BCTOX's Marine Biotoxins Surveillance System in BC from Jan 2016 - Apr 2019: shifting patterns of biotoxins on the west coast of Canada; Data from CFIA

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Public health surveillance is "the continuous, systematic collection, analysis and interpretation of health-related data needed for the planning, implementation, and evaluation of public health practice" according to WHO.

BCTOX is hopeful that this initiative will draw the attention of public health professionals to the changing patterns of marine biotoxins that may cause shellfish poisoning. The graphs could be predictive indices for what is going to come next month!

Bi-weekly marine bio-toxin monitoring in West Coast BC from Jan 2016to Apr 2019

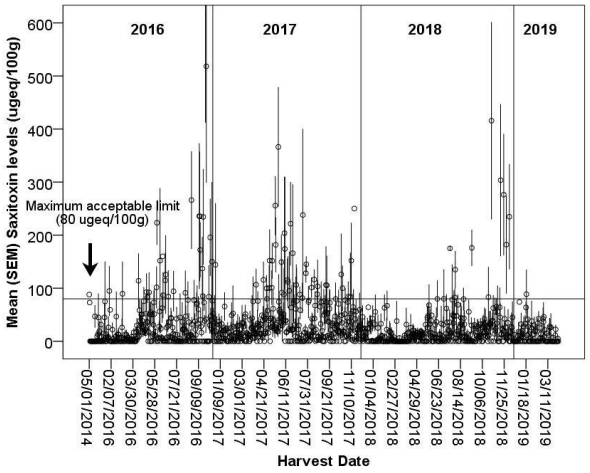
Saxitoxin (STX)

Background Saxitoxin (STX)-group toxins are a group of closely related tetrahydropurines and mainly produced by dinoflagellates belonging to the genus Alexandrium such as Alexandrium tamarensis.

STX cause paralytic shellfish poisoning (PSP) in humans, characterised by a range of symptoms from a slight tingling sensation or numbness around the lips to fatal respiratory paralysis. In fatal cases, respiratory arrest occurs 2 to 12 hours following consumption of contaminated shellfish.[1]

Results Saxitoxin (ug/100g) that may cause Paralytic shellfish poisoning (PSP) among detected shellfish samples in BC (Jan 2017 to Jan 2019)

- Positive cases were always detected (more than 99%)
- Above regulatory limit of 80 ug/100g was frequent
- Below regulatory limit Saxitoxin levels were more common in winters 2016 to 2019. Peaks are mot associated with falls or summers.



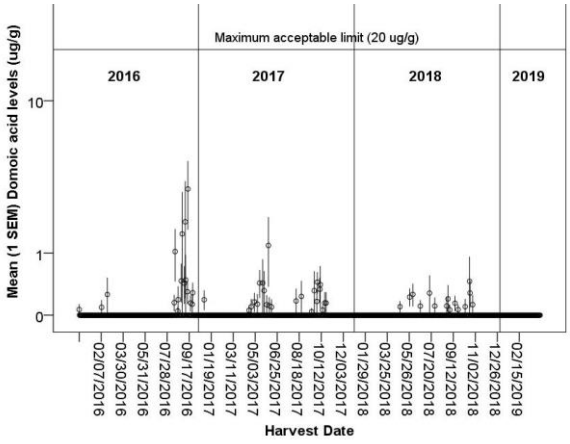
Domoic acid (DA)

Background Domoic acid, an excitatory amino acid is produced by diatoms that called Pseudo-nitzschiae, of which at least 14 strains are toxic;[2] it accumulates in filter-feeding molluscs (as well as certain crustaceans and finfish). Acute exposure to DA is associated with amnesic shellfish poisoning (ASP), a syndrome characterized by both gastrointestinal and neurological manifestations and which led to three deaths in a 1987 Canadian Atlantic Coast outbreak.[3] The U.S. Food and Drug Administration (FDA), the European Food Safety Authority (EFSA), and Health Canada promulgated regulatory limits for DA [4] [5] based on assessment of that outbreak.[3]

Results Domoic acid (ug/g) that may cause Amnesic shellfish poisoning (ASP) among detected shellfish samples in BC (Jan 2017 to Jan 2019):

- Very few positive cases detected (less than 1%)
- No case was above the regulatory limit of 20 ug/100g.

Below regulatory limits Domoic acid levels were observed in falls of 2016, 2017, 2018 and summer of 2017.

