MAY 30, 2024

Oregon officials warn about paralytic shellfish poisoning from mussels

Chris Chase published in Food Safety & Health

7 things to know about the FDA's warning about shellfish from the Pacific Northwest

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At least 20 are left violently ill after being poisoned by paralytic shellfish harvested over the weekend

- Some of those afflicted with the potentially deadly illness were hospitalized
- So far, no one has died from the foodborne illness found in mussels in Oregon
- Symptoms include nausea, vomiting, diarrhea and sometimes, trouble breathing

Holiday weekend horror: Historic paralytic shellfish poisoning on the Oregon coast — May–June 2024

Madison Walton
CDC Epidemic Intelligence Service Officer
Assigned to Oregon Health Authority

Terran Gilbreath
CSTE Applied Epidemiology Fellow
Assigned to Oregon Health Authority

Rosalie Trevejo and June Bancroft
Oregon Health Authority Senior Epidemiologists

Case Definition

- **Presumptive cases** were defined as having consumed shellfish harvested from the Oregon coast during May 14–July 12, 2024, and
  - new onset paresthesia and/or numbness of the mouth within 5 hours of consumption.
- **Confirmed cases** also provided leftover shellfish that tested positive for paralytic shellfish toxin.

Case Identification

30 reports

24 cases

7 cases

1211 responses

10 cases

OHA fellows designed and implemented an online public survey which was distributed to all Oregon Department of Fish and Wildlife shellfish license holders and later shared more widely in an OHA press release. Of the 1,211 survey responses, 10 additional cases were identified that met the case definition.

Paralytic Shellfish Poisoning

Focused Questionnaire

Oregon Health Authority | Acute and Communicable Disease Prevention Section

Script: Hello, my name is _____, and I am calling from Oregon Health Authority. We are following up with people who have recently been sick with paralytic shellfish poisoning after consuming shellfish. This is a short survey, estimated to take about 20 minutes. Is now a good time to talk?

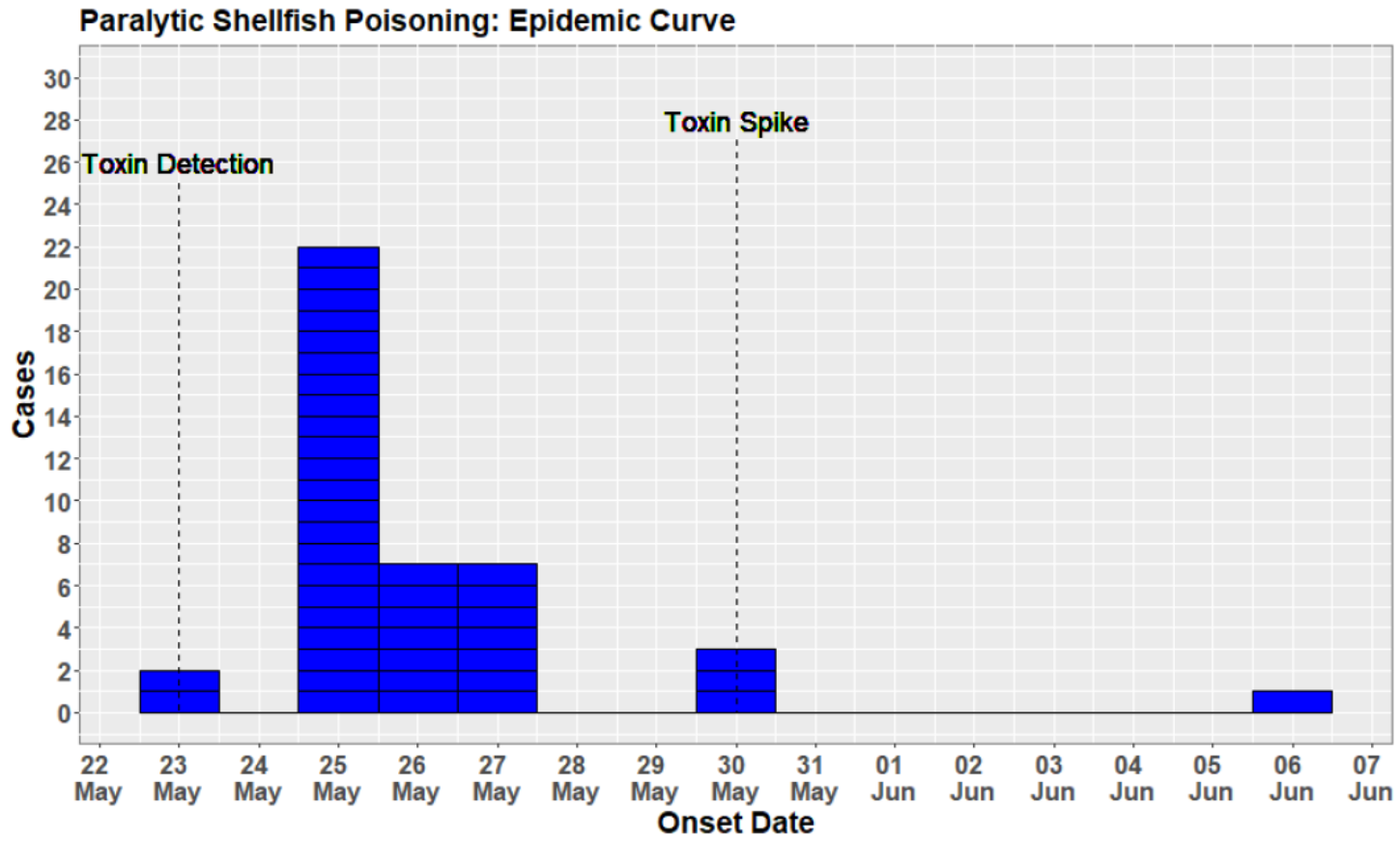
Contact Information

1. Name _____
2. Orpheus ID _____
3. Address (Street, City, Zip code) _____
4. County _____
5. Phone number: _____

Symptoms & Medical Care Questions

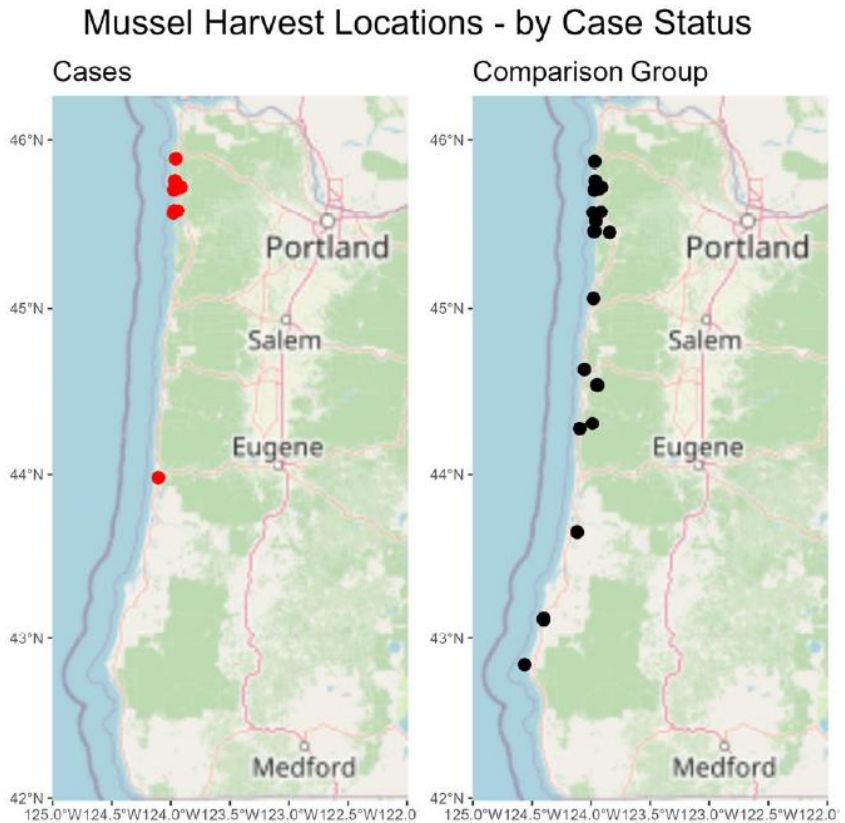
6. Did you experience symptoms?	☐ Y	☐ N	☐ U
a. Numbness in your mouth?	☐ Y	☐ N	☐ U
b. Nausea?	☐ Y	☐ N	☐ U
c. Vomiting?	☐ Y	☐ N	☐ U
d. Headache?	☐ Y	☐ N	☐ U
e. Muscle weakness?	☐ Y	☐ N	☐ U
f. Tingling of your hands or feet?	☐ Y	☐ N	☐ U
g. Vertigo (feeling like you or the room is spinning)?	☐ Y	☐ N	☐ U
h. Lightheadedness or a floating sensation?	☐ Y	☐ N	☐ U
i. Difficulty speaking (dysphonia)?	☐ Y	☐ N	☐ U
j. Difficulty swallowing (dysphagia)?	☐ Y	☐ N	☐ U
k. Respiratory arrest?	☐ Y	☐ N	☐ U

Epidemic Curve



For context, May 25-27 was the Saturday–Monday of Memorial Day weekend: 86% of cases had illness onset dates in that three-day window over Memorial Day weekend. .

Mussel Harvesting



8/15/2024

Known mussel harvesting locations were reported for 30 cases and included 13 unique beaches as mussel and/or clam harvest sites. No beaches were reported for harvested oysters. Harvest beach sites spanned approximately 164 miles of Oregon's 363-mile coastline.

