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Chapter 6: Nebraska Experience

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Chapter 6: Nebraska Experience

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Abstract

Nebraska agencies and public health organizations collaboratively addressed cyanobacterial issues for the first time after two dogs died within hours of drinking water from a small private lake south of Omaha on May 4, 2004. A necropsy on one of the dogs revealed that the cause of death was due to ingestion of Microcystin toxins. Within two weeks after the dog deaths, state and local officials jointly developed strategies for monitoring cyanobacterial blooms and issuing public health alerts and advisories. Weekly sampling of public lakes for microcystin toxins and cyanobacteria was initiated during the week of May 17, 2004. ELISA laboratory equipment and supplies were purchased to achieve a quick turnaround time for measuring weekly lake samples for total microcystins so that public health advisories and alerts could be issued prior to each weekend's recreational activities. A conservative approach was selected to protect human health, pets, and livestock, which included collecting worst-case samples from cyanobacterial blooms; freezing and thawing of samples to lyse algal cells and release toxins prior to laboratory analysis; and using action levels of 15 ppb and 2 ppb of total microcystins, respectively, for issuing health alerts and health advisories. During 2004, five dog deaths, numerous wildlife and livestock deaths, and more than 50 accounts of human skin rashes, lesions, or gastrointestinal illnesses were reported at Nebraska lakes. Health alerts were issued for 26 lakes and health advisories for 69 lakes. Four lakes were on health alert for 12 or more weeks. The primary cyanobacterial bloom-forming genera identified in Nebraska lakes were Anabaena, Aphanizomenon, and Microcystis. Preliminary assessments of lake water quality data

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indicated that lower lake levels from the recent drought and low nitrogen to phosphorus ratios may have contributed, in part, to the increased numbers of cyanobacterial complaints and problems that occurred in 2004.

Background

Over the past two decades, occasional pet, livestock, and wildlife deaths, and human skin rashes and gastrointestinal illnesses have been associated with lakes and ponds in Nebraska, but rarely were cyanobacterial blooms suspected as the cause. In October 2003, a workshop taught by Dr. Russell Rhodes of Southwest Missouri State University for several Nebraska agencies, raised awareness of the frequency and magnitude of cyanobacterial problems in the United States and throughout the world. On May 4, 2004, after two dogs died within a few hours of drinking water from Buccaneer Bay Lake near Plattsmouth, Nebraska agencies began to actively address cyanobacterial issues for the first time. A water sample and a necropsy on one of the dogs revealed that the dog deaths were likely due to high levels of the cyanobacteria toxin Microcystin LR. The Microcystin LR concentration of the water was 69.4 ppb. These dog deaths were reported in the national news and investigated by the Centers for Disease Control and Prevention. During this same timeframe, three more dog deaths were reported at two other lakes with cyanobacterial blooms. Meetings were held between the Nebraska Department of Environmental Quality (NDEQ), Nebraska Health and Human Services System (NHHSS), Nebraska Game and Parks Commission (NGPC), and the University of Nebraska-Lincoln (UNL). Excellent cooperation and quick action were demonstrated by these agencies in developing joint strategies for cyanobacterial monitoring and public notification within two weeks after the dog deaths occurred at Buccaneer Bay Lake.

Methods

NDEQ purchased Enzyme-Linked Immunosorbent Assay (ELISA) laboratory test kits for analyzing the levels of total microcystins in Nebraska lakes. ELISA kits provided a low cost, semi-quantitative analytical method for measuring concentrations of total microcystins, which are the most common toxins released by cyanobacteria. In 2004, analysis of 748 samples using ELISA test kits instead of High Performance Liquid Chromatography (HPLC) or Liquid Chromatography/Mass Spectrometry (LC/MS) analyses resulted in an estimated savings of $77,000. Another advantage of analyzing water samples with ELISA kits was the quick turnaround time, which allowed weekly updates of lake microcystin conditions and public health alerts and advisories prior to each weekend's recreational activities. NDEQ initiated a weekly microcystin monitoring program on May 17, 2004, which targeted public and private lakes with known or suspected cyanobacterial problems. Citizen complaints were also important in providing information on lakes where blooms were occurring. UNL coordinated a volunteer monitoring program for private lakes, and upon request, supplied lake homeowners with a sample kit. Samples returned to UNL were analyzed under a microscope for cyanobacterial genera and relative biomass estimates. UNL referred samples with a high biomass of cyanobacterial genera to NDEQ for analysis of total microcystins. Likewise, NDEQ referred samples with high levels of total microcystins to UNL for microscopic identifications and biomass estimates. A weekly routine was established in which water samples were collected and delivered to the laboratory on Monday and Tuesday, processed using freeze-thaw methods on Wednesday, and analyzed on Thursday. Sample results were reported on Thursday, and, if necessary, warning signs were posted at lakes on Friday.

