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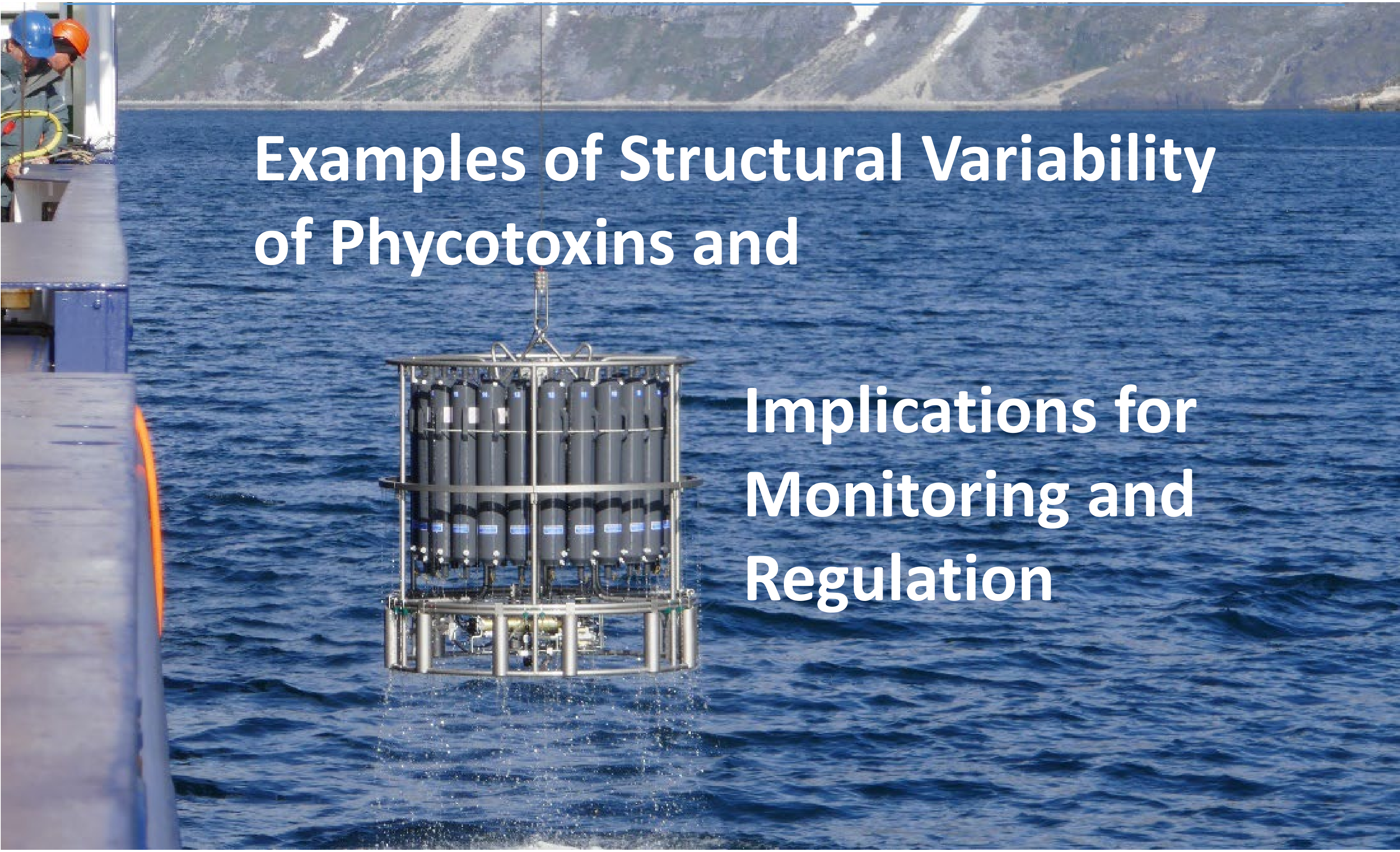
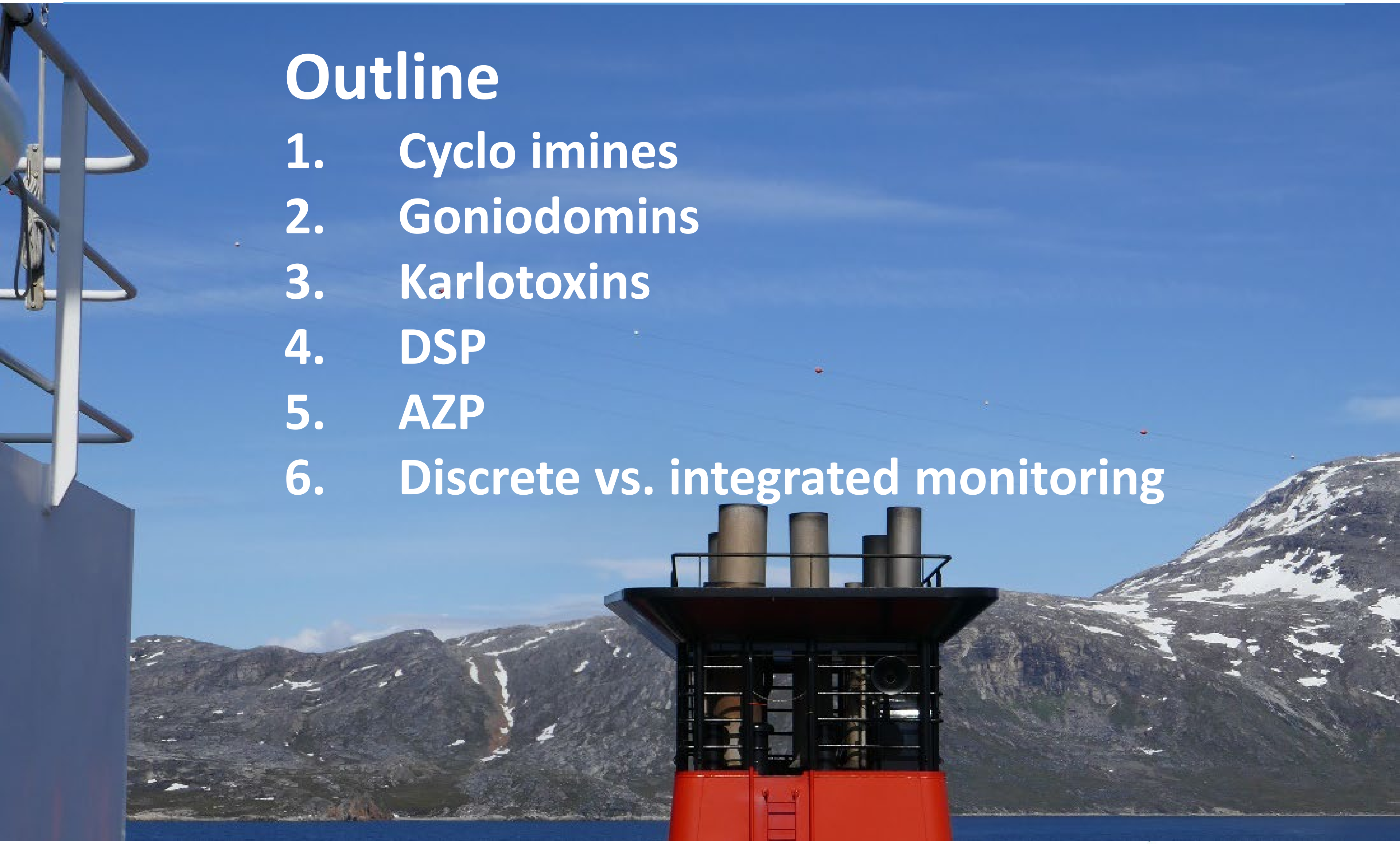


Examples of Structural Variability of Phycotoxins and Implications for Monitoring and Regulation

Bernd Krock, Facultad de Ciencias, UdelaR, Montevideo, Uruguay, 23. February 2022

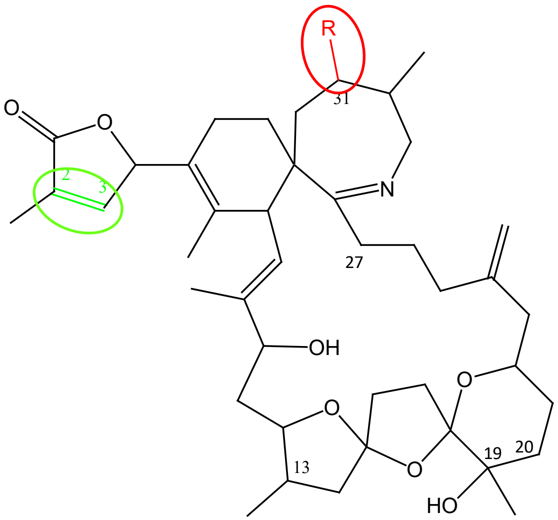


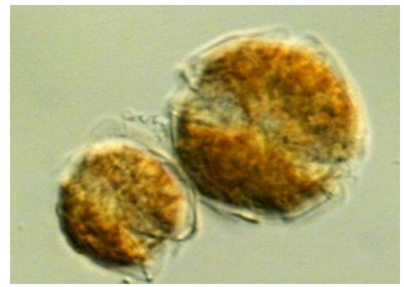
Outline

1. Cyclo imines
2. Goniodomins
3. Karlotoxins
4. DSP
5. AZP
6. Discrete vs. integrated monitoring

1. Cyclo imines

Spirolides – Chemical Structures





Alexandrium ostenfeldii

Spirolide A: R = H, $\Delta^{2,3}$

B: R = H

C: R = Me, $\Delta^{2,3}$

D: R = Me

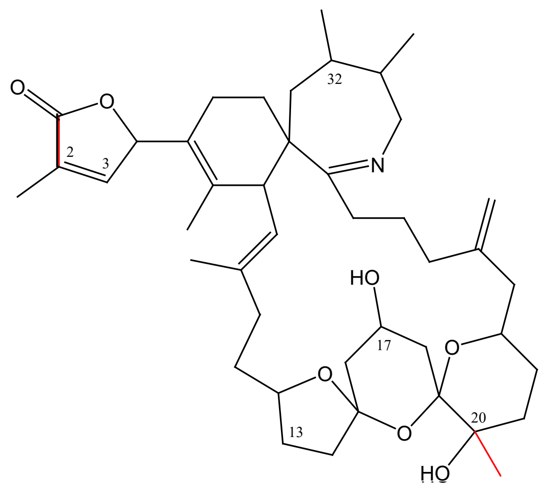
27-hydroxy-13-desmethyl-SPX C

27-hydroxy-13,19-didesmethyl-SPX C

27-oxo-13,19-didesmethyl-SPX C

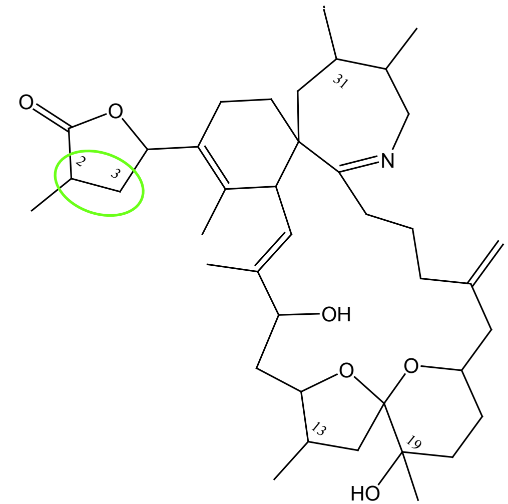
20-hydroxy-13,19-didesmethyl-SPX C

20-hydroxy-13,19-didesmethyl-SPX D



SPX G

20-methyl-SPX G



SPX H

SPX I

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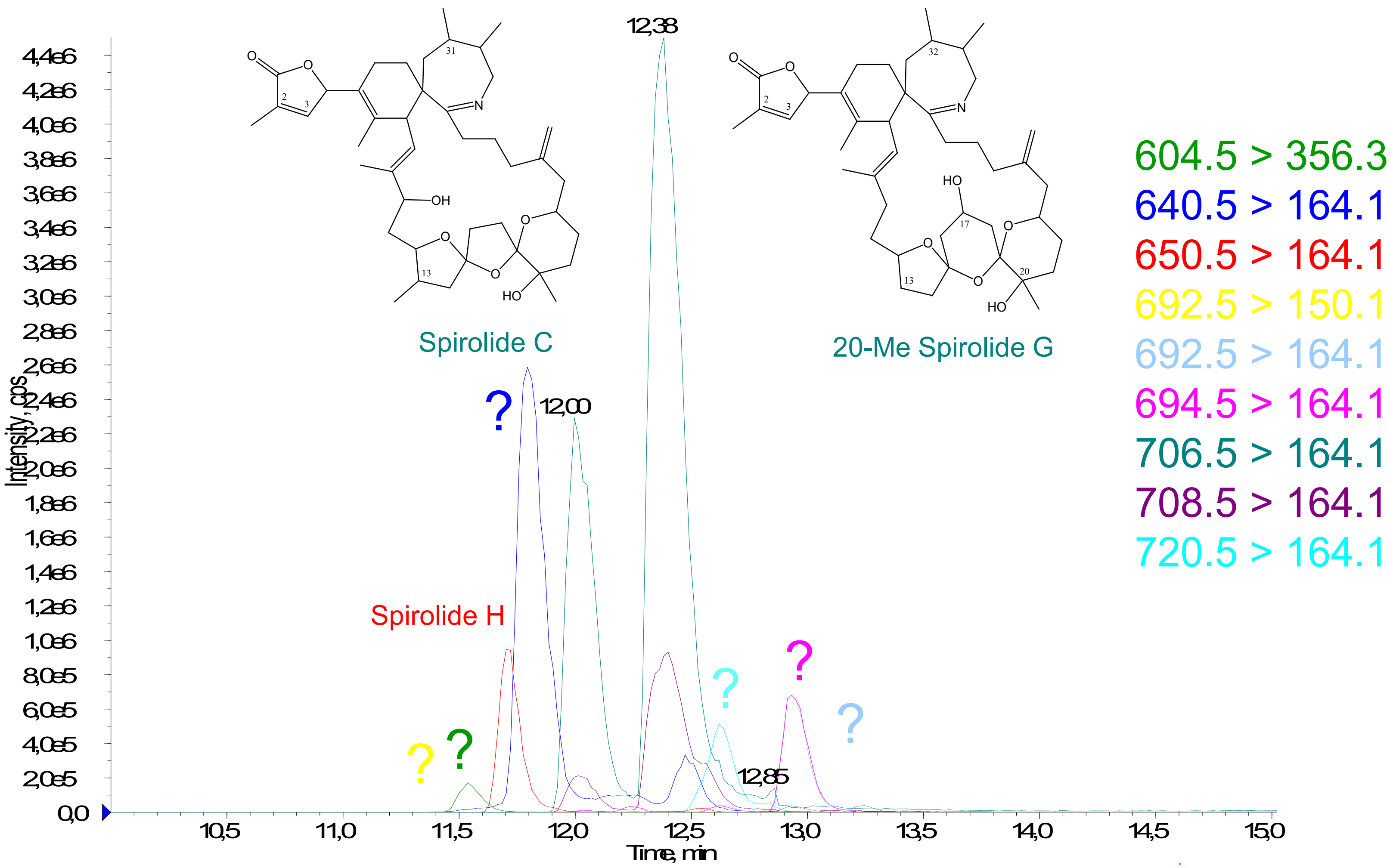
1. Cyclo imines