Symptom Profile (n=42)

Mouth numbness
100%

Paresthesia
67%

Muscle weakness
43%

Floating sensation
40%

Nausea
33%

Vertigo
31%

Vomiting (29%)

Headache (24%)

Difficulty speaking or swallowing (12%)

Other symptoms reported were vomiting, headache, and difficulty speaking or swallowing.

Care Seeking Behaviors

54% sought care
(n=41)

17% hospitalized
(n=41)

2% ventilated
(n=37)

100% survived

and no patients died as a result of this outbreak.

Illness Severity by Care-Seeking Behaviors

		
Median Symptom Duration	**35.4 hours** (range: 2–113, n=20)	**52.2 hours** (range: 21–76, n=17)
Median Age	**45.5 years** (range: 11–76, n=22)	**52.2 years** (range: 17–76, n=17)

Shellfish Exposures

85%
Mussels
(n=41)

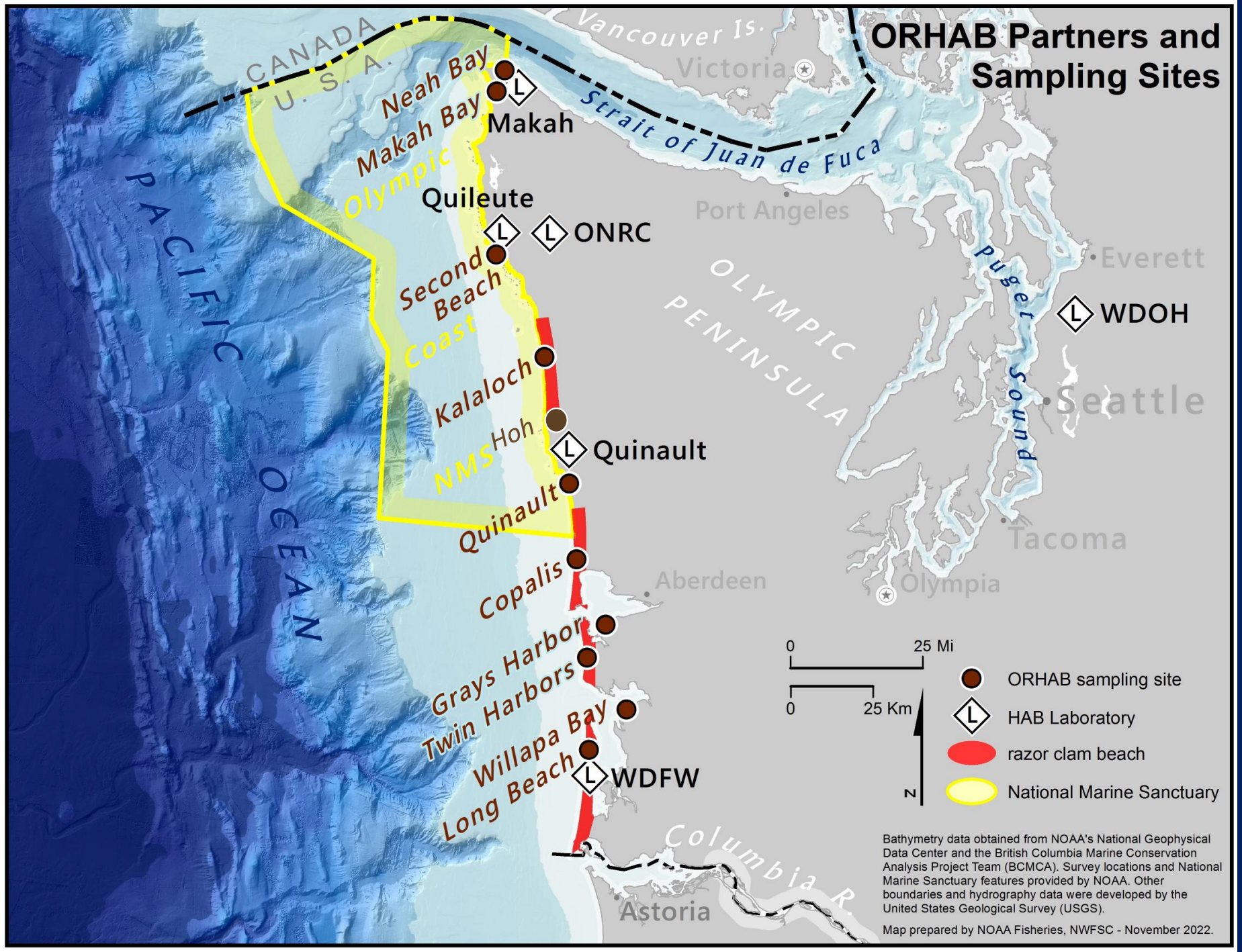
19%
Clams
(n=42)

2%
Oysters
(n=42)

0%
Crab
(n=41)

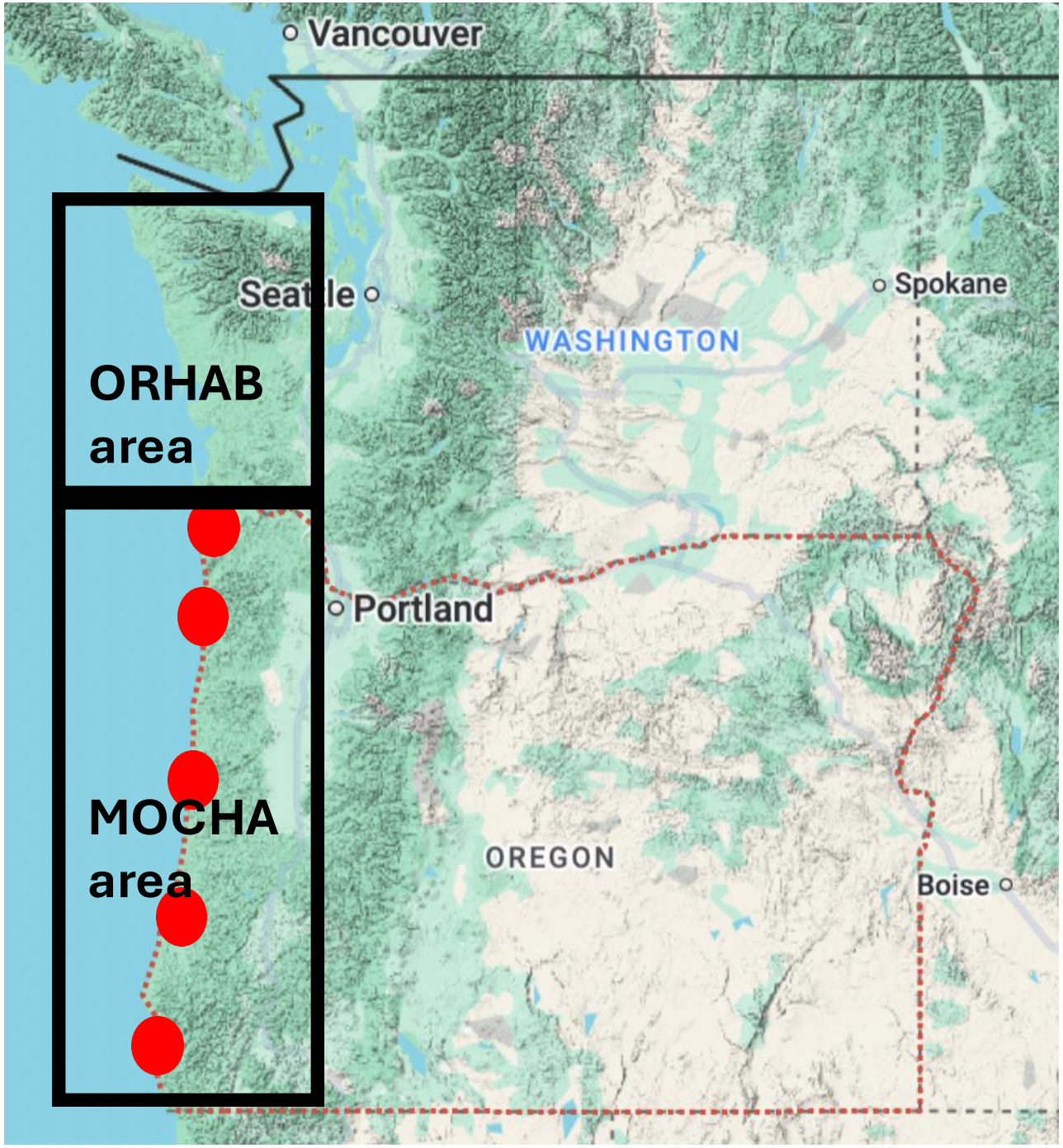
Saxitoxin concentrations were extremely elevated.

- Oregon Department of Agriculture limit to close beaches to harvesting
  - >80 µg/100 g of shellfish meats
- Mussels tested
  - 1,138 µg/100 g
  - 3,537 µg/100 g
  - 5,500 µg/100 g


ORHAB Partners and Sampling Sites
CANADA
U. S. A.
Vancouver Is.
Victoria
Strait of Juan de Fuca
Port Angeles
Everett
Seattle
Tacoma
Olympia
Aberdeen
Astoria
Columbia R.
Puget Sound
OLYMPIC PENINSULA
PACIFIC OCEAN
Neah Bay
Makah Bay
Olympic Coast
Makah
Quileute
ONRC
Second Beach
Kalaloch
NMS
Hoh
Quinault
Quinault
Copalis
Grays Harbor
Twin Harbors
Willapa Bay
Long Beach
WDFW
WDOH
0
25 Mi
0
25 Km
N
ORHAB sampling site
HAB Laboratory
razor clam beach
National Marine Sanctuary
Bathymetry data obtained from NOAA's National Geophysical Data Center and the British Columbia Marine Conservation Analysis Project Team (BCMCA). Survey locations and National Marine Sanctuary features provided by NOAA. Other boundaries and hydrography data were developed by the United States Geological Survey (USGS).
Map prepared by NOAA Fisheries, NWFSC - November 2022.