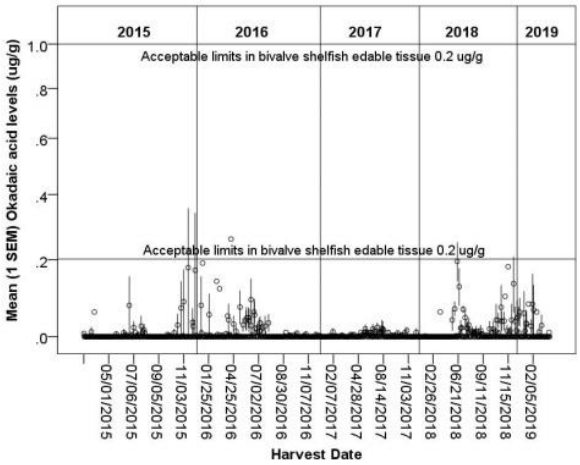


Okadaic acid (OA)

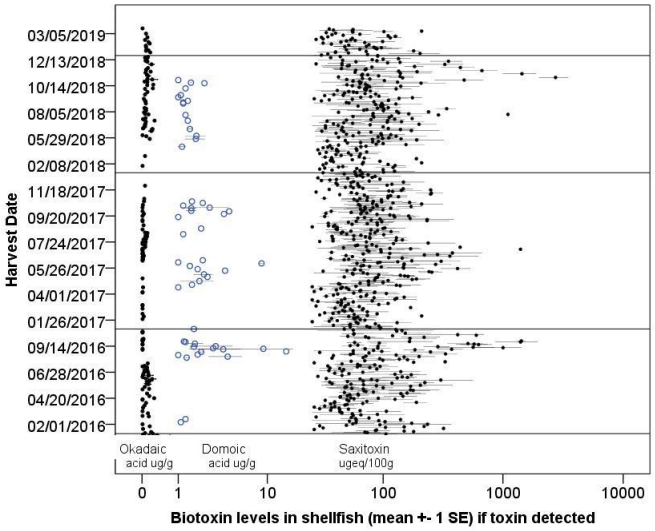
Background OA-group toxins are usually produced by planktons in the sea, and can contaminate shellfish, notably bivalve molluscs such as oysters, mussels, scallops, and clams. Contaminated shellfish may cause diarrhetic shellfish poisoning (DSP). [Note: DSP can also be caused by other toxins, not only OA-toxins.][6]

Results Okadaic acid (sum of okadaic acid and dinophysis toxins (DTX-1, DTX-2 and DTX-3) that may cause Diarrhetic Shellfish Poisoning (DSP) among shellfish samples in BC (Jan 2017 to Jan 2019):

- Very few positive cases detected (less than 1%)
- Very few cases were above the regulatory limit of 0.2 ug/g.
- Higher Okadaic acid levels happened more commonly in falls.



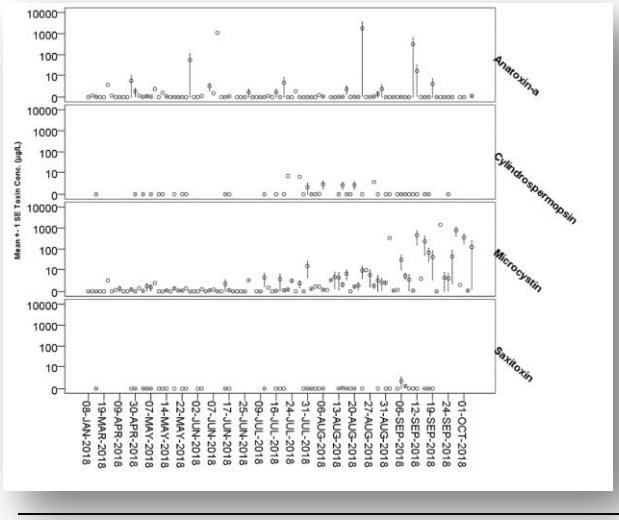
Saxitoxin, Domoic acid and Okadaic acid do not always follow th3 same pattern in west coast BC (Jan 2016 to Apr 2019)



Other biotoxins. Data from WASHINGTON STATE Toxic Algae, Shifting pattern of biotoxins

Regulatory authorities in B.C. do not require routine environmental measurements for other marine biotoxins including Anatoxin-a, Cylindrospermopsin and Microcystin.