Alexandrium ostenfeldii (AOSH2, Nova Scotia, Canada)



1. Cyclo imines

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Alexandrium ostenfeldii (Disko Island, Greenland)

	Stat	SPX-1	C	20-meG	H	Cp 1	Cp 2	Cp 3	Cp 4	Cp 5	Cp 6	Cp 7	Cp 8
P1 D5	506	–	77.1	16.8	–	–	–	–	–	–	3.4	2.7	–
P1 H10	516	0.7	–	84.3	–	0.1	–	0.3	–	0.8	–	–	13.7
P2 E3	516	31.2	–	–	41.3	–	27.5	–	–	–	–	–	–
P2 E4	516	19.2	–	–	–	1.2	–	–	–	70.1	–	–	9.4
P2 F2	516	5.1	63.6	–	6.7	0.1	4.1	–	–	10.6	–	3.8	–
P2 F3	516	–	82.9	17.1	–	–	–	–	–	–	–	–	–
P2 F4	516	2.7	57.3	39.7	–	–	–	–	–		0.1	–	–
P2 F7	516	1.4	31.1	–	25.1	1.2	10.0	–	–	29.0	–	–	2.3
P2 G2	516	0.2	40.2	18.4	7.1	–	11.1	–	–	11.6	–	–	11.3
P2 G9	516	–	100.0	–	–	–	–	–	–	–	–	–	–
P2 H4	516	–	95.4	4.6	–	–	–	–	–	–	–	–	–
P2 H8	516	2.4	–	89.0	–	–	–	–	–	0.3	–	–	8.2
P3 F1	516	0.2	–	81.7	–	–	0.1	0.2	–	1.0	–	–	16.9
P4 C6	516	–	50.3	49.7	–	–	–	–	–	–	–	–	–
P4 E3	516	1.2	96.3	2.2	–	–	–	0.3	–	–	–	–	–
P4 D8	516	–	31.4	–	14.1	–	–	9.0	36.1	9.4	–	–	–
P4 F10	516	–	68.6	20.0	0.2	–	–	–	–	–	–	–	11.3
P4 G2	516	–	–	100.0	–	–	–	–	–	–	–	–	–
P3 A12	516	–	52.2	–	47.8	–	–	–	–	–	–	–	–
P2 H2	516	–	–	92.5	–	–	–	0.9	–	–	–	–	6.6
P2 G3	516	18.1	1.3	0.1	–	–	–	–	–	72.7	–	–	7.8
P3 E4	516	0.2	99.6	–	–	–	–	0.2	–	–	–	–	–
P4 F4	516	–	77.4	19.6	0.3	–	–	0.4	–	2.1	–	–	–
P1 F5	524	0.1	79.5	19.8	–	–	–	0.2	–	–	0.1	0.2	–
P1 F7	524	0.1	78.3	20.9	–	–	0.1	0.4	–	–	0.1	–	–
P1 F8	524	–	92.1	6.6	–	–	0.1	0.4	–	–	0.2	0.5	–
P1 F9	524	0.2	64.7	33.2	–	–	0.1	1.4	–	–	0.3	–	–
P1 F10	524	0.1	68.4	30.5	–	–	0.1	0.9	–	–	0.1	–	–
P1 F11	524	–	87.3	6.4	–	–	–	–	–	–	–	5.4	–
P1 G3	524	0.6	92.3	6.6	–	–	–	0.6	–	–	–	–	–
P1 G5	524	0.7	76.1	21.7	0.4	–	–	0.4	–	–	0.3	0.4	–
P1 G11	524	0.2	84.2	14.2	0.5	–	–	0.3	–	–	0.3	0.3	–
P1 G8	524	–	88.6	6.5	–	–	–	–	–	–	–	4.9	–
P1 F6	524	0.1	85.1	13.8	–	–	0.1	0.1	–	–	0.1	0.3	–
P1 F4	524	0.1	77.2	22.3	–	–	–	–	–	–	0.1	0.2	–
P1 G6	524	–	70.5	28.0	0.3	–	–	0.6	–	–	0.2	0.3	–

high toxin variabilty ***within*** populations

Tillmann, U., et al. (2014) Harmful Algae 39, 259-270.

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1. Cyclo imines

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Cyclic imines – Chemical Variability

Known Variants

Mass transition	toxin
508>490	GYM A
510>492	16-desme GYM D
522>504	12-me GYM A
524>506	GYM B/C/D
526>508	GYM E
650>164	H
652>164	I
678>164	13,19-didesme C
692>164	13-desme C, G, undescribed
692>178	27-oxo-13,19-didesme C
692>150	A, undescribed
694>164	13-desme D, 20-hydroxy.-13,19-didesme C, pinnatoxin G
694>180	27-hydroxy-13,19-didesme C
694>150	B
696>164	20-hydroxy-13,19-didesme D
706>164	C, 20-me G
706>164	27-hydroxy-13-desme C
708>164	D
766>164	pinnatoxin F
784>164	pinnatoxin E

Undescribed Variants

Mass transition	spirolide
640>164	undescribed
644>164	undescribed
658>164	undescribed
658>150	undescribed
674>164	undescribed
678>150	undescribed
692>150	A, undescribed
696>164	undescribed
698>164	undescribed
710>164	undescribed
710>150	undescribed
720>164	undescribed
722>164	undescribed
722>180	undescribed

Tillmann, U., et al. (2014) Harmful Algae 39, 259-270
Zurhelle, C., et al. (2018) Marine Drugs 16(11).

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1. Cyclo imines

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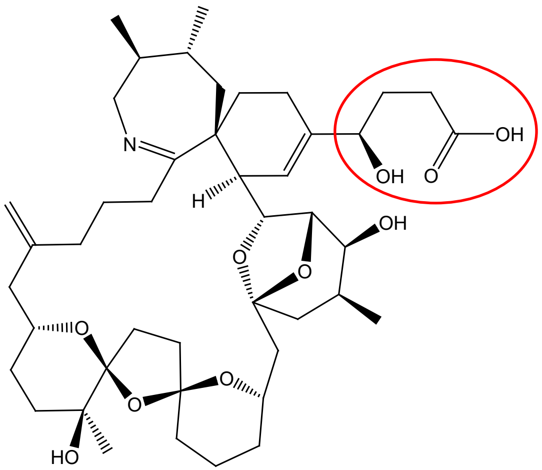
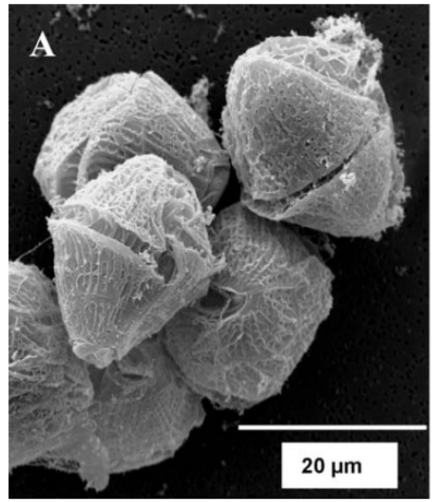
Pinnatoxins – structures

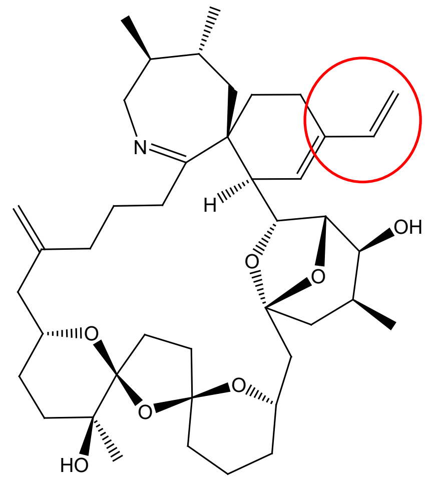


Pinnatoxin E

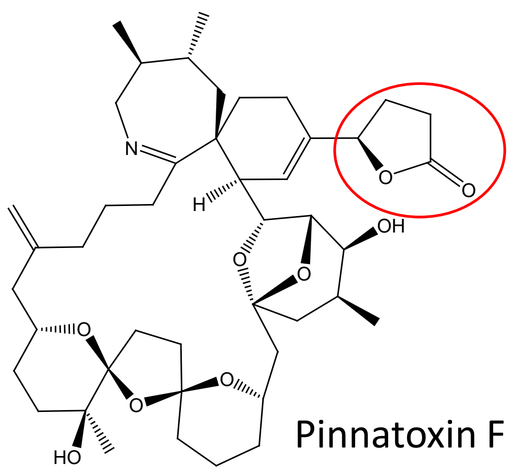


Rhodes, L., et al., 2010, Harmful Algae, 9, 384-389.

Vulcanodinium rugosum



Pinnatoxin G



Pinnatoxin F

Rhodes, L., et al. (2011) N.Z. J. Mar. Freshwater Res. 45(4): 703-709.

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1. Cyclo imines

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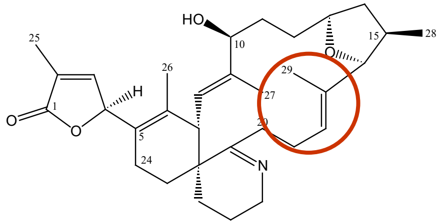
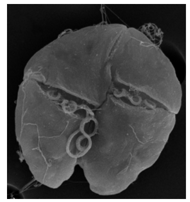
Gymnodimines - Structures

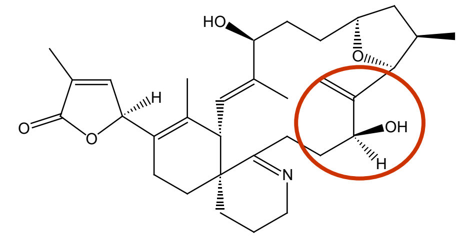


Gymnodimine A

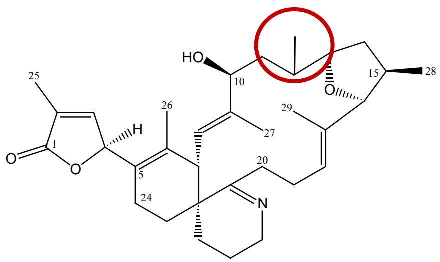


Karenia selliformis

www.inaturalist.org/taxa/470162-Karenia-selliformis

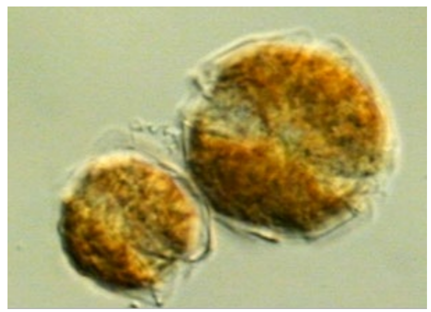


Gymnodimine B/C

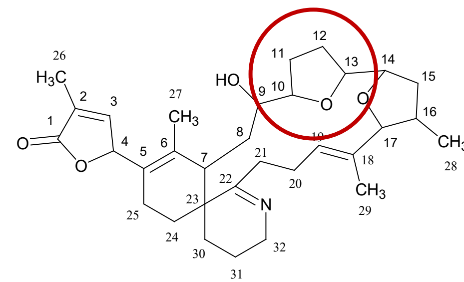


12-methyl-Gymnodimine A

Van Wagoner, R.M., et al. (2011)
Tetrahed. Lett. 52(33), 4243-4246.

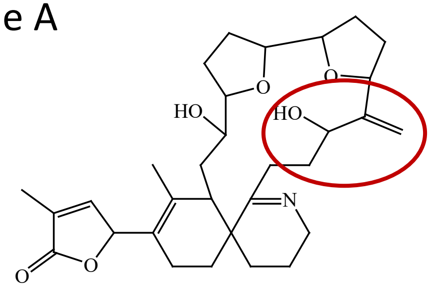


Alexandrium ostenfeldii

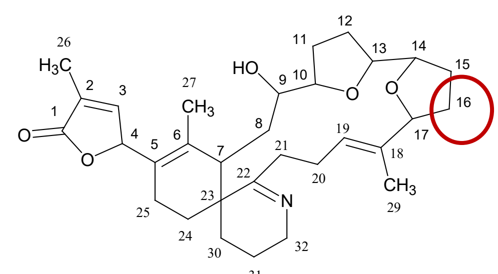


Gymnodimine D

Harju, K., et al. (2016) Toxicon 112, 68-76.



Gymnodimine E



16-desmethyl-Gymnodimine D

Zurhelle, C., et al. (2018) Marine Drugs 16(11).

