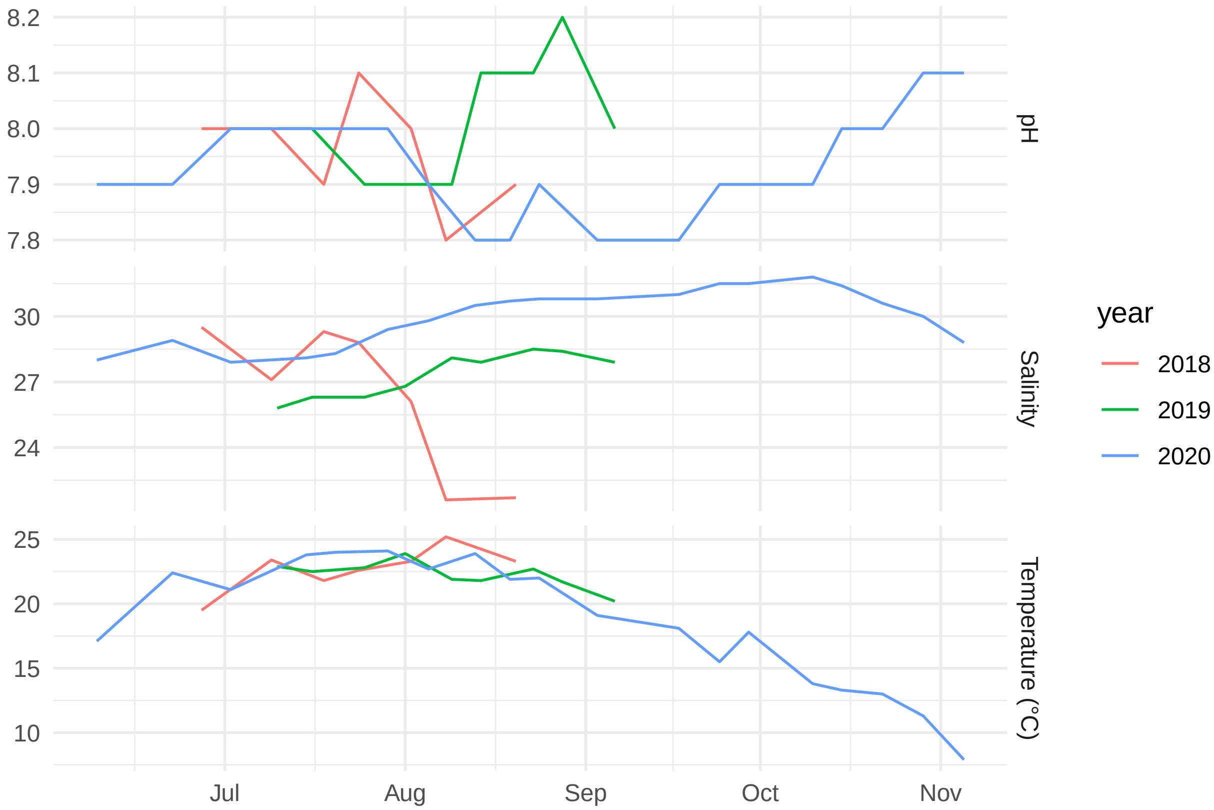
