Overview of Oregon Cyanobacterial Experience

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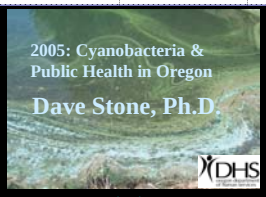


11/08/05

BEND BULLETIN

John Day River

THURSDAY, AUGUST 5, 2004 • THE BULLETIN

Algae a danger to animals

Blue-green form has killed dogs, bighorn sheep

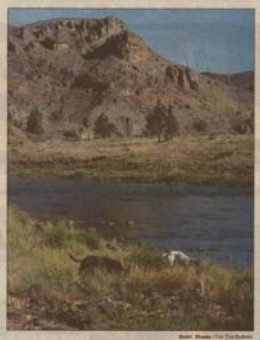
By Scott Staats
For The Bulletin

At least 20 bighorn sheep and seven dogs have died in Central and Eastern Oregon the last three years during the summer months. At first, the deaths seemed mysterious, but now the mystery appears to be solved.

According to Walt Van Dyke, wildlife biologist with the Oregon Department of Fish and Wildlife in Ontario, the bighorns died two summers ago from drinking water containing blue-green algae. The deaths occurred within a 20-square mile area near Leslie Gulch and the upper Owyhee Reservoir.

"We know for sure we had at least nine sheep die directly from blue-green algae poisoning," Van Dyke said. "We figured the others died from the same thing since they were near springs and intermittent creeks."

Water samples confirmed the presence of the toxic algae and a necropsy of a ram showed kidney failure, which a veterinarian concluded was due to a water- or plant-borne toxin.



Two dogs sniff around near Priest Hole along the John Day River. Between 2001 and 2003, six dogs died near Priest Hole. Their deaths are believed to be caused by toxic blue-green algae.

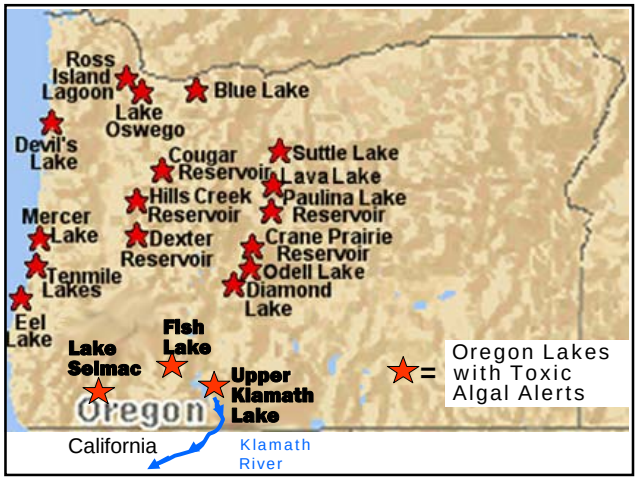
blooms have occurred in the past, noting that it's hard to keep dogs away from every seep or puddle while hunting.

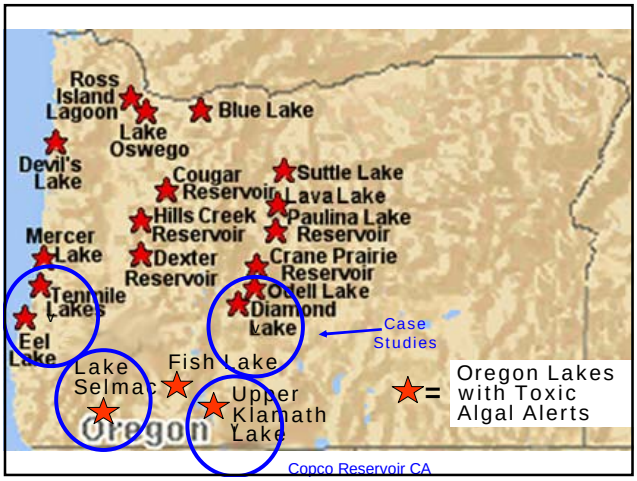
Blue-green algae blooms appear to be a natural phenomenon associated with drought. Van Dyke warns that, "All chukar hunters need to be careful, it's not just an Owyhee problem."

Between 2001 and 2003 there were several dog deaths reported along the John Day River with six occurring at Priest Hole and one near Clarno. The deaths appear to be caused by toxic cyanophyte blooms, also know as blue-green algae. Dogs are particularly susceptible because the scum sticks to their coats and is swallowed during licking. Most of the dogs died within an hour of contacting the water.

The dog deaths prompted BLM wildlife biologist Scott Cooke to do some research on blue-green algae. He found that the organism has characteristics of bacteria, and it can perform photosynthesis.