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2. Goniodomins

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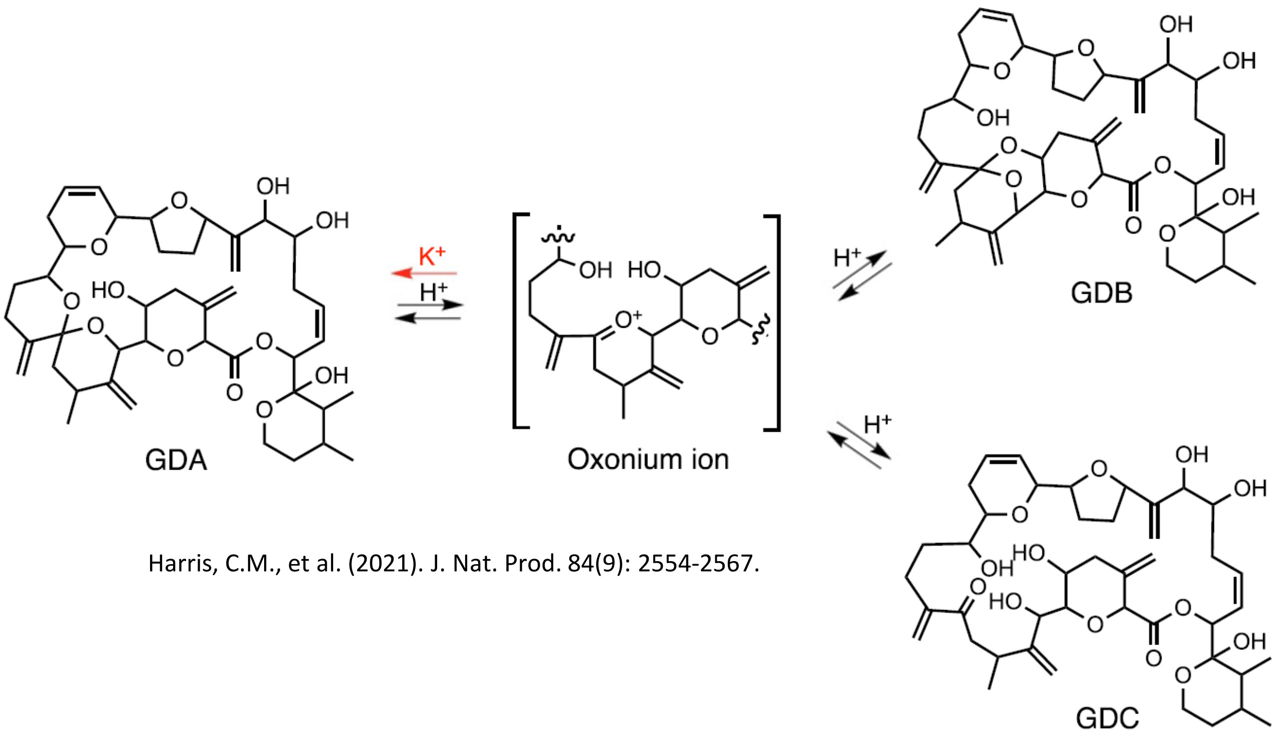
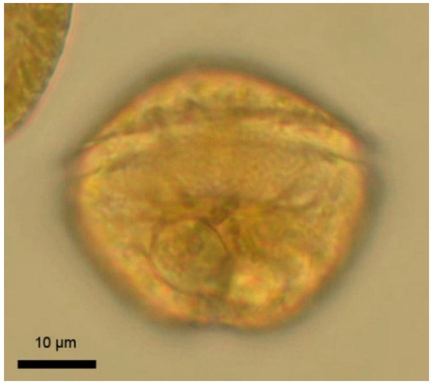
Goniodomins – Structures



Harris, C.M., et al. (2021). J. Nat. Prod. 84(9): 2554-2567.



Alexandrium pseudogonyaulax

Producing species:

Alexandrium
- *monilatum*
- *pseudogonyaulax*
- *hiranoi*
- *taylorii*

Tillmann, U., et al. (2020). Toxins 12(9): 564.

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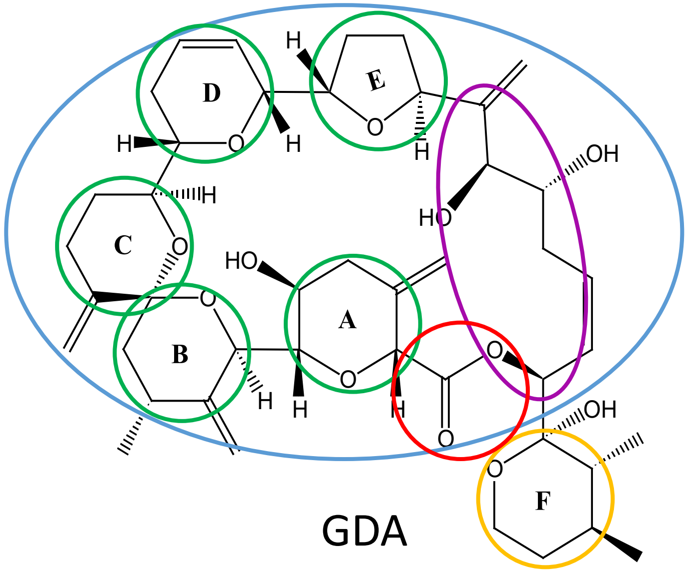
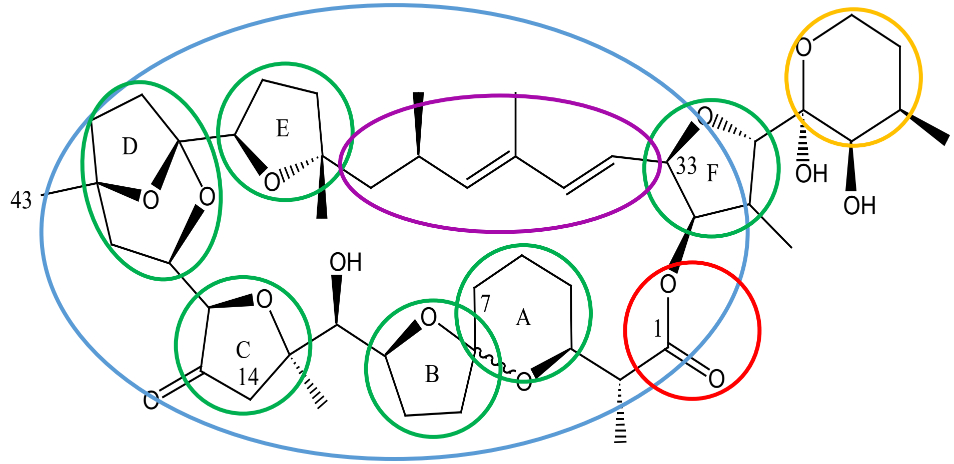
2. Goniodomins

Goniodomins – Structural characteristics



GDA



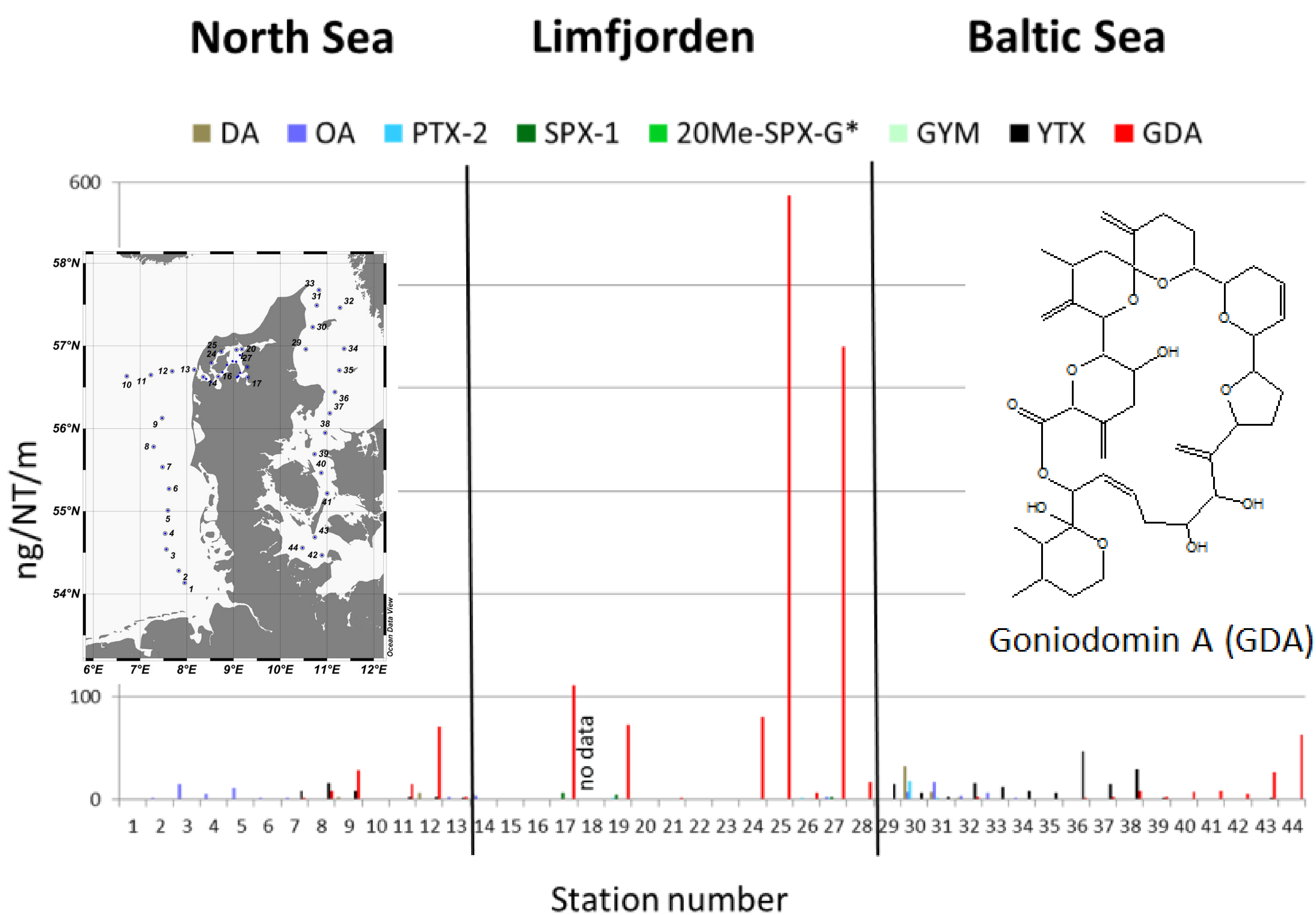
PTX-2

Macrocycle, exocyclic ether ring, ether rings, 6-membered carbon chain, lactone function

Toxicity: unknown hepatotoxic

Due to the structural similarity of GDA and pectenotoxins (PTX), related toxicological effects can be assumed.

2. Goniodomins

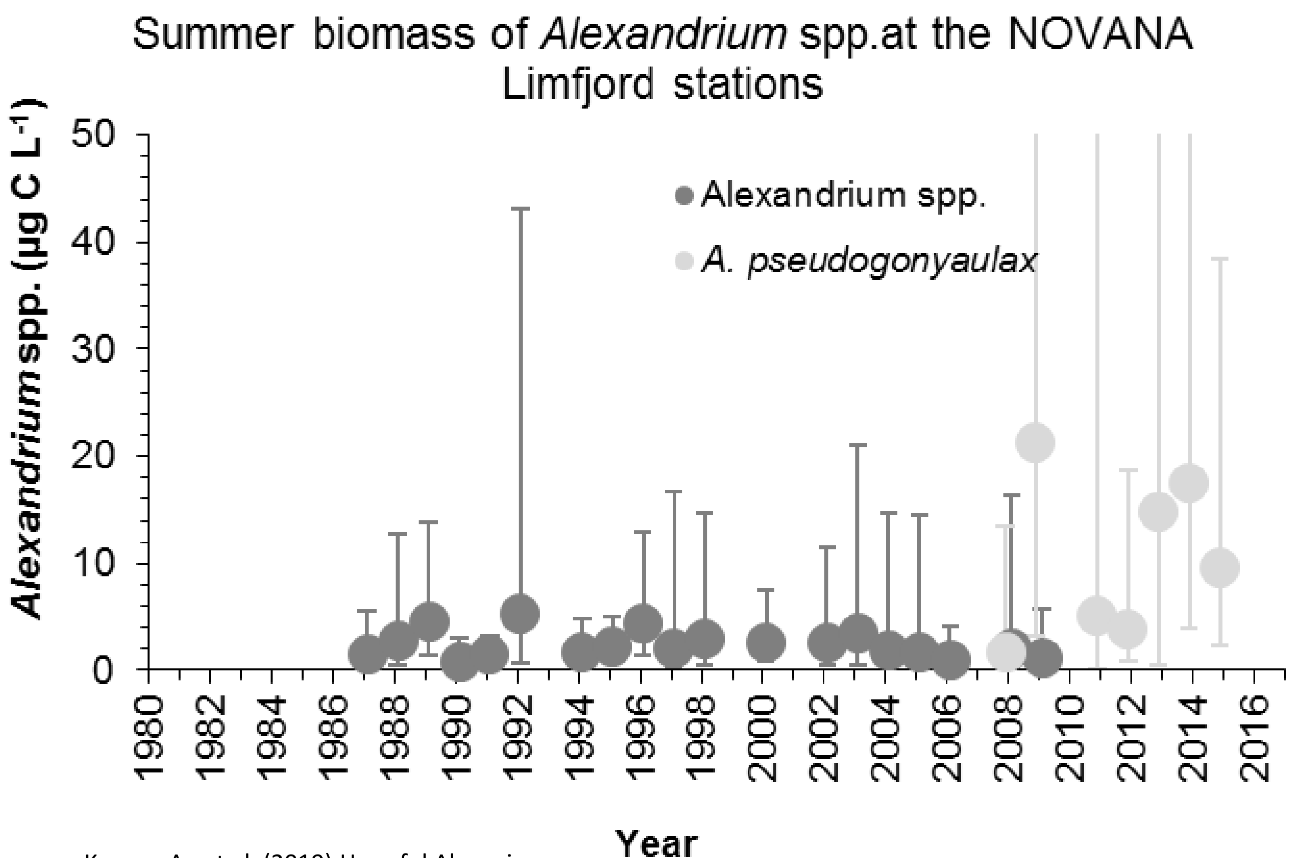


Krock, B., et al. (2018) Toxicon 155: 51-60.

