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

TOHS AP Research STEM

Introduction

Domoic acid (see Figure 1) is a naturally occurring neurotoxin produced in cell culture by *Pseudo nitzschia* (see Figure 2), a type of a pennate phytoplanktonic diatom or algae (Mos, 2001). Domoic acid biomagnifies; through consumption, domoic acid is passed from bivalves (mussels, clams, ect.), anchovies and other domoic acid host to consumers. The first-level organisms are affected mildly or not at all by domoic acid which accumulates in their digestive glands and tissues (Mos, 2001), while the mammals and birds who consume them may experience severe or fatal effects. Domoic acid has had a number of devastating effects on humans. Acute gastrointestinal symptoms include- nausea, vomiting, and diarrhea (Teitelbaum, et al., 1990); and neurological symptoms, include- confusion, disorientation, long-term amnesia, seizures, and comas (Perl, et al., 1990). A large outbreak of neurologic abnormalities among people who had eaten cultured blue mussels (Mytilus edulis L.) in eastern Prince Edward Island in Canada brought attention to this toxin in 1987 where 153 human cases of acute intoxication were reported, resulting in 3 casualties (Perl, et al., 1990). Recent issues such as the elevated level of domoic acid found in Washington in 2015 and along the California coast in 2016 and 2017 have resurfaced scientific concern.

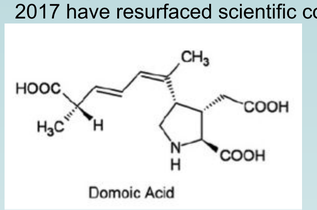

Figure 1. Structural formula of domoic acid, $C_{15}H_{21}NO_6$ (Tasker, 2016)

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

Purpose

Determining the ocean conditions in which *Pseudo nitzschia* blooms thrive and produce domoic acid, will allow us to predict future concentrations in various locations. Knowing the factors which help the algae grow and produce domoic acid, will help determine what action should be taken to end or restrict future growth and production of domoic acid.

Methods

- **Secondary data collection**
  - NOAA: World Ocean Atlas 2013 Version 2 (WOA13 V2)
  - Temperature (℃), Salinity (ppt), Oxygen (mL/L), Phosphate (µmol/L), Silicate (µmol/L), Nitrate(µmol/L)
- **Systematic Literature Review**
  - *P. nitzschia* Concentration (10^4 cell L^{-1}), Cellular DA in H_20 (pg $cell^{-1}$), Domoic Acid Concentrations in Bivalve Tissues (µg g^{-1})
  - Sources: EBSCOhost, Wiley Online Library, ScienceDirect, Elsevier

Abstract

In 1987, scientists began to investigate blue mussels (*M. edulis L.*) sold by restaurants and stores in Prince Edward Islands after many reports of sickness among consumers and the death of three elderly consumers. Samples of these mussels presented traces of a biotoxin diatom, called domoic acid. Researchers soon discovered that it was produced by an algae, *Pseudo nitzschia*, in nearby waters and when consumed is responsible for amnesic shellfish poisoning. Since then, outbreaks of domoic acid have appeared all over the world including off the coast of California, Argentina, Uruguay, and in the Gulf of Mexico. Using data from NOAA, this study is a comparison of domoic acid concentrations with ocean temperature, salinity, pH, oxygen, phosphate, and silicate concentrations. Results show ocean conditions have little to no effect on the production of domoic acid from *Pseudo nitzschia*; however these results indicate further research be conducted.

Research Question & Hypothesis

Research Question: *Do ocean conditions affect the growth of Pseudo nitzschia and production of domoic acid?*

Alternate Hypothesis: *Domoic acid 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: *Domoic acid concentrations will not be higher in areas with increased temperature, salinity, dissolved oxygen, phosphate, silicate, and nitrate.*

Results

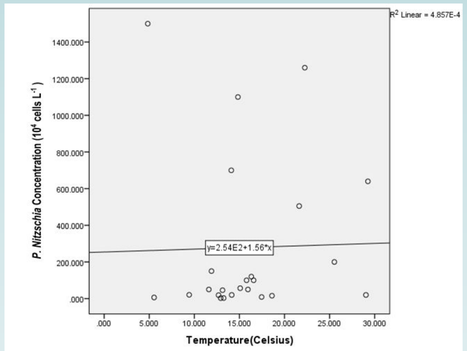

Figure 4a. Graphical comparison of *P. nitzschia* to temperature. (4b-f in paper)