Cooke said that there are now warning signs along the John Day River in places such as Service Creek, Twickenham, Priest Hole, Burnt Ranch and Clarno. With river levels now very low from irrigation (136 cfs at Service Creek) and warm temperatures, there could be blooms again this year. At this time, there have not been any samples taken to test for blue-green algae, but after





Upper Klamath and Agency Lakes

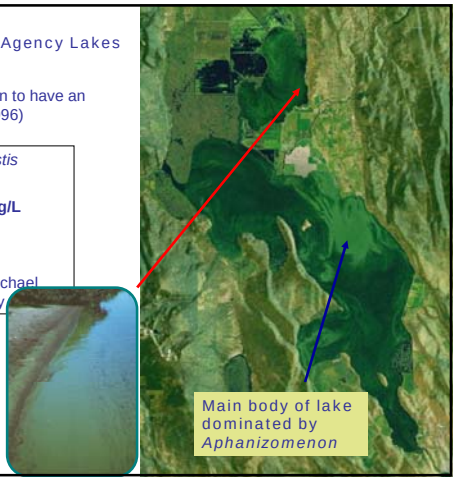
First Lake in Oregon to have an advisory issued (1996)

Agency Lake *Microcystis* bloom; July 31, 1996

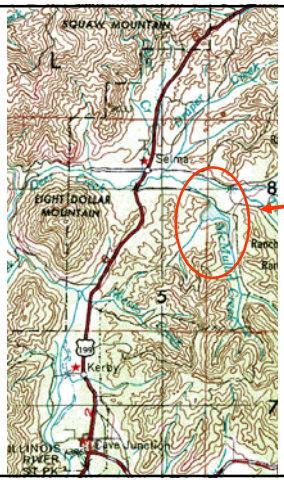
Shoreline scum: **30 mg/L (=30,000 µg/L)**

Offshore: 600 µg/L

Analyzed by W. Carmichael Wright State University



Toxic Algal Blooms in Lake Selmac, Oregon.



Lake Selmac

Reservoir formed in 1961
160 acres
Mean depth 2.1 m

Managed by Josephine County Parks Department

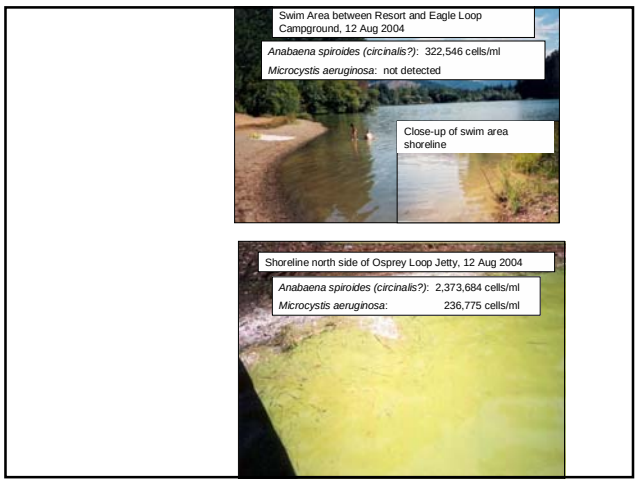
High recreational use:

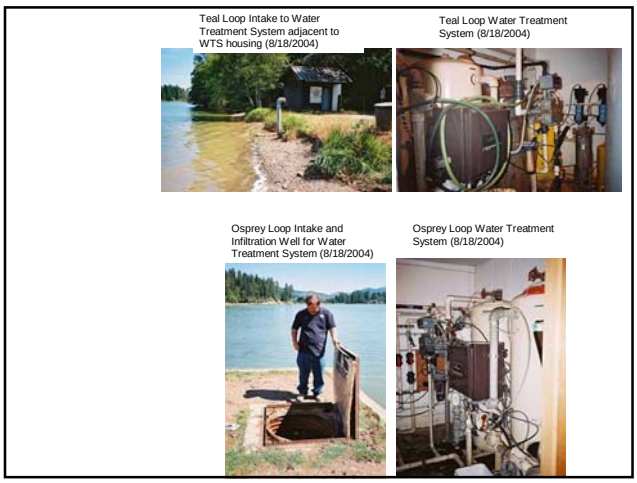
Chiefly camping and fishing

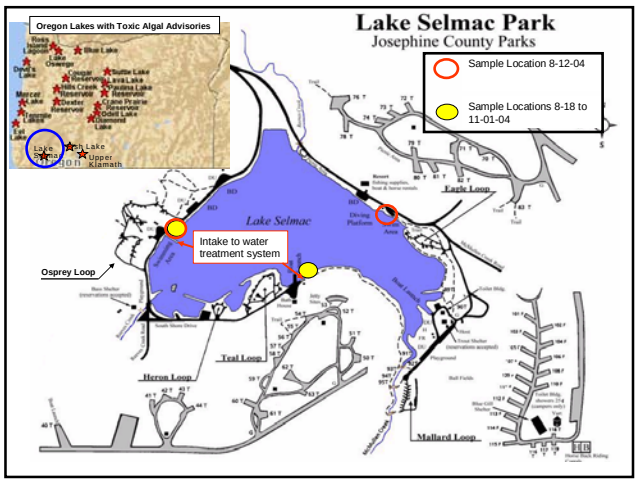
Treated Lake water utilized at campground facilities.

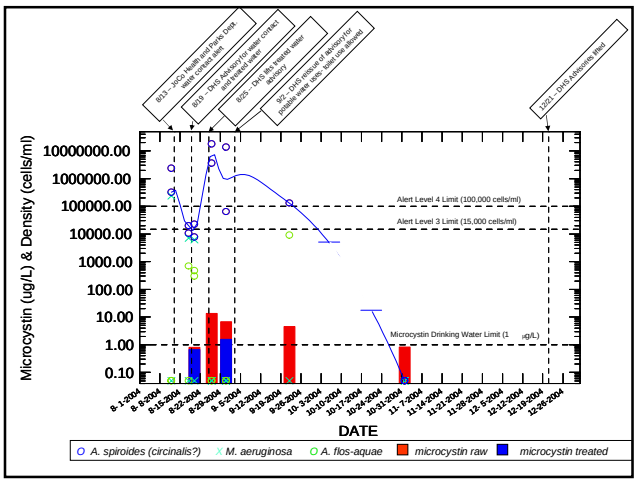
400 campers/week

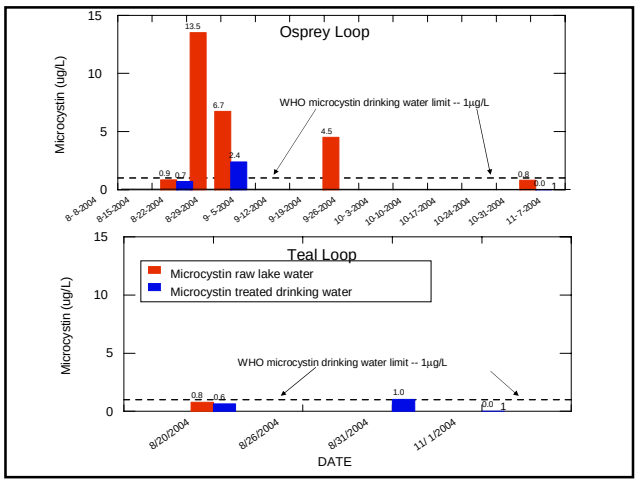
Very important economically for Josephine County Parks Operations


Swim Area between Resort and Eagle Loop Campground, 12 Aug 2004
Anabaena spiroides (circinalis?): 322,546 cells/ml
Microcystis aeruginosa: not detected
Close-up of swim area shoreline
Shoreline north side of Osprey Loop Jetty, 12 Aug 2004
Anabaena spiroides (circinalis?): 2,373,684 cells/ml
Microcystis aeruginosa: 236,775 cells/ml


Teal Loop Intake to Water Treatment System adjacent to WTS housing (8/18/2004)
Teal Loop Water Treatment System (8/18/2004)
Osprey Loop Intake and Infiltration Well for Water Treatment System (8/18/2004)
Osprey Loop Water Treatment System (8/18/2004)


Oregon Lakes with Toxic Algal Advisories
Lake Selmac Park
Josephine County Parks
Sample Location 8-12-04
Sample Locations 8-18 to 11-01-04
Lake Selmac
Intake to water treatment system
Osprey Loop
Eagle Loop
Teal Loop
Heron Loop
Mallard Loop


Microcystin (ug/L) & Density (cells/ml)
10000000.00
1000000.00
100000.00
10000.00
1000.00
100.00
10.00
1.00
0.10
Alert Level 4 Limit (100,000 cells/ml)
Alert Level 3 Limit (15,000 cells/ml)
Microcystin Drinking Water Limit (1 ug/L)
DATE
A. spiroides (circinalis?)
M. aeruginosa
A. flos-aquae
microcystin raw
microcystin treated

