Cyanobacterial toxins and cyanopeptide transformation kinetics by singlet oxygen and pH-dependence in sunlit surface waters

Regiane Natumi[1], Christoph Dieziger[1], Elisabeth M.-L. Janssen[1*]

[1] Department of Environmental Chemistry, Swiss Federal Institute of Aquatic Science and Technology (Eawag), 8600 Dübendorf, Switzerland

Electronic Supplementary Information

The electronic supplementary information contains 56 pages numbered S1-S56, 3 texts, 28 figures, and 9 tables.

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Text S1. Additional Materials

The following chemicals were purchased from Sigma-Aldrich/Merck AG: L-tyrosine (≥98%), calcium chloride dehydrate (≥99%), magnesium sulfate heptahydrate (≥99.5%), di-potassium hydrogen phosphate trihydrate (≥99%), potassium phosphate monobasic (≥99%), sodium acetate trihydrate (≥99.5%), sodium carbonate (≥99.9%), sodium nitrate (≥99%), ethylenediaminetetraacetic acid disodium salt dehydrate (≥99%), copper(II) sulfate pentahydrate (99-100.5%), boric acid (99.5-100.5%), TES buffer (≥99%, titration), sodium hydroxide (≥99%), acetic acid (99.8%) and formic acid (98-100%). Sodium bicarbonate (≥99.7%), cobalt (II) chloride hexahydrate (>98.5%) and sodium molybdate dehydrate (≥99.5%) were obtained from Fluka. Manganese (II) chloride tetrahydrate was purchased from Riedel-de-Haen. Methanol (MeOH, Optima®LC/MS 99.9%) and acetonitrile (≥99.99%) were obtained from Thermo Scientific. Nanopure water was obtained using a NANOpure®21 Barnstead from Thermo Fischer Scientific. Deuterium oxide (≥99.8 Atom%D) was purchased from ACROS Organics™. Furfuryl alcohol (>98%), perinaphthenone (>97%) and p-nitroanisole (>97%, recristalized) were purchased from Sigma-Aldrich and pyridine (≥99.9%) was purchased from Chromosolv. Argon (≥99.99%) was obtained from Alphagaz1.

Table S1. Composition of modified WC growth medium (Guillard et al 1972).

Components	Concentration (mg L^{-1})
$K_2HPO_4.3H_2O$	11.4
$NaNO_3$	85
$CaCl_2.2H_2O$	36.8
$MgSO_4.7H_2O$	37
$NaHCO_3$	12.6
Na_2EDTA	4.36
$FeCl_3.6H_2O$	3.15
$CuSO_4.5H_2O$	0.01
$ZnSO_4.7H_2O$	0.022
$CoCl_2.6H_2O$	0.01
$MnCl_2.4H_2O$	0.18
$Na_2MoO_4.2H_2O$	0.006
H_3BO_3	1.00
TES buffer	115

Guillard, R.R. and C.J. Lorenzen, Yellow-Green Algae with Chlorophyllide C. Journal of Phycology, 1972. 8(1): p. 10-&.

Text S2. Semi-preparative high performance liquid chromatography

Further purification of biomass extracts was performed by semi-preparative high performance liquid chromatography (HPLC) coupled to a UV-VIS/DAD detector (Dionex UltiMate3000 HPLC, Thermo Fischer Scientific). Chromatographic separation was carried out on a KINETEX® C18 column (5 µm, 150 x 4.6 mm, 100A, Phenomenex) with pre-column (VanGuard® Cartridge, Waters) and inline filter (BGB®). Column temperature was set to 40°C. The mobile phases consisted of (A) nanopure water and (B) methanol. Binary gradient elution was carried out at a flow rate of 1.2 mL min^{-1} and increasing eluent B from 20% to 95% between 0 to 25 min. The injection volume was 100 µL. Nine fractions were collected every two minutes from 6 min to 22 min with a fraction collector (FoxyJr, Conquer Scientific). Each individual fraction was then evaporated until dryness by vacuum-assisted evaporation (Syncore® Analyst R-12, BÜCHI Labortechnik AG, 40°C, 120 rpm, 20 mbar). The compounds were resuspended with 200 µL of EtOH/H_2O (70/30% v/v) and the final volume was adjusted gravimetrically to 1.0 mL in water. This cyanopeptide solution was kept at 4°C if used within 24 hours and otherwise at -20°C.

