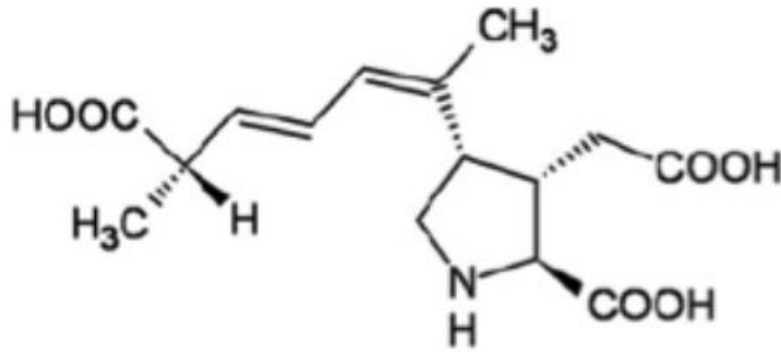


# The Effects of Ocean Conditions on the Production of Domoic Acid from *P. nitzschia*

Thousand Oaks High School  
AP Research STEM

# Domoic Acid



Domoic Acid

Figure 1. Structural formula of domoic acid (Tasker, 2016)

- $C_{15}H_{21}NO_6$
- Naturally occurring neurotoxin produced in cell culture by *Pseudo nitzschia*
- Biomagnification

## *Pseudo nitzschia*

- Marine plankton diatom
- DA is transferred up food chain through consumption



**Figure 2.** *P. nitzschia* under a microscope (An Image Based Key: Algae (PS Protista), Cyanobacteria, and other aquatic objects, 2017)



Prince Edward Island, December 1987

Consumption of blue mussels (*M. edulis* L.)



153 cases of acute intoxication



Discovery of DA Poisoning



# Domoic Acid Poisoning/ Amnesic Shellfish Poisoning

acute gastrointestinal  
symptoms:

- nausea
- vomiting
- diarrhea

neurological symptoms:

- confusion
- disorientation,
- long-term amnesia
- seizures



# Deaths

- 3 elderly people
  - Prince Edward Island, 1987
- >400 California sea lions (*Zalophus californianus*)
  - California, 1998
- Hundreds of brown pelicans and Brandt's cormorants
  - Monterey Bay, 1991

(Perl, et al., 1990)  
(Lefebvre, et al., 1999)  
(Work, et al., 1993)



# Purpose

Determining the ocean conditions in which *Pseudo nitzschia* blooms thrive and produce domoic acid, so we can best predict future concentrations in various locations



# Research Question

How do ocean conditions affect the growth of *Pseudo nitzschia* and production of domoic acid?





# Hypothesis

*Alternate Hypothesis: DA concentrations will be higher in areas with increased temperature, salinity, dissolved oxygen, phosphate, silicate, and nitrate because these conditions provided nutrients that aid to the growth of plants and algae.*

*Null Hypothesis: Ocean conditions will have little to no effect on DA concentrations and Pseudo nitzschia growth.*



# Methods

- Peer reviewed papers from CSUCI library

## Sources

- EBSCOhost
- Wiley Online Library
- ScienceDirect
- Elsevier

## Key Search Terms

- *Pseudo nitzschia*
- Domoic acid
- Amnesic shellfish poisoning



# Methods

NOAA → NODC → WOA13 V2

National  
Oceanic  
and  
Atmospheric  
Administration

National  
Ocean  
Data  
Center

World Ocean  
Atlas  
2013  
Version 2

# Ocean Conditions from WOA13

- Temperature (°C)
- Salinity (ppt)
- Oxygen (mL/L)
- Phosphate ( $\mu\text{mol/L}$ )
- Silicate ( $\mu\text{mol/L}$ )
- Nitrate ( $\mu\text{mol/L}$ )



Figure 3. NOAA logo



# WOA13 V2

- 1° grid
- 1955-2012 average by month
- Split into decades for temperature & salinity
  - 1985-94
  - 1995-2004
  - 2005-2012