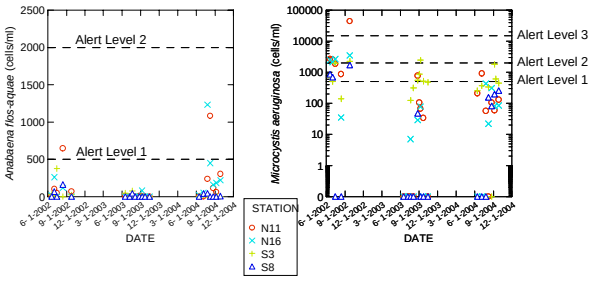


Sept. 22, 2003

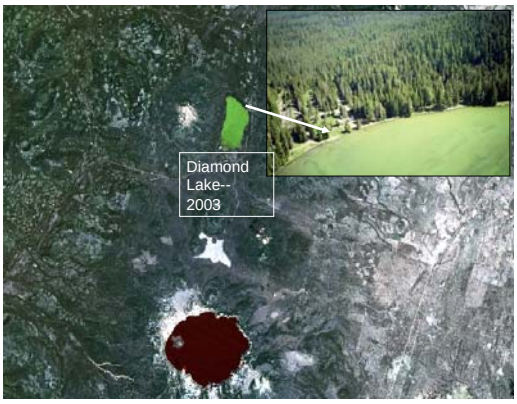
Contact: Bonnie Widerburg (503) 731-4180
Technical Contact: Cindy Gaines (503) 731-4012

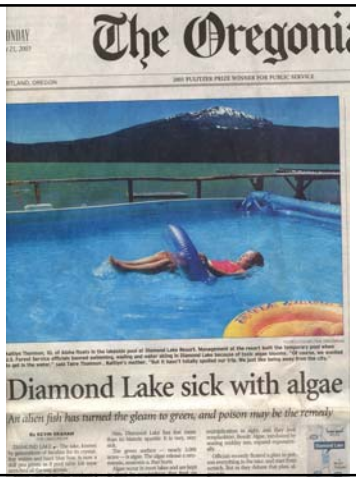
Health advisory: potential recreational and drinking water hazard in Tenmile Lakes

Public health officials at the Oregon Department of Human Services (DHS) and Coos County Health Department are advising lakefront property owners, visitors and other interested persons of another bloom of Microcystis aeruginosa in Tenmile Lakes, located about 10 miles north of Coos Bay on the Oregon coast. Similar advisories were issued for these same lakes in 1997, 2001 and 2002 for recreational contact. Drinking water advisories have been made for the lakes each year since 1997.



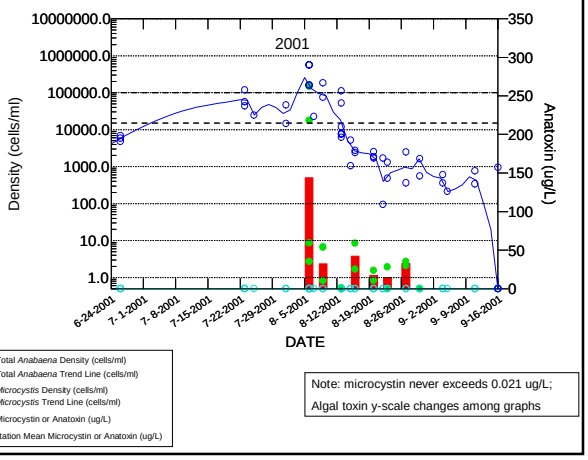
Density of *Microcystis aeruginosa* and *Anabaena flos-aquae* in Tenmile Lakes, 2002-2004