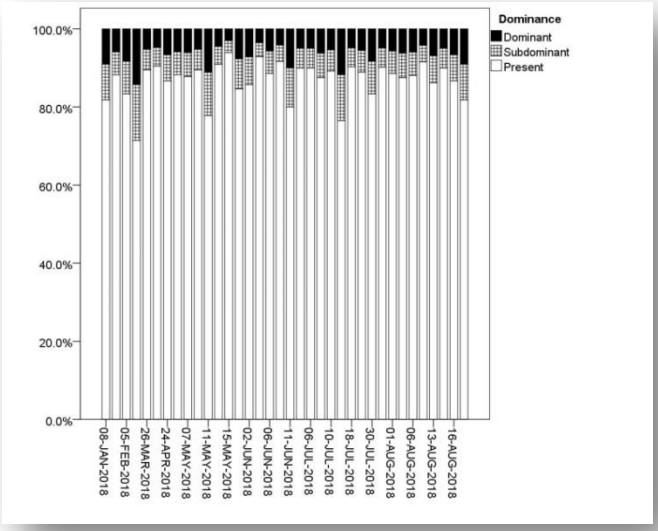
This information, however, is available from Washington State, which is the closest available information. The pattern is shown below (2018 Jan to Sep).

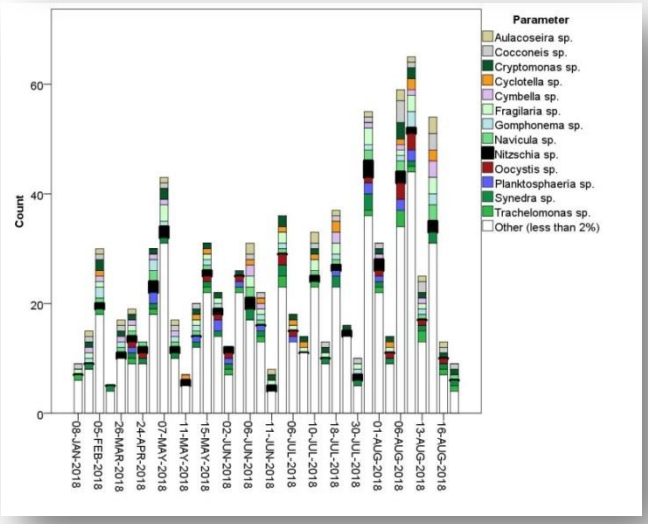


Phytoplankton's - WASHINGTON STATE *(2018 Jan to Sep)*[n= 995]

Regulatory authorities in B.C. do not require routine environmental measurements of Phytoplanktons.

This information; however, is available from Washington State, which is the closest available information. The pattern is shown below (2018 Jan to Sep).





BCTOX's Marine Biotoxins Surveillance System in BC

2-7- ***Palytoxin and analogues***

Shifting pattern of biotoxins on the west coast of Canada

1. Other Marine Miotoxins

1- ***Algae bloom*** are simple plants that do not have ordinary leaves or roots. True algae (*green* algae) start to bloom in late spring and early summer in rather colder areas or near water.

--- They are the result of excess nutrients, particularly phosphates originating from fertilizers; other sources include excess carbon and nitrogen and catalyst residual sodium carbonate.

--- Algae are short-lived, and decaying dead organic matter consumes dissolved oxygen in the water, resulting in hypoxia and die off of plants and animals in large numbers.

2- ***Harmful algae bloom*** (or ***red tide***); involves toxic phytoplankton such as dinoflagellates of the genus Alexandrium and Karenia, or diatoms of the genus Pseudo-nitzschia. Such blooms often take on a red or brown hue. They produce natural toxins.

--- Reappearance of blue-green algae at Elk Lake that are lethal to dogs is a constant concern for water quality, prompting a CRD advisory notice (2018-11-20).[7]

2-1- *Saxitoxin*

Dinoflagellate Alexandrium fundyense produces Saxitoxin that causes paralytic shellfish poisoning

2-2- *Domoic acid*

Pseudo-nitzschia diatom produces Domoic acid that causes amnesic shellfish poisoning.

2-3- *Okadaic acid*

--- Dinoflagellates Dinophysis produce Okadaic acid (sum of okadaic acid and dinophysis toxins (DTX-1, DTX-2 and DTX-3) that cause Diarrhetic Shellfish Poisoning (DSP)

2-4- *Azaspiracid*

Dinoflagellate Azadinium spinosum produces Azaspiracid (a phycotoxin) and analogues. Azaspiracid can result in severe acute symptoms that include nausea, vomiting, diarrhea, and stomach cramps.