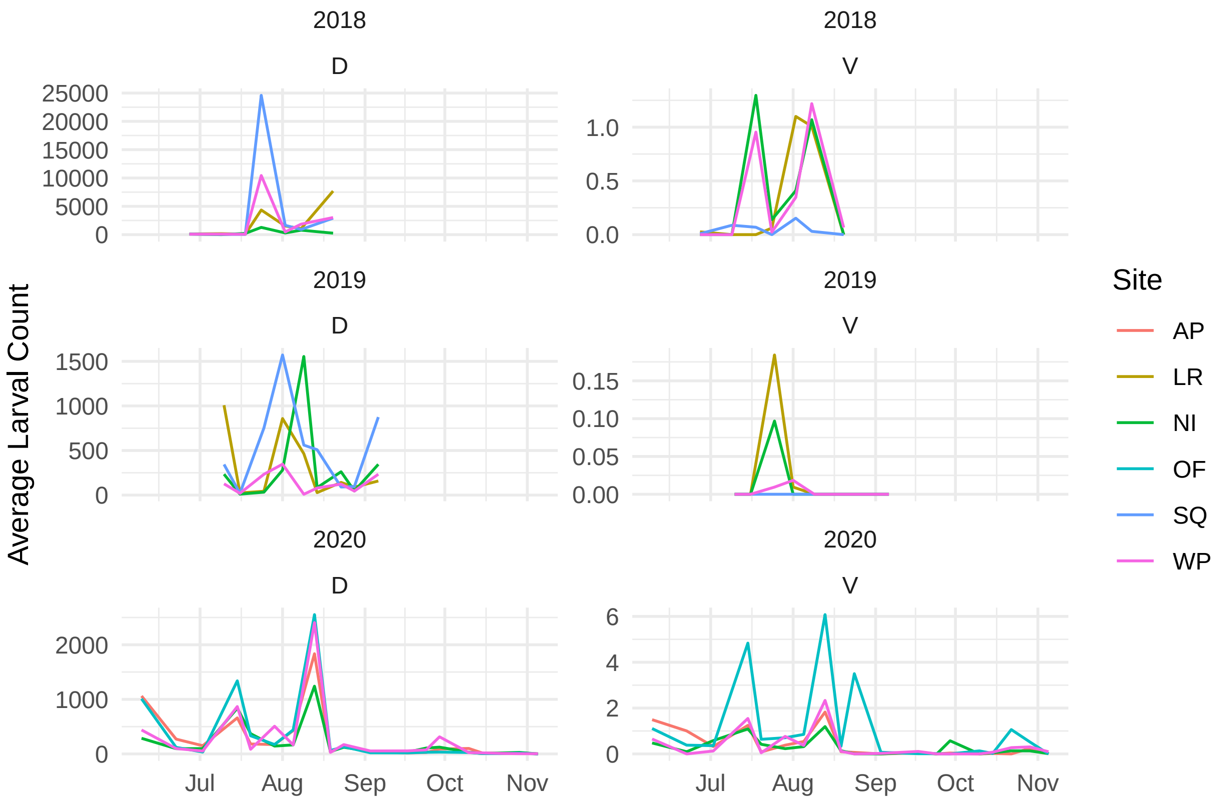