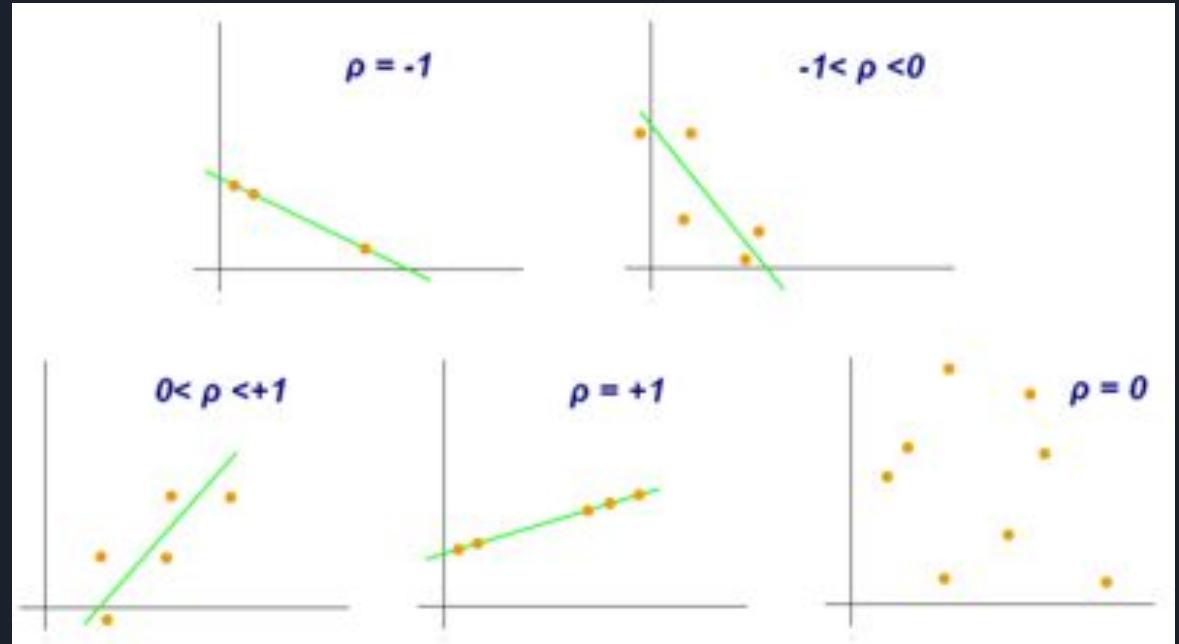


# Systematic Literature Review

- Pseudo Nitzschia Concentration ( $10^4$  cell L<sup>-1</sup>)
- Cellular DA in H<sub>2</sub>O (pg cell<sup>-1</sup>)
- Domoic Acid Concentrations in Bivalve Tissues ( $\mu\text{g g}^{-1}$ )

# Pearson Correlation Coefficient (PCC)

measure of the linear correlation between two variables



**Figure 4.** Examples of scatter diagrams with different PCCs (statistics.laerd.com)

# Ocean Conditions vs *P. nitzschia*

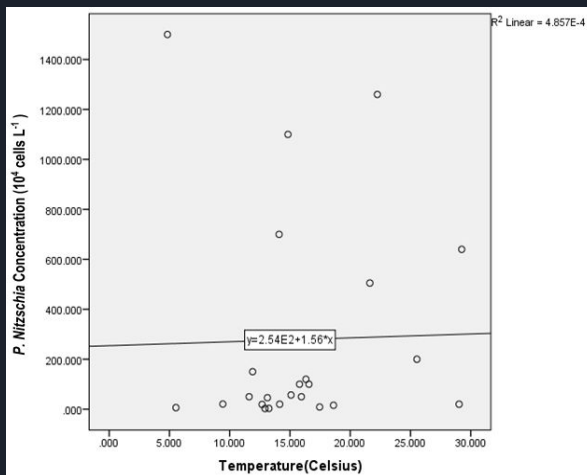
**Table 1.** *P. nitzschia* concentration in  $10^4$  cells  $L^{-1}$  compared to ocean conditions.