Because of its initial unfamiliarity with cyanobacterial issues, Nebraska chose to err on the side of safety by selecting conservative approaches for protecting public health, which included measuring worst-case cyanobacterial bloom conditions and human exposure risks, and using ELISA kits to analyze samples. The ELISA kits measured all microcystin congeners, not just the LR congener. Therefore, sample results measuring all microcystin congeners were compared to the World Health Organization (WHO) action level for only one of the congeners, Microcystin LR. Also, lake samples were frozen and thawed three times prior to analysis with the ELISA kits to lyse the cyanobacterial cells and release the toxins. Thus, the sample results were likely higher than the free microcystin levels in the lakes. This was done to simulate the exposure risk that might exist from ingestion of lake water and the release of toxins from cyanobacterial cells in the stomach. These conservative procedures provided a safety margin in case grab samples failed to measure the highest concentrations of total microcystins in a lake, or other cyanobacterial toxins such as anatoxins, saxitoxins, or cylindrospermopsins, which are not measured by the ELISA kit, were present. In 1998, WHO recommended that Microcystin LR concentrations of 20 ppb or higher should trigger further action for recreational uses. Nebraska chose an initial, more conservative action level of 15 ppb of total microcystins for issuing health alerts in 2004, and a level of 2 ppb of total microcystins for issuing health advisories. The action level of 15 ppb of total microcystins was selected because it was more protective than the 20 ppb of Microcystin LR recommended by WHO. Methods used to notify the public about potential health concerns from exposure to cyanobacteria included the development of a fact sheet about cyanobacteria (Fig. 1); weekly updates to microcystin sampling results and health alerts on the NDEQ web site (Fig. 2); emails to interested agencies and organizations;

news releases and interviews with newspapers, radio, and TV stations; and posting of warning signs at lake beaches and boat ramps (Fig. 3 see Color Plate 4).

Results and Discussion

On Monday, July 12, 2004, the east swimming beach at Pawnee Lake near Emerald, Nebraska was sampled for total microcystins after a dense algal bloom was observed during routine E. coli monitoring. E. coli concentrations were slightly elevated (276/100ml compared to the single sample criterion of 235/100 ml), and the most recent five-sample geometric mean of 179/100 ml exceeded the geometric mean criterion of 126/100 ml; however, E. coli concentrations of this magnitude are relatively common in Nebraska lakes. No documented complaints about gastrointestinal illnesses after swimming in Nebraska lakes had ever been received by state officials prior to the weekend of July 17-18, 2004. Levels of total microcystins at the east swimming beach exceeded 15 ppb on July 12, 2004, and a health alert was issued for Pawnee Lake on Thursday, July 15. Local authorities were asked to post signs at the boat ramp and at both swimming beaches on Pawnee Lake prior to the weekend of July 17-18. Unfortunately, due to the short notice and logistics of mass-producing warning signs, only one sign was posted at the east swimming beach, and no signs were posted at the boat ramp or west swimming beach. Heavy public use of the lake occurred that weekend, and more than 50 calls were received from the public, complaining about symptoms such as skin rashes, lesions, blisters, vomiting, headaches, and diarrhea after swimming or skiing in Pawnee Lake. Although unfortunate, this incident provided evidence that the initial health alert action level adopted in Nebraska was indicative of a serious health threat, and that the state needed to do a better job of informing the public. During 2004, in addition to five dog deaths and the Pawnee Lake human health problems, several livestock and wildlife deaths and additional complaints of skin rashes and gastrointestinal illnesses were reported at other lakes. No cyanobacterial toxin data were collected in Nebraska prior to 2004; therefore, trends regarding the incidence of cyanobacterial harmful algal blooms could not be determined. However, the numbers of cyanobacterial problems reported in 2004 were unprecedented. A total of 671 microcystin samples (748 including QC samples) were collected from 111 different lakes in 2004, resulting in health alerts for 26 lakes and health advisories for 69 lakes. A total of 22 of the 26 health alert lakes (84.6%) were located in the eastern one-third of Nebraska (Fig. 4). Most of the state's population lives in eastern Nebraska, which is intensively farmed with many areas of high to very high erosion potential. Most lakes in this area typically receive high nutrient loadings. Also, housing developments are common at sandpit lakes along the Platte River in eastern Nebraska, and many of these are suspected of having failing septic systems, which may contribute to the nutrient levels of these lakes.