Monitoring Oregon's Coast for Harmful Algae (MOCHA)

- Phytoplankton samples are collected weekly at the following sites: Clatsop beaches (3), Cannon Beach (1), South Beach (1), Bastendorff Beach (1) and Gold Beach (1).



HAB early warning system

Expensive, time consuming
LAST MINUTE CLOSURES

1. Dig for clams

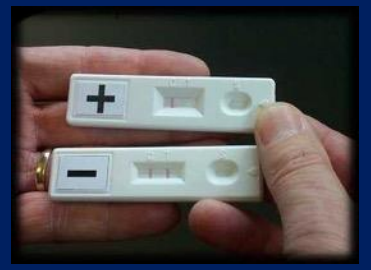
2. Test clams at Dept. of Health (DOH)

Cost & time effective
MAY BE SAFER

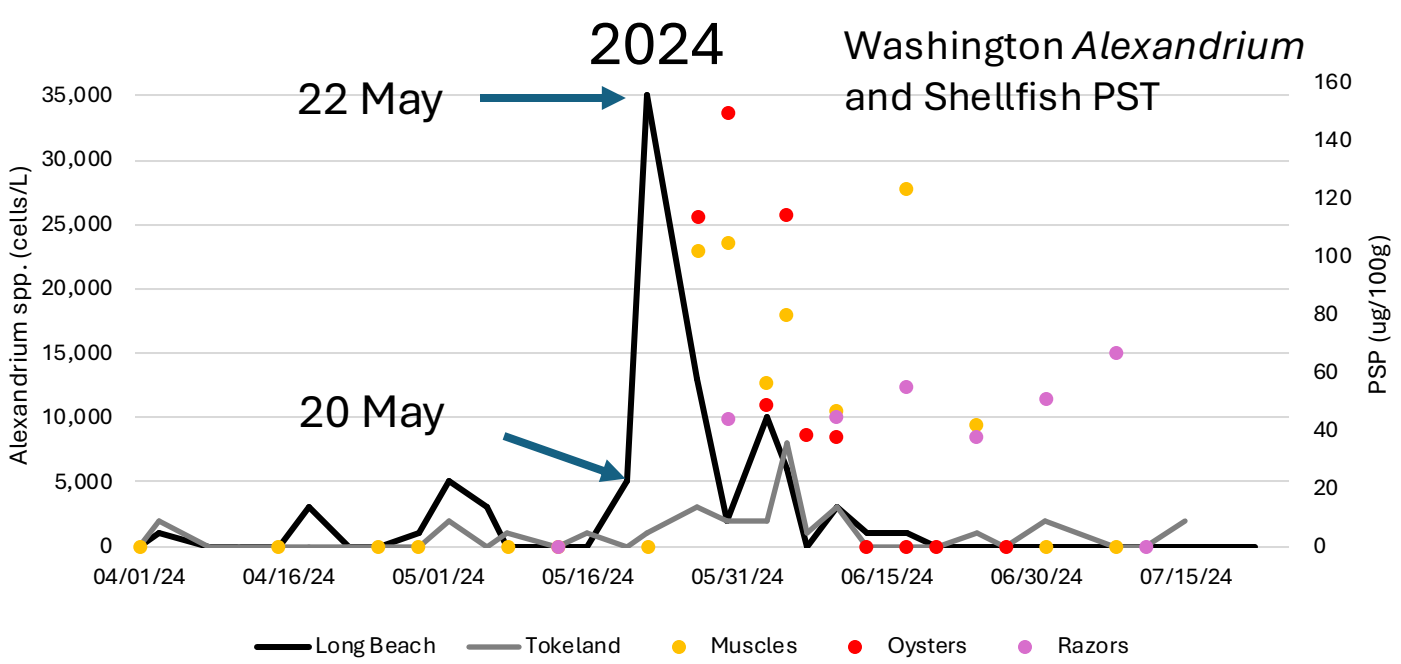
1. Collect plankton

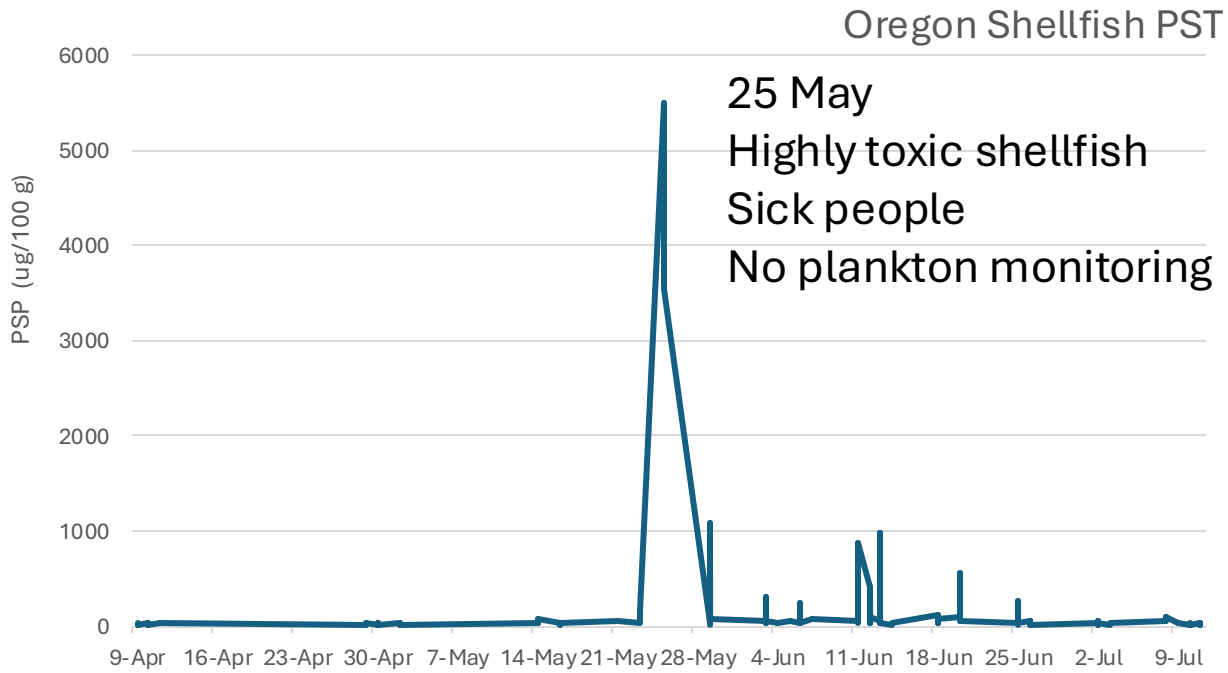
2. Look for toxic cells

3. Test for toxin (seawater & clams)



4. Test clams at DOH

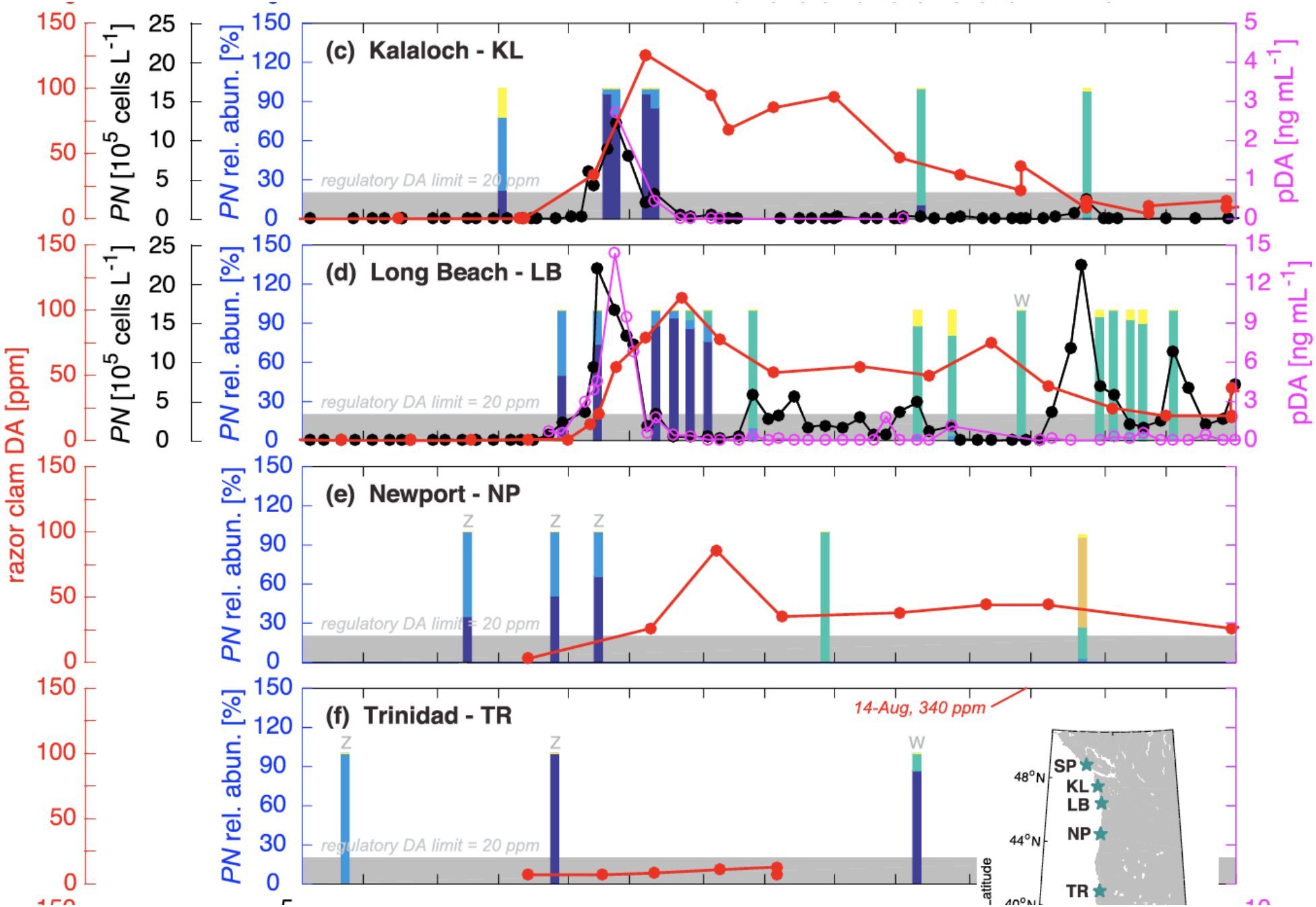




- At least 5 days early warning is possible with phytoplankton monitoring
- In 2024, no phytoplankton monitoring in OREGON from mid-May to mid-June

