Background Information: HAB Related Wildlife Intoxication Events

The most commonly associated HAB related toxins reported in fish and wildlife reported deaths. Other toxins may be tested that ae not listed, including brevetoxins (marine) and guanitoxin (previously known as anatoxin-a(s)), depending on exposure history.

Toxin:	**Microcystins/ Nodularins MCs/NODs**	**Anatoxin-a/ Homoanatoxin-a ATX/HTX**	**Saxitoxins STX, PSP toxins, PSTs**	**Cylindrospermopsin CYN**	**Brevetoxins PbTx, NSP toxins**	**Domoic Acid DA, ASP toxins**
LD_{50} (oral):	> 5,000 µg/kg [1]	> 5,000 µg/kg [2,3]	≥440 µg/kg[4]	> 4,000 µg/kg [5]	520 - 6,600 µg/kg [6]	≥ 7,500 µg/kg [7]
LD_{50} (i.p.):	~35 - 250 µg/kg [8,9]	≥ 210 µg/kg [3,10,11]	~10 µg/kg[4]	> 50 µg/kg [12]	170 - 400µg/kg [6,13]	3,600 µg/kg [14]
R-GV (water):	20 ppb (ng/mL)	59 ppb (ng/mL)	30 ppb (ng/mL)	6 ppb (ng/mL)	none	none
Shellfish Limits:	none	none	800 µg/kg	none	800 µg/kg	20,000 µg/kg
Acute Symptoms:	nausea, diarrhea, vomiting, visual disturbance, headache, confusion, muscle weakness, bleeding (from gums, nose), liver failure, shock, seizure, death (hours to days) [15,16].	muscle fasciculations, vomiting, muscle paralysis, sudden collapse, respiratory paralysis (from neuromuscular blockade), death (minutes to hours). [10,17,18]	vomiting, tingling, numbness, loss of motor control, weakness, muscle paralysis, respiratory paralysis, death (minutes to hours).[19,20]	vomiting, malaise, swollen liver, bloody diarrhea (persists for weeks), bleeding mucous membranes, intestinal hemorrhage, death (hours to days) [12,21,22].	nausea, diarrhea, vomiting, abdominal pain, paresthesia, myalgia, ataxia, bradycardia, vertigo, mydriasis, inability to stand, seizures, respiratory irritation, death [2324]	nausea, vomiting, tremors, behavioral changes, seizures, rigidity, sedation, convulsions, weaving, confusion, memory loss, disorientation, coma, death [25,26]
Chronic/Sub-Chronic Symptoms	gastrointestinal disturbance/pain, liver disease	none known	none known	hepatic & renal injury[12], possibly carcinogenic	unknown	Learning/Memory impairment
Where they are found (*for exposure history*):	MCs (and NODs) that cause intoxication are found in the water column (planktonic) [15,27,28] and in the benthos [29]. MCs are the most frequently reported causative agent in cyanobacteria related intoxications.	ATX/HTX (and related derivatives) can be present at high levels in the benthos [18,30–32]. ATX is also frequently found (lower levels) in the water column and may cause intoxication if large amounts of water are consumed	STX is responsible for paralytic shellfish poisoning (PSP) associated with marine dinoflagellates [33], but are also produced by freshwater cyanobacteria (benthic and planktonic) [34,35]	High levels of CYN are rare in the United States, but cannot be ruled out as a source of intoxication. Most CYN sources are planktonic, with some benthic sources described (e.g. *Microseira* in Australia).	Intoxication usually occurs through ingestion of vector animals that accumulate PbTX via trophic transfer from marine dinoflagellates. Inhalation causes irritation to mucous membranes[23]	Intoxication usually occurs through ingestion of vector animals that accumulate DA through trophic transfer from marine diatoms (*Pseudonitzschia*) [25]
Mammals:	Intoxication of mammals is well documented, with levels found in nature to have poisoned deer [36], canines [15,28],	ATX and HTX have been shown to cause the death of canines [31,32], livestock [17,38], and presumably more	STX has been shown to cause the death of animals such as canines [33], and humans [19,39,40] due to consumption of	CYN has been suspected in cattle deaths [22] and to have caused the Palm Island Mystery Disease with humans [41].	Humans and marine mammals (e.g. dolphins, manatees) have been intoxicated by eating contaminated vector	Humans and marine mammals (e.g. whales, sea lions) have been intoxicated by eating