High concentrations of total microcystins (>15 ppb) were measured in Nebraska lakes from May through December, although health alerts and advisories occurred most frequently during the months of July, August, and September. Preliminary remote sensing data indicated that cyanobacterial succession in lakes varied significantly throughout the year, even among lakes located in close proximity to one another (e.g. Fremont State Lakes). Four lakes (Carter Lake near Omaha, Swan Creek Lake (5A) near Tobias, Pawnee Lake near Emerald, Iron Horse Trail Lake near Humboldt) were on health alert status for 12 or more weeks during 2004. The most common cyanobacterial genera identified in Nebraska lake samples were Anabaena (32.0%) and Microcystis (30.0%), followed by Oscillatoria (14.3%) and Aphanizomenon (4.9%). A total of 24.8% of the lake samples analyzed in response to citizen complaints had a high or very high biomass of cyanobacteria. Preliminary assessments of concentrations of total microcystins and ancillary data indicated that lower water levels from the recent drought conditions and lower nitrogen to phosphorus ratios may have contributed, in part, to the increased numbers of cyanobacterial complaints and problems that occurred in 2004. To date, no problems with levels of total microcystins have been documented in drinking water sources in Nebraska. However, 85% of the state's residents use groundwater as their source of drinking water and the remaining 15% primarily obtain their drinking water from the Missouri River.

New Developments

Several changes to the microcystin sampling and public notification protocols were made in 2005. The health alert action level was raised from 15 to 20 ppb to correspond more closely with the WHO recommended action level for recreation. However, it should be noted that the Nebraska action level of 20 ppb of total microcystins is still more protective than the WHO action level of 20 ppb, which is based solely on Microcystin LR concentrations. Lakes were placed on health alert status in 2005 if the weekly total microcystins concentration equaled or exceeded the 20 ppb action level. However, once a health alert was issued for a lake, the weekly total microcystins concentration had to fall below 20 ppb for two consecutive weeks before the lake was removed from health alert status. In contrast, lakes were dropped from health alert status in 2004 based on weekly changes in levels of total microcystins. In addition, the health advisory action level of 2 ppb was dropped in 2005 because using both an advisory level and an alert level was confusing to the public. In 2005, swimming beach sampling protocols were changed to better represent the lake conditions that most adults and children are exposed to. Grab samples were collected at the mid-point of designated swimming areas in knee-deep water. In 2004, worst-case samples were often collected from surface scums along the shorelines.