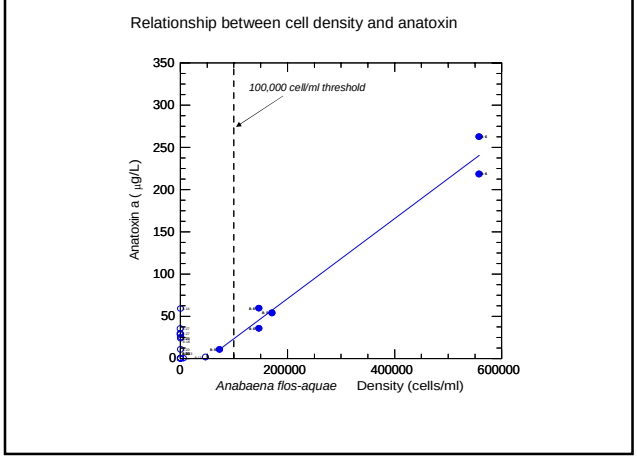


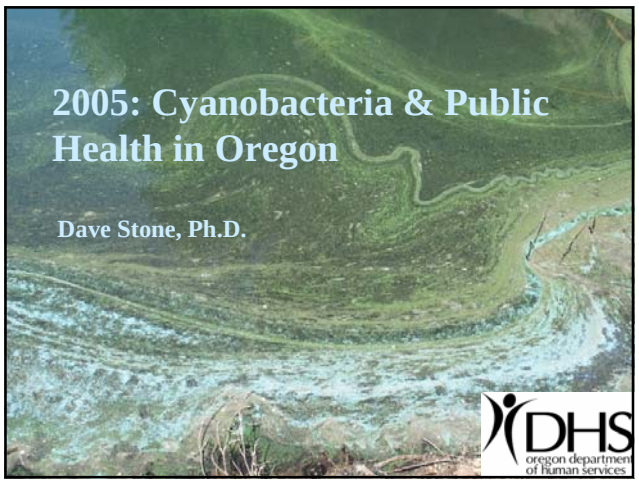

The Oregoni

Diamond Lake sick with algae

An alien fish has turned the gleam to green, and poison may be the remedy







Possible Exposure Pathways:

-chronic ingestion through contaminated drinking water

-ingestion of water, inhalation of droplets or contact with nasal mucous membranes through recreational contact

-consumption of fish and shellfish from contaminated waters

-dermal contact with toxins through bathing or recreational activities such as wading, swimming, skiing and canoeing

Children are more susceptible to toxins for a variety of reasons, including smaller body size, potential for more incidental ingestion and response to symptoms.

Risk Levels & Standards:

Drinking water (provisional): 1 ug/L microcystin-LR (WHO)
3 ug/L anatoxin-a (Austaralia)

BGA dietary supplements: 1 ppm microcystin (ODA)

Tolerable Daily Intake (provisional): 0.04 ug/kg/day (WHO)

Recreational Bathing Waters (WHO):

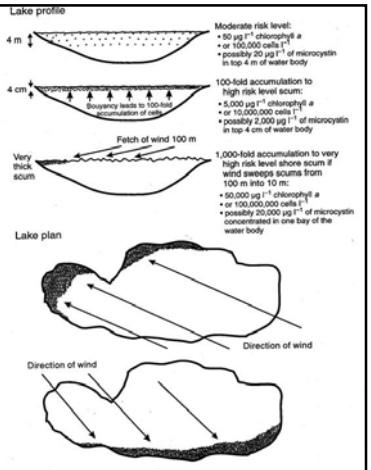
Relatively **low-risk** of adverse effects: 20,000 cells/ml
(4 ug/L microcystin)
Moderate probability of adverse effects: 100,000 cells/ml
(20 ug/L microcystin)
High probability of adverse effects: scums

Special considerations:

- Scums can increase local cell density and toxin concentration in hours. This has numerous implications for public health and presents a challenge for routine water monitoring schedules.
- During bloom die-offs, the water may look more inviting, but toxin levels may be at their highest.
- The incidence of low-level symptoms (nausea, vomiting, diarrhea) associated with recreational exposure to algal toxins is most likely under-reported
- Most likely, not all toxic cyanobacteria have been identified and not all possible toxins have been discovered
- Children and people with pre-existing medical conditions should be considered as susceptible risk groups.

Scum Formation Increases Risk from Low or Moderate to High

From: Chorus and Bartram (1999)



- Planktonic cyanobacteria regulate their buoyancy to seek water depths and areas that provide suitable environment for growth.
- Buoyancy is slow process and many cells end up at water surface where they are blown by wind and may concentrate in certain areas. Monitoring must take into account the hourly changes of cyanotoxin occurrence in a waterbody.

Excerpted From:
WORLD HEALTH ORGANIZATION 2003
Guidelines for safe recreational water environments. Volume 1, Coastal and fresh waters.
ISBN 92 4 154580 1 WHO,GENEVA

CHAPTER 8

Algae and cyanobacteria in fresh water

"Subacute liver injury is likely to go unnoticed for two reasons:

• liver injury results in externally noticeable symptoms only when it is severe;
• acute dose–response curves for microcystins are steep.

Therefore, little acute damage may occur until levels close to severe acute toxicity are reached. As a result of the lack of apparent symptoms at moderate exposure, exposure is likely to be continued by people uninformed of the risk (e.g., for consecutive days of a holiday or a hot spell), which will increase the risk of cumulative liver damage.