Figure 1: map of Great Bay area with markers for sampling sites

physiochemical stuff



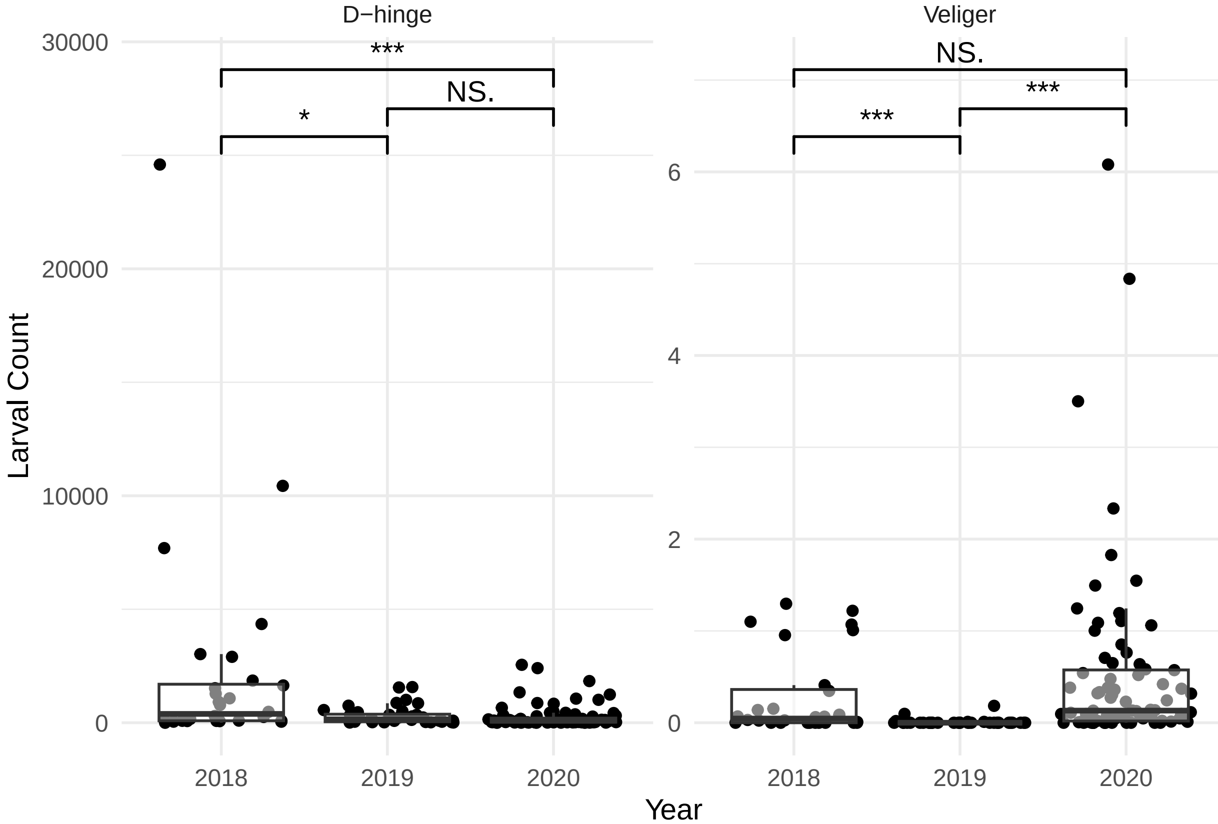
larvae type across year and site



larvalType	2018	2019	2020
D-hinge	2293	325	273
Veliger	0.29	0.0088	0.53

larvalType	Site	2018	2019	2020
D-hinge				
D-hinge	LR	2144	313	NA
D-hinge	NI	419	316	200
D-hinge	SQ	4319	535	NA
D-hinge	WP	2291	135	283
D-hinge	AP	NA	NA	277
D-hinge	OF	NA	NA	334
Veliger				
Veliger	LR	0.31	0.022	NA
Veliger	NI	0.42	0.011	0.29
Veliger	SQ	0.05	0	NA
Veliger	WP	0.37	0.0031	0.36
Veliger	AP	NA	NA	0.39
Veliger	OF	NA	NA	1.1

```
## Warning in wilcox.test.default(c(0.026200764, 0.008733588, 0, 0, 0,
## 0.087300979, : cannot compute exact p-value with ties
```