Table S2. Buffer composition for tyrosine and cyanopeptide test.

Buffer type	Measured pH/pD for tyrosine experiment	Buffer molarity (mM) for tyrosine experiment	Measured pH/pD for cyanopeptide experiment	Buffer molarity (mM) for cyanopeptide experiment
phosphate, H_2O	7.05	10	6.91	2
phosphate, H_2O	7.67	2	7.74	2
carbonate, H_2O	9.03	5	8.97	5
carbonate, H_2O	9.87	5	9.78	5
phosphate, H_2O	11.77	10	11.57	2
phosphate, D_2O	12.19	10	12.20	2

Table S3. **Mole fraction (*x*) of D_2O and H_2O** in photochemical steady-state experiments.

Experimental condition	***x*D_2O**	***x*H_2O**	**$[^1O_2]$ss**
Tyrosine, pD 12	0.93	0.07	1.66E-11
Cyanopeptides, pD 12	0.95	0.05	1.72E-11

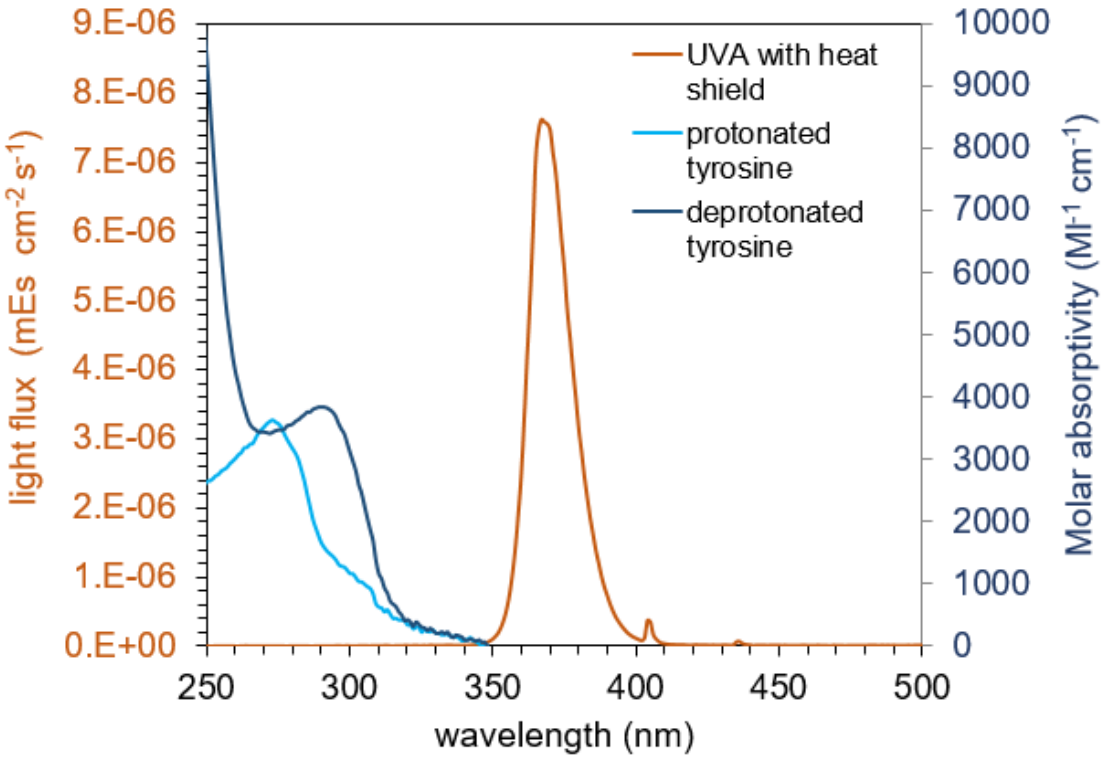


Figure S1. Light spectrum of UVA light of 2 bulbs, with polymer heat shield between the lamps and the samples to reduce heat transmission from the lamps (269 LEE Heat Shield, Lee Filters, Hampshire, UK) and molar absorptivity of deprotonated and protonated **tyrosine at pH 7.03 and pH 12.12**, respectively (secondary y-axis).