There are two aspects of chronic microcystin damage to the liver—progressive active liver injury (Falconer et al., 1988) and the potential for promotion of tumour growth. Tumour-promoting activity of microcystins is well documented, although microcystins alone have not been demonstrated to be carcinogenic. Promotion of mouse skin tumours has been shown after initiation by topical exposure to a carcinogen
(dimethylbenzanthracene) followed by ingestion of a *Microcystis aeruginosa* extract (Falconer & Buckley, 1989; Falconer & Humpage, 1996)."

TABLE 8.3. GUIDELINES FOR SAFE PRACTICE IN MANAGING RECREATIONAL WATERS[a]

Guidance level or situation	How guidance level derived	Health risks	Typical actions[b]
Relatively low probability of adverse health effects			
20 000 cyanobacterial cells/ml or 10 µg chlorophyll-a/litre with dominance of cyanobacteria	• From human bathing epidemiological study	• Short-term adverse health outcomes, e.g., skin irritations, gastrointestinal illness	• Post on-site risk advisory signs • Inform relevant authorities
Moderate probability of adverse health effects			
100 000 cyanobacterial cells/ml or 50 µg chlorophyll-a/litre with dominance of cyanobacteria	• From provisional drinking-water guideline value for microcystin-LR[c] and data concerning other cyanotoxins	• Potential for long-term illness with some cyanobacterial species • Short-term adverse health outcomes, e.g., skin irritations, gastrointestinal illness	• Watch for scums or conditions conducive to scums • Discourage swimming and further investigate hazard • Post on-site risk advisory signs • Inform relevant authorities
High probability of adverse health effects			
Cyanobacterial scum formation in areas where whole-body contact and/or risk of ingestion/aspiration occur	• Inference from oral animal lethal poisonings • Actual human illness case histories	• Potential for acute poisoning • Potential for long-term illness with some cyanobacterial species • Short-term adverse health outcomes, e.g., skin irritations, gastrointestinal illness	• Immediate action to control contact with scums; possible prohibition of swimming and other water contact activities • Public health follow-up investigation • Inform public and relevant authorities

[a] Derived from Chorus & Bartram, 1999.
[b] Actual action taken should be determined in light of extent of use and public health assessment of hazard.
[c] The provisional drinking-water guideline value for microcystin-LR is 1 µg/litre (WHO, 1998).

Microcystins are relatively persistent in the aquatic environment.

Studies in Australia have shown that microcystin-LR was present up to 21 days following treatment of a *Microcystin aeruginosa* bloom with an algicide.15

Studies conducted in natural waters in the United Kingdom indicated that five days were required for the destruction of 50% of the toxin.16

Biodegradation and photolysis are means by which released microcystin-LR can naturally decrease in concentration.17,18

Cousins *et al*.19 demonstrated that the primary biodegradation of microcystin-LR in reservoir water had a first half-life of approximately four days. It was noted, however, that the half-life of this toxin in natural waters would likely vary considerably with changes in water temperature and the size of the microbial population.

WHO Recommends...

➢Avoid areas with visible algae and/or scums. Direct contact and ingestion are associated with the greatest health risk.

➢If no scums are visible, but water shows a strong greenish discoloration such that you cannot see your feet when standing knee deep (after sediment has settled) avoid bathing, immersion of head, and/or ingestion.

➢Avoid waterskiing in visible scums or waters with a strong greenish coloration as described above because of the potentially substantial risk of exposure to aerosols.

➢If sailing, sailboarding or undertaking any other activity likely to involve accidental immesion, wear clothing that is loose fitting in the openings.

➢ Use of wet suits for water sports may result in greater risk of rashes as the algal material trapped in the wet suit will be in contact with the skin for longer periods of time.

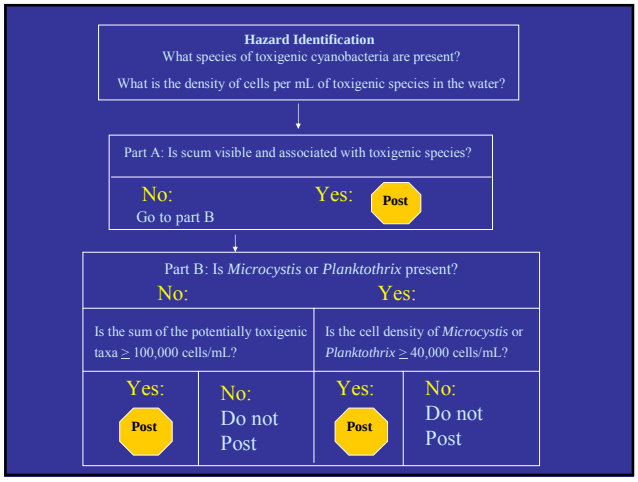
➢After coming ashore, shower or wash to remove algal material.