Location	<i>P. Nitzschia</i> Concentration	Temperature(Celsius)	Salinity(ppt)	Oxygen(mL/L)	Phosphate( $\mu$ mol/L)	Silicate( $\mu$ mol/L)	Nitrate( $\mu$ mol/L)	Source
Cardigan Bay	1500	4.833	29.311	6.89				Rao, et al., 1988
Cardigan Bay	120	16.323	28.264	5.462	0.54	0.893	0.03	Bates, et al., 1998
Cardigan Bay	46	13.126	32.292	6.205	0.689	3.023	0.583	Bates, et al., 1998
Monterey Bay	100	15.793	33.921	6.373	0.625	5.327	3.054	Quilliam, 1999
Santa Barbara	1100	14.834	32.902	6.233	0.75	4.11	0.051	Trainer, et al., 2000
Santa Barbara Channel	19	12.683	33.44	6.134	0.47	4.588	1.279	Anderson, et al., 2009
Passamaquoddy Bay	100	16.575	28.945	4.65	0.27	0.97	0.125	Bates, et al., 1998
Argentine Sea	6.1	5.537	34.044	6.998	1.16	3.714	11.553	Almandoz, et al., 2007
Uruguay Coast	200	25.53	35.517	5.072	0.062	1.538	0.123	Méndez, et al., 2012
Croatian Adriatic Sea	150	11.897	38.725	5.887	0.03	2.7	0.53	Ujević, et al., 2010
Monterey Bay	50	15.947	33.415	6.373	0.625	5.327	3.054	Lefebvre, et al., 2002
Hood Canal	50	11.61	32.163	6.193	0.64	7.369	0.2	Bates, et al., 1998
Mobile Bay	505	21.625	36.101	4.604	0.104	1	0	Liefer, et al., 2013
Chesapeake Bay	20.7	9.427	33.937	5.437	0.705	1.88		Anderson, et al., 2010
Juan de Fuca eddy	2.69	12.929	31.834	6.005	1.639	32.95	17.247	Marchetti, et al., 2004
Mediterranean Kalloni Gulf	700	14.096	38.82	5.136	0.074	1.623	0.681	Ujević, et al., 2010
M'diq Bay, Morocco	8.8	17.458	36.473	5.338	0.18	3	0.592	Leblad, et al., 2013
M'diq Bay, Morocco	15.7	18.611	36.582	4.821	0.127	3.989	0	Leblad, et al., 2013
Juan de Fuca eddy	20	14.145	31.57	7.499	0.915	21.093	9.935	Trainer, et al., 2002
St Joseph Bay	1260	22.246	35.259	5.061	0.049	1.268	0.096	O'dea, 2012
Central West Florida	640	29.246	35.649	4.48	0	0	2	O'dea, 2012
Southwest Florida	20	29.03	35.917	4.661	0.037	2.35	0.1	O'dea, 2012
Kalaloch beach(Washington)	280	13.234	31.743	6.21	0.755	21.499	3.791	Trainer, et al., 2002
Los Angeles Harbor	56.7	15.084	33.438	6.031	0.367	2.686	0.242	Schnetzler, et al., 2007
Scottish west coast	3.04	13.254	34.657	6.182	0.245	1.4	0.575	Fehling, et al., 2004