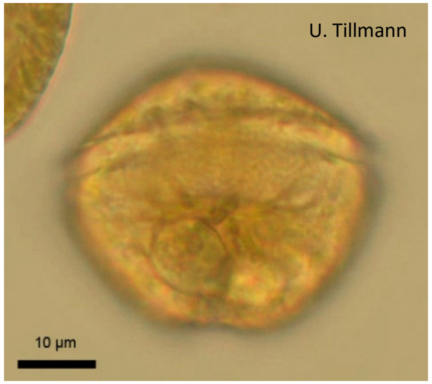
2. Goniodomins

Goniodomins – Community change

Community shift from an *Alexandrium catenella/ostenfeldii* to *A. pseudogonyaulax*



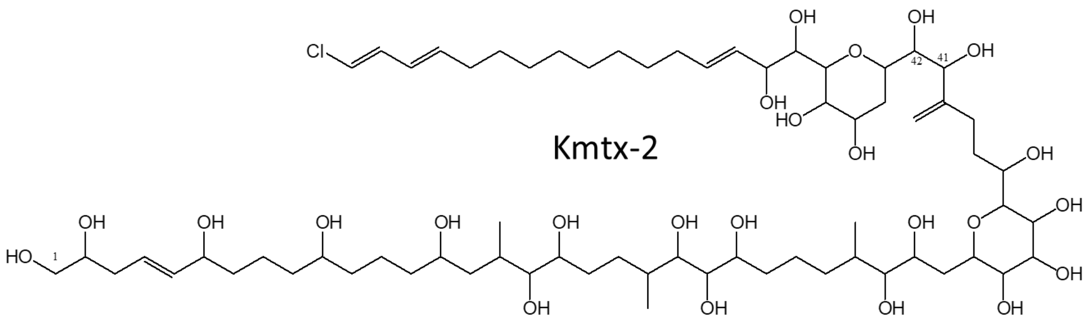
Kremp, A., et al. (2019) Harmful Algae, in press



Alexandrium pseudogonyaulax

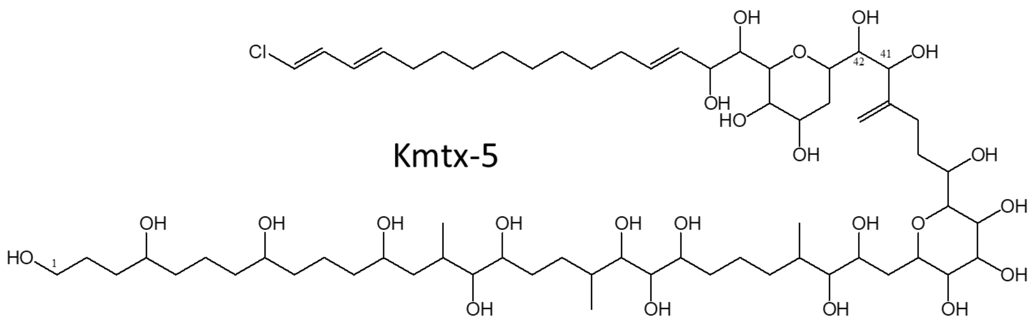
Producer of goniodomins

3. Karlotoxins



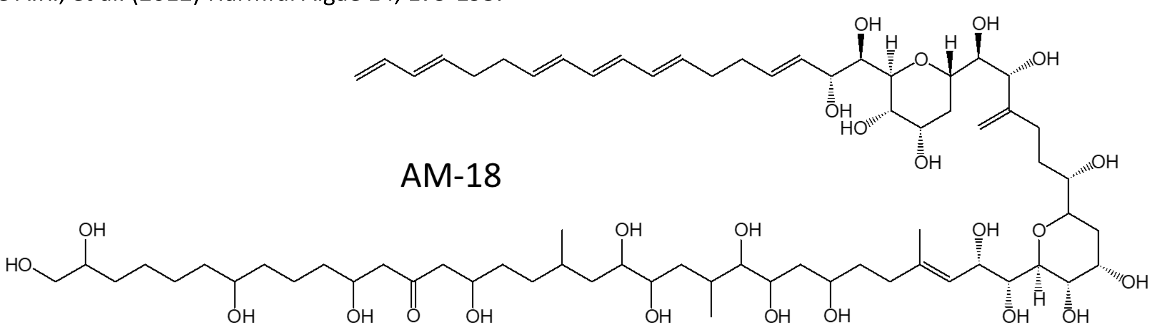
Kmtx-2

Peng, J., et al. (2010) JACS 132(10), 3277-3279.



Kmtx-5

Place A.R., et al. (2012) Harmful Algae 14, 179-195.

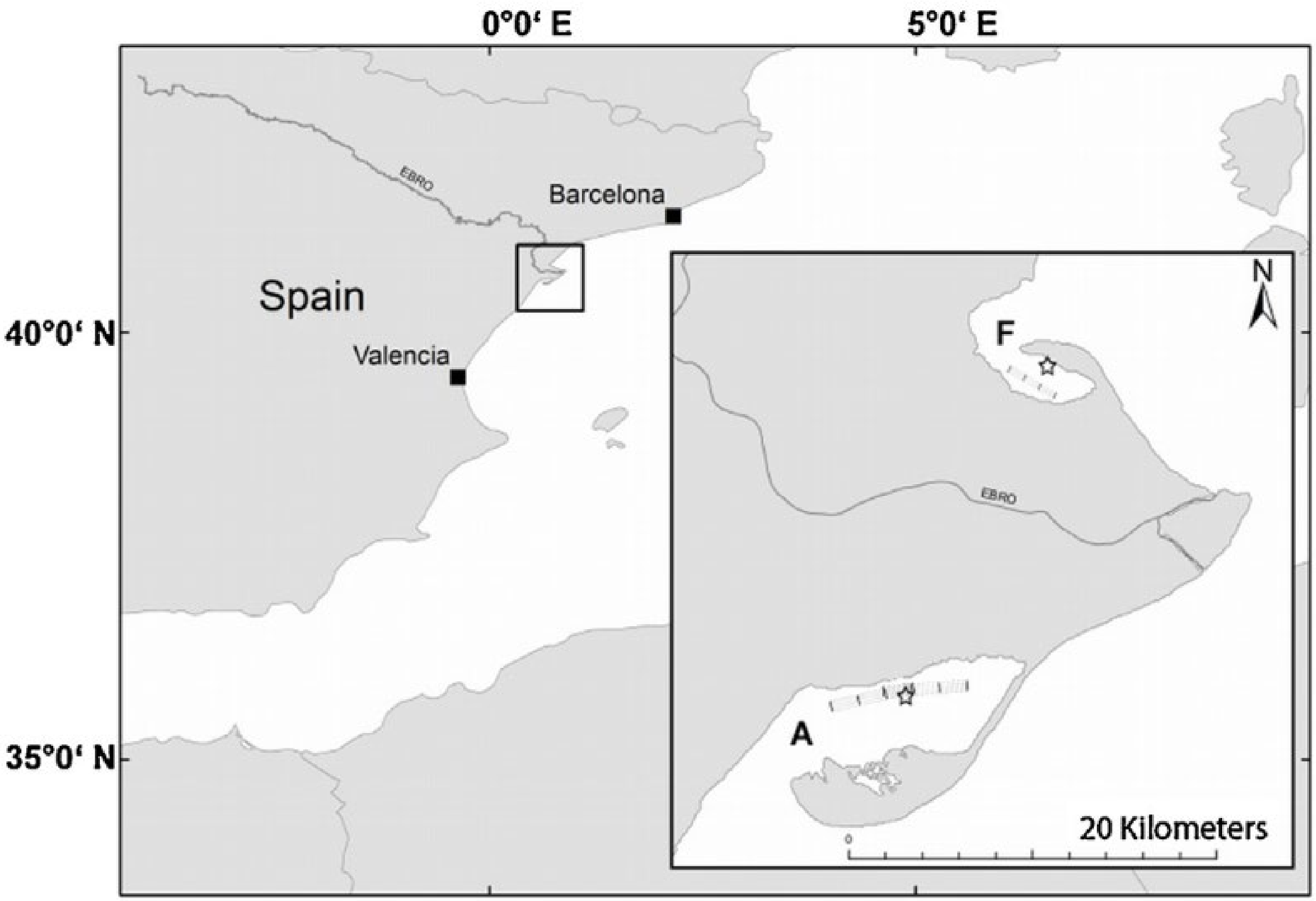


AM-18

Nuzzo, G., et al. (2014) J. Nat. Prod. 77(6), 1524-1527.

Karlodinium veneficum
E11, Fangar, Spain

3. Karlotoxins



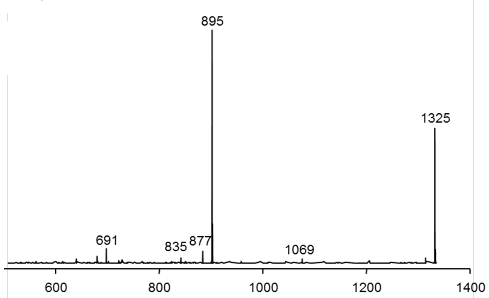
F = Fangar Bay

A = Alfacs Bay

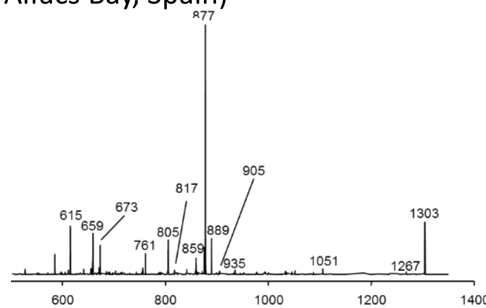
Busch, J.A., et al. (2016) Harmful Algae 55, 191-201.

3. Karlotoxins

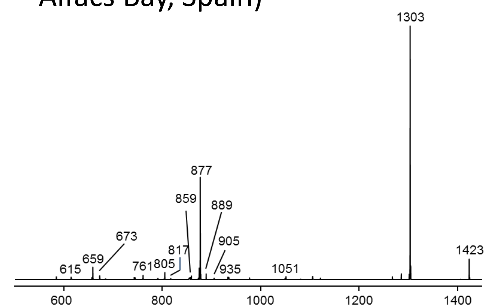
KmTx-5 (Strain E11, Fangar Bay, Spain)



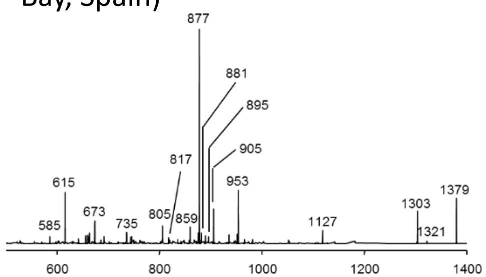
KmTx-10 (Strain K10, Alfacs Bay, Spain)



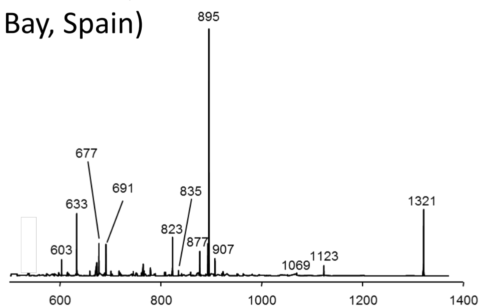
sulfo-KmTx-10 (Strain K10, Alfacs Bay, Spain)



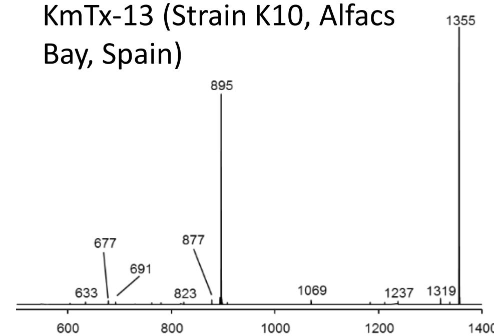
KmTx-11 (Strain K10, Alfacs Bay, Spain)



KmTx-12 (Strain K10, Alfacs Bay, Spain)



KmTx-13 (Strain K10, Alfacs Bay, Spain)



Krock, B., et al. (2017) Marine Drugs 15(12), 1-20.

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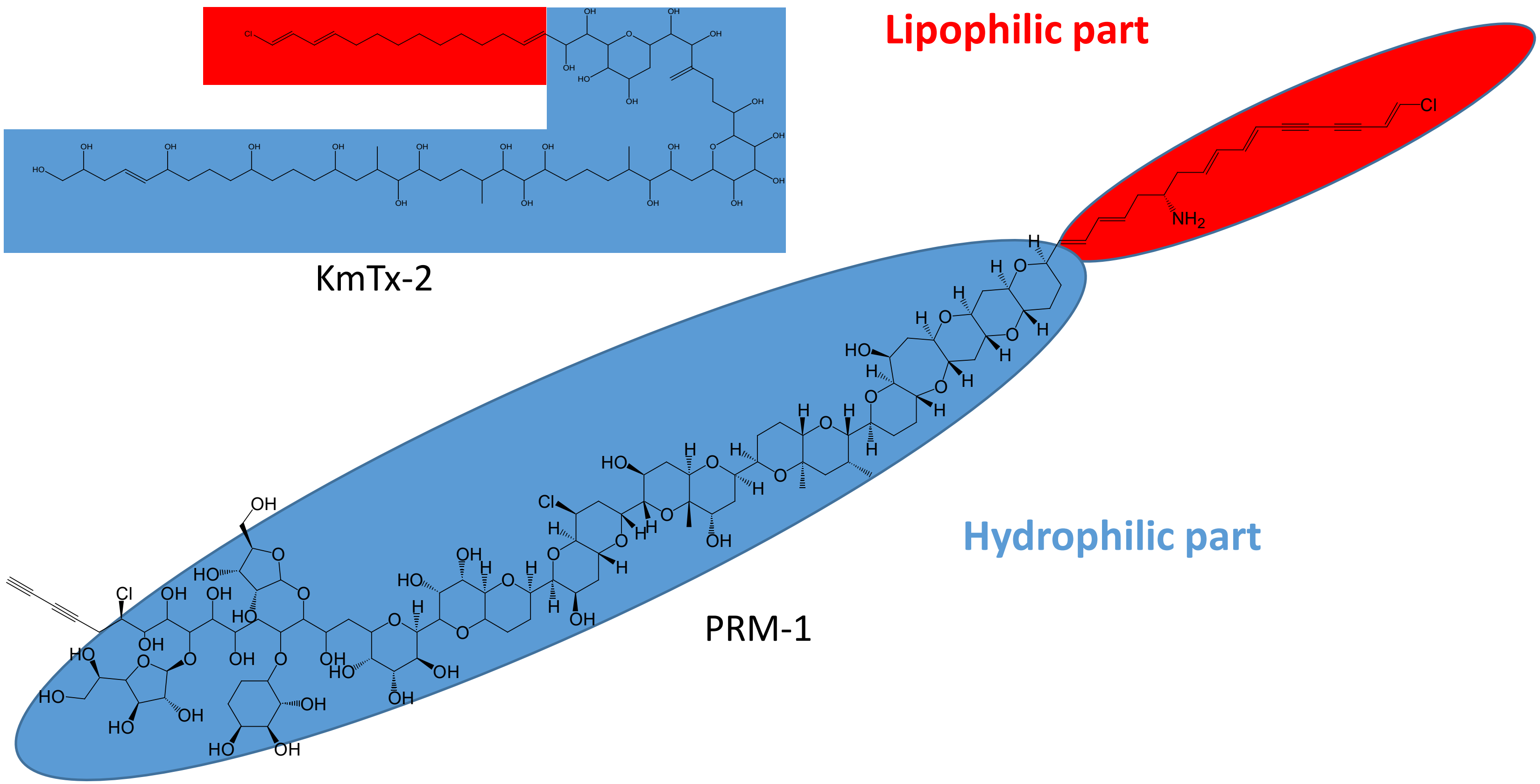
Karlotoxins – Ichthyotoxicity



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3. Karlotoxins

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Ichthyotoxins – Variability

Amphidinols: 20 + known variants

Karlotoxins: 20 + known variants

Prymnesins: 100 + variants

Other ichthyotoxic species:

Alexandrium spp.
Chattonella spp.
Chrysocromulina spp.
Fibrocapsa japonica
Heterosigma akashiwo
Protoceratium reticulatum
Pseudochattonella c.f. *veruculosa*

Ichthyotoxins:

Unknown !!