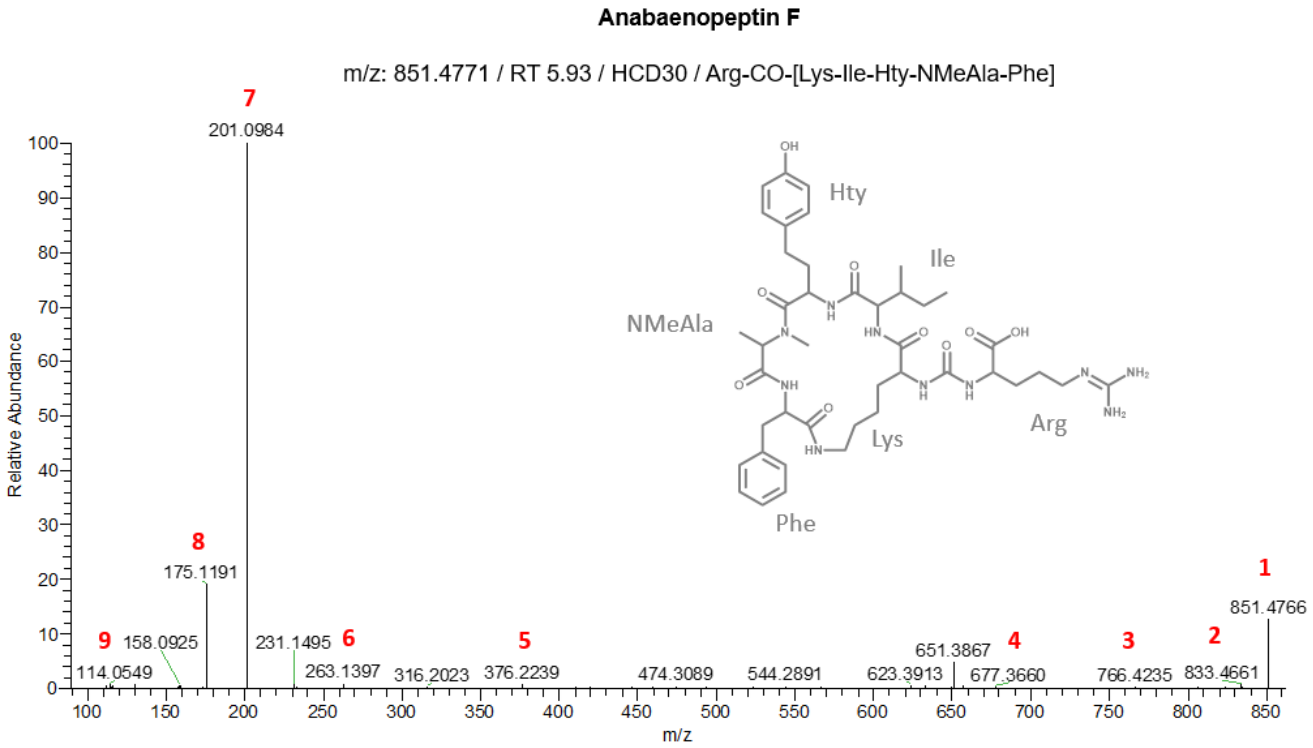
Text S3. Photon fluence rate

The photon fluence rate, I^0 (Es m^{-2} s^{-1}) between 290 and 400 nm of the solar simulator was assessed with the chemical actinometer para-nitroanisol and pyridine according to the following equation (Dulin and Mill 1982):

$$I^0_{290-400nm} = \frac{k_{obs,PNA}}{2.303 \cdot \phi_{PNA} \cdot \sum_{\lambda=290nm}^{400nm} (f_{p,\lambda} \cdot \varepsilon_{PNA,\lambda})}$$