EU and FDA regulatory limit is 160 µg/kg (reports from Europe).

--- No information is available online from BC

2-5- *Brevetoxin*

Karenia brevis dinoflagellate produces brevetoxin that causes neurotoxic shellfish poisoning (common in Florida and the Gulf of Mexico).

NSP is diagnosed through gastrointestinal and neurological symptoms: nausea and vomiting, paresthesias of the mouth, lips and tongue as well as distal paresthesias, ataxia, slurred speech and dizziness. Neurological symptoms can progress to partial paralysis and respiratory distress.[8]

--- No information is available online from BC

--- Officials in *Florida* say dolphins seem to be red tide's latest victims as more than 20 have washed up dead. Scientists attributed the deaths to brevetoxin (2018-11-27).[9]

2-6- *Cyclic imines*

"The dinoflagellates Karenia selliformis and Alexandrium ostenfeldii / A. peruvianum have been implicated in the biosynthesis of gymnodimines and spirolides, while Vulcanodinium rugosum produces pinnatoxins and portimine."[10 11]

--- No information is available online from BC.

"Most incidents of palytoxin poisoning have manifested after oral intake of contaminated seafood. Poisonings in humans have also been noted after inhalation, cutaneous/systemic exposures with direct contact of aerosolized seawater during Ostreopsis blooms and/or through maintaining aquaria containing Cnidarian zoanthids."[12]

"Common symptoms include numbness, paraesthesia and swelling around the site of exposure (cutaneous exposure), rhinorrhea, cough, dyspnea (inhalational exposure), perioral paraesthesia, dysgeusia (oral exposure) and eye irritation (ocular exposure)"[13]

2-7-1 *Coral*

Toxic coral in aquarium sends Quebec family to hospital - Zoanthid corals can be toxic, be aware when handling them. (Global News)[14]

The green type Zoanthid coral is a common feature of saltwater aquariums, but can contain palytoxin (photo adopted from ([15] [16]))

--- Case report; Seven members of a family exposed to toxic Zoanthid coral (that may contain palytoxin) in their home aquarium. They bought the aquarium second-hand from a business where it had been on display and transported it with its contents to his home in Gatineau, Quebec. They experienced sneezing within minutes followed by chest pains, problems breathing, fever, shaking, and vomiting (2018-04-24).[16] [17]

--- Case report; While cleaning his fish tank in Oxfordshire, U.K. an aquarium owner scraped the coral's surface (pulsing xenia), and inadvertently a particular kind of deadly toxin known as palytoxin was released into the air.

--- The family went to bed, but became deeply sick the following day, experiencing acute breathlessness, coughing and other symptoms. All six people in the house were hospitalized, along with four firefighters and two dogs (2018-04-07).[18]

--- No information is available online from BC.

2-8- *Pectenotoxin*

--- No information is available online from BC

2-10- *Yessotoxin and analogues*

Abalone photo adapted from reference (2014-02-08).[19]

Lingulodinium polyedrum and Gonyaulax spinifera Dinoflagellates produced Yessotoxins that are related to ciguatoxins. Yessotoxins cause diarrhetic shellfish poisoning. [20]

EU regulatory limit is 1 µg of YTXs per g (1 mg/kg).

--- Case report; Thousands of dead red abalone washed up on the beaches of Sonoma County in Northern California in August 2011. Later scientists from the University of California found that a harmful algal bloom was to blame: the causative agent was Yessotoxin (2014-04-17).[21]

--- No information is available online from BC

2-9- *Tetrodotoxin and analogues*

After ingestion of puffer fish. The flesh of the puffer fish (i.e. fugu) is considered a delicacy in Japan.

"Paresthesias initially affect the tongue, lips, and mouth and progress to involvement of the extremities. Gastrointestinal symptoms may be seen and include nausea, vomiting, and less often, diarrhea. Muscle weakness, headache, ataxia, dizziness, urinary retention, floating sensations, and feelings of doom may occur. An ascending flaccid paralysis can also develop.

Other reported effects include diaphoresis, pleuritic chest pain, fixed dilated pupils, dysphagia, aphonia, seizures, bradycardia, hypotension, and heart block. Death can occur within hours secondary to respiratory muscle paralysis or dysrhythmias.