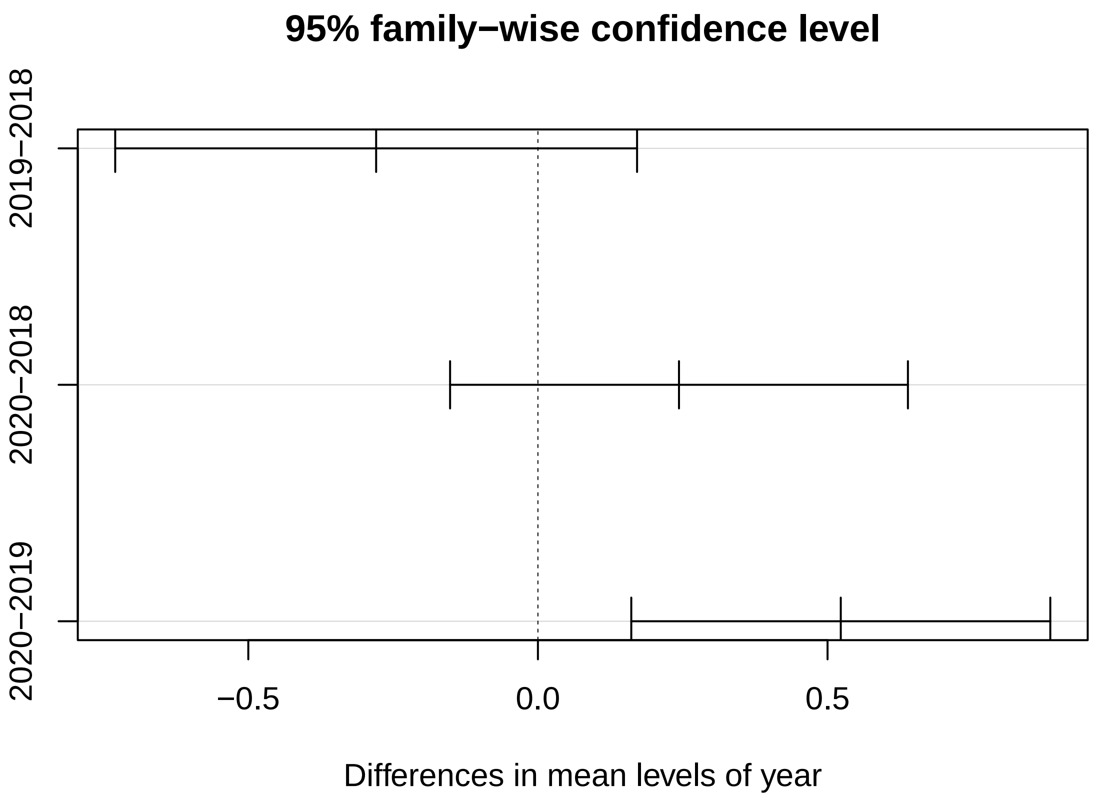
ANOVA stuff

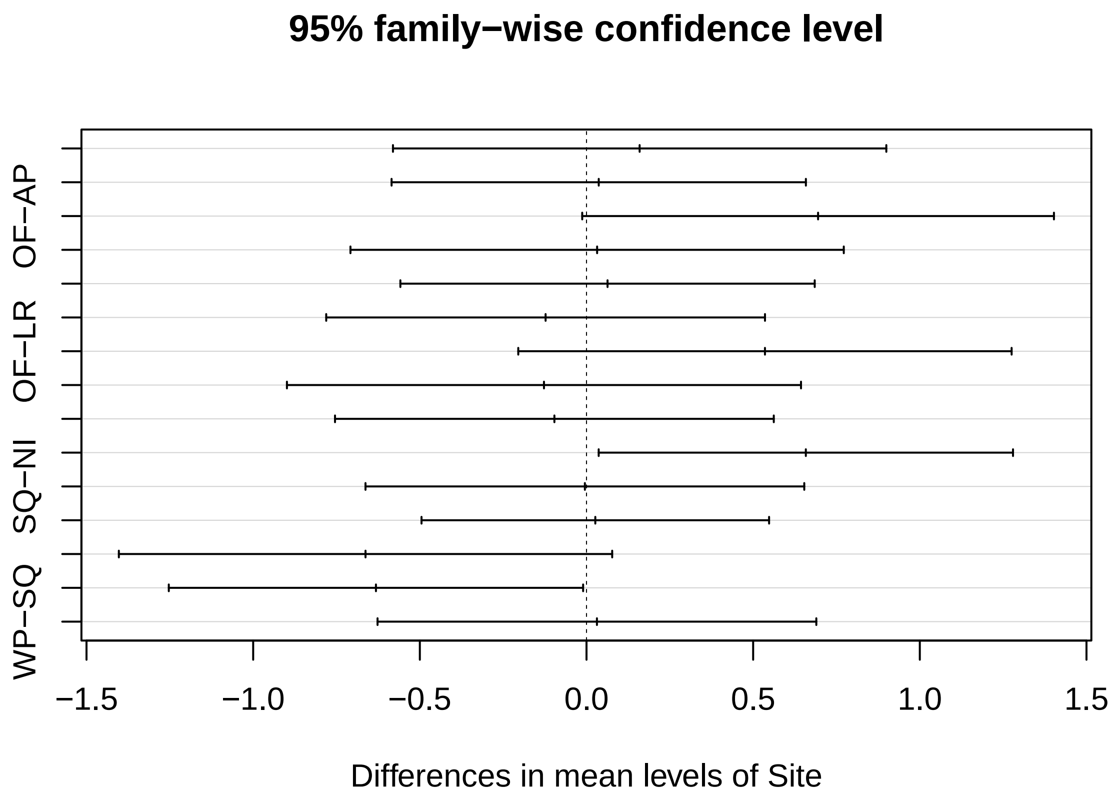
	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
year	2	89956271	44978136	8.801522	<0.001	***
Site	5	25737592	5147518	1.007289	0.416	