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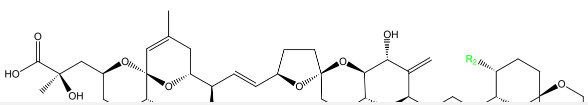
3. Karlotoxins

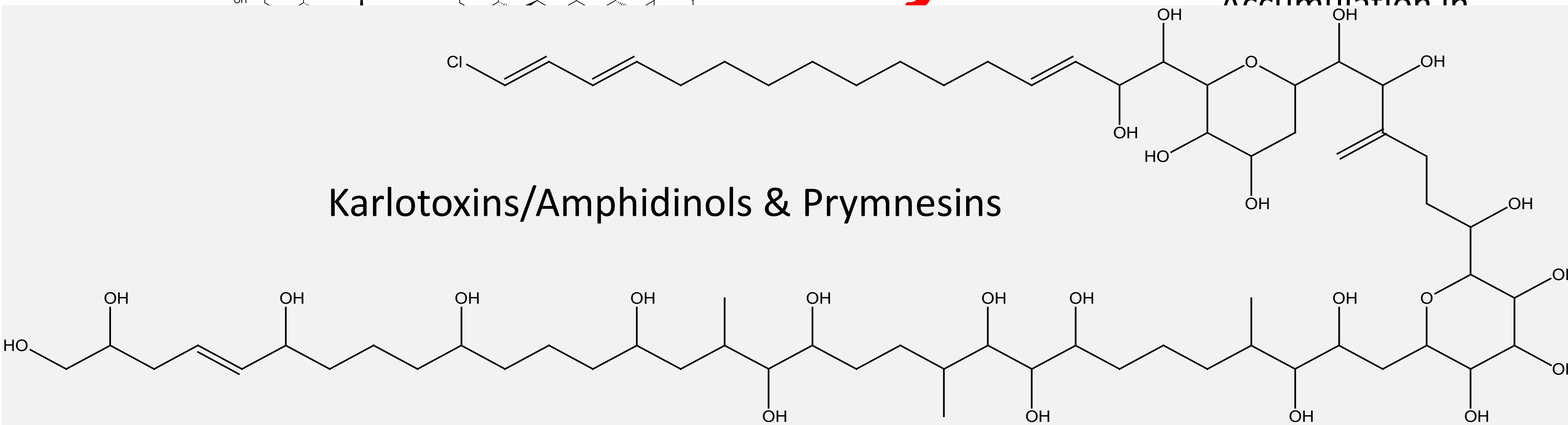
Ichthyotoxins – Variability

Structure | Ecological function | Impact



?

Accumulation in

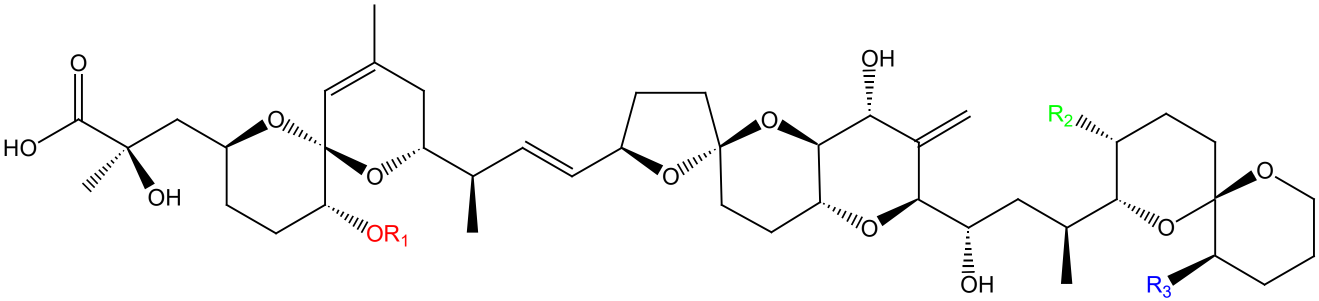


Karlotoxins/Amphidinols & Prymnesins

aquacultures

√

4. DSP Toxins



	R1	R2	R3
OA	H	CH_3	H
DTX1	H	CH_3	CH_3
DTX2	H	H	CH_3
DTX3	CH_3CO	CH_3	CH_3
Acyl-OA	CH_3CO	CH_3	H

Dinophysis spp.
Prorocentrum spp.

OA: Okadaic acid (first isolated from the sponge *Halichondria okadaii*)

4. DSP Toxins

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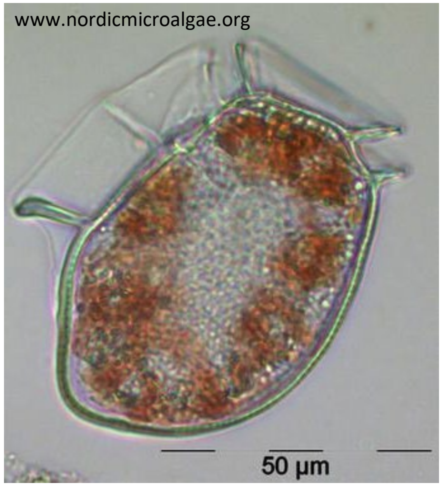
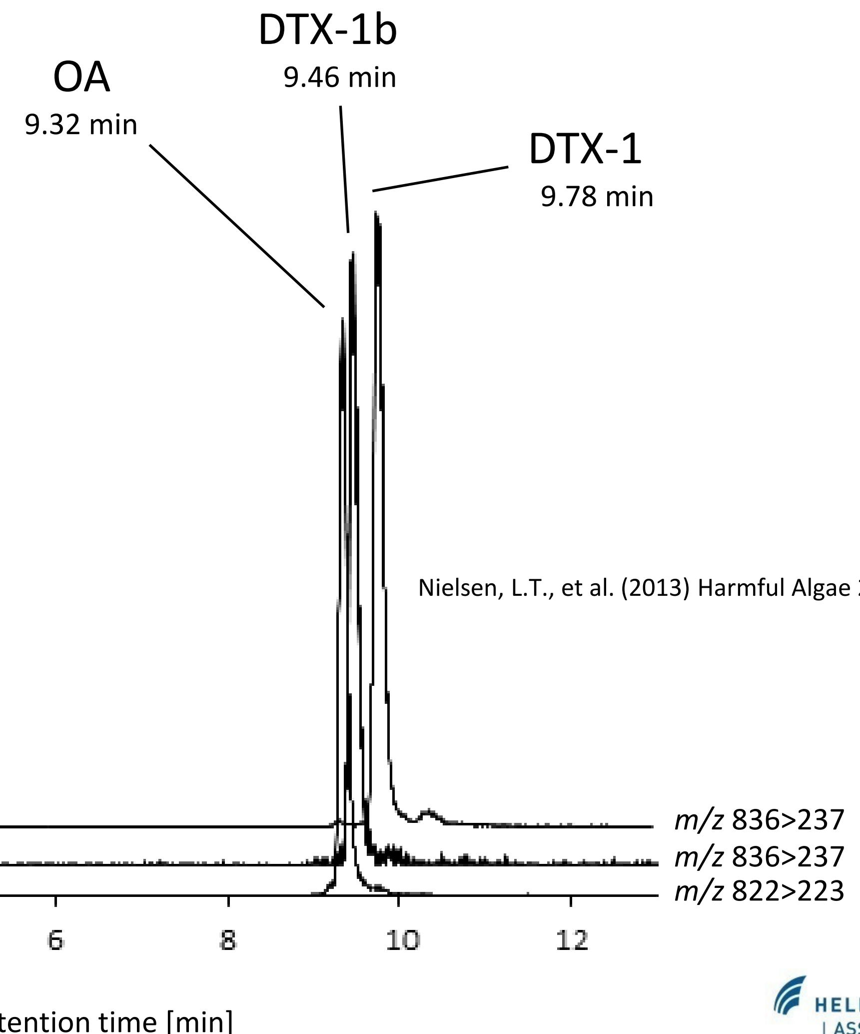


Dinophysis acuta



Nielsen, L.T., et al. (2013) Harmful Algae 23, 34-45.

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4. DSP Toxins

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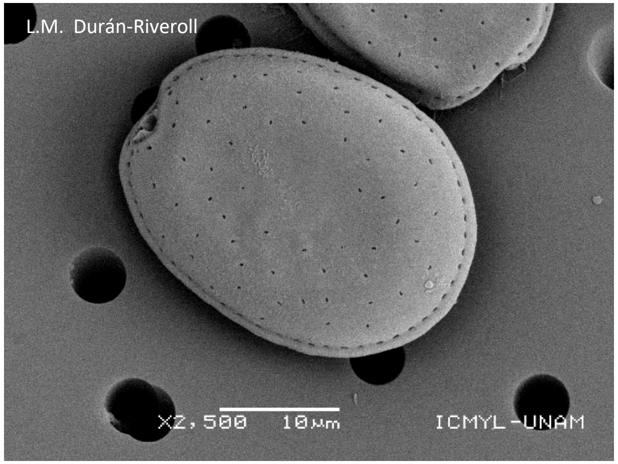
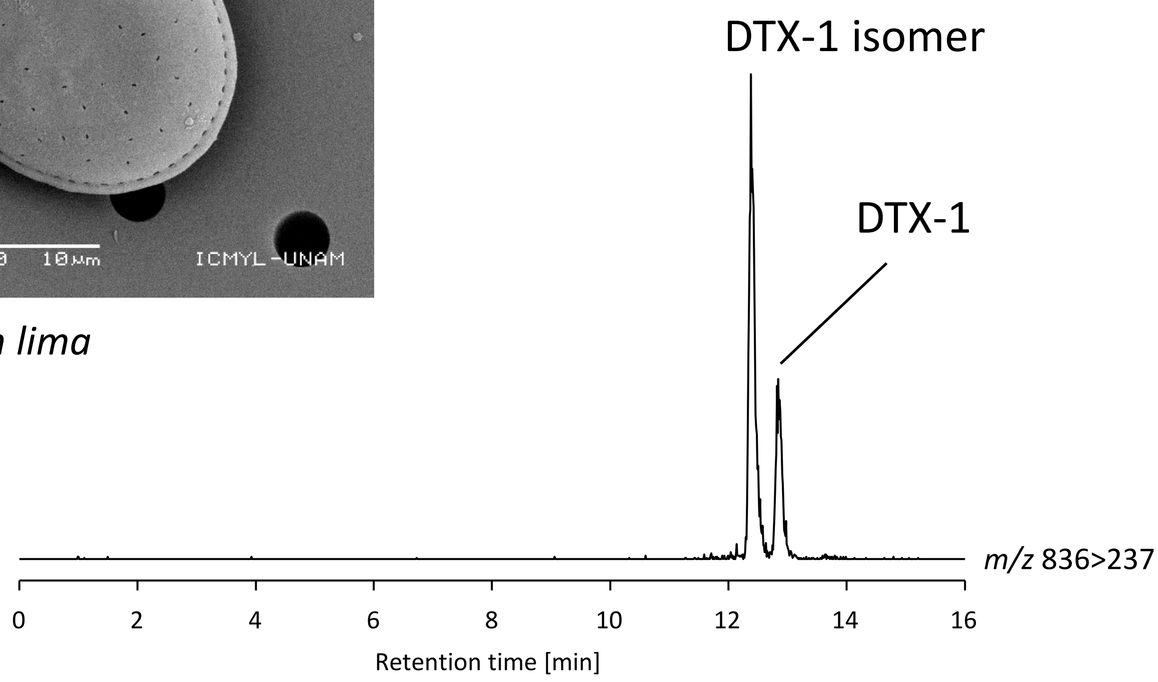


Prorocentrum lima

Prorocentrum lima, Mexico



Tarazona-Janampa U.I. et al., (2020). Frontiers in Marine Science 7(569).

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4. DSP Toxins

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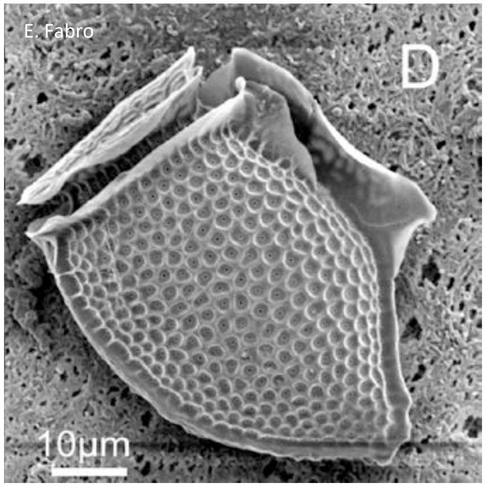
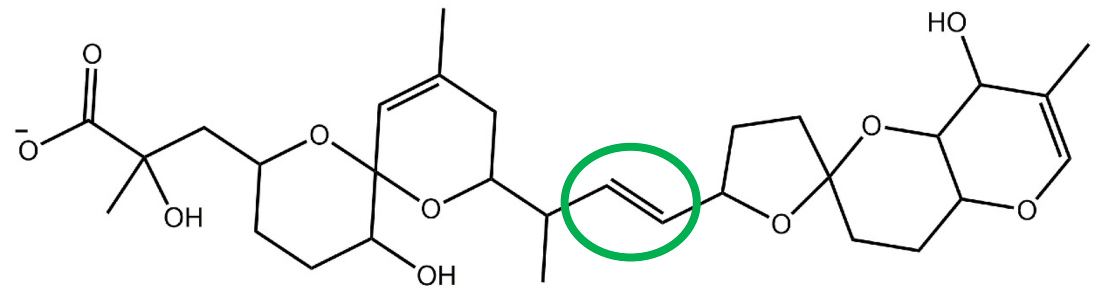
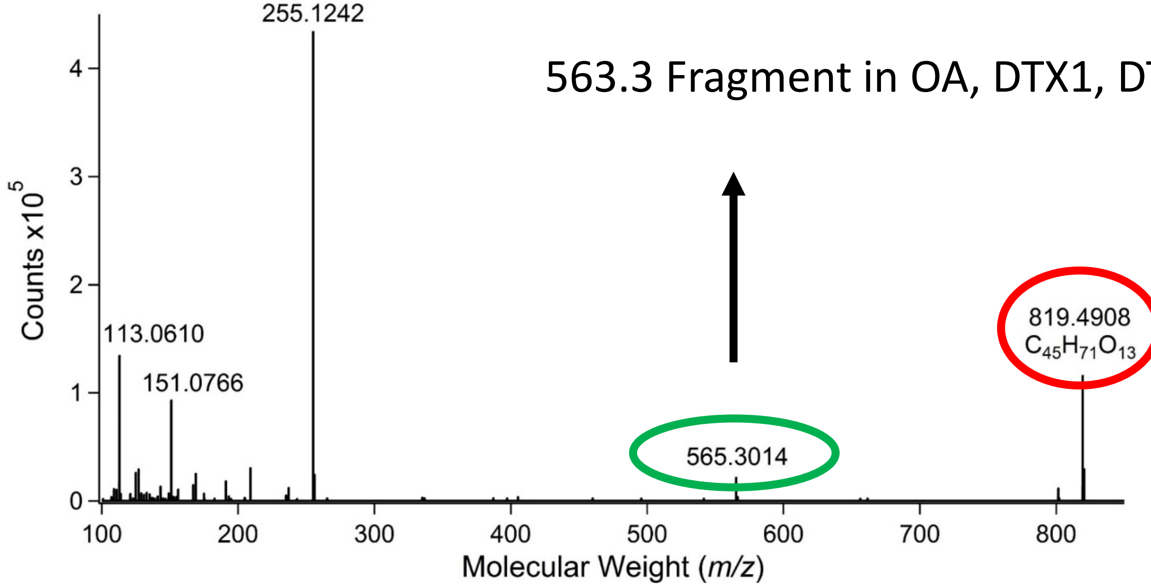


Dinophysis norvegica

Dihydro-DTX1





Deeds, J.R., et al. (2020). Toxins 12(9): 533.