Special studies were initiated in 2005 to better identify causes and ecological consequences of cyanobacterial blooms. NDEQ contracted with UNL to conduct a cyanobacterial remote sensing project. This project will evaluate the potential of remote sensing as a tool for early detection of cyanobacterial harmful algal blooms based upon analysis of images acquired by aircraft overflights and in-situ monitoring. Spectrally based algorithms will be developed for detecting and quantifying in real time the presence of pigments associated with cyanobacteria, including phycocyanin (a blue pigment found in cyanobacteria) and chlorophyll a. A preliminary map of phycocyanin mask images for the Fremont State Lakes showing the presence of cyanobacteria is displayed in Fig. 5. Images or maps of cyanobacterial blooms may also be useful in guiding field sampling efforts. Another objective of this project is to develop a model for predicting cyanobacterial blooms based on parameters such as zooplankton, phytoplankton, total microcystins, nutrients, turbidity, pH, water temperature, depth, stratification, air temperature, wind, cloud cover, and precipitation. A study of the concentrations of total microcystins in fish tissue will be conducted in 2005 to determine if fish caught from health alert lakes are safe to eat. Fish fillets and entrails of various game fish species from three lakes, Pawnee Lake, Fremont Lake #20, and Carter Lake, which have most frequently been on health alert status in 2004 and 2005, will be analyzed for levels of total microcystins. Nebraska currently advises the public not to eat whole fish from health alert lakes and to consider practicing catch and release as a safety precaution. The results of this study will be used to modify existing fish consumption advisories. Future studies will analyze lake samples for individual cyanotoxins such as Anatoxin-a; Cylindrospermopsin; Microcystin LR, LA, LF, LW, and RR; and chemical and physical water quality parameters and plankton population dynamics, which may help explain why some lakes have persistent cyanobacterial problems.

In 2005, an interagency workgroup was formed to discuss and recommend potential methods for preventing, controlling, and mitigating cyanobacterial blooms in different types of lakes including large flow-through impoundments ≥ 25 acres (i.e. reservoirs built for flood control and irrigation), small flow-through impoundments < 25 acres (i.e. farm and urban ponds), and closed systems (i.e. oxbow lakes, sand and barrow pits). Preliminary recommendations include reducing nutrient inputs; installing watershed treatments to reduce nutrient runoff; dredging to remove in-lake sediments, nutrients, and increase depth; controlling rough fish populations; applying alum treatments to inactivate phosphorus; and applying algacides. The effectiveness and cost of these options are limited by factors such as lake size, watershed size, outlet structure, sources of water, and remediation costs.

NEWS RELEASE
Issued jointly from the
Nebraska Department of Health and Human Services
Regulation and Licensure
Nebraska Department of Environmental Quality
Nebraska Game and Parks Commission
UN-L Water Quality Extension Program

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Kathie Osterman, Communications and Legislative Services, (402) 471-9313
Jim Carney, Game and Parks Commission, (402) 471-5547
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FACT SHEET:
Precautions and facts regarding toxic algae

What is toxic blue-green algae?

Although it technically is not a true algae, what is commonly referred to as toxic blue-green algae refers to certain strains of cyanobacteria that produce toxins. These toxins were found in a number of Nebraska lakes in 2004.

Toxic blue-green algae can dominate the algal populations of a lake under the right combinations of water temperature, low water depths, and nutrients (such as high nitrogen and phosphorus concentrations from wastewater discharges and/or runoff from agricultural land and communities).

What should I look for to avoid toxic algae?

The toxic strains of blue-green algae usually have heavy surface growths of pea-green colored clumps, scum or streaks, with a disagreeable odor and taste. It can have a thickness similar to motor oil and often looks like thick paint in the water. Algae blooms usually accumulate near the shoreline where pets and toddlers have easy access and the water is shallow and more stagnant. It is important to keep a watchful eye on children and pets so that they do not enter the water. Aspects to watch out for include:
Water that has a neon green, pea green, blue-green or reddish-brown color.
Water that has a bad odor.
Foam, scum or a thick paint-like appearance on the water surface.
Green or blue-green streaks on the surface, or accumulations in bays and along shorelines.

Fig. 1. Fact sheet about cyanobacteria (toxic algae)

What are the risks and symptoms?

Pets and farm animals have died from drinking water containing toxic blue-green algae (or licking their wet hair/fur/paws after they have been in the water). Blue-green algae toxins have been known to persist in water for several weeks after the bloom has disappeared.