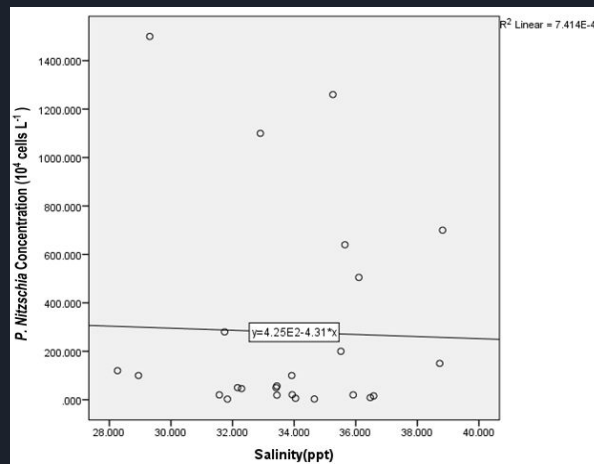


# Ocean Conditions vs *P. nitzschia*

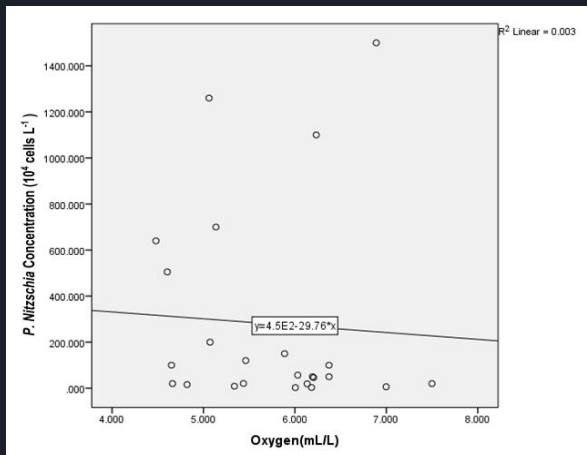
a



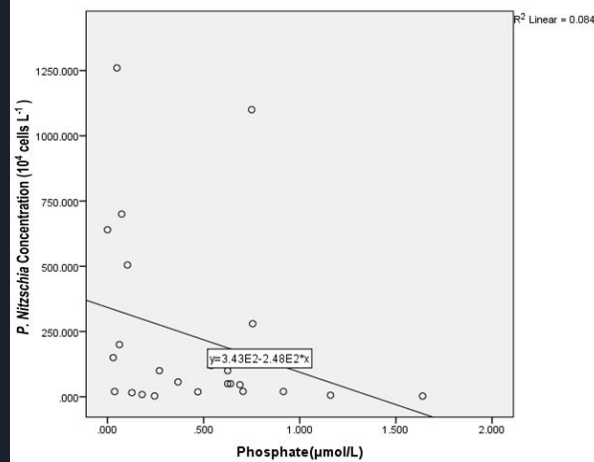
b



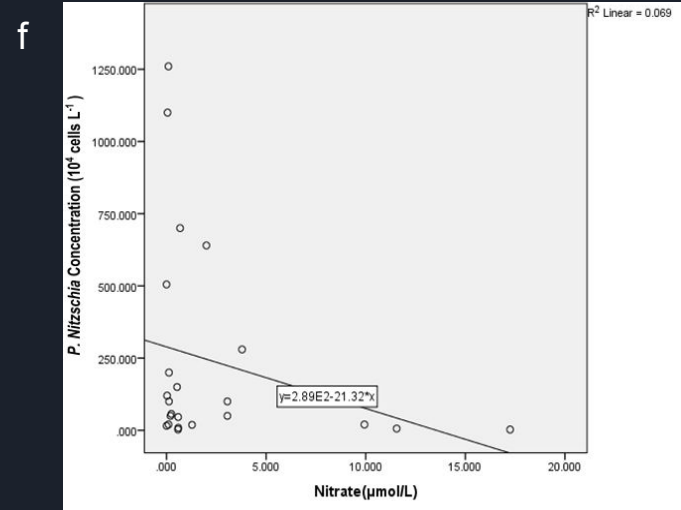
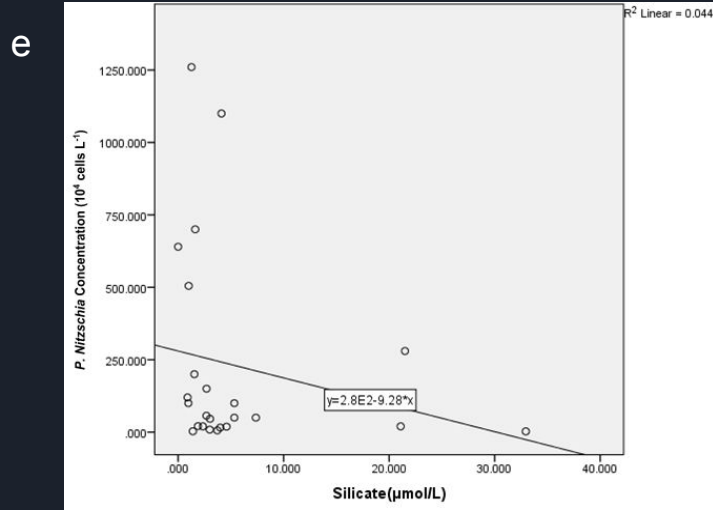
c



d



# Ocean Conditions vs *P. nitzschia*



**Figure 4a-f.** Graphical comparison of *P. Nitzschia* to various ocean conditions during each DA outbreak in study: temperature(a), salinity(b), oxygen(c), phosphate(d), silicate(e), and nitrate(f).

-Negative: salinity(.234), silicate(-.225), nitrate(-.263), oxygen(-.307), phosphate(-.278)

-Positive: temperature(.309)

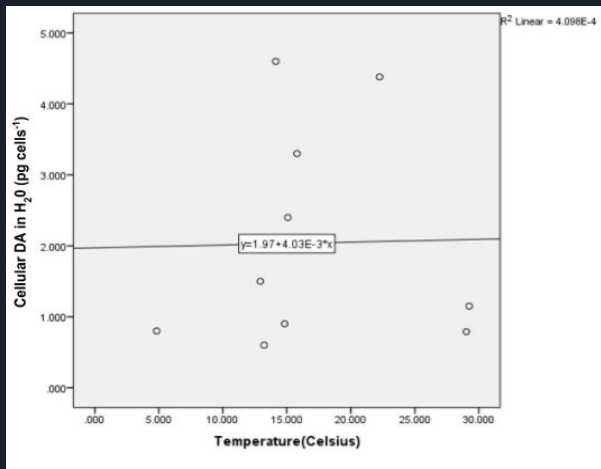