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5. AZP Toxins

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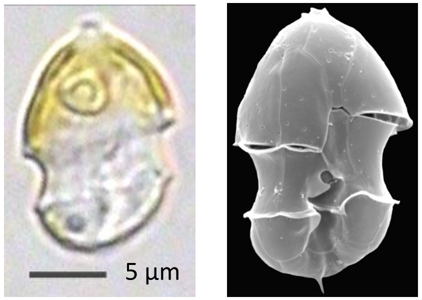
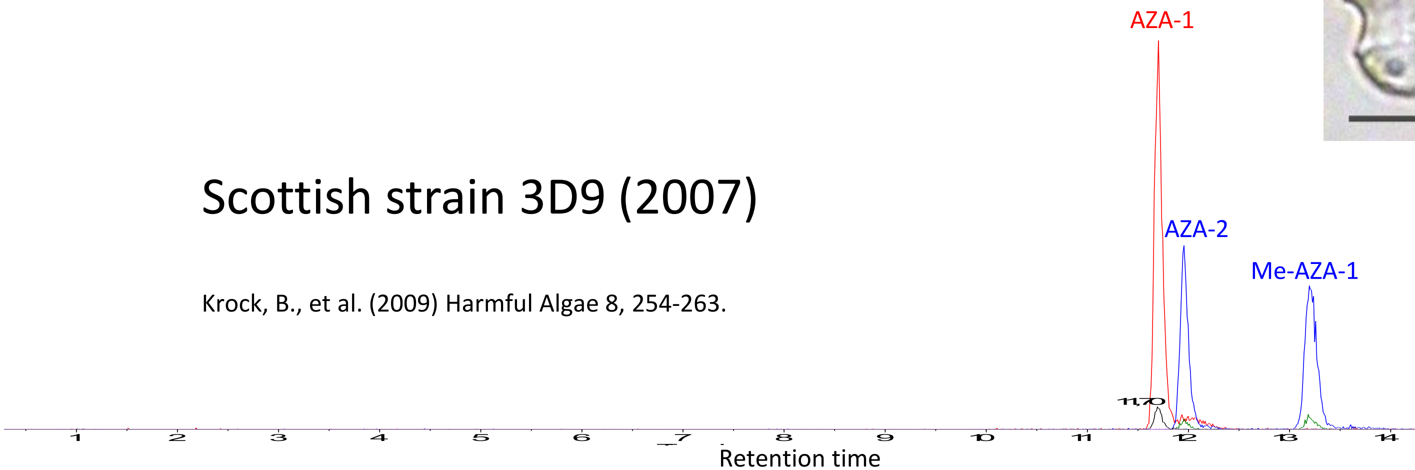
Azadinium as AZA producer



A. spinosum

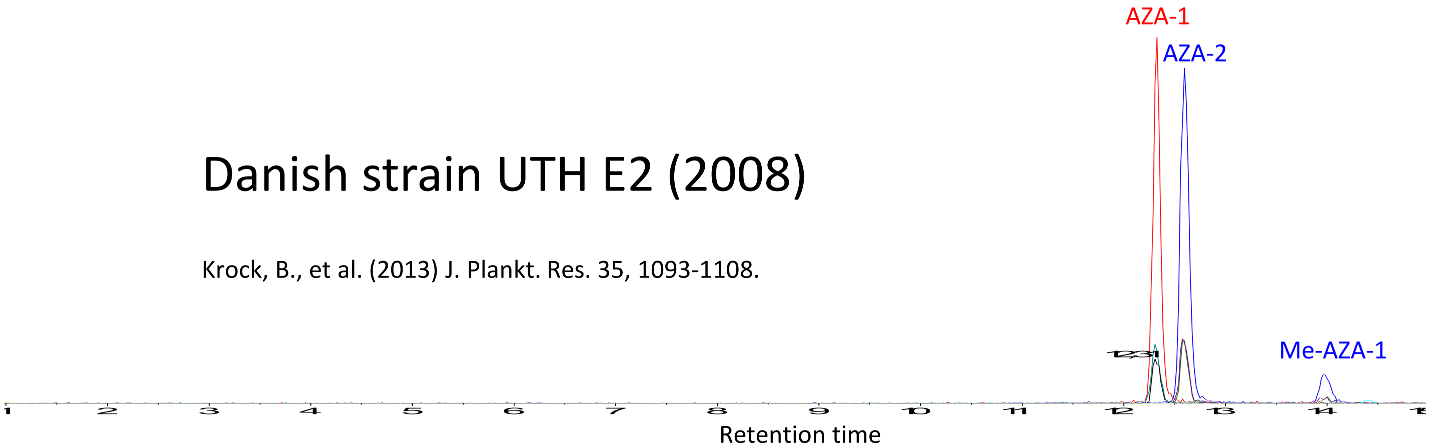
Scottish strain 3D9 (2007)

Krock, B., et al. (2009) Harmful Algae 8, 254-263.



Danish strain UTH E2 (2008)

Krock, B., et al. (2013) J. Plankt. Res. 35, 1093-1108.



m/z 842>824
m/z 856>838

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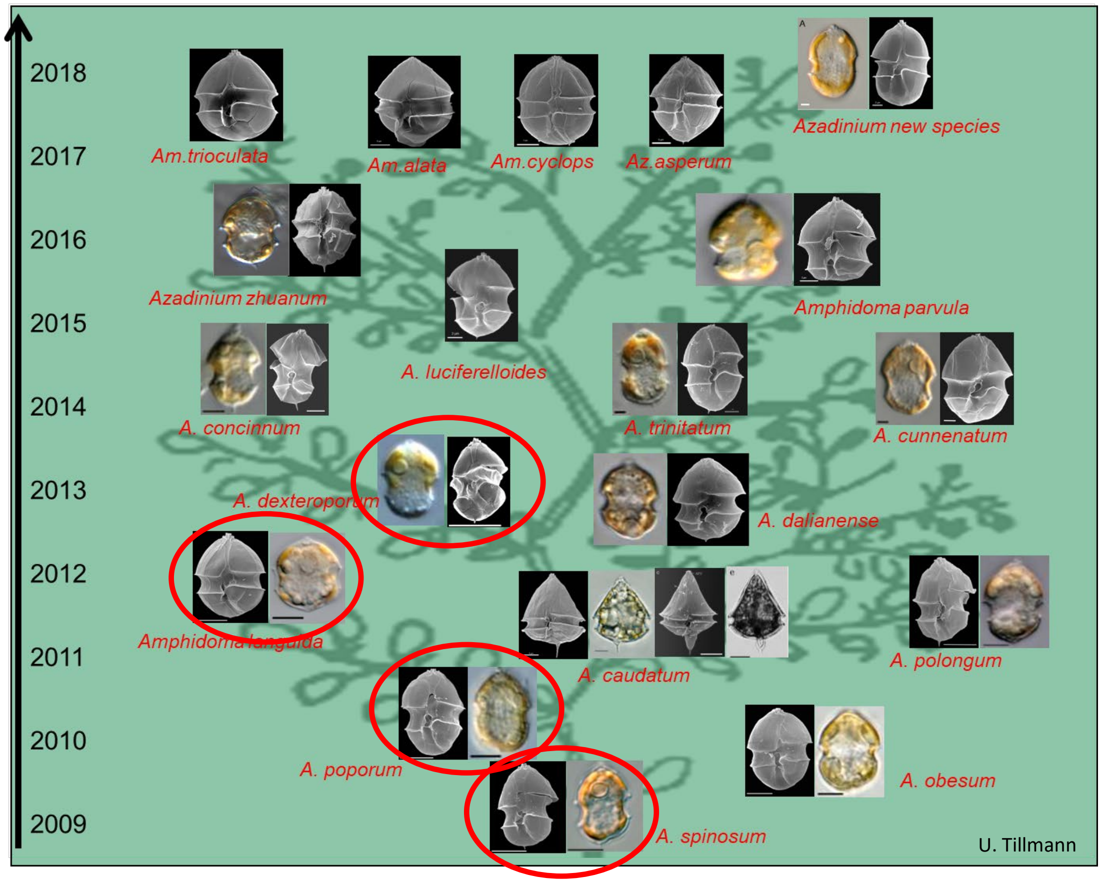
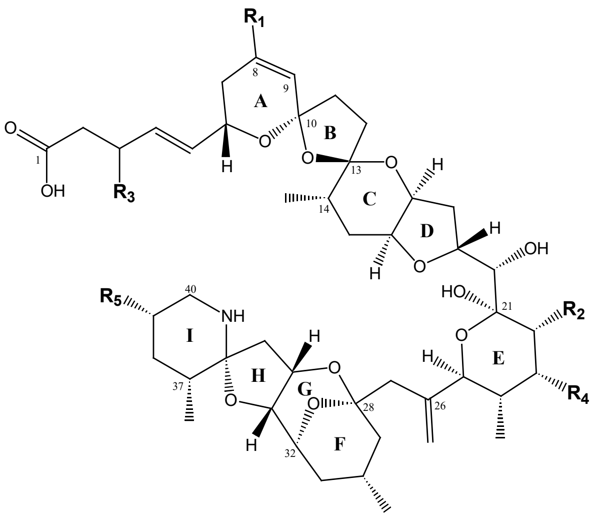
5. AZP Toxins

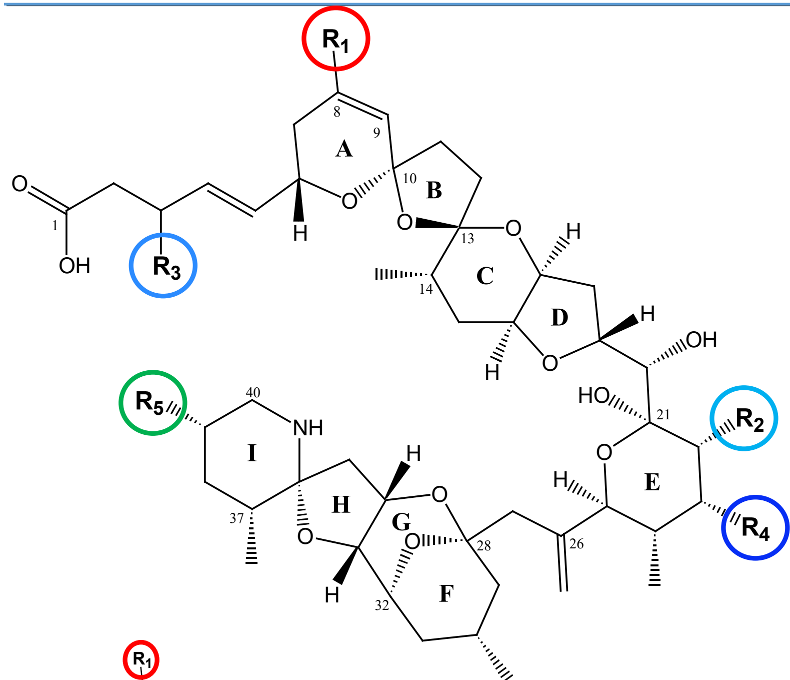


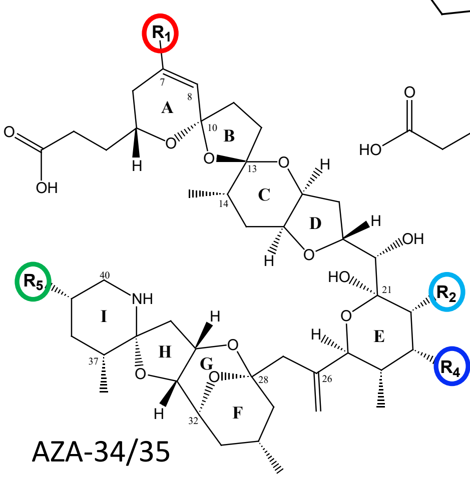
2018
2017
2016
2015
2014
2013
2012
2011
2010
2009
Am.trioculata
Am.alata
Am.cyclops
Az.asperum
Azadinium new species
Azadinium zhuanum
Amphidoma parvula
A. luciferelloides
A. concinnum
A. trinitatum
A. cunnenatum
A. dexteroporum
A. dalianense
Amphidoma languida
A. caudatum
A. polongum
A. poporum
A. obesum
A. spinosum
U. Tillmann



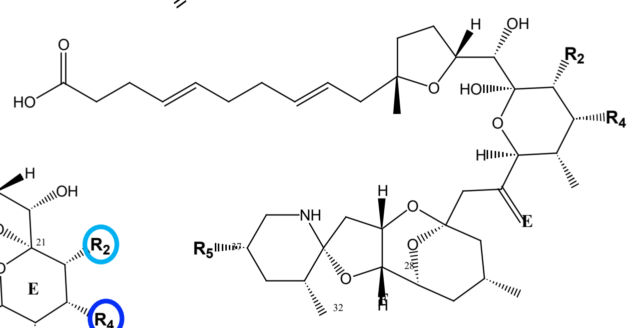
R1
R2
R3
R4
R5
A
B
C
D
E
F
G
H
I
OH
HO
NH