2015

Early Warning

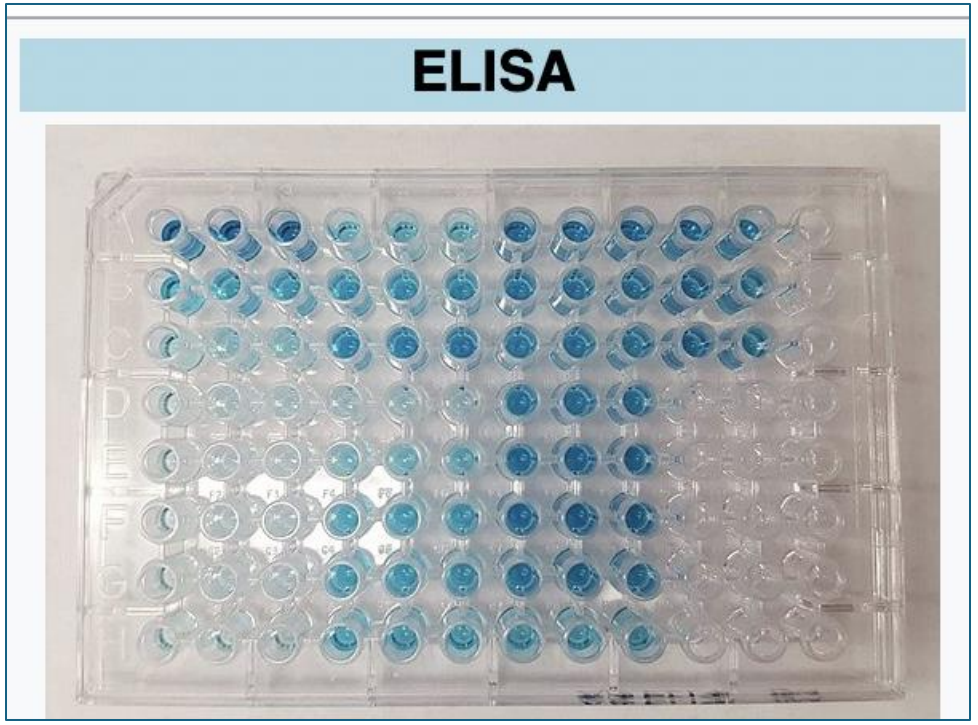


Possible screening tests

Tests available for the detection of saxitoxins (Paralytic Shellfish Poison, PSP), domoic acid (Amnesic Shellfish Poison, ASP) and okadaic acid (Diarrhetic Shellfish Poison, DSP)

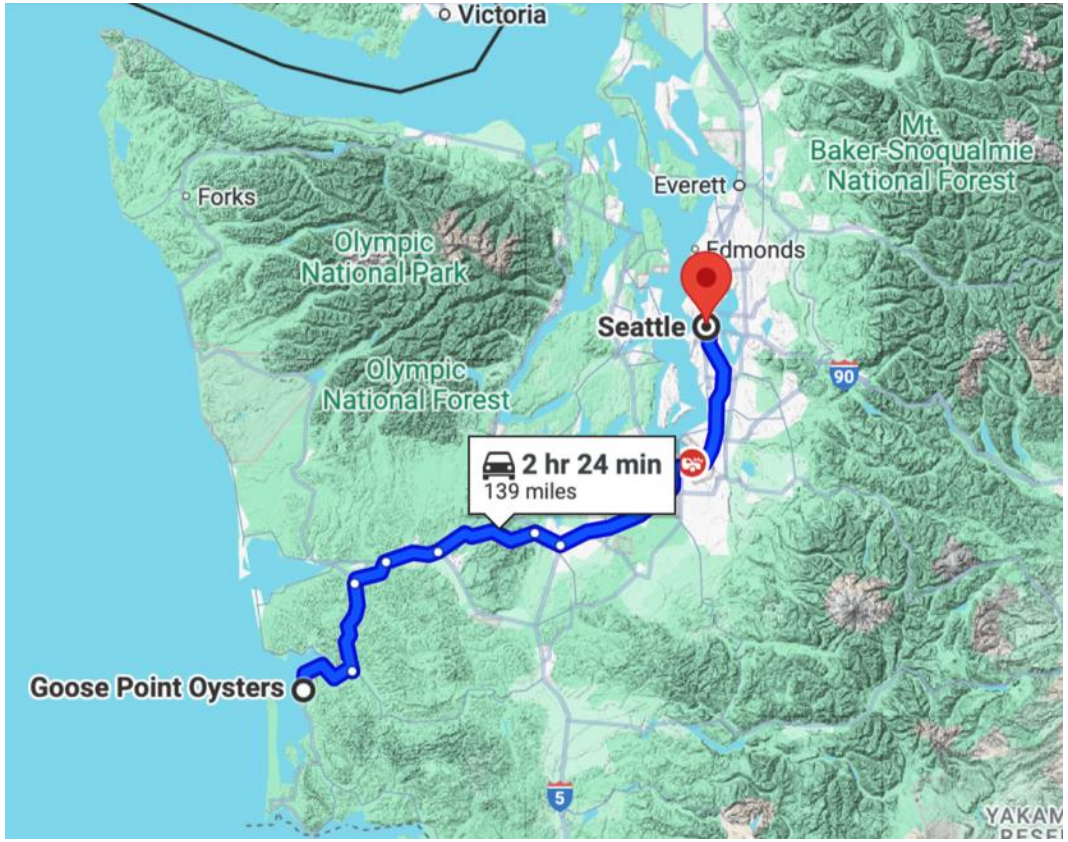
Portable and rugged digital reader for accurate qualitative and semi-quantitative measurements and data management and reporting.

Semi-quantitative



Quantitative

Possible uses of rapid test



Shellfish growers could save a trip to Seattle by screening their shellfish for toxins

Acknowledgements

- NOAA NCCOS Emergency Response Funding
- ORHAB partners
- WDOH, ODFW for samples
- NANOOS for lab funding
- Oregon Health Authority

Olympic Region Harmful Algal Blooms
ORHAB PARTNERSHIP

Questions? Contact Vera Trainer
verat@uw.edu

Paralytic Shellfish Posioning Rapid Test Results

Misty Peacock, Salish Sea Research Center, Northwest Indian College

Megan Schulz, Kira Walters, Rosa Hunter, Anthony Odell, and Vera Trainer

Paralytic shellfish toxins

Mouse bioassay – standard method

Enzyme Linked Immunosorbent Assay (ELISA)