The risks to humans come from external exposure (prolonged contact with skin) and from swallowing the water. Symptoms from external exposure are skin rashes, lesions and blisters. More severe cases can include mouth ulcers, ulcers inside the nose, eye and/or ear irritation and blistering of the lips. Symptoms from ingestion can include headaches, nausea, muscular pains, central abdominal pain, diarrhea and vomiting. Severe cases could include seizures, liver failure, respiratory arrest – even death, although this is rare. The severity of the illness is related to the amount of water ingested, and the concentrations of the toxins.

Are some people more at risk?

Yes. Some people will be at greater risk from toxic blue-green algae than the general population. Those at greater risk include:
Children. Toddlers tend to explore the shoreline of a lake, causing greater opportunity for exposure. Based on body weight, children tend to swallow a higher volume of water than adults, and therefore could be at greater risk.
People with liver disease or kidney damage and those with weakened immune systems.

Here are some tips on what you can do, and things to avoid:
Be aware of areas with thick clumps of algae and keep animals and children away from the water.
Don't wade or swim in water containing visible algae. Avoid direct contact with algae.
Make sure children are supervised at all times when they are near water. Drowning, not exposure to algae, remains the greatest hazard of water recreation.
If you do come in contact with the algae, rinse off with fresh water as soon as possible.
Don't boat or water ski through algae blooms.
Don't drink the water, and avoid any situation that could lead to swallowing the water.

Fig. 1. (cont.) Fact sheet about cyanobacteria (toxic algae)

Is it safe to eat fish from lakes that are under a Health Alert?

The toxins have been found in the liver, intestines and pancreas of fish. Most information to date indicates that toxins do not accumulate significantly in fish tissue, which is the meat that most people eat. It is likely that the portions of fish that are normally consumed would not contain these toxins. However, it is ultimately up to the public to decide whether they want to take the risk, even if it is slight. Fishing is permitted at lakes that are under a Health Alert, but anglers may want to consider practicing catch and release at these lakes.

Where can I find out more information about lake sampling for toxic algae?

The Nebraska Department of Environmental Quality is conducting weekly and monthly sampling at select public lakes that are either popular recreational lakes, or have historically had toxic algae problems. This information is updated weekly on the agency web site, www.deq.state.ne.us.

What should I do if I have concerns regarding a private lake?

As part of the University of Nebraska Water Quality Extension Program, UN-L has developed a "Volunteer Monitoring Program" and lake test kits that will be sent to interested lake associations, owners, etc. so they can collect a sample and send it to UN-L for analysis. To obtain more information and a test kit please contact the program at (402) 472-7783, or (402) 472-8190.

If I think a public lake has a toxic algae bloom, who do I call?

Please contact the Department of Environmental Quality's Surface Water Section at (402) 471-0096, or (402) 471-2186.

If I am experiencing health symptoms, who do I call?

If you experience health symptoms, notify your physician, and also report it to the Nebraska Health and Human Services System at (402) 471-2937. You can also contact the Nebraska Regional Poison Center at 800-222-1222 for more information.

For more information, contact
MoreInfo@NDEQ.state.NE.US
Nebraska Department of Environmental Quality
1200 "N" Street, Suite 400
PO Pox 98922
Lincoln, Nebraska 68509
(402) 471-2186 FAX (402) 471-2909

Fig. 1. (cont.) Fact sheet about cyanobacteria (toxic algae)

TOXIC BLUE-GREEN ALGAE SAMPLING RESULTS

DEQ is conducting weekly and monthly sampling for toxins at a number of public recreational lakes across Nebraska, and the results will be updated weekly, usually on Fridays. Depending on circumstances, there may be additional lakes added to the weekly sampling schedule.

Samples taken: September 19 and 20, 2005, unless noted otherwise
Analysis completed: September 23, 2005

The analysis of recent sampling shows that the following lakes are currently considered in Health Alert status:

Conestoga Reservoir
Kirkman's Cove
Pawnee Reservoir

An explanation of Health Alert: This designation means that the state believes that the level of toxins in the water make it unsafe for full-body recreational activities, such as swimming.

During a Health Alert at a public lake, signs will be posted advising the public to use caution. Affected swimming beaches will be closed. Boating and other recreational activities will be allowed, but the public will be advised to use caution and avoid prolonged exposure to the water, particularly avoiding any activity that could lead to drinking the water.