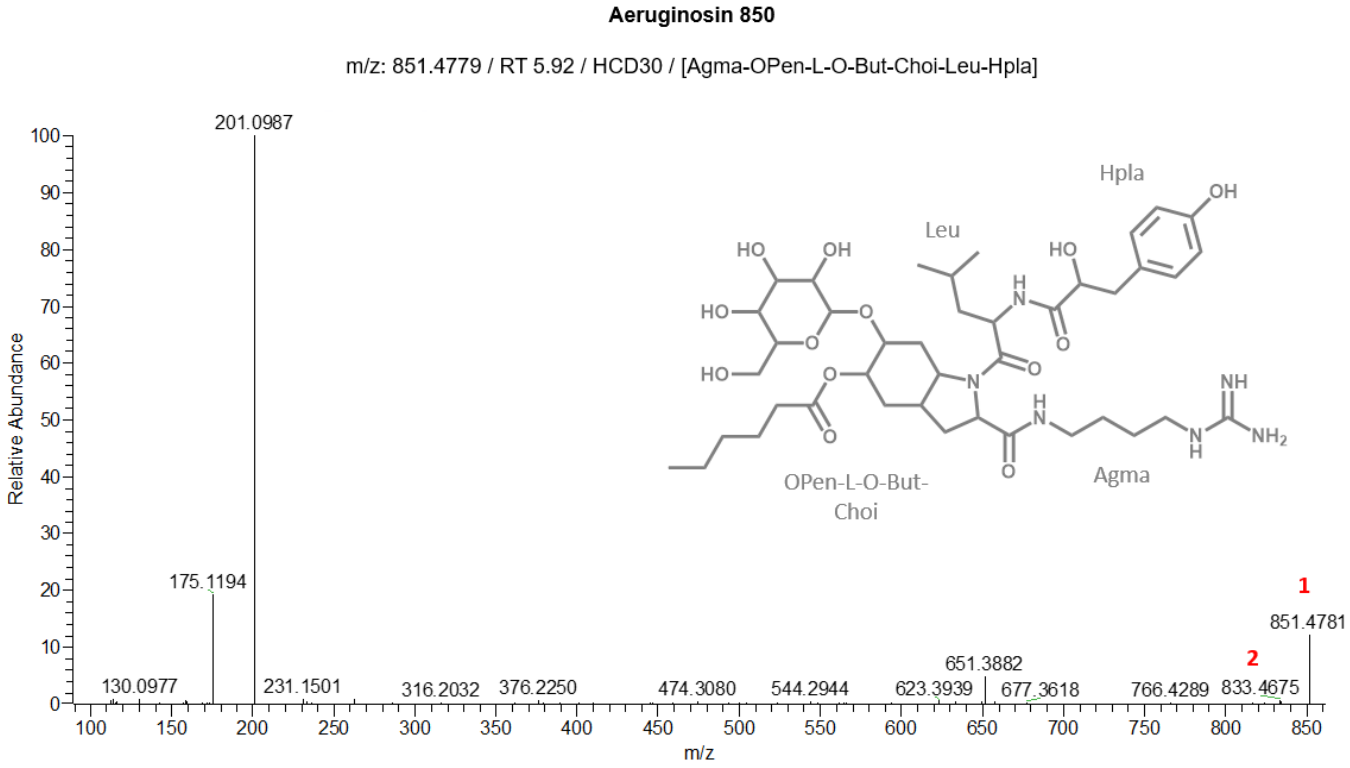
Where $k_{obs,PNA}$ is the observed rate constant of *para*-nitroanisole (PNA) (s^{-1}); Φ_{PNA} is the wavelength-independent quantum yield of the PNA in presence of pyridine (PYR; Φ = 0.44[Pyr] + 0.00028); $f_{p,\lambda}$ is the normalized emission spectrum of the light source at the wavelength λ (nm); and $\varepsilon_{PNA,\lambda}$ (m^2 mol^{-1}) is the molar absorption coefficient of PNA at λ.

Dulin, D. and T. Mill, Development and Evaluation of Sunlight Actinometers. Environmental Science & Technology, 1982. 16(11): p. 815-820.