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
year	2	6.806097	3.403048	5.983259	0.003	**
Site	5	8.094962	1.618993	2.846522	0.018	*

```
##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = avgCount ~ year + Site, data = dfV)
##
## $year
##                 diff        lwr       upr     p adj
```

```
## 2019-2018 -0.2792997 -0.7297583 0.1711589 0.3087649
## 2020-2018  0.2435629 -0.1516454 0.6387712 0.3131078
## 2020-2019  0.5228626  0.1611645 0.8845606 0.0023363
##
## $Site
##               diff         lwr         upr     p adj
## LR-AP  0.159430793 -0.58062535  0.89948694 0.9891535
## NI-AP  0.036729731 -0.58478796  0.65824742 0.9999793
## OF-AP  0.694818261 -0.01281076  1.40244728 0.0574501
## SQ-AP  0.031861195 -0.70819495  0.77191734 0.9999957
## WP-AP  0.063168829 -0.55834886  0.68468652 0.9996993
## NI-LR -0.122701062 -0.78090203  0.53549990 0.9944416
## OF-LR  0.535387468 -0.20466868  1.27544361 0.2977486
## SQ-LR -0.127569598 -0.89869045  0.64355125 0.9968322
## WP-LR -0.096261964 -0.75446293  0.56193900 0.9982403
## OF-NI  0.658088530  0.03657084  1.27960622 0.0312214
## SQ-NI -0.004868536 -0.66306950  0.65333243 1.0000000
## WP-NI  0.026439098 -0.49493376  0.54781195 0.9999903
## SQ-OF -0.662957065 -1.40301321  0.07709908 0.1067946
## WP-OF -0.631649432 -1.25316712 -0.01013174 0.0440142
## WP-SQ  0.031307634 -0.62689333  0.68950860 0.9999930
```


95% family−wise confidence level
2019−2018
2020−2018
2020−2019
−0.5
0.0
0.5
Differences in mean levels of year



	Estimate	CI (lower)	CI (upper)	Std. Error	t value	Pr(>|t|)	
(Intercept)	-1280.34280	-3261.128482	700.4429	1001.7611	-1.278092	0.203	
Temp	96.84751	1.465156	192.2299	48.2386	2.007677	0.047	*

	Estimate	CI (lower)	CI (upper)	Std. Error	t value	Pr(>|t|)	
(Intercept)	5168.0288	396.4260	9939.631605	2413.1868	2.141578	0.034	*
Sal	-156.7242	-323.1738	9.725422	84.1801	-1.861772	0.065	.