5. AZP Toxins





AZA-34/35



AZA-33

Toxin	R_1	R_2	R_3	R_4	R_5	$\Delta_{7,8}$	$[M+H]^+$
AZA-1	H	CH_3	H	H	CH_3	√	842
AZA-2	CH_3	CH_3	H	H	CH_3	√	856
AZA-3	H	H	H	H	CH_3	√	828
AZA-4	H	H	OH	H	CH_3	√	844
AZA-5	H	H	H	OH	CH_3	√	844
AZA-6	CH_3	H	H	H	CH_3	√	842
AZA-7	H	CH_3	OH	H	CH_3	√	858
AZA-8	H	CH_3	H	OH	CH_3	√	858
AZA-9	CH_3	H	OH	H	CH_3	√	858
AZA-10	CH_3	H	H	OH	CH_3	√	858
AZA-11	CH_3	CH_3	OH	H	CH_3	√	872
AZA-33	-	CH_3	H	H	CH_3	-	716
AZA-34	H	CH_3	-	H	CH_3	√	816
AZA-35	CH_3	CH_3	-	H	CH_3	√	830
AZA-36	CH_3	CH_3	OH	H	H	√	858
AZA-37	H	CH_3	OH	H	H	-	846
AZA-38	nd	nd	nd	nd	H	nd	830
AZA-39	nd	nd	nd	nd	H	nd	816
AZA-40	CH_3	CH_3	H	H	H	√	842

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5. AZP Toxins

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AZA	R1	R2	R3	R4	R5	R6	R7	[M+H]+	Frag. Type	origin	status	reference
AZA1	H	H	H	CH3	H	CH3	CH3	842,5	362 262	A. spinosum	phycotoxin	Rehmann et al. 2008
AZA2	H	CH3	H	CH3	H	CH3	CH3	856,5	362 262	spin/pop/lang	phycotoxin	Rehmann et al. 2008
AZA3	H	H	H	H	H	CH3	CH3	828,5	362 262	shellfish	metabolite	Rehmann et al. 2008
AZA4	OH	H	H	H	H	CH3	CH3	844,5	362 262	shellfish	metabolite	Rehmann et al. 2008
AZA5	H	H	H	H	OH	CH3	CH3	844,5	362 262	shellfish	metabolite	Rehmann et al. 2008
AZA6	H	CH3	H	H	H	CH3	CH3	842,5	362 262	shellfish	metabolite	Rehmann et al. 2008
AZA7	OH	H	H	CH3	H	CH3	CH3	858,5	362 262	shellfish	metabolite	Rehmann et al. 2008
epi AZA7	OH	H	H	CH3	H							Rossi et al. 2017
AZA8	H	H	H	CH3	OH							Rehmann et al. 2008
AZA9	OH	CH3	H	H	H							Rehmann et al. 2008
AZA10	H	CH3	H	H	OH							Rehmann et al. 2008
AZA11	OH	CH3	H	CH3	H						abol	Rehmann et al. 2008
AZA12	H	CH3	H	CH3	OH							Rehmann et al. 2008
AZA13	OH	H	H	H	OH							Rehmann et al. 2008
AZA14	OH	H	H	CH3	OH							Rehmann et al. 2008
AZA15	OH	CH3	H	H	OH							Rehmann et al. 2008
AZA16	OH	CH3	H	CH3	OH	CH3	CH3	888,5	362 262	shellfish	metabolite	Rehmann et al. 2008
AZA17	H	H	H	COOH	H	CH3	CH3	872,5	362 262	shellfish	metabolite	Rehmann et al. 2008
AZA18												Rehmann et al. 2008
AZA19	H	CH3	H	COOH	H	CH3	CH3	886,5	362 262	shellfish	metabolite	Rehmann et al. 2008
AZA20												Rehmann et al. 2008
AZA21	OH	H	H	COOH	H	CH3	CH3	888,5	362 262	shellfish	metabolite	Rehmann et al. 2008
AZA22												Rehmann et al. 2008
AZA23	OH	CH3	H	COOH	H	CH3	CH3	902,5	362 262	shellfish	metabolite	Rehmann et al. 2008
AZA24												Rehmann et al. 2008
AZA25	H	H	H	H	H							Kilkoyne et al. 2018
AZA26	H	H	H	H	O							Kilkoyne et al. 2018
AZA27	H	CH3	H	H	H							Kilkoyne et al. 2018
AZA28	H	CH3	H	H	O							Kilkoyne et al. 2018
AZA29	H	H	CH3	H	H							Rehmann et al. 2008
AZA30	H	H	CH3	CH3	H							Rehmann et al. 2008
AZA31												Rehmann et al. 2008
AZA32	H	CH3	CH3	CH3	H							Rehmann et al. 2008
AZA33	–	–	H	CH3	H							Kilkoyne et al. 2014
AZA34	–	H	H	CH3	H	CH3	CH3	816,5	362 262	A. spinosum	phycotoxin	Kilkoyne et al. 2014
AZA35	–	CH3	H	CH3	H	CH3	CH3	830,5	362 262	A. spin/A. dexterop	phycotoxin	Kilkoyne et al. 2014, Rossi et al. 2017
AZA36	OH	CH3	H	CH3	H	H	CH3	858,5	348 248	A. poporum	phycotoxin	Krock et al. 2015
AZA37	OH	H	H	CH3	H	H	CH3	846,5	348 248	A. poporum	phycotoxin	Krock et al. 2015
AZA38	nd	nd	nd	nd	nd	nd	nd	830,5	348 248	A. languida	phycotoxin	Krock et al. 2012
AZA39	nd	nd	nd	nd	nd	nd	nd	816,5	348 248	A. languida	phycotoxin	Krock et al. 2012
AZA40	H	CH3	H	CH3	H							Krock et al. 2014
AZA41	H	CH3	H	CH3	H							Krock et al. 2014
AZA42	OH	CH3	H	CH3	H							Krock et al. 2018
AZA43	–	H	H	CH3	H							Tillmann et al. 2017
AZA44	H	H	H	COOH	OH							Kilkoyne et al. 2015
AZA45	H	CH3	H	COOH	OH							Kilkoyne et al. 2015
AZA46	OH	H	H	COOH	OH							Kilkoyne et al. 2015
AZA47	OH	CH3	H	COOH	OH							Kilkoyne et al. 2015
AZA48	OH	H	H	H	H							Kilkoyne et al. 2018
AZA49	OH	CH3	H	H	H							Kilkoyne et al. 2018
AZA50	H	CH3	H	CH3	H							Tillmann et al. 2018
AZA51	OH	CH3	H	CH3	H							Tillmann et al. 2018
AZA52	nd	nd	nd	nd	nd							Tillmann et al. 2018
AZA53	nd	nd	nd	nd	nd							Tillmann et al. 2018
AZA54	nd	nd	nd	nd	nd	nd	nd	870,5	362 262	A. dexteroporum	Phycotoxin	Rossi et al. 2017
AZA55	nd	nd	nd	nd	nd	nd	nd	868,5	362 262	A. dexteroporum	Phycotoxin	Rossi et al. 2017
AZA56	nd	nd	nd	nd	nd	nd	nd	884,5	362 262	A. dexteroporum	Phycotoxin	Rossi et al. 2017
AZA57	nd	nd	nd	nd	nd	nd	nd	826,5	362 262	A. dexteroporum	Phycotoxin	Rossi et al. 2017
AZA58	nd	nd	nd	nd	nd	nd	nd	828,5	362 262	A. dexteroporum	Phycotoxin	Rossi et al. 2017
AZA59	OH	H	H	CH3	H	CH3	CH3	860,5	362 262	A. poporum	Phycotoxin	Kim et al. 2017
AZA60	H	H	H	OH	CH3	nd	nd	826,5	362 262	shellfish	metabolite	Kilkoyne et al. 2018
AZA61	H	CH3	H	OH	CH4	nd	nd	840,5	362 262	shellfish	metabolite	Kilkoyne et al. 2018
AZA62	nd	nd	nd	nd	nd	nd	nd	870,5	362 262	A. poporum	Phycotoxin	Krock et al. 2018

Currently
62 published AZAs

26 AZAs from
planktonic origin

And at least
additional
10 known AZAs

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5. AZP Toxins

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Azaspiracids - Variants

AZAs produced by algae

AZA-1	AZA-41
AZA-2	AZA-42
epi-AZA-7	AZA-43
AZA-11	AZA-50
AZA-33	AZA-51
AZA-34	AZA-52
AZA-35	AZA-53
AZA-36	AZA-54
AZA-37	AZA-55
AZA-38	AZA-56
AZA-39	AZA-57
AZA-40	AZA-58
AZA-59	AZA-62

AZA shellfish metabolites of AZA-1 and -2

AZA-3	AZA-14	AZA-25	AZA-47
AZA-4	AZA-15	AZA-26	AZA-48
AZA-5	AZA-16	AZA-27	AZA-49
AZA-6	AZA-17	AZA-28	AZA-60
AZA-7	AZA-18	AZA-29	AZA-61
AZA-8	AZA-19	AZA-30	
AZA-9	AZA-20	AZA-31	
AZA-10	AZA-21	AZA-32	
AZA-11	AZA-22	AZA-44	
AZA-12	AZA-23	AZA-45	
AZA-13	AZA-24	AZA-46	

Two AZAs of phytoplankton origin result in 38 shellfish metabolites!

Krock, B., et al. (2019) Harmful Algae 82, 1-8.

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5. AZP Toxins

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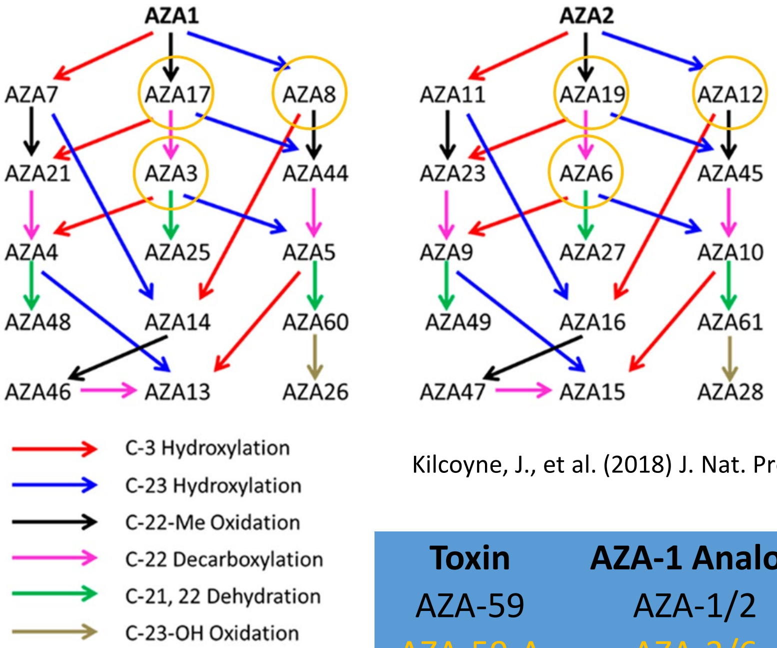
Azaspiracids – Metabolism in Bivalves



Kilcoyne, J., et al. (2018) J. Nat. Prod. 81(4), 885-893.

Toxin	AZA-1 Analog	m/z $[M+H]^+$	m/z $[M+H-H_2O]^+$	Retentiontime [min]
AZA-59	AZA-1/2	860	842	10,6
AZA-59-A	AZA-3/6	846	828	10,1
AZA-59-B	AZA-8/12	876	858	9,6
AZA-59-C	AZA-17/19	890	872	9,9
AZA-59-D	?	890	872	10,3
AZA-59-E	No analog	892	874	9,0
AZA-59-F	No analog	878	860	9,65

Krock, B., et al. in preparation

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5. AZP Toxins

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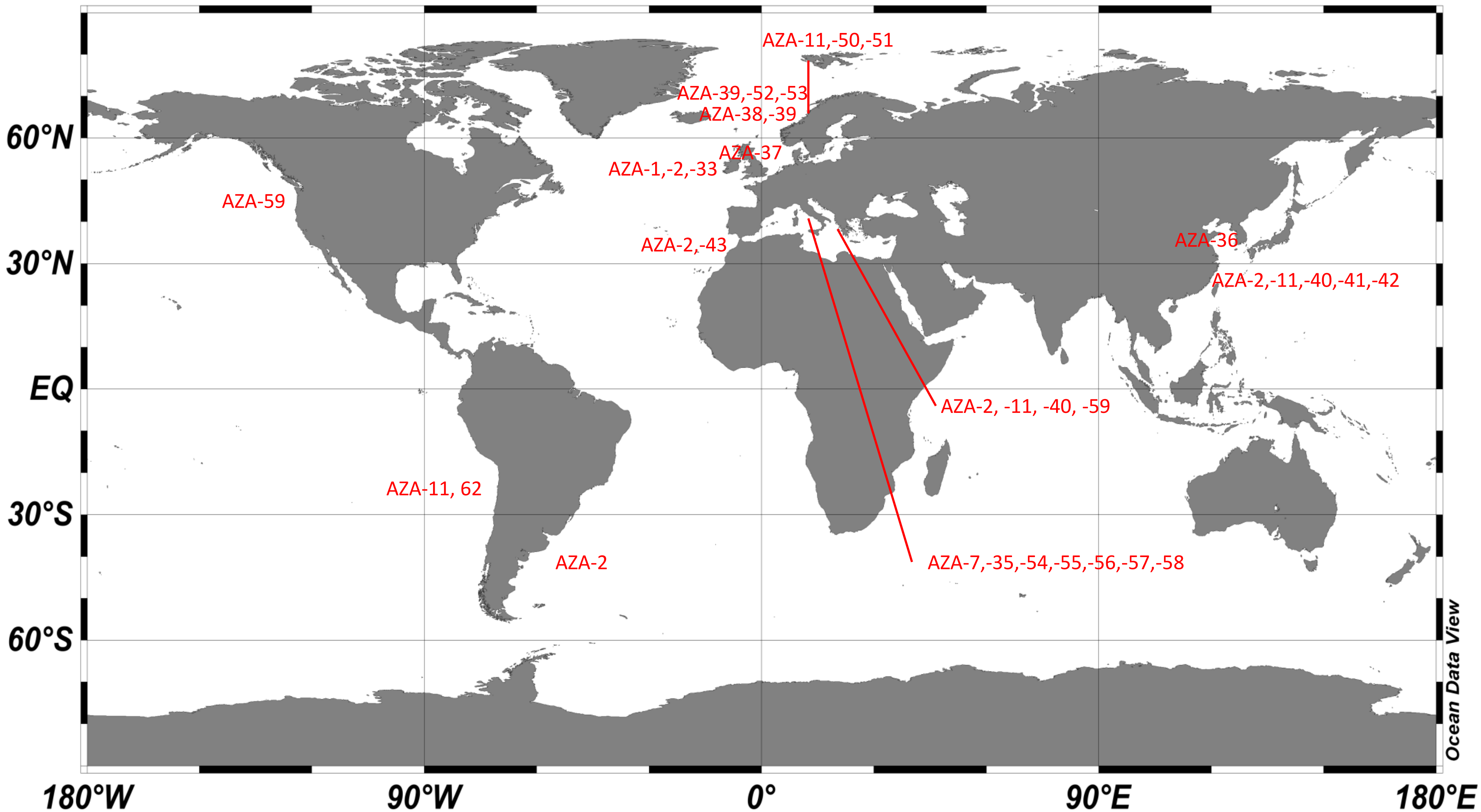
Azaspiracids – Geographic distribution