# Ocean Conditions vs DA in H<sub>2</sub>O

**Table 2.** Cellular DA concentration in H<sub>2</sub>O in pg cells<sup>-1</sup> compared to ocean conditions.

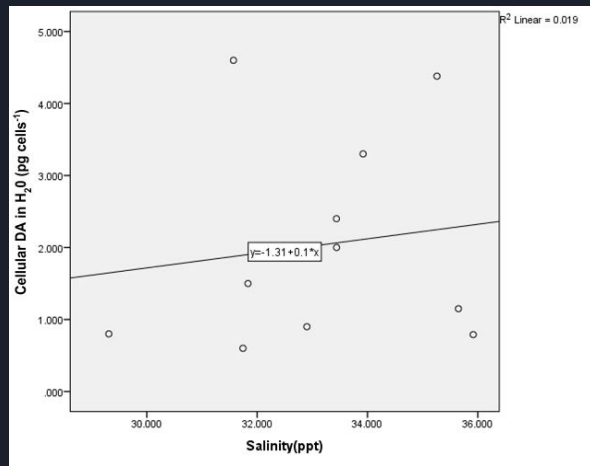
Cellular DA Concentraion H2O	Temperature(Celsius)	Salinity(ppt)	Oxygen(mL/L)	Phosphate(μmol/L)	Silicate(μmol/L)	Nitrate(μmol/L)
0.8	4.833	29.311	6.89			
3.3	15.793	33.921	6.373	0.625	5.327	3.054
0.9	14.834	32.902	6.233	0.75	4.11	0.051
2	12.683	33.44	6.134	0.47	4.588	1.279
1.5	12.929	31.834	6.005	1.639	32.95	17.247
4.6	14.145	31.57	7.499	0.915	21.093	9.935
4.38	22.246	35.259	5.061	0.049	1.268	0.096
1.15	29.246	35.649	4.48	0	0	2
0.79	29.03	35.917	4.661	0.037	2.35	0.1
0.6	13.234	31.743	6.21	0.755	21.499	3.791
2.4	15.084	33.438	6.031	0.367	2.686	0.242