	Estimate	CI (lower)	CI (upper)	Std. Error	t value	Pr(>|t|)	
(Intercept)	-16954.08	-48835.797	14927.631	16123.834	-1.051492	0.295	
pH	2217.47	-1788.896	6223.836	2026.177	1.094411	0.276	

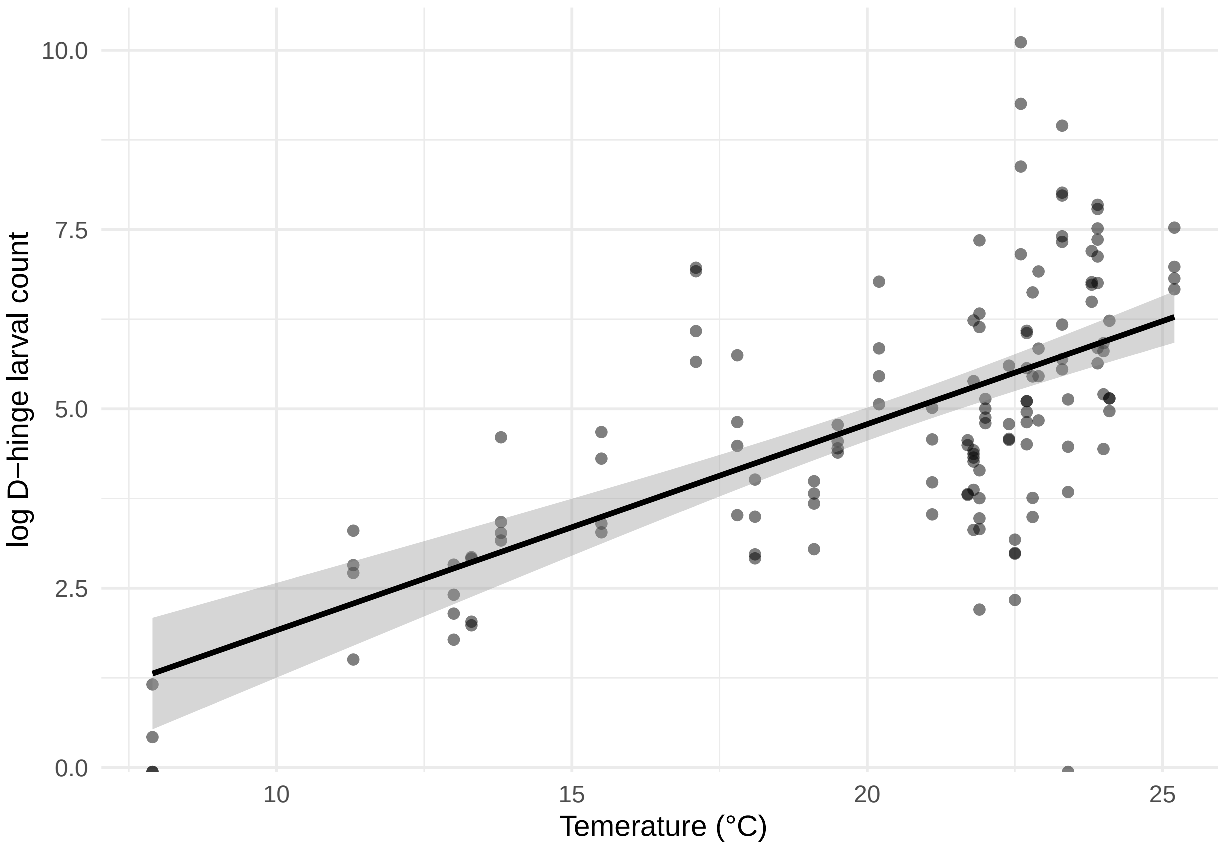
	Estimate	CI (lower)	CI (upper)	Std. Error	t value	Pr(>|t|)	
(Intercept)	-0.3857221	-1.0519607	0.2805166	0.3369430	-1.144769	0.254	
Temp	0.0360793	0.0039973	0.0681612	0.0162251	2.223671	0.028	*

	Estimate	CI (lower)	CI (upper)	Std. Error	t value	Pr(>|t|)	
(Intercept)	0.0061674	-1.6229892	1.6353241	0.8239285	0.0074854	0.994	
Sal	0.0119843	-0.0448462	0.0688148	0.0287414	0.4169704	0.677	