Clinical effects in the mildest of cases resolve within hours, whereas the more severe cases may not resolve for days. Treatment is supportive; there is no specific antitoxin. Patients who have progressed to having generalized paresthesias, extremity weakness, pupillary dilation, or reflex changes should be admitted to the hospital for observation until peak effects have passed. Those with respiratory failure should be intubated and placed on mechanical ventilation.

Vasopressor support may be necessary for hypotension refractory to intravenous fluids. Atropine has been used for symptomatic bradycardia."[22]

Image adapted from MedScape

Ciguatoxin

Ciguatera fish poisoning (CFP)

Ciguatera is caused by eating contaminated reef fish. Symptoms include diarrhea, vomiting, numbness, itchiness, sensitivity to hot and cold, dizziness, and weakness. Onset can occur from half an hour to up to two days. Diarrhea may last four days. Certain symptoms typically remain for a few weeks to months. Heart difficulties such as a slow heart rate and low blood pressure may occur.[23] --- Recreational exposure to cyanobacteria can cause GI, pruritic skin rashes and hay fever. [24]

Scombroid Fish Poisoning: Histamine Poisoning

3- *Cyanobacteria (blue green algae)*

Cyanobacteria are aquatic and photosynthetic bacteria that live in the water, and can manufacture their own food.

Cyanobacterial toxins

Cyanotoxin – not related to cyanide – contains neurotoxins, hepatotoxins, cytotoxins, and endotoxins. It causes rapid death by respiratory failure.

--- No information is available online from BC.

Anatoxin-a

Anatoxin-a is produced by cyanobacters and causes loss of coordination, muscular fasciculations, convulsions and death by respiratory paralysis.

Cylindrospermopsin
Microcystin
BCTOXScope (CYANOscope)

BCTOX publishes your pictures of cyanobacteria samples found in BC with your name.

Email your image(s) to BCTOX@yahoo.com

--- Even if you are not sure that it is cyanobacteria, upload it please!

Make sure to include the date, geographical area and other relevant information.

Examples

Photo

Photo

--- Algae gallery by Washington State. Toxic Alga is publicly accessible!

Decision Tree for Drinking Water: Cyanobacterial Toxins – Step Descriptions (No information is available online from BC)

STEP A: STEP A: Initial screening for suspected blooms: Examine the water for one or more of total nitrogen and phosphorus. Check for bloom formation.

STEP B: If yes to any of: nitrogen (N)>658 µg/L; phosphorus (P)> 26µg/L; an N:P ratio < 23; changes in secchi depth; or blooms observed, go to Step C. If no, return to Step A.

STEP C: Sample the raw water. Use a portable field kit to test for the presence of microcystins.

STEP D: If the presence of microcystins is detected (>1.0µg/L) with a field test kit, go to step E, and alert the health authority of a potential issue. If microcystins are absent, return to step A.

STEP E: Use a portable test kit to test the treated water supply for microcystins.

STEP F: If the portable test kit indicates microcystins are present (>1.0µg/L) in the treated water, send a sample to the lab for confirmation and immediately notify the health authority.

STEP G: If the lab results indicate the seasonal MAC of 1.5µg/L has been exceeded, immediately contact the health authority for consultation and decision making.

Others

References

1. Lelong A, Hégaret H, Soudant P, et al. Pseudo-nitzschia (Bacillariophyceae) species, domoic acid and amnesic shellfish poisoning: revisiting previous paradigms. Phycologia 2012;**51**(2):168-216.

2. Perl TM, Bedard L, Kosatsky T, et al. An outbreak of toxic encephalopathy caused by eating mussels contaminated with domoic acid. N Engl J Med 1990;**322**(25):1775-80.

3. EFSA. Scientific opinion. Marine biotoxins in shellfish – Summary on regulated marine biotoxins. Scientific Opinion of the Panel on Contaminants in the Food Chain (Question No EFSA-Q-2009-00685). Adopted on 13 August 2009 The EFSA Journal 2009;1306:1-23.

4. National Shellfish Sanitation Program (NSSP) Guide for the Control of Molluscan Shellfish. From the U.S. Food and Drug Administration website http://www.fda.gov/Food/GuidanceRegulation/FederalStateFoodPrograms/ucm2006754.htm In: U.S. Department of Health and Human Services, ed.: Public Health Service, Food and Drug Administration,, 2017 Revision.