Based on antibody detection of toxin

May not recognize all forms of saxitoxin equally well

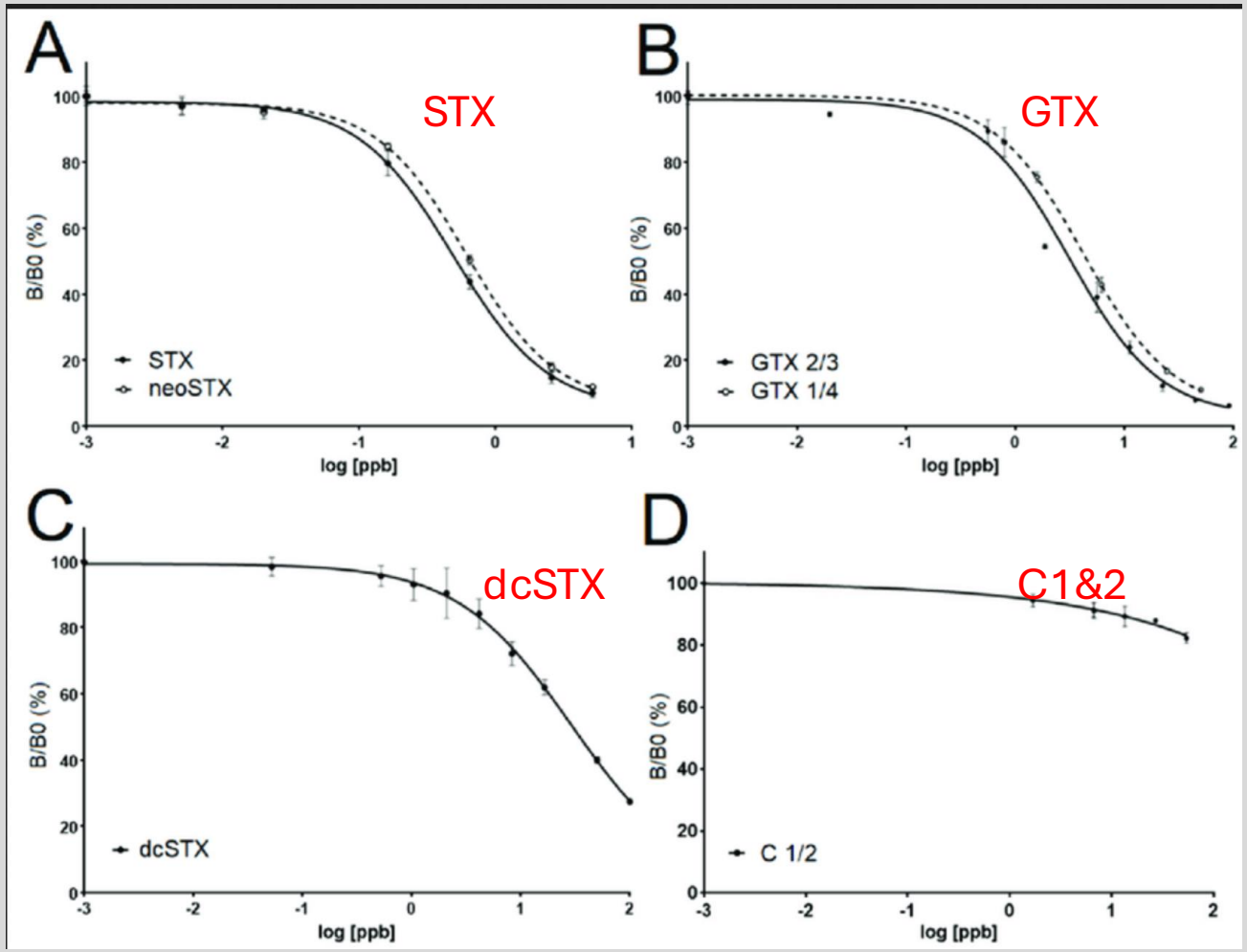
Therefore, screening tests need validation!

Saxitoxin structure and cross-reactivity

Performance Data

Test reproducibility:	Coefficients of variation (CVs) for standards: <10%, CVs for samples: <15%	
Selectivity:	This ELISA recognizes Saxitoxin and other PSP toxins to varying degrees:	
Cross-reactivities:	Saxitoxin (STX)	100% (per definition)
	Decarbamoyl STX	29%
	GTX 2 & 3	23%
	GTX-5B	23%
	Lyngbyatoxin	13%
	Sulfo GTX 1 & 2	2.0%
	Decarbamoyl GTX 2 & 3	1.4%
	Neosaxitoxin	1.3%
	Decarbamoyl Neo STX	0.6%
	GTX 1 & 4	<0.2%

Cross-reactivities with other classes of algal toxins have not been observed.