6. Discrete vs. Integrated Monitoring

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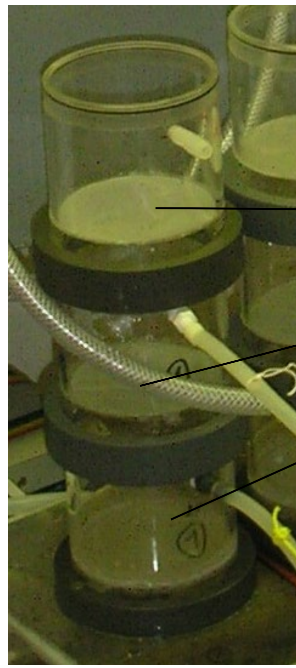
Phytoplankton Sampling (Discrete Monitoring)

Plankton net
Pore size 20 µm



Filter array

200 µm (zooplankton)

50 µm (big phytoplankton)

20 µm (small phytoplankton)

LC-MS/MS

6. Discrete vs. Integrated Monitoring

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SPATT = Solid Phase Adsorption Toxin Tracking (Integrated Monitoring)

- Water is pumped through a porous lipophilic resin (HP 20)
  → passively adsorbing dissolved toxins in the seawater
- Pros:
  - Time-integrating sampling
    → Toxin dynamics
  - Low-cost; easy sampling
    → Potential as an early warning system
- Cons:
  - Lack of calibration
  - Monitoring of dissolved toxins only
  → no information on the current plankton presence

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6. Discrete vs. Integrated Monitoring

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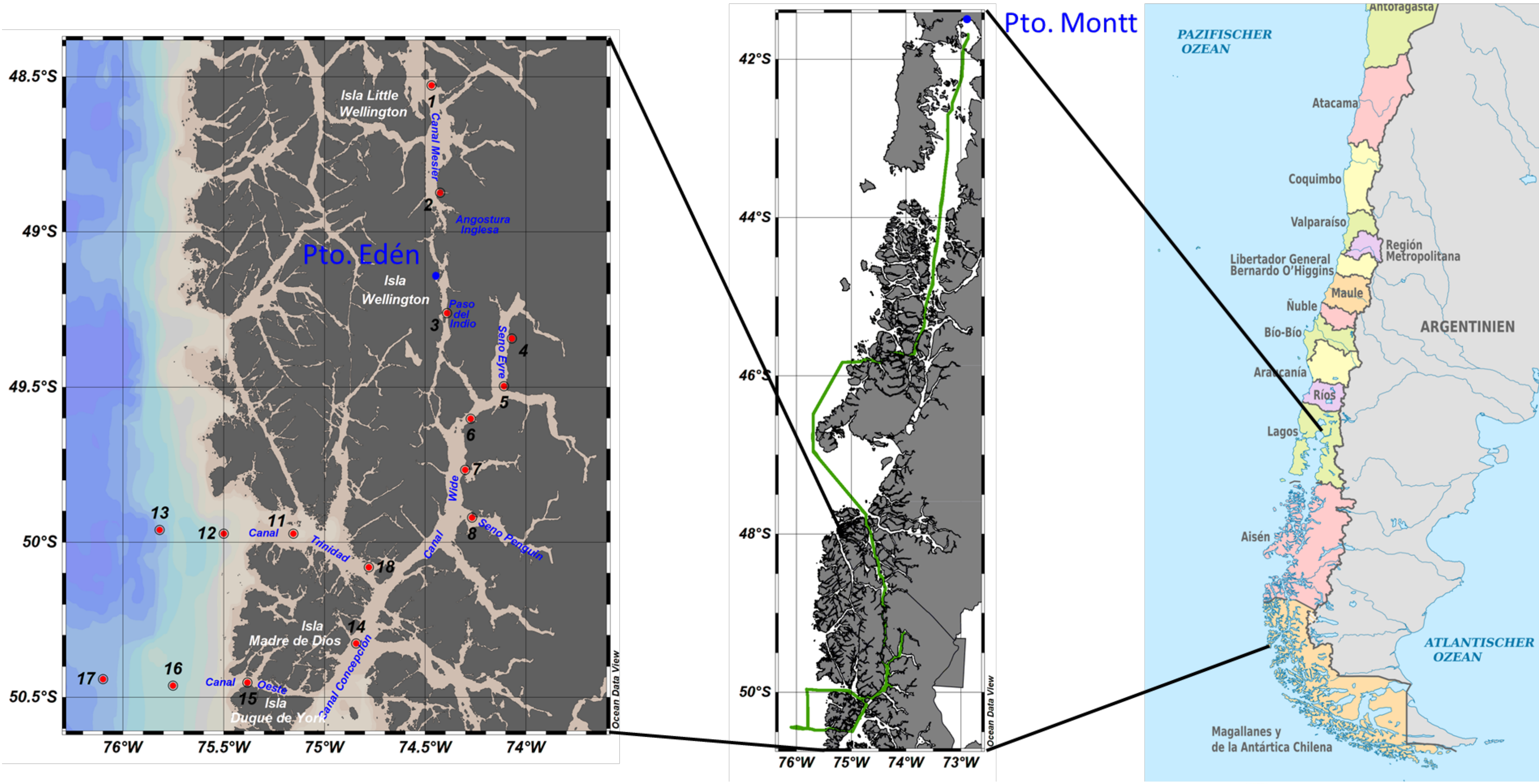
UND MEERESFORSCHUNG

PROFAN Expedition - Nov. 2019 - RV Cabo de Hornos



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6. Discrete vs. Integrated Monitoring

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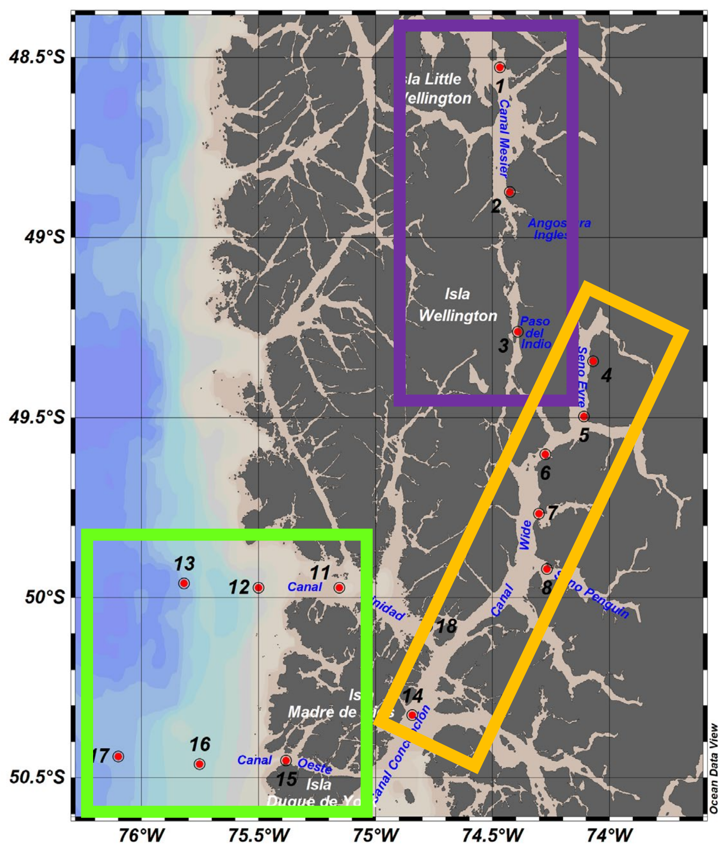
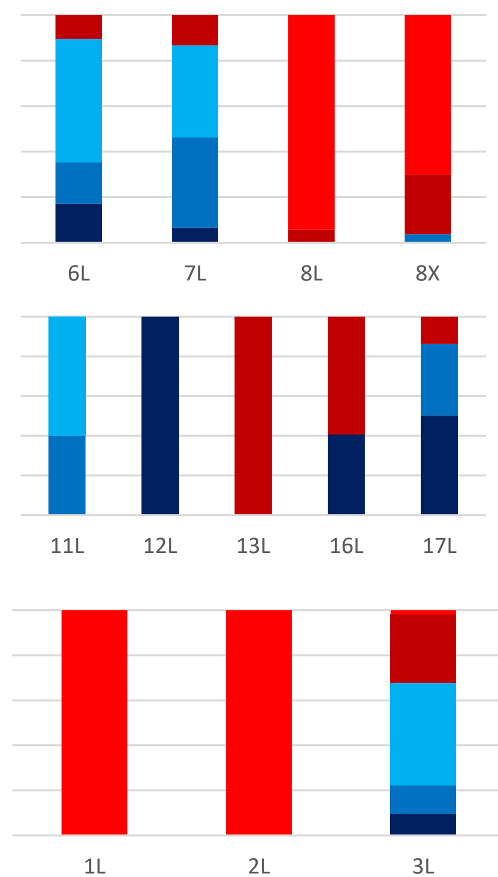
■ OA ■ DTX1 ■ YTX ■ homo-YTX ■ 45 OH Homo YTXs ■ PTX2 ■ PTX2sa



Discrete sampling (Stations)

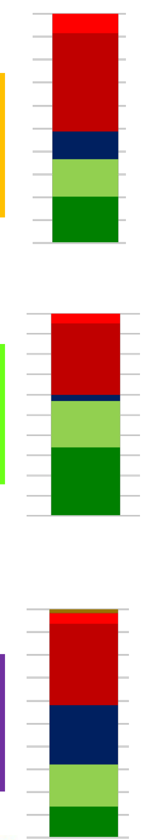


Integrated sampling (SPATTs)

Area 2

Area 3

Area 4



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6. Discrete vs. Integrated Monitoring

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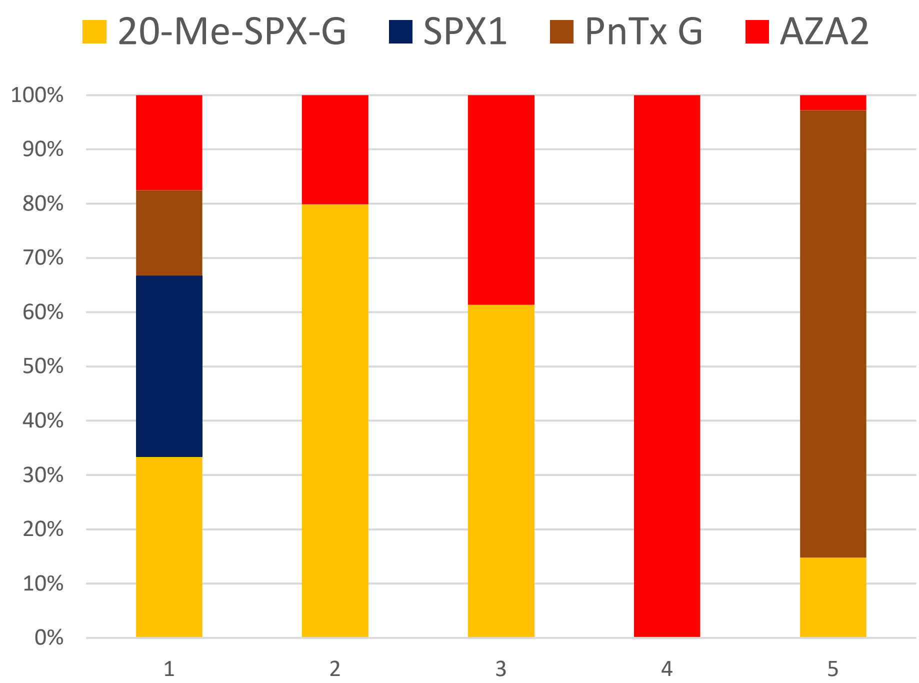
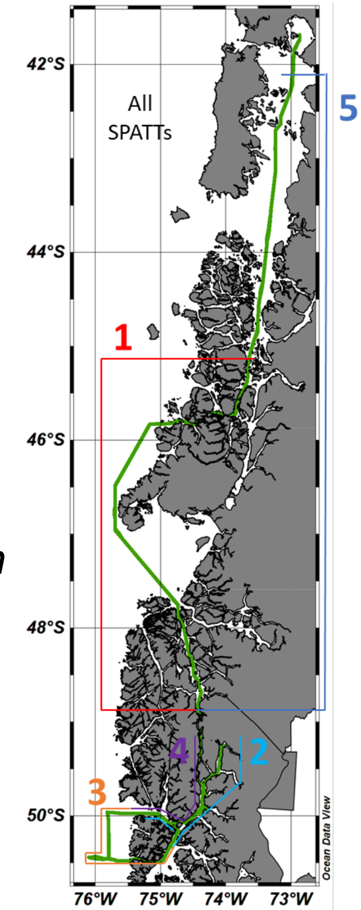
Integrated sampling (SPATTs)



20-Me-SPX-G, SPX1 (spirolides)
Alexandrium ostenfeldii

PnTx G (pinnatoxins)
Vulcanodinium rugosum

AZA2 (azaspiracids)
Azadinium poporum



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Conclusions

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UND MEERESFORSCHUNG

- Phycotoxin variability of known toxin classes is high and yet not fully explored
- Phycotoxin profiles are geographically very variable
- Phycotoxin profiles in a given area may change over time
- Ichthyotoxins are rarely characterized, but pose an increasing threat due to increasing aquacultural activities

- Toxins from planktonic origin are modified by vector organisms and futher augment chemical variabilty of toxins
- Regulated toxins do not reflect levels of actual toxin content

- Integrated phycotoxin sampling (SPATT) provides indirect, but complementary information on local occurrence of HAB species and phycotoxins

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Thanks for Your Attention!

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Any
Questions?
Scientific FjordFlux Crew in front of Cape Horn