The level established in 2005 for a Health Alert is 20 parts per billion of total microcystins. Lakes under Health Alert will be sampled weekly, and the Health Alert will stay in effect until the level stays below 20 parts per billion for two consecutive weeks.

Fig. 2. Weekly updates to total microcystins sampling results and health alerts on the NDEQ web site (**www.deq.state.ne.us**).

The chart below shows the lakes that were sampled, and the level of toxin found at the lake.

Lake Name	County	Level of Total Microcystins (ppb)	Is it on alert?
Bluestem Res. at swimming beach	Lancaster	0.11	No
Carter Lake at north boat ramp*	Douglas	Area 10 beach – 3.45 Lieber's Point beach – 4.68	No
Conestoga Res. at boat ramp	Lancaster	>30	YES
Fremont Lake #9 at Fremont Beach	Dodge	0.44	No
Fremont Lake #10 at Brick's Bay Beach	Dodge	0.09	No
Fremont Lake #20	Dodge	East beach – 3.80 West Beach – 3.59	No
Iron Horse Trail at swimming beach	Pawnee	0.45	No
Kirkman's Cove	Richardson	15.18	**YES**—must remain below 20 ppb for 2 cons. Wks
Louisville Lake #2 at swimming beach	Cass	3.61	No
Maskenthine Lake at steel pier	Stanton	0.97	No
Pawnee Reservoir	Lancaster	East beach – >30 West beach – not sampled	**YES**
Summit Lake at swimming beach	Burt	2.18	No
Wagon Train Lake at swimming beach	Lancaster	0.00	No

*The north boat ramp is located on the Nebraska side of Carter Lake.

Fig. 2. (cont.) Weekly updates to total microcystins sampling results and health alerts on the NDEQ web site (**www.deq.state.ne.us**).

If a private lake is under a Health Alert, the Nebraska Department of Environmental Quality will inform the head of the lake association or other lake representative, and ask them to take the appropriate measures to ensure users of the lake are informed of the potential hazards.

For more information about toxic blue-green algae, please see the related Fact Sheet.
For more information, contact
MoreInfo@NDEQ.state.NE.US

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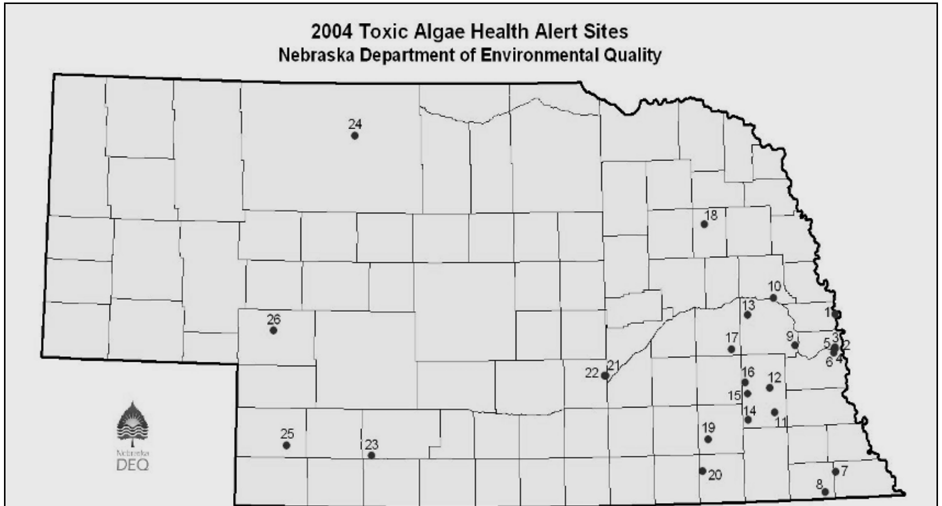
Fig. 2. (cont.) Weekly updates to microcystins sampling results and health alerts on the NDEQ website (**www.deq.state.ne.us**).

Fig. 3. Posting of warning signs at lake beaches and boat ramps. (See Color Plate 4).