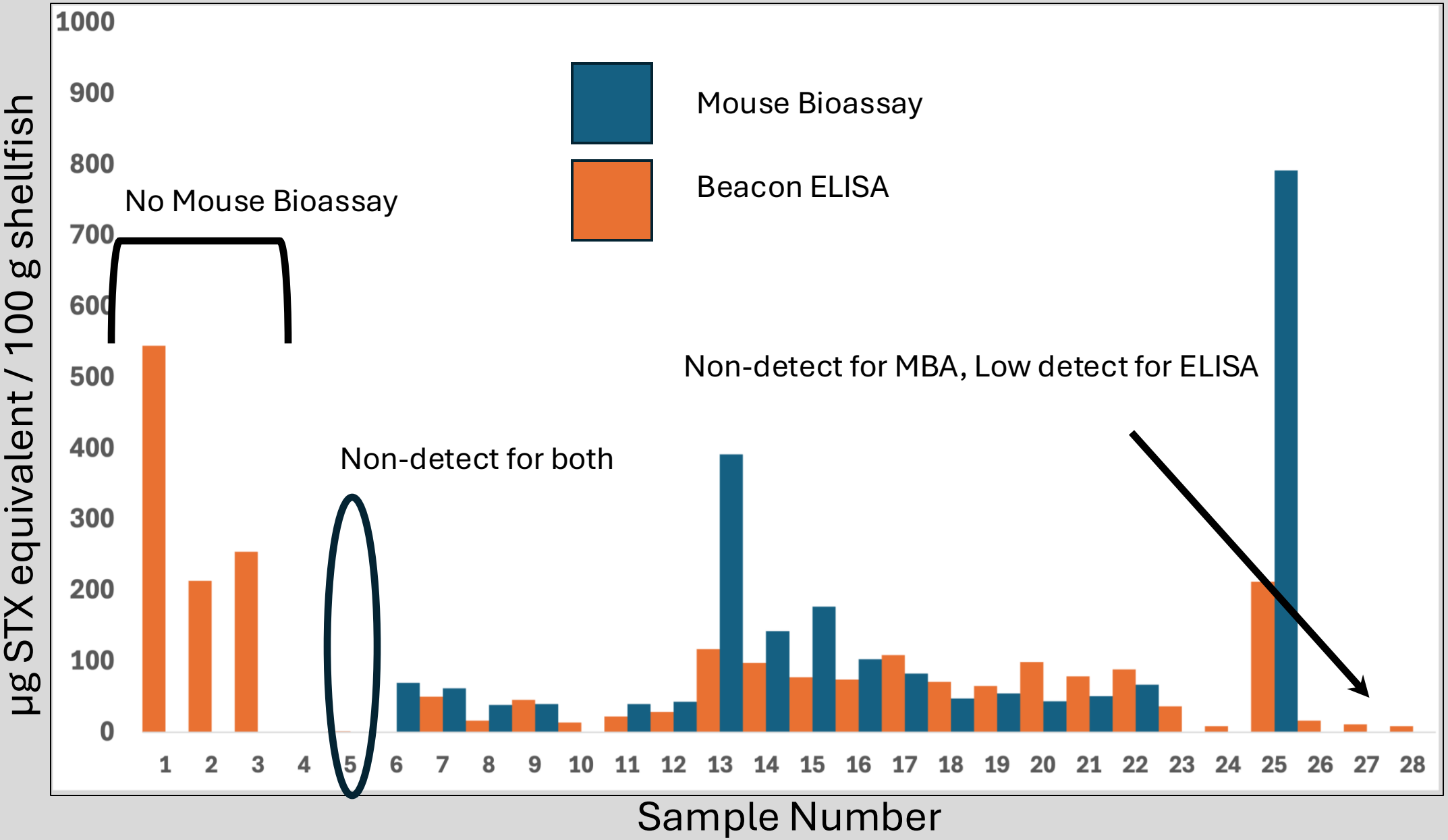


McCall et al. 2019

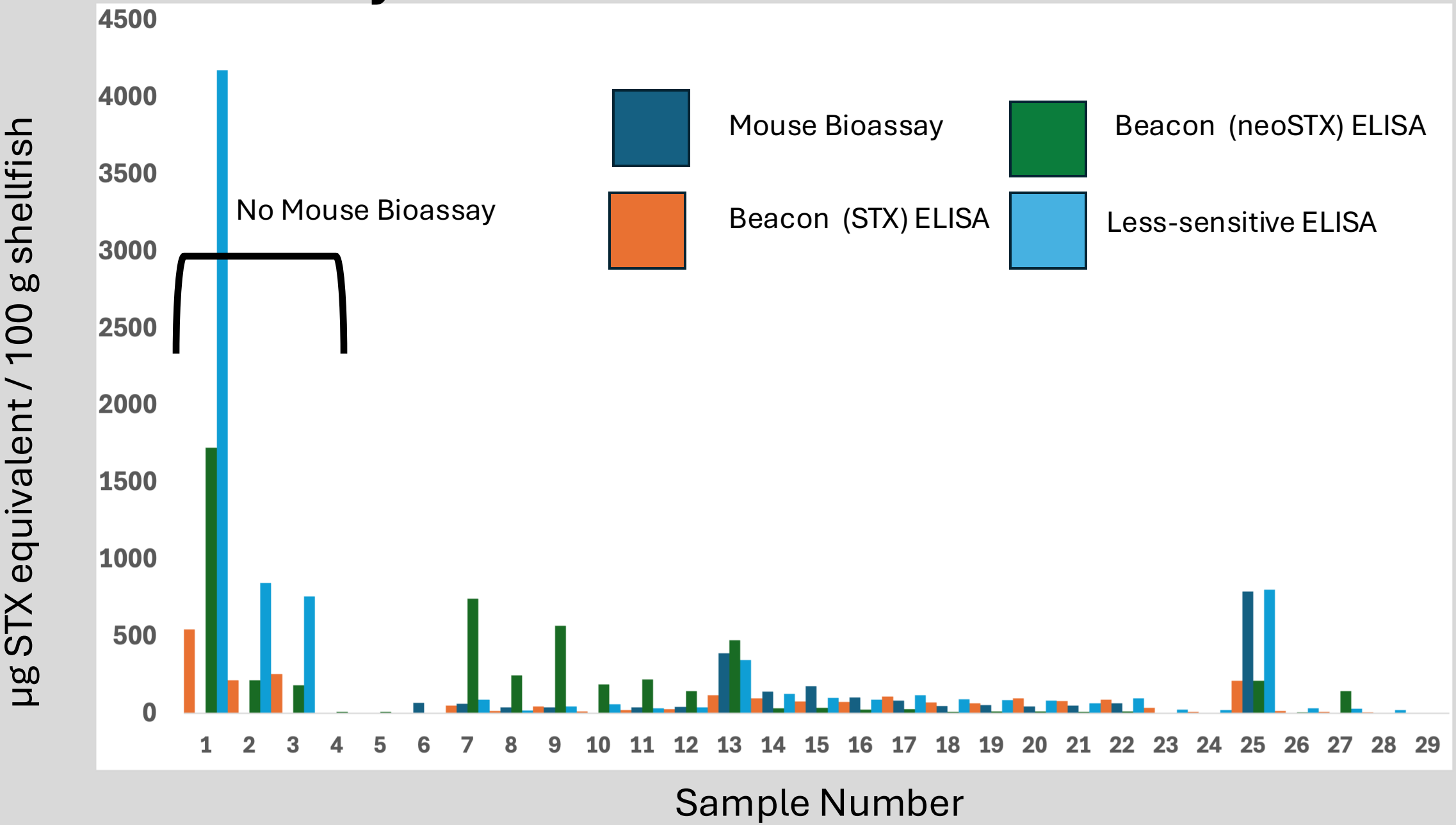
Issues with antibody-based tests

- Matrix effects
- Methanol
- Dilution
- Analytical capacity
- User error

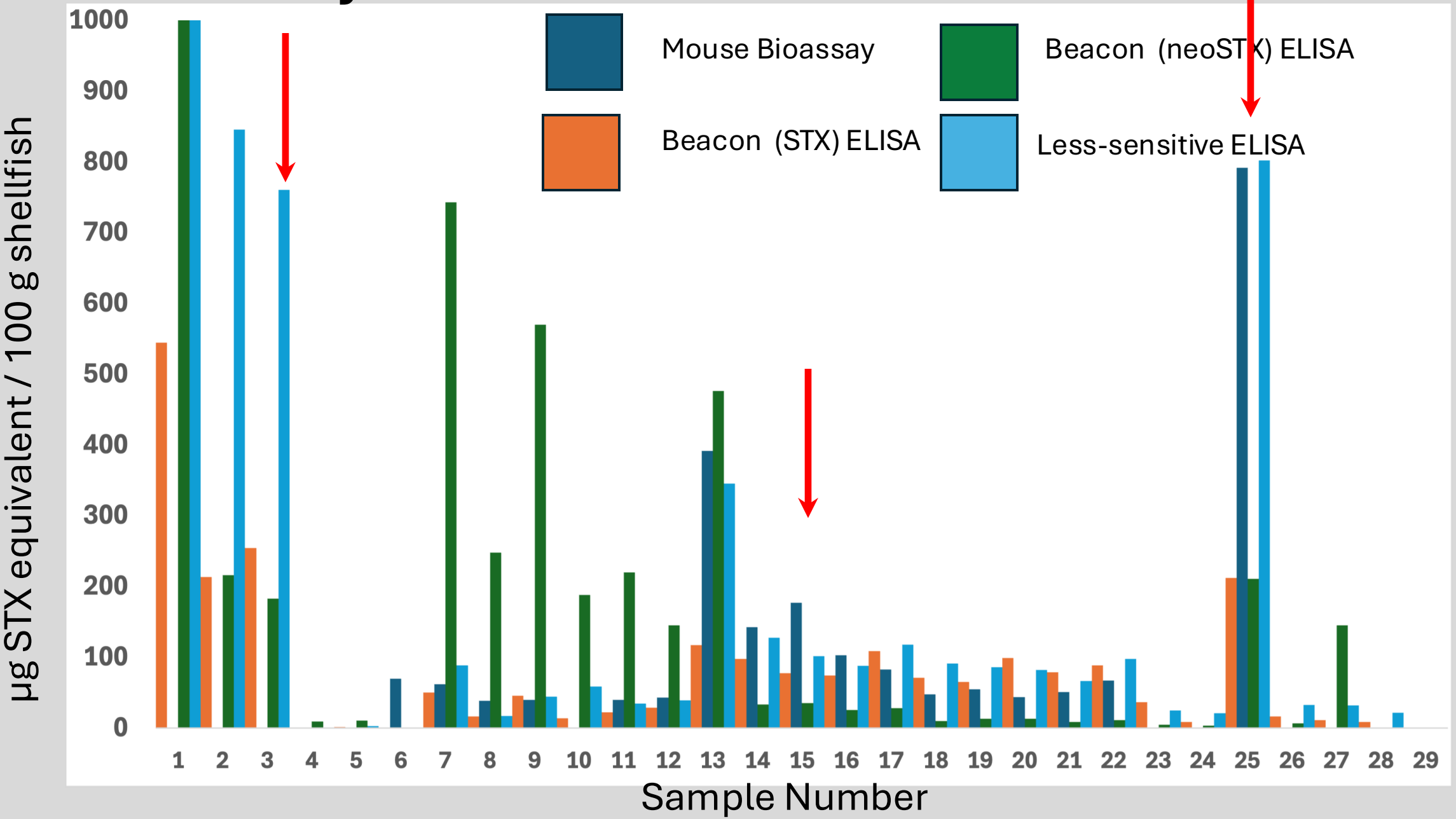
Mouse Bioassay and Beacon ELISA



Mouse Bioassay and Beacon ELISA



Mouse Bioassay and Beacon ELISA



Bigelow lab analysis (HPLC)

		Sample 3	Sample 15	Sample 25
Total Toxicity (µgSTXdiHCleq/100g)		2035.7	105.9	392.0
Individual Toxicities (µgSTXdiHCleq/100g)	GTX4	7.5	15.9	27.1
	GTX1	16.9	17.6	44.5
	dcGTX3	1.0	<LOD	<LOD
	GTX5	0.8	2.0	2.5
	dcGTX2	0.6	<LOD	<LOD
	GTX3	11.6	18.0	31.0
	GTX2	5.0	13.8	11.6
	NEO	1521.3	17.0	158.3
	dcSTX	<LOD	<LOD	<LOD
	STX	419.1	21.7	108.3
	C1	2.3	<LOD	1.2
	C2	49.5	<LOD	7.5

