Cyanotoxins In California's Fish And Shellfish: Current Framework And Future Opportunities

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Outline

- Key Questions For Fish/Shellfish Monitoring
- Existing Framework For Persistent/Legacy Chemicals
- Why CyanoHABs Are Different And Overarching Constraints
- Current CA Voluntary Response To CyanoHABs
- Potential Considerations And Future Opportunities
- Conclusions

Fish/Shellfish Tissue Monitoring: What Questions Do We Need To Answer?

When and how often are fish/shellfish exposed?

How fast do they accumulate/depurate?

What species?

How many?

What locations?

When and how often?

What tissues?

What methods?

How long will it take?

How much will it cost?

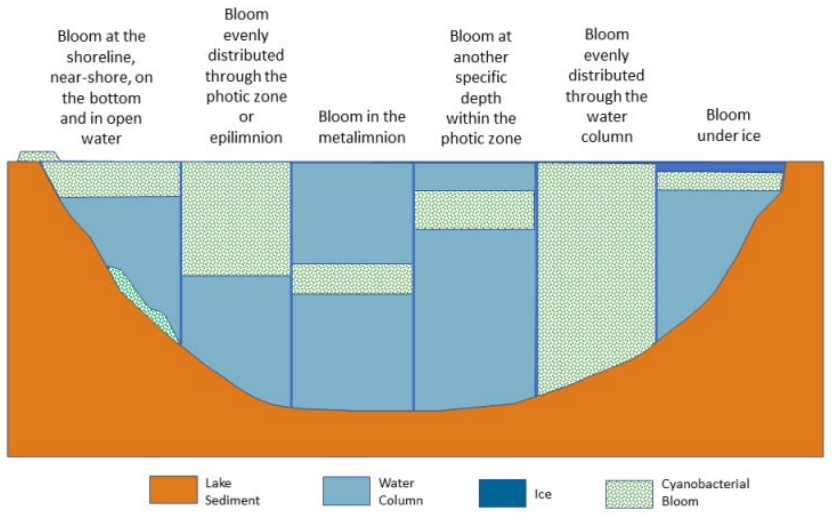
Existing Monitoring and Advisory Framework for Persistent/Legacy Chemicals in Fish/Shellfish

- Informed by decades of research in the lab and across water body types
- Fish/shellfish exposure is ongoing and relatively stable/persistent over years
- Concentrations in in fish/shellfish tissue are generally stable and persistent
- Key drivers are mercury and PCBs
  - Higher trophic level and older fish have higher levels of mercury
  - Bottom feeding species with high lipid content and older fish have higher levels of pesticides and chlorinated organic chemicals
  - Mercury accumulates in muscle tissue whereas organic chemicals accumulate in skin, fat, and internal organs
- Analytical methods well established, analytical standards and certified reference materials for tissues available
- State and Federal agencies developed tissue thresholds for natural elements, industrial chemicals, and legacy pesticides
- Stable conditions allow for infrequent sampling, long-term advisory posting, and compatible with 1+ year timeline between sample collection and final advisory posting

Why are CyanoHABs Different?

Amount, location, duration, and frequency of given cyanobacteria taxa (and associated cyanotoxins) vary considerably and on shorter timeframe (hours, days, weeks)

- Vertical migration of buoyant cells
- Change in vertical position with lake conditions such as mixing events
- Lateral movement with wind/waves
- Successional shifts in taxa between seasons and years



Examples of cyanobacteria distribution in a lake or pond. In addition to planktonic species, many lakes and ponds have benthic species as well.
Source: Modified from Graham et al. (2008). https://hcb-1.itrcweb.org/monitoring/#4_1

Why are Cyanotoxins Different?

- Both toxic and non-toxic cyanobacteria may be present and drivers for toxin production are being actively researched
- Relative intracellular and dissolved/extracellular concentrations vary with toxin class and cyanobacteria condition
  - Most cyanotoxins found within cells (intracellular) and release when cells lyse, such as with environmental conditions, treatment, or ingestion
  - Cylindrospermopsin known exception with significant portion released from intact cells
  - Extracellular toxins generally less stable with exposure to abiotic and biotic degradation

Why are Cyanotoxins in Fish/Shellfish Different?