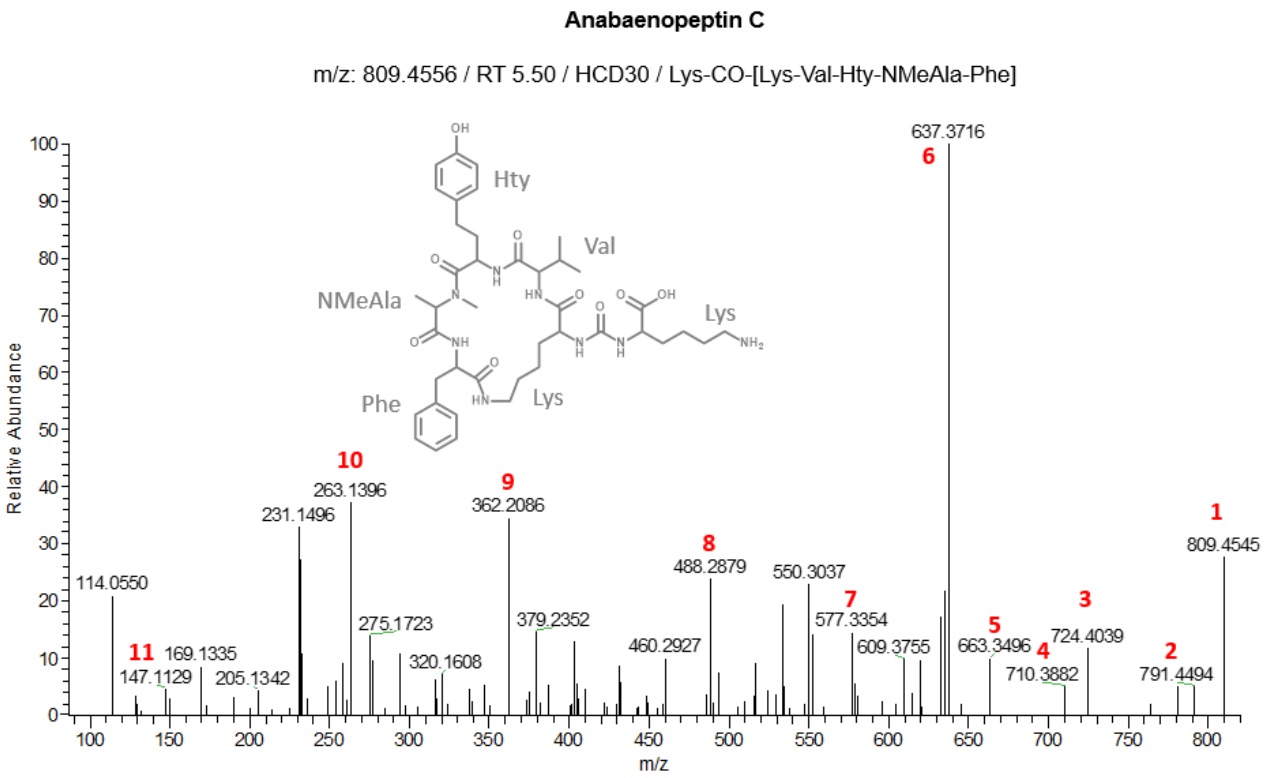
Fragment number	Calculated m/z	Peak m/z	Fragment
1	851.4774	851.4766	$[M + H]^+$
2	833.4671	833.4661	$[M – H_2O + H]^+$
3	766.4248	766.4235	$[M - NMeAla + H]^+$
4	677.3659	677.3660	$[M – Arg]^+$
5	376.2232	376.2239	$[NMeAla \mid Htyr \mid Ile + H]^+$
6	263.1391	263.1397	$[NMeAla \mid Htyr + H]^+$
7	201.0982	201.0984	$[Arg – CO + H]^+$
8	175.119	175.1191	$[Arg + 2H]^+$
9	114.0550	114.0549	$[NMeAla + CO + H]^+$

Figure S2. MS/MS annotation at HCD30 for Anabaenopeptin F.