# Ocean Conditions vs DA in H<sub>2</sub>O

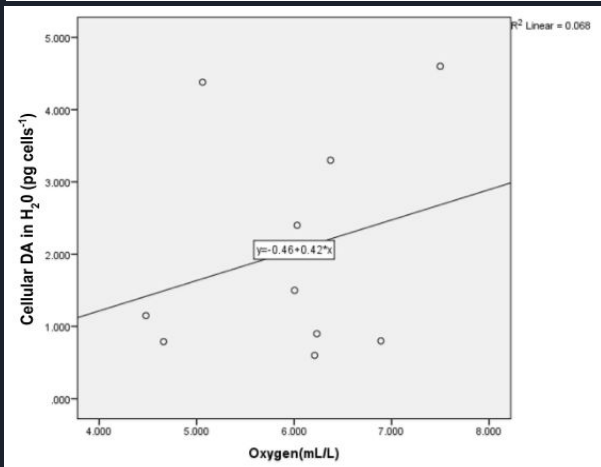
a



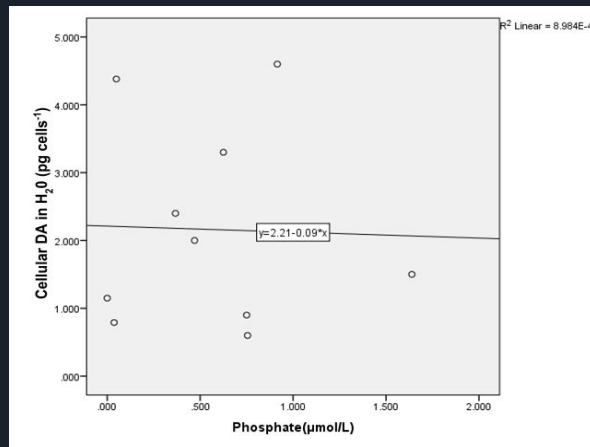
b



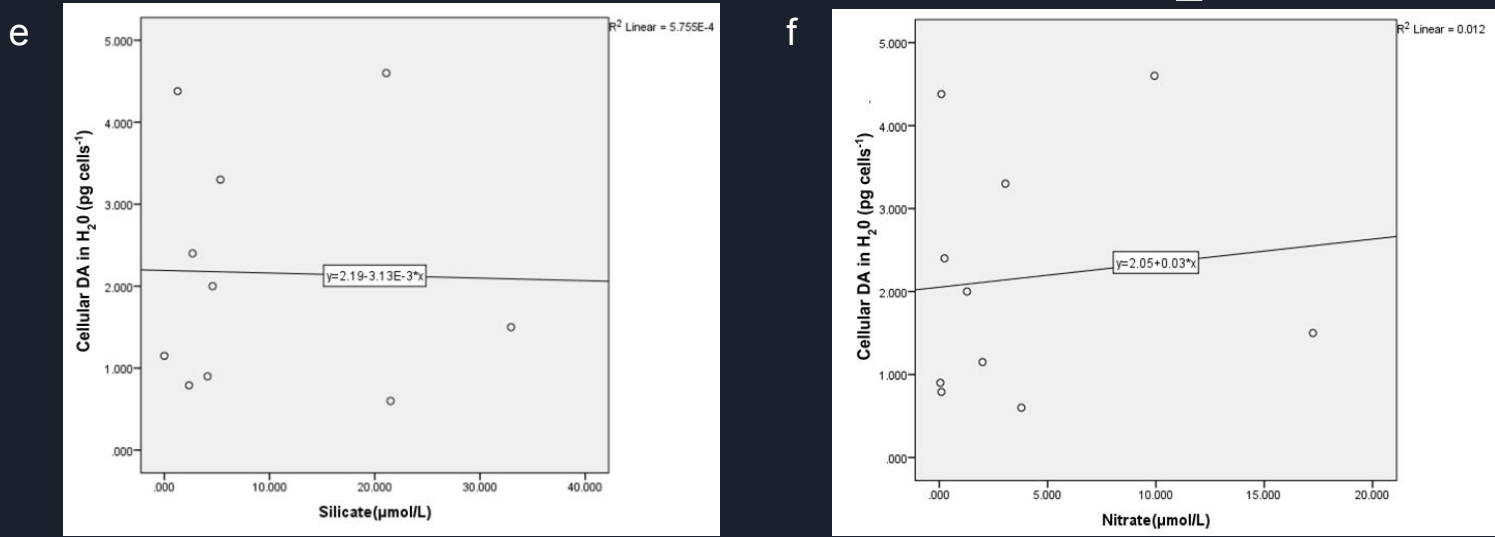
c



d



# Ocean Conditions vs DA in H<sub>2</sub>O



**Figure 5a-f.** Graphical comparison of Cellular DA concentrations in water to various ocean conditions during examined DA outbreaks: temperature(a), salinity(b), oxygen(c), phosphate(d), silicate(e), and nitrate(f).

-Negative: silicate(-.024), phosphate(-.030)

-Positive: temperature(-.162), nitrate(.110), salinity(-.057), oxygen(.395)

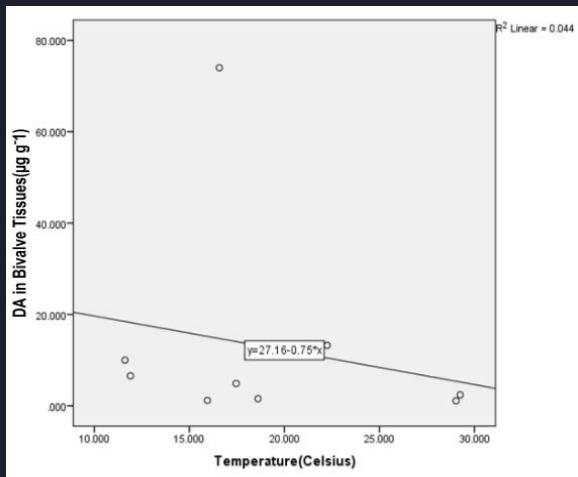
# Ocean Conditions vs DA in Bivalve Tissues

**Table 3.** DA concentration in bivalves in  $\mu\text{g g}^{-1}$  compared to ocean conditions.

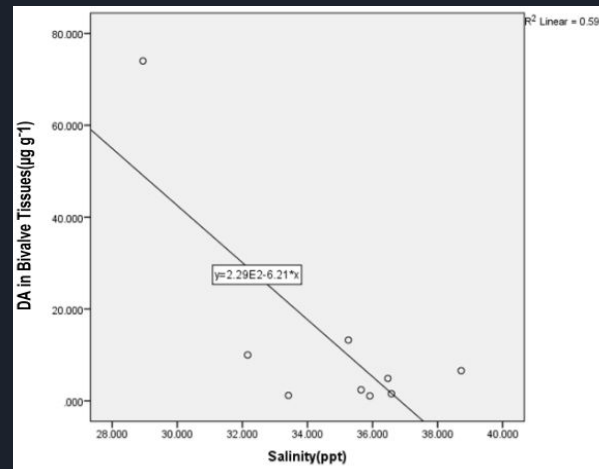
Domoic Acid Concentration Bivalves	Temperature(Celsius)	Salinity(ppt)	Oxygen(mL/L)	Phosphate( $\mu\text{mol/L}$ )	Silicate( $\mu\text{mol/L}$ )	Nitrate( $\mu\text{mol/L}$ )
74	16.575	28.945	4.65	0.27	0.97	0.125
6.586	11.897	38.725	5.887	0.03	2.7	0.53
1.2	15.947	33.415	6.373	0.625	5.327	3.054
10	11.61	32.163	6.193	0.64	7.369	0.2
4.9	17.458	36.473	5.338	0.18	3	0.592
1.57	18.611	36.582	4.821	0.127	3.989	0
13.25	22.246	35.259	5.061	0.049	1.268	0.096
2.42	29.246	35.649	4.48	0	0	2
1.09	29.03	35.917	4.661	0.037	2.35	0.1