	Estimate	CI (lower)	CI (upper)	Std. Error	t value	Pr(>|t|)	
(Intercept)	13.834493	3.271204	24.3977816	5.342270	2.589628	0.011	*
pH	-1.694823	-3.022242	-0.3674039	0.671328	-2.524583	0.013	*

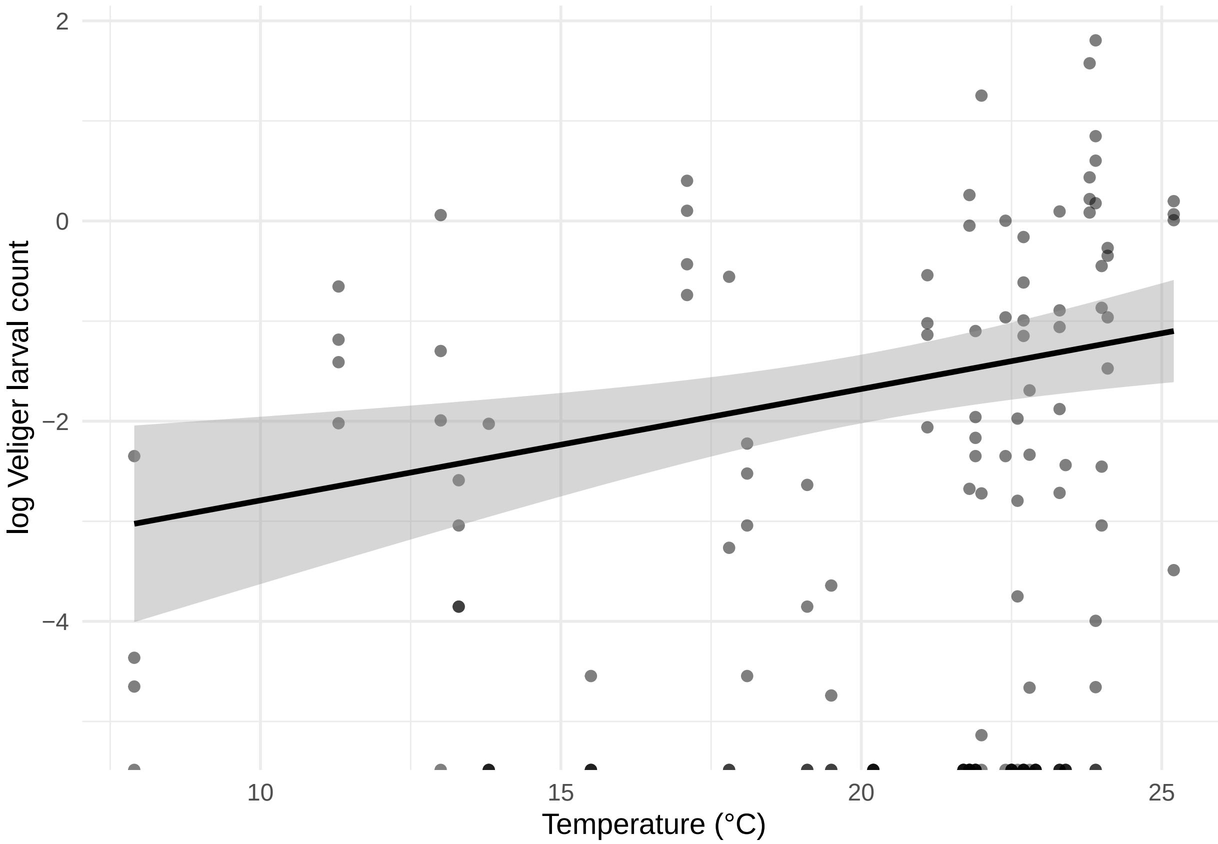
```
## `geom_smooth()` using formula = 'y ~ x'

## Warning: Removed 3 rows containing non-finite values (`stat_smooth()`).
```