	cattle [37] and other animals.	that have gone undiagnosed.	marine vector species (e.g. shellfish).		organisms (fish, sea grass)[42].	contaminated vector organisms [25]
Shellfish:	Evidence of bioaccumulation of MCs in shellfish indicate they could be a potential threat to other animals if ingested	Limited evidence suggests that shellfish rapidly eliminate ATX and would not pose a significant long-term health risk.	High levels of STX and analogs have been shown to bioaccumulate in shellfish causing paralytic shellfish poisoning (PSP) [19,40,43].	Evidence of bioaccumulation of CYN in shellfish indicate they could be a potential threat to other animals if ingested [44,45].	High levels of PbTX and metabolites have been shown to bioaccumulate in shellfish causing neurotoxic shellfish poisoning (NSP) [42,46]	High levels of DA and isomers have been shown to bioaccumulate in shellfish causing amnesic shellfish poisoning (ASP) [25]
Birds:	While the i.p. LD_{50} of MCs (quail) indicate similar toxic potential [47], oral toxicity has not been researched sufficiently. MC intoxication is often combined with other stressors (e.g. avian botulism) [48,49].	Birds are susceptible to ATX intoxication with similar effects and at comparable doses to mammals [17]. However, bird die-offs have not been directly attributed to ATX thus far.	Bird die-offs are typically indirectly associated with STX (emaciation as a result of HAB impact on prey availability) [50,51]. Primary intoxication is caused by consumption of vector species [52].	Reports of CYN intoxication of birds were not found at the time of this literature search.	Bird die-offs have been attributed to PbTX, with highest levels observed in bile, stomach contents, and liver [24]	Bird mortality events have been attributed to both the direct action of DA and as a consequence of HAB effects on prey items [25,50].
Fish:	MCs are less toxic to fish than mammals. Although speculated to bioaccumulate MCs, fish are shown to biodilute MCs from the environment, resulting in low levels found in liver tissue, with even lower or below detection in muscle tissue of those exposed [53,54]	ATX is slightly less toxic to fish than mammals [17,55]. Symptoms include muscle rigidity, rapid opercular movement, abnormal swimming [17,56]. ATX is shown to rapidly eliminate from tissues [55].	Piscivores may be at risk of STX intoxication from consuming prey, but toxicity data are lacking. Fish, such as puffer fish, may accumulate tetrodotoxins and STX, presenting risks to consumers [57].	Fish kills have not been attributed CYN intoxication. CYN has been shown to distribute to liver, kidney, intestine, and gills [58]. Studies showing CYN in fillet using sufficiently selective techniques are lacking.	Fish can become intoxicated by PbTX, but can also accumulate the toxin at high levels before succumbing to intoxication, presenting a risk as a vector to piscivores and marine mammals [42]	Fish do not appear to be intoxicated (or behavior changed) by DA under natural bloom conditions, but are a known vector for intoxication of birds [59]
Preferred specimens for **Acute Exposure** are the stomach contents (if available) and/or urine Preferred specimens for **Chronic exposure** are target organ, bile, blood, liver, kidneys, brain, and/or muscle tissue (dependent on project goals)						

LD_{50} = Estimated median lethal dose as determined through experiments with mice (or rats)
NOAEL = No observed adverse effect level
R-GV = Recreational Guidance Value presented by the World Health Organization calculated from the NOAEL and variable uncertainty factors

Document Author: Amanda Foss; Date: 9/11/2020

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