# Ocean Conditions vs DA in Bivalve Tissues

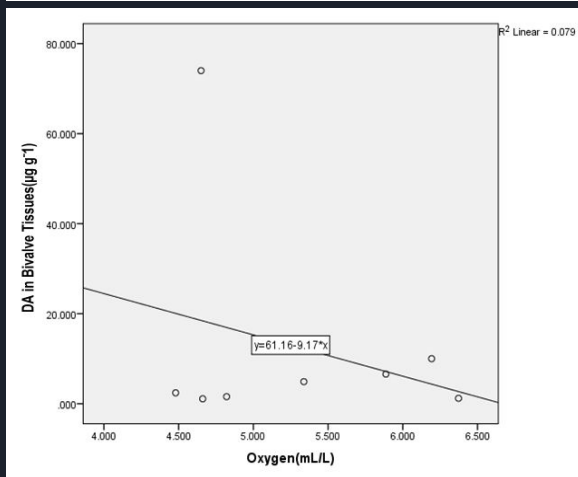
a



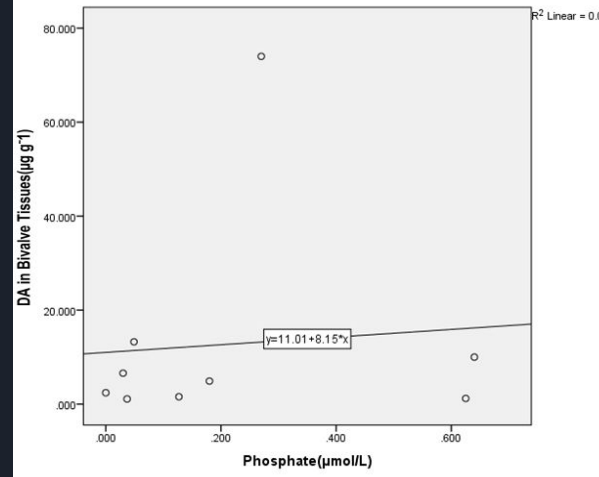
b



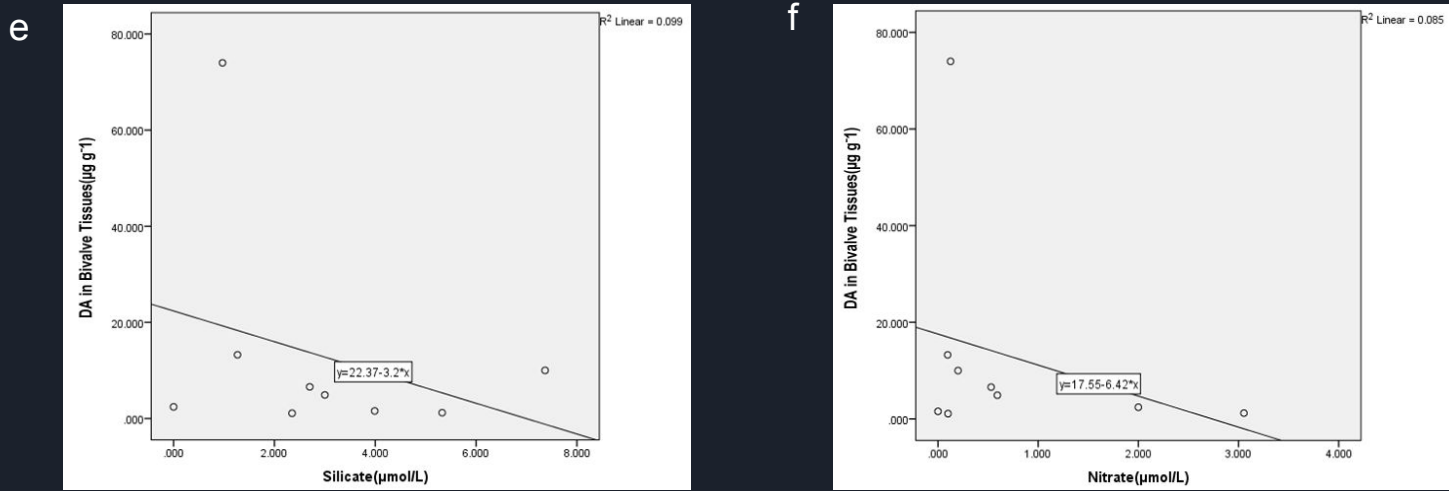
c



d



# Ocean Conditions vs DA in Bivalve Tissues



**Figure 6a-f.** Graphical comparison of DA concentrations in bivalve tissues to various ocean conditions during examined DA outbreaks: temperature(a), salinity(b), oxygen(c), phosphate(d), silicate(e), and nitrate(f).

Negative: temperature(-.209), silicate(-.314), salinity(-.768), nitrate(-.292), oxygen(-.281)

Positive: phosphate(.087)