- Corresponding exposure may vary significantly with current cyanobacteria and cyanotoxin conditions
  - Need to document exposure conditions before/during time of sample collection
  - Cyanobacteria cell/colony shape may affect predator preference
- Relationships with trophic level and age/size class are not clearly established
- Analytical methods vary, analytical standards are limited, and methods used often measure free toxin only
- Research on bioaccessibility of free and bound toxins ongoing as applicable methods become available
- Differences in field and lab exposure conditions and analytical methods complicate understanding of tissue distribution – generally higher in internal organs than muscle with some exceptions
  - Chorus and Welker, 2021 (Section 5.3): "*Trends that can be discerned are that consuming molluscs and crustaceans collected from environments with blooms might cause higher risks, particularly because they are eaten with the viscera which can contain large amounts of toxic cyanobacteria. In contrast, the edible portions of higher trophic-level organisms (e.g., muscle tissue of fish), excluding viscera, have less chance of containing a large amount of free toxin*."

Overarching Constraints

- Given the temporal and spatial variability of HABs, the existing model of fish tissue monitoring and fish consumption advisories for persistent/legacy chemicals is not applicable
  - Logistics and workload
  - Sufficient budget and allocation of resources
- Comparisons across existing studies is difficult due to:
  - Lack of standardized analytical methods
  - Limited and changing availability of analytical standards
  - Limited documentation of specific HAB conditions to which the organisms may have been exposed

Current Response to FHABs in CA

Voluntary visual observations and water monitoring by land/water body manager

Voluntary reporting of bloom and/or HAB-related illness

Tiered analysis for water samples
- Microscopy
- qPCR for toxin producing genes
- ELISA for potential toxin classes

Voluntary guidance on posting and de-posting criteria based on toxin thresholds for 3 toxin classes

Voluntary posting of advisories by city/county based on presence of bloom and/or cyanotoxin concentrations in water

Trigger Levels For Human and Animal Health				
Criteria*	No Advisory [a]	Caution (TIER 1)	Warning (TIER 2)	Danger (TIER 3)
Total Microcystins [b]	< 0.8 µg/L	0.8 µg/L	6 µg/L	20 µg/L
Anatoxin-a	Non-detect [c]	Detected [c]	20 µg/L	90 µg/L
Cylindrospermopsin	< 1 µg/L	1 µg/L	4 µg/L	17 µg/L
Cell Density of potential toxin producers	< 4,000 cells/mL	4,000 cells/mL	_____	_____
Site-specific indicator(s)	No site-specific indicators present	Discoloration, scum, algal mats, soupy or paint-like appearance. Suspected illness	_____	_____

Current Framework for Cyanotoxins in CA Fish and Shellfish

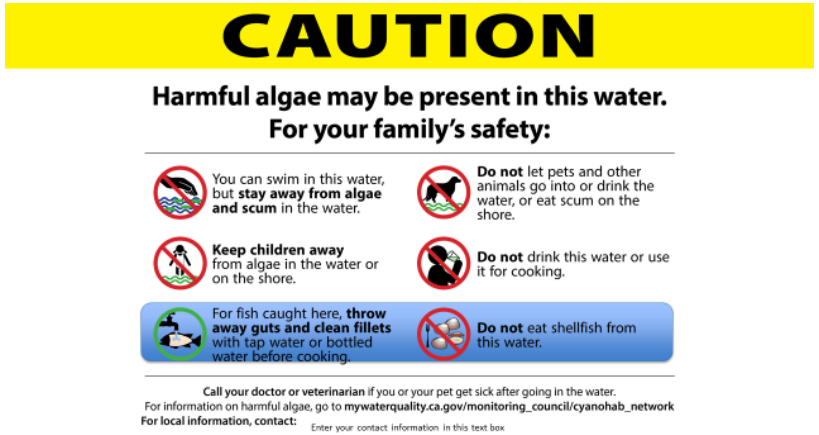
Fish/shellfish consumption incorporated into FHAB advisory signage based on water thresholds