5. Scientific Opinion. Marine biotoxins in shellfish – Saxitoxin group. Scientific Opinion of the Panel on Contaminants in the Food Chain (Question No EFSA-Q-2006-065E) Adopted on 25 March 2009 The EFSA Journal 2009;1019:1-76.

6. EFSA. Marine biotoxins in shellfish – okadaic acid and analogues. Scientific Opinion of the Panel on Contaminants in the Food chain (Question No EFSA-Q-2006-065A) Adopted on 27 November 2007 The EFSA Journal 2008 589:1-62.

7. Mirror SN. Algae bloom at Elk Lake prompts CRD advisory notice. https://www.sookenewsmirror.com/news/algae-bloom-at-elk-lake-prompts-crd-advisory-notice/ (acessed Nov 28, 2018). 2018-11-20.

8. Watkins SM, Reich A, Fleming LE, et al. Neurotoxic Shellfish Poisoning. Marine Drugs 2008;6(3):431-55.

9. CityNews. Officials: Red tide suspected as dead dolphins wash ashore. https://www.660citynews.com/2018/11/27/officials-red-tide-suspected-as-dead-dolphins-wash-ashore/ (accessed Nov 28, 2018). 2018-11-27.

10. Molgo J, Marchot P, Araoz R, et al. Cyclic imine toxins from dinoflagellates: a growing family of potent antagonists of the nicotinic acetylcholine receptors. J Neurochem 2017;142 Suppl 2:41-51.

11. Visciano P, Schirone M, Berti M, et al. Marine Biotoxins: Occurrence, Toxicity, Regulatory Limits and Reference Methods. Frontiers in Microbiology 2016;7(1051).

12. Patocka J, Gupta RC, Wu QH, et al. Toxic potential of palytoxin. J Huazhong Univ Sci Technolog Med Sci 2015;35(5):773-80.

13. Thakur LK, Jha KK. Palytoxin-induced acute respiratory failure. Respiratory Medicine Case Reports 2017;20:4-6.

14. GlobalNews. Toxic coral in aquarium sends Quebec family to hospital. https://globalnews.ca/video/4175960/toxic-coral-in-aquarium-sends-quebec-family-to-hospital 2018-04-29.

15. CBCNews-2018-04-25. Toxic coral in home aquarium blamed for making Gatineau family sick. http://www.cbc.ca/news/canada/ottawa/toxic-coral-blamed-for-sickening-gatineau-family-1.4633810.

16. CBC. Toxic coral in home aquarium blamed for making Gatineau family sick. https://www.cbc.ca/news/canada/ottawa/toxic-coral-blamed-for-sickening-gatineau-family-1.4633810 (accessed Nov 25, 2018). 2018-04-24.

17. Global News. How toxic coral in your aquarium could send you to hospital. https://globalnews.ca/news/4167774/toxic-coral-aquarium/ (accessed Nov 23, 2018). 2018-04-25.

18. The Weather Network. Toxin almost kills family and pets after fish tank cleaning. https://www.theweathernetwork.com/news/articles/coral-toxin-almost-kills-family-in-britain-during-fish-tank-cleaning/98938 (accessed Nov 28, 2018). 2018-04-07.

19. The Press Democrat. New rules reduce abalone season, trim catch. https://www.pressdemocrat.com/news/1855752-181/new-rules-reduce-abalone-season (accessed Nov 29, 2018). 2014-02-08.

20. Paz B, Daranas AH, Norte M, et al. Yessotoxins, a Group of Marine Polyether Toxins: an Overview. Marine Drugs 2008;6(2):73-102.

21. Phys.Org. Scientists solve the case of the red abalone die-off using forensic genomics. https://phys.org/news/2014-04-scientists-case-red-abalone-die-off.html (accessed Nov 03, 2018). 2014-04-17.

22. Lawrence D, McLinskey N, Huff JS, et al. CHAPTER 4 - Toxin-Induced Neurologic Emergencies. In: Dobbs MR, ed. Clinical Neurotoxicology. Philadelphia: W.B. Saunders, 2009:30-46.

23. Stewart I, Seawright AA, Shaw GR. Cyanobacterial poisoning in livestock, wild mammals and birds--an overview. Adv Exp Med Biol 2008;619:613-37.

24. Stewart I, Webb PM, Schluter PJ, et al. Recreational and occupational field exposure to freshwater cyanobacteria--a review of anecdotal and case reports, epidemiological studies and the challenges for epidemiologic assessment. Environ Health 2006;5:6.