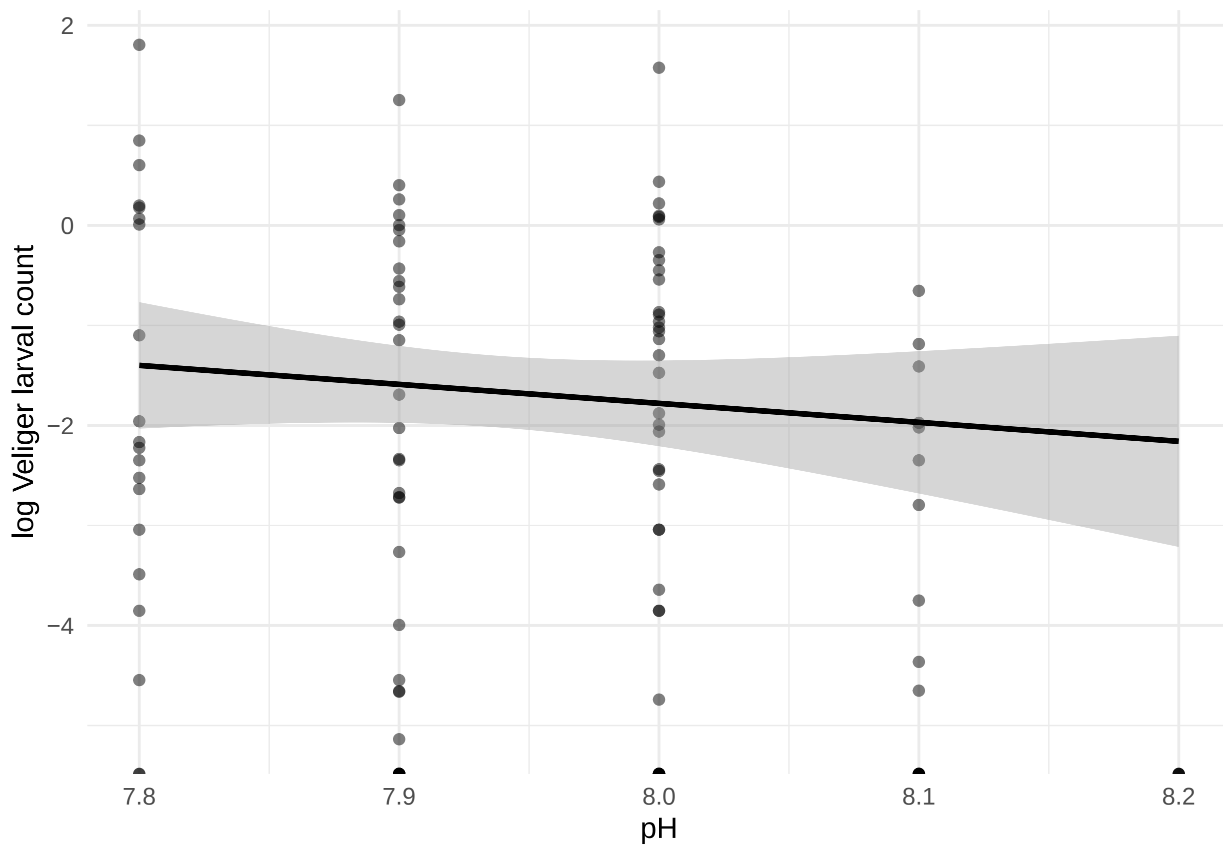

```
## `geom_smooth()` using formula = 'y ~ x'

## Warning: Removed 55 rows containing non-finite values (`stat_smooth()`).
```




```
## `geom_smooth()` using formula = 'y ~ x'
```

```
## Warning: Removed 55 rows containing non-finite values (`stat_smooth()`).
```



2
0
−2
−4
log Veliger larval count
7.8
7.9
8.0
8.1
8.2
pH