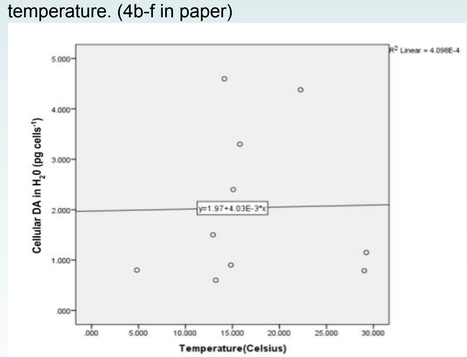

Figure 5a. Graphical comparison of cellular domoic acid concentrations in water to temperature. (5b-f in paper)

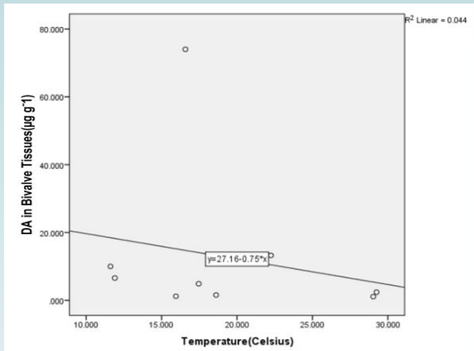

Figure 6a. Graphical comparison of domoic acid concentrations in bivalve tissues to temperature. (6b-f in paper)

Table 1. Pearson Correlation Coefficients (r).

	P. nitzschia concentration	Domoic Acid in H_20	Domoic Acid in Bivalves
Temperature	.309	-.162	-.209
Salinity	.234	-.057	-.768
Oxygen	-.307	.395	-.281
Phosphate	-.278	-.030	.087
Silicate	-.225	-.024	-.319
Nitrate	-.263	.110	-.292

Discussion

The goal of the study was to determine if there is a correlation between ocean conditions and the concentrations of *P. nitzschia* or domoic acid. The steeper slope (-2.48E2) of Figure 4d shows that as the amount of phosphate in the water increases, the amount of *P. nitzschia* decreases and because of this low phosphate levels can be used as a predictor for a growth in *P. nitzschia* blooms. Cellular domoic acid in H_20 (Figure 5), was not strongly impacted by any of the ocean conditions as the slopes ranged from -4.03E-3 to .42. The Pearson correlation coefficient ranged from -.057 to .395, showing that there is a very slight linear correlation. In Figure 5, data points seemed to have a stronger correlation and higher Pearson correlation coefficients despite one outlying value for domoic acid in bivalves (74 µg g-1). The simple linear regression analysis models shows that *P. nitzschia* concentration had very minimal effects on the domoic acid content in water (Figure 7a) (slope -2.92E-4) and the domoic acid concentration in bivalve tissues (Figure 7b) (slope -1.41E-3). However there was a lack of significance noted in the T test, so the null hypothesis- ocean conditions have little to no effect on the *P. nitzschia* growth and domoic acid concentrations- can be retained. One potential source error occurred when receiving data from the WOA 13, as each of the latitude and longitude value had to be rounded to the nearest degree.

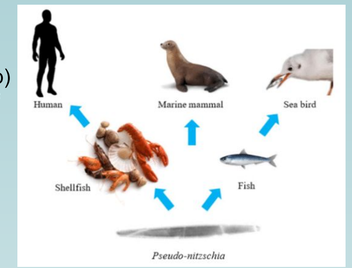

Figure 3. Biomagnification of domoic acid. (Awan, 2017)

Conclusion

Results indicate that there is little correlation (-.768 < r < .395) between ocean temperature, salinity, oxygen, phosphate, silicate, nitrate, and *P. nitzschia* or DA concentration. However patterns indicate that further work should be conducted.

Further Work

Results of this study were inconclusive as ocean conditions proved to not be statistically significant factors in *P. nitzschia* or domoic acid content, however certain patterns cannot be ignored and need further investigation. Future studies need to aim to collect various data points from the same location over a series of several months to see if there is a change in toxin or algae concentration within the same region. In addition, fisheries concerned with bloom potential need to collaborate with NOAA to assure that further studies on the issue can be conducted.

Acknowledgements

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

References

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