Index	Water Body	Index	Water Body
1	Carter Lake north of Omaha	14	Olive Creek Reservoir near Kramer
2	Bellevue Rod & Gun Club south lake near Bellevue	15	Conestoga Reservoir near Denton
3	Hanson Lake #4 south of Bellevue	16	Pawnee Reservoir near Emerald
4	Hanson Lake #1 south of Bellevue	17	Redtail WMA near Dwight
5	Hanson Lake #2 south of Bellevue	18	Maskentine Reservoir near Stanton
6	Buccaneer Bay Lake near Plattsmouth	19	Swan Lake #5A near Tobias
7	Kirkman's Cove near Humboldt	20	Alexandria SRA West Lake
8	Iron Horse Trail Reservoir near DuBois	21	Hidden Lake near Grand Island
9	Thomas Lake near Ashland	22	Arends Lake near Grand Island
10	Fremont Lake #20 near Fremont	23	Red Willow Reservoir near McCook
11	Wagon Train Reservoir near Hickman	24	Merritt Reservoir near Valentine
12	Wedgewood Lake in Lincoln	25	Enders Reservoir near Imperial
13	Czechland Reservoir near Praque	26	Lake McConaughy near Ogallala

Fig. 4. Location of health alert lakes in 2004.

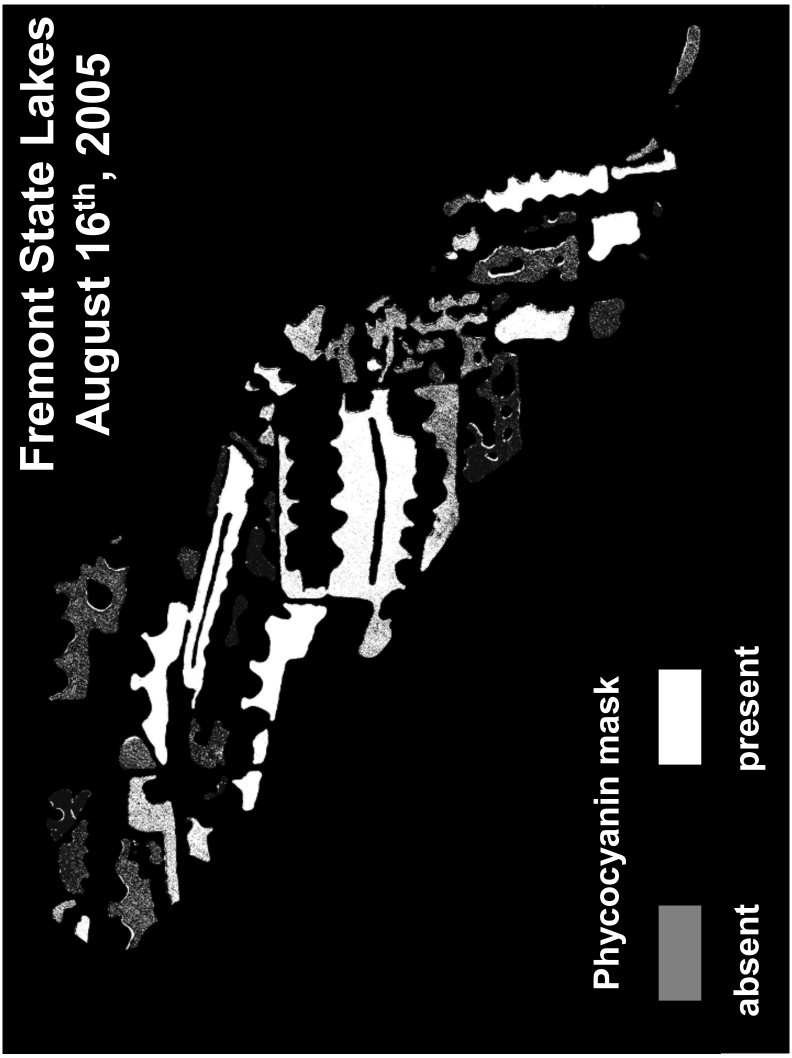


Fig. 5. Map of phycocyanin mask images for the Fremont State Lakes showing the presence of cyanobacteria.