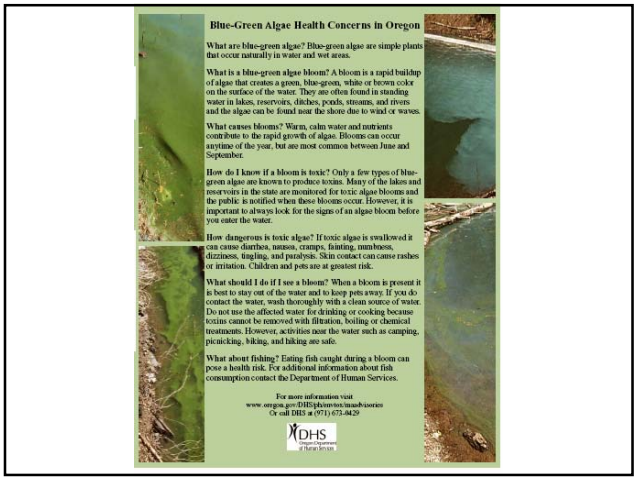
Recap of pre-2005 guidelines:

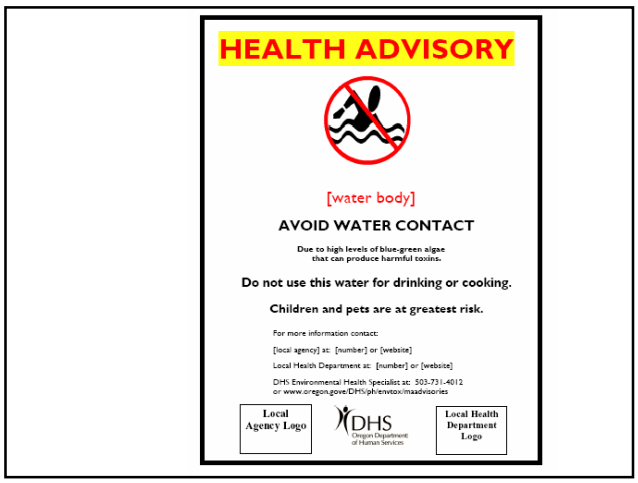
Prior to 2005, advisory postings occurred at 15000 cells/ml at many lakes, following WHO Alert Level III guidelines or based on presence of scum with toxigenic species

Communication/posting procedures were inconsistent

November 2004 Blue Green Algae Interagency meeting
Themes from decision-making sub-group
-consistency in state-wide approach
-flexibility in management options







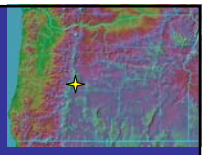
Retraction of advisories:

Without toxin analysis: DHS recommends a waiting period of two weeks after cell densities fall below Part B of the guidelines and with sufficient evidence of a declining bloom

With toxin analysis: DHS recommends a waiting period of one week after cell densities fall below Part B of the guidelines and a toxin analysis that indicates microcystin is below 8 ug/L or anatoxin-a is below 3 ug/L.

Considerations: total microcystins are preferred (not just dissolved and more equivalents than –LR); ideally, samples for toxin analysis would be collected near cell count locations

Health Advisories - Recreational contact:



Crane Prairie

Issued on June 24, 2005

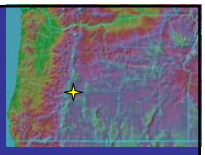
Due to *Anabaena flos-aquae* counts > 100,000 cells/mL

Retracted on July 22, 2005

Issue:

Communication - cell count vs. toxin

Health Advisories - Recreational contact:



Eastern Half of Odell Lake

Issued on July 19, 2005

Based on Anabaena flos-aquae > 100,000 cells/mL

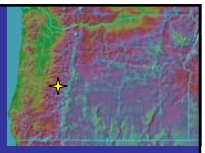
Toxin analysis: 10 ug/L microcystin-LR dissolved

Retracted on August 4, 2005

Issue:

Uptake in fish (kokanee)

Health Advisories - Recreational contact:



Hills Creek Reservoir

Advisories issued:

Larison Cove – June 24, 2005: visible scum

Packard Arm – July 21, 2005: visible scum

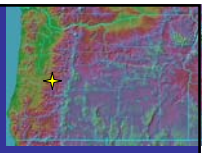
Eastern most arm – August 19, 2005: visible scum

Retracted on September 26, 2005

Issue:

Very high *Microcystis* bloom in Packard Arm

Health Advisories - Recreational contact:



Lookout Point Reservoir

Advisories issued:

Goodman Creek – July 13, 2005: visible scum

Hampton boat ramp – August 22, 2005: visible scum

Advisories lifted:

Hampton boat ramp – September 14, 2005

Goodman Creek – September 26, 2005

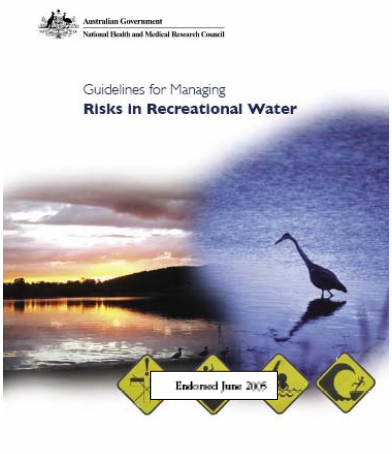


Table 6.2 Interpretation of cyanobacterial levels for recreational waters

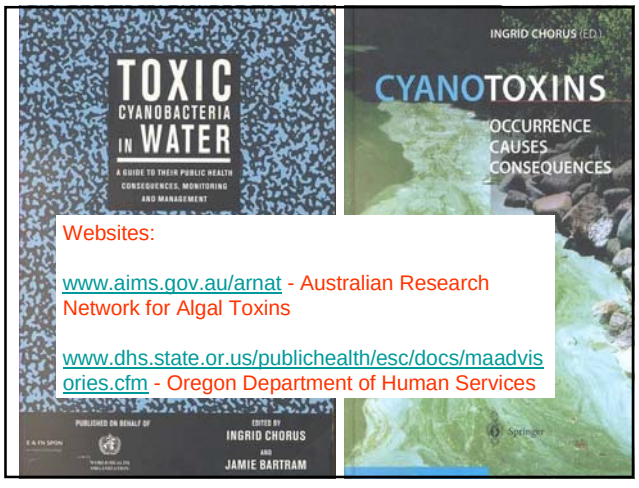
Green level Surveillance mode	Amber level Alert mode	Red level Action mode
>500 to < 5000 cells/mL *M. aeruginosa* or biovolume equivalent of > 0.04 to < 0.4 mm^3/L for the combined total of all cyanobacteria	≥5000 to <50 000 cells/mL *M. Aeruginosa* or biovolume equivalent of ≥ 0.4 to < 4 mm^3/L for the combined total of all cyanobacteria	Level 1 guideline: ≥ 10 µg/L total microcystins or ≥ 50 000 cells/mL toxic *M. aeruginosa* or biovolume equivalent of ≥4 mm^3/L for the combined total of all cyanobacteria where a known toxin producer is dominant in the total biovolume or Level 2 guideline: The total biovolume of all cyanobacterial material exceeds 10 mm^3/L or cyanobacterial scums are consistently present .

Table 6.3 Monitoring program associated with cyanobacterial alert levels

Cyanobacterial alert level	Monitoring requirement
Surveillance mode(Green level)	Routine sampling to measure cyanobacterial levels.
Alert mode (Amber level)	Investigations into the causes of the elevated levels and increased sampling to enable the risks to recreational users to be more accurately assessed.
Action mode(Red level)	Local authority and health authorities to warn the public that the water body is considered to be unsuitable for primary contact recreation.

Table 6.6 Recommended actions at different alert levels

Level	Recommended actions
Surveillance mode (green level)	Regular monitoring: ▪weekly sampling and cell countsbat representative locations in the water body where known toxigenic species are present (ie *Microcystis aeruginosa, Anabaena circinalis, Cylindrospermopsis raciborskii Aphanizomenon ovalisporum, Anabaena bergii, Nodularia spumigena*); or ▪fortnightly for other types including regular visual inspection of water surface for scums.
Alert mode (amber level)	▪Notify agencies as appropriate. ▪ Increase sampling frequency to twice weeklycat representative locations in the water body where toxigenic species (above) are dominant within the alert level definition (ie total biovolumed) to establish population growth and spatial variability in the water body. ▪ Monitor weekly or fortnightly where other types are dominant. ▪ Make regular visual inspections of water surface for scums. ▪ Decide on requirement for toxicity assessment or toxin monitoring.
Action mode (red level)	▪Continue monitoring as for alert mode. ▪ Immediately notify health authorities for advice on health risk. ▪ Make toxicity assessment or toxin measurement of water if this has not already been done. ▪Health authorities warn of risk to public health (ie the authorities make a health risk assessment considering toxin monitoring data, sample type and variability).



Websites:

www.aims.gov.au/arnat - Australian Research Network for Algal Toxins

www.dhs.state.or.us/publichealth/esc/docs/maadvisories.cfm - Oregon Department of Human Services