SeaTox kit background

toxins

MDPI

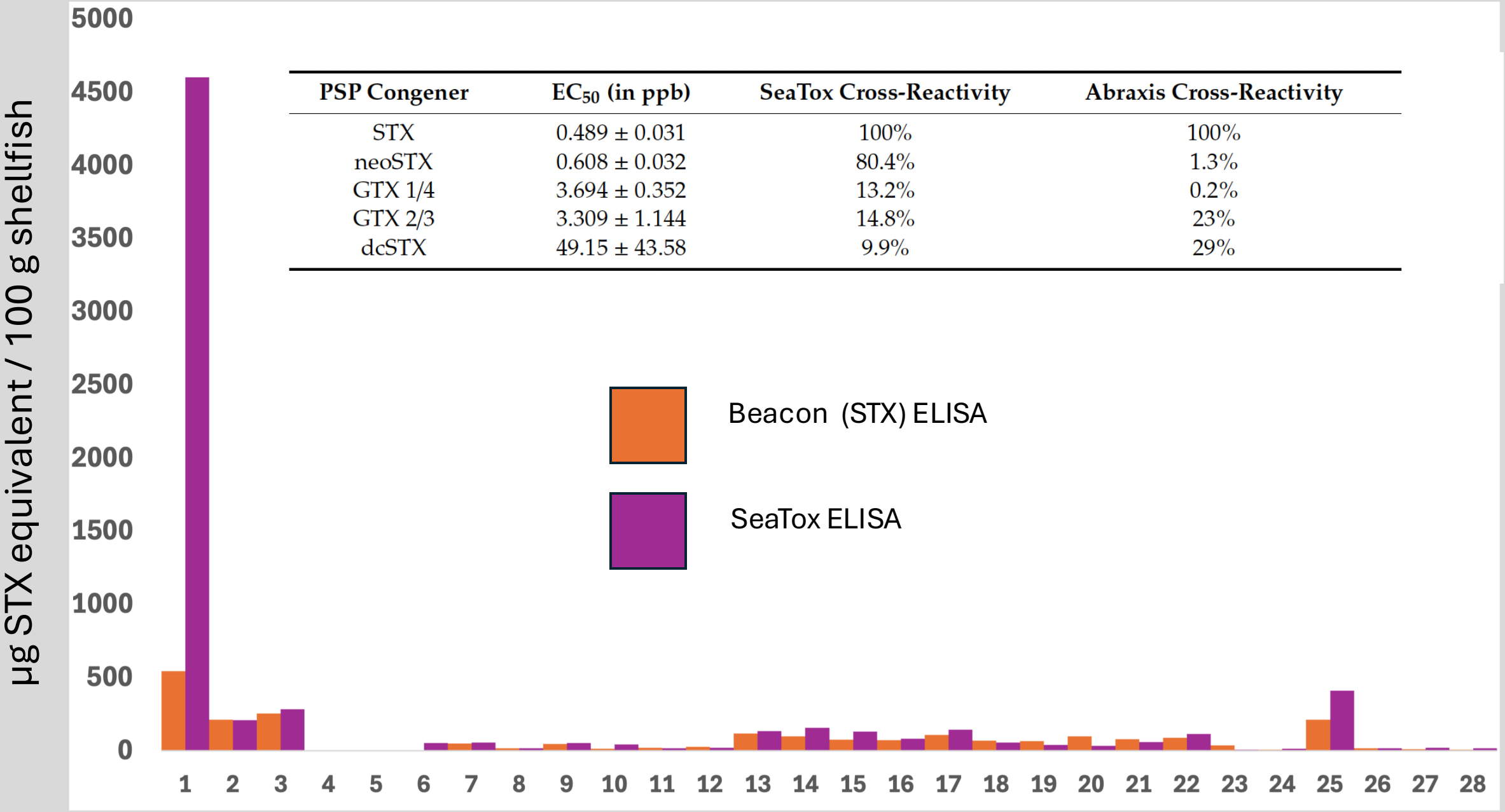
Article

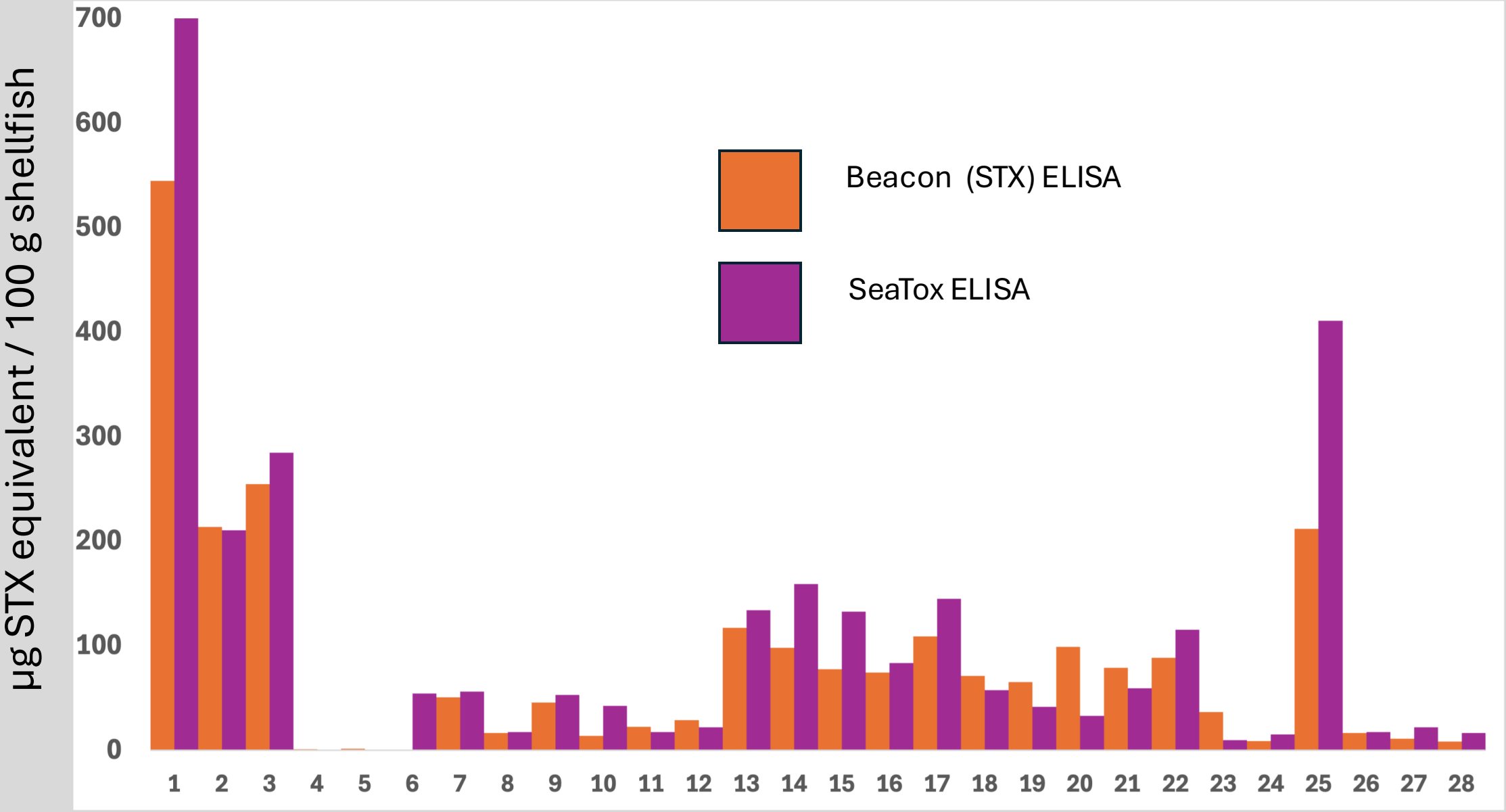
Improved Accuracy of Saxitoxin Measurement Using an Optimized Enzyme-Linked Immunosorbent Assay

Jennifer R. McCall [1,*], W. Christopher Holland [2], Devon M. Keeler [3], D. Ransom Hardison [2] and R. Wayne Litaker [4,†]

SeaTox and Beacon ELISA

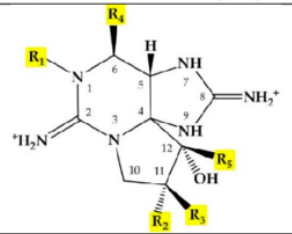
PSP Congener	EC_{50} (in ppb)	SeaTox Cross-Reactivity	Abraxis Cross-Reactivity
STX	0.489 ± 0.031	100%	100%
neoSTX	0.608 ± 0.032	80.4%	1.3%
GTX 1/4	3.694 ± 0.352	13.2%	0.2%
GTX 2/3	3.309 ± 1.144	14.8%	23%
dcSTX	49.15 ± 43.58	9.9%	29%




µg STX equivalent / 100 g shellfish
700
600
500
400
300
200
100
0
Beacon (STX) ELISA
SeaTox ELISA
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
Sample Number

Saxitoxin structure and cross-reactivity

Structure of saxitoxin (STX)



Analogues	R_1	R_2	R_3	R_4	R_5	Sources	Reference
STX	H	H	H	$OCONH_2$	OH	*Alexandrium andersoni, Alexandrium catenella, Alexandrium fundyense, Alexandrium tamarense, Gymnodinium catenatum, Pyrodinium bahamense*	[7–12]
neoSTX	OH	H	H	$OCONH_2$	OH	*A. andersoni, A. catenella, A. fundyense, A. tamarense, G. catenatum, P. bahamense*	[7–12]
Mono-sulfated							
GTX1	OH	H	OSO_3^-	$OCONH_2$	OH	*A. catenella, A. fundyense, A. minutum, A. tamarense, G. catenatum*	[8–10,12,13]
GTX2	H	H	OSO_3^-	$OCONH_2$	OH	*A. catenella, A. fundyense, A. minutum, Alexandrium ostenfeldii, A. tamarense, G. catenatum*	[8,10,12–15]
GTX3	H	OSO_3^-	H	$OCONH_2$	OH	*A. catenella, A. fundyense, A. minutum, A. ostenfeldii, A. tamarense, G. catenatum*	[8,9,12–15]
GTX4	OH	OSO_3^-	H	$OCONH_2$	OH	*A. catenella, A. fundyense, A. minutum, A. tamarense, G. catenatum*	[8–10,13,16]
GTX5 (B1)	H	H	H	$OCONHSO_3^-$	OH	*A. catenella, A. fundyense, A. tamarense, G. catenatum, P. bahamense*	[8–12]
GTX6 (B2)	OH	H	H	$OCONHSO_3^-$	OH	*A. catenella, A. fundyense, A. ostenfeldii, A. tamarense, G. catenatum, P. bahamense*	[8–12]
Di-sulfated							
C1	H	H	OSO_3^-	$OCONHSO_3^-$	OH	*A. catenella, A. fundyense, A. ostenfeldii, A. tamarense, G. catenatum*	[8–10,12,15,17,18]
C2	H	OSO_3^-	H	$OCONHSO_3^-$	OH	*A. catenella, A. fundyense, A. ostenfeldii, A. tamarense, G. catenatum*	[8–10,12,15,18]
C3	OH	H	OSO_3^-	$OCONHSO_3^-$	OH	*A. catenella, G. catenatum*	[14,19]
C4	OH	OSO_3^-	H	$OCONHSO_3^-$	OH	*A. catenella, G. catenatum*	[14,19]
Decarbamoylated							
dcSTX	H	H	H	OH	OH	*A. catenella, G. catenatum, P. bahamense*	[8,11,12]
dcneoSTX	OH	H	H	OH	OH	*A. tamarense*	[20]
dcGTX1	OH	H	OSO_3^-	OH	OH	*G. catenatum*	[21]
dcGTX2	H	H	OSO_3^-	OH	OH	*A. catenella, A. fundyense, G. catenatum*	[8,12,17]
dcGTX3	H	OSO_3^-	H	OH	OH	*A. catenella, A. fundyense, G. catenatum*	[8,12,17]

Future Directions:

Liquid Chromatography Mass Spectrometry

JOURNAL ARTICLE

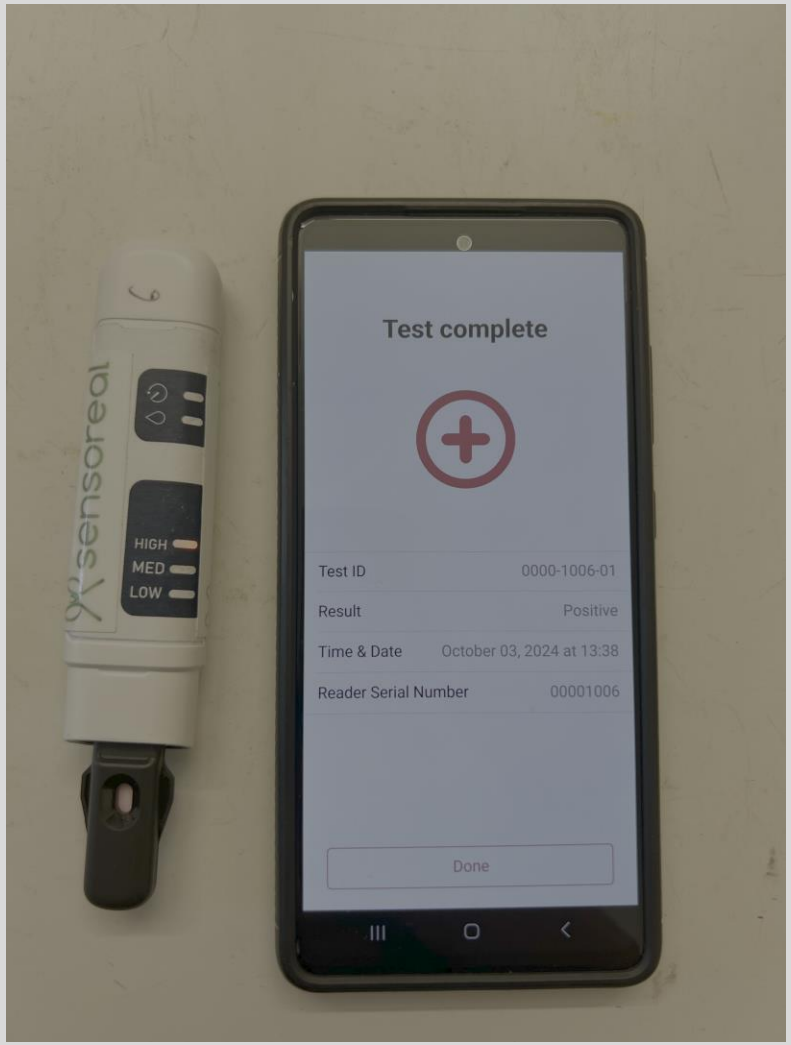
Ultrahigh-Performance Hydrophilic Interaction Liquid Chromatography with Tandem Mass Spectrometry Method for the Determination of Paralytic Shellfish Toxins and Tetrodotoxin in Mussels, Oysters, Clams, Cockles, and Scallops: Collaborative Study

Andrew D Turner ✉, Monika Dhanji-Rapkova, Sum Y T Fong, James Hungerford, Paul S McNabb, Michael J Boundy, D Tim Harwood, Collaborators Author Notes

Journal of AOAC INTERNATIONAL, Volume 103, Issue 2, March-April 2020, Pages 533–562, https://doi.org/10.5740/jaoacint.19-0240

Published: 20 April 2020 **Article history** ▾

Sensoreal PSP Alert



PSP ALERT

Your shield against shellfish toxins.

Sensitivity, specificity and reliability
PSP Alert has undergone extensive testing across three different species of shellfish, demonstrating a sensitivity of 100%. The tests revealed a false negative rate of 0% and a false positive rate of 6.7%. Additionally, a specificity of 91% was observed.

Simple sample preparation
PSP Alert offers a simplified, instrument-free method for extracting PSP toxins, ensuring easy and efficient sample preparation for users.

Negligible cross-reactivity
PSP Alert is the pioneering kit in the industry capable of detecting 12 variants of PSP toxins, featuring a patent-pending internal conversion step.

Portable and user friendly
PSP Alert was developed with user convenience in mind, resulting in a compact design. The kit includes all necessary reagents and utensils, making it suitable for field use.

Repeatability
100% (Consistent results across 5 consecutive testing runs using naturally contaminated samples).

Ruggedness
100% (no change in test results with a 20% variation in sample extraction time).

Rapid test results
Results available in 30 minutes after sample preparation.

Variety of species
Tested on butter clams, sea mussels and blue mussels.

Benchmarked and validated by CFIA
PSP Alert has been benchmarked against HPLC-PCOX at the Canadian Food Inspection Agency (CFIA), the current gold standard for detecting shellfish toxins.

Data storage and management (optional)
The digital reader features Bluetooth connectivity, allowing it to store and transfer test results via a dedicated mobile app.

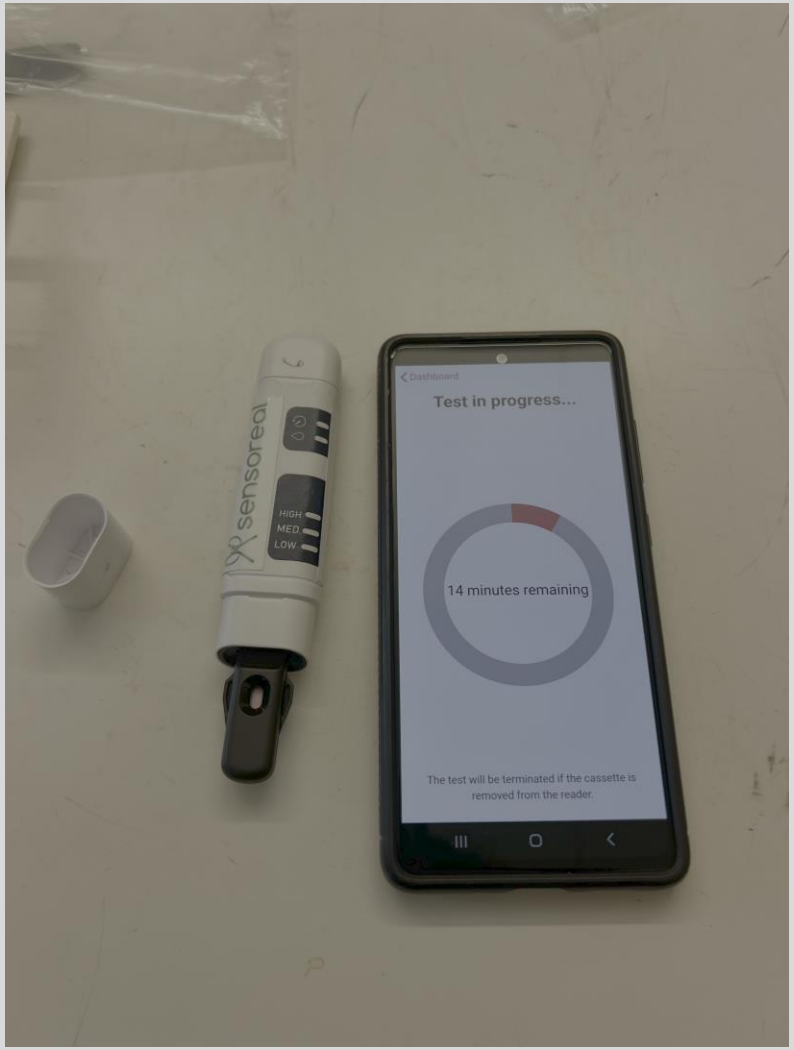
Semi-quantitative tests (optional)
PSP Alert also offers the option to display semi-quantitative results, an industry first. The results are:

- Low (PSP Toxin <35ug STX diHCl eq/100g)
- Medium (PSP Toxin = 35-80ug STX diHCl eq/100g)
- High (PSP Toxin> 80ug STX diHCl eq/100g)

sensoreal

sensoreal.com | sepehr@sensoreal.com

Sensoreal data



Sensoreal data

High Toxin (above the regulatory limit)

Negative Toxin (non-detect)

Approaching regulatory limit

	Mouse Bioassay	Sensoreal
1		Pos-High
2		Pos-High
3		Pos-High
4	NTD	Neg- Low
5	NTD	Neg- Low
6	70	Neg-medium
7	62	Neg-low
8	39	Neg-low
9	40	Neg-low
10	NTD	Neg- low/medium
11	40	Neg-low
12	43	Neg-medium
13	392	Pos-High
14	143	Neg-medium
15	177	Neg-medium
16	103	Pos-High
17	83	Neg-medium
18	48	Neg-medium
19	55	Neg-low
20	44	Neg-low
21	51	Neg-medium
22	67	Neg-low
23	NTD	Neg-low
24	NTD	Neg-low
25	792	Pos-High
26	NTD	Neg-low
27	NTC	Neg-low
28	NTD	Neg-low

AquaBC test (previously Jellet Rapid Test)

The ART biotoxin detection system

AquaBC Rapid Testing

Tests available for the detection of saxitoxins (Paralytic Shellfish Poison, PSP), domoic acid (Amnesic Shellfish Poison, ASP) and okadaic acid (Diarrhetic Shellfish Poison, DSP)

Portable and rugged digital reader for accurate qualitative and semi-quantitative measurements and data management and reporting.

Toxin	Sample	Extraction method
PSP	Shellfish	AOAC (lab) Rapid (field)
	Phytoplankton	Rapid
ASP	Shellfish	Methanol (lab) Rapid (field)
	Phytoplancton	Rapid
DSP	Shellfish	AOAC (lab only)

AquaBC test results from Christina DeWit

	Sesoreal	Mouse Bioassay	AquaBC
1	Pos-High		POS
2	Pos-High		POS
3	Pos-High		POS
4	Neg- Low	NTD	NEG
5	Neg- Low	NTD	NEG
6	Neg-medium	70	POS
7	Neg-low	62	POS
8	Neg-low	39	POS
9	Neg-low	40	POS
10	Neg- low/medium	NTD	POS
11	Neg-low	40	POS
12	Neg-medium	43	POS
13	Pos-High	392	POS
14	Neg-medium	143	POS
15	Neg-medium	177	POS
16	Pos-High	103	POS
17	Neg-medium	83	POS
18	Neg-medium	48	POS
19	Neg-low	55	POS
20	Neg-low	44	POS
21	Neg-medium	51	POS
22	Neg-low	67	POS
23	Neg-low	NTD	POS
24	Neg-low	NTD	NEG
25	Pos-High	792	POS
26	Neg-low	NTD	POS
27	Neg-low	NTC	POS
28	Neg-low	NTD	POS

High Toxin (above the regulatory limit)

Negative Toxin (non-detect)

Approaching regulatory limit

Hy’shqe (Thank You)

Questions?