# *P. nitzschia* vs DA in H<sub>2</sub>O & Bivalve Tissues

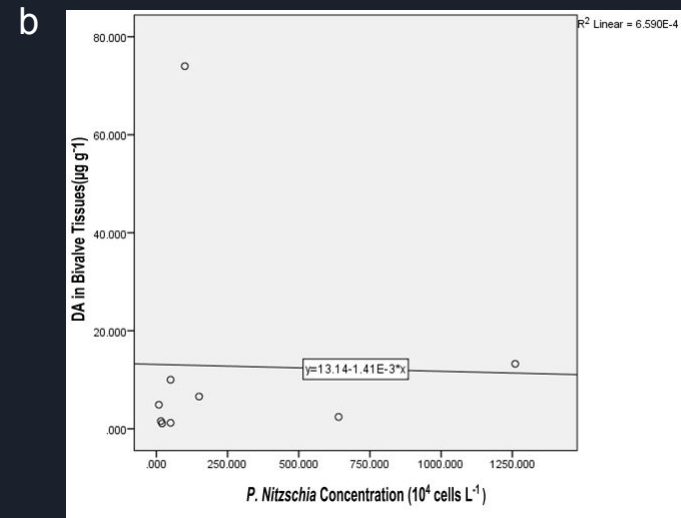
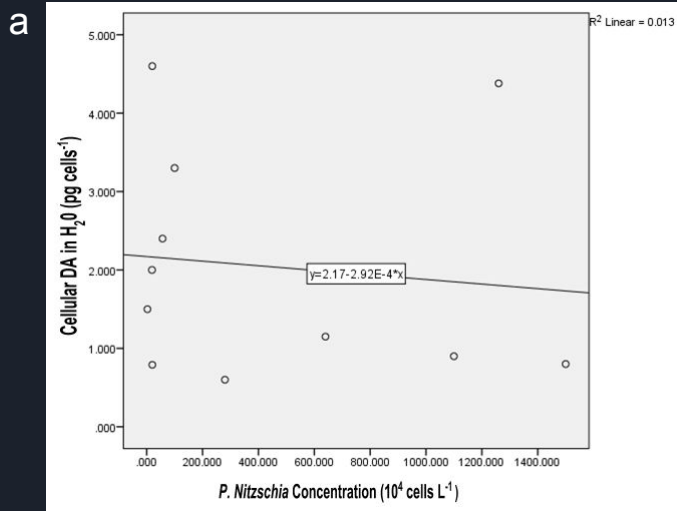


Figure 7a-b. Graphical comparisons between *P. Nitzschia* Concentration and the concentration of cellular DA in water(a) and DA concentration in bivalve tissues(b).

a) PCC = .073

b) PCC = -.026



# Discussion

- T-test results:  $p > 0.05$
- Null hypothesis can be accepted
- Alternate hypothesis should not be rejected until further work is conducted



# Source of Error

- Data collected over a long period of time (1987-2012)
- Latitude values rounded to the nearest 1°
- Lack of replicable data on DA concentrations



# Conclusion

Results indicate that there is little correlation between ocean conditions and *P. nitzschia* or DA concentration. However patterns indicate that further work should be conducted.



# Further Work

- Obtain concentrations for months surrounding the outbreak
- Use climate change predictions to predict locations of future growth



# Acknowledgements

Thank you Dr. Zin Htway,  
Dr. Nikki Malhotra,  
Michelle Magnusson and  
Bronte Brazier!



# References

Lefebvre, K. A., Powell, C. L., Busman, M., Doucette, G. J., Moeller, P. D., Silver, J. B., Miller, P. E., Hughes, M. P., Singaram, S., Silver, M. W., Tjeerdema, R. S. (1999). Detection of domoic acid in northern anchovies and california sea lions associated with an unusual mortality event. *Natural Toxins*, 7(3), 85-92.

doi:10.1002/(sici)1522-7189(199905/06)7:3<85::aid-nt39>3.0.co;2-q


Mos, L. (2001). *Domoic acid: a fascinating marine toxin*. Elsevier Science, 9, 79-85

Tasker, R. A. (2016). Domoic Acid and Other Amnesic Toxins: Toxicological Profile. *Marine and Freshwater Toxins*, 93-112. doi:10.1007/978-94-007-6419-4\_21

Teitelbaum, J. S., Zatorre, R. J., Carpenter, S., Gendron, D., Evans, A. C., Gjedde, A., & Cashman, N. R. (1990). Neurologic Sequelae of Domoic Acid Intoxication Due to the Ingestion of Contaminated Mussels. *New England Journal of Medicine*, 322(25), 1781-1787. doi:10.1056/nejm199006213222505

Perl, T. M., Bédard, L., Kosatsky, T., Hockin, J. C., Todd, E. C., & Remis, R. S. (1990). An Outbreak of Toxic Encephalopathy Caused by Eating Mussels Contaminated with Domoic Acid. *New England Journal of Medicine*, 322(25), 1775-1780. doi:10.1056/nejm199006213222504

Work, T. M., Barr, B., Beale, A. M., Fritz, L., Quailiam, M. A., & Wright, J. L. (1993). Epidemiology of domoic acid poisoning in brown pelicans (*pelecanus occidentalis*) and Brandt's cormorants. *Journal of Zoo and Wildlife Medicine*, 24(1), 54-62.



# The Effects of Ocean Conditions on the Production of Domoic Acid from *P. nitzschia*

Thousand Oaks High School  
AP Research STEM