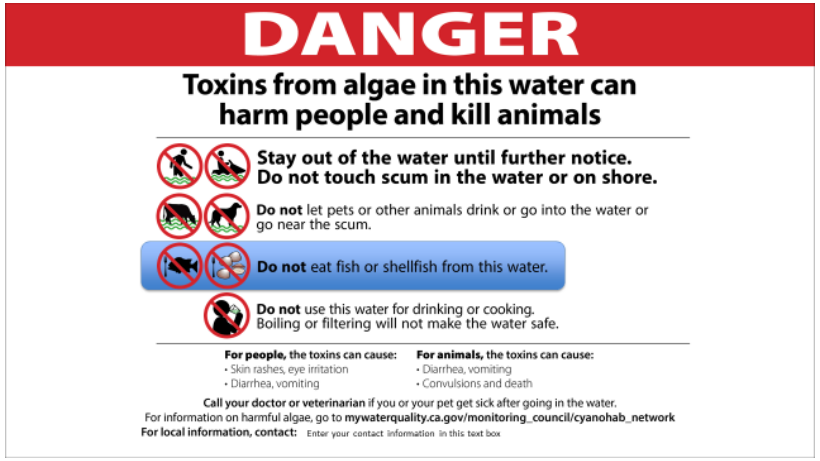
- Caution: do not eat shellfish and remove the guts for fish and rinse fillet in clean water
- Danger: do not eat fish or shellfish from this water

Messaging on potential HABs included with all OEHHA fish advisories

- *Harmful algal blooms are increasing in California and may occur throughout the year in some water bodies. OEHHA recommends that you check the California harmful algal bloom (HAB) portal to see if a bloom has been reported at this water body and learn healthy water habits to protect yourself, your family, and your pets during your visit.*

Annual recreational mussel quarantine for coasts, bays, and estuaries (generally May 1-Oct. 31)





Potential Considerations and Future Opportunities

Location

- Considerations:
  - Grab water samples represent point in time from single location, often near the water surface and from the shoreline
  - Fish mobility may vary with life stage/age and water body conditions
  - Shellfish have limited mobility once attached but water they filter may come from broader area
- Opportunities:
  - Consider broader spatial coverage (both lateral and vertical) for HAB characterization
  - Increase understanding of how locations and behaviors of different fish and shellfish species may affect their exposure to given cyanobacteria taxa and associated cyanotoxins
  - Potentially apply recommendations for fish/shellfish consumption to entire water body

Timing

- Considerations:
  - Grab water samples represent point in time
  - Fish/shellfish tissues may represent recent exposure or may be residual from earlier exposure
- Opportunities:
  - Document HAB conditions before, during, and after biological tissue sampling, including:
    - cyanobacteria taxa
    - cyanotoxins (concentrations and intracellular/extracellular location)
    - water body conditions such as stratification, salinity gradients in estuarine environments, or treatment
  - For water bodies with frequent, recurrent or ongoing HAB events, consider repeated sampling to increase understanding of potential cumulative accumulation
  - For water bodies with elevated, limited duration exposure and initial detectable tissue concentrations, consider repeated sampling over time to inform potential depuration

Species and Tissue Distribution

- Considerations:
  - In general, internal organs have higher concentrations over a longer period then muscle tissue, but there are exceptions
  - Shellfish general higher whole body concentration than fish as fillet only
  - State and Federal agencies provide general recommendation to remove skin, fat, and internal organs due to accumulation of other contaminants in those tissues.
- Opportunities:
  - Increase understanding of how cyanobacteria taxa and intracellular/extracellular distribution of cyanotoxins in the water body affect:
    - relative accumulation and depuration across species (both fish and shellfish)
    - which tissues accumulate cyanotoxins, including potential change over time following exposure
  - Increase understanding of bioaccessibility of free and bound cyanotoxins in tissues

Conclusions

- Potential exposure of fish/shellfish to cyanotoxins can vary significantly over space and time, even within a single water body
- Lack of standardized analytical methods, understanding of free and bound toxins, and limited analytical standards complicate interpretation of existing data
- Cyanotoxins in fish and shellfish require a different framework/paradigm than existing tissue monitoring and consumption advisories for persistent/legacy chemicals
- As standardized methods and additional standards become available, targeted research can help us answer the key questions for cyanotoxin-specific tissue monitoring and inform a framework for cyanotoxin-specific consumption advisories that is feasible given the high variability

Questions?

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https://oehha.ca.gov/risk-assessment/harmful-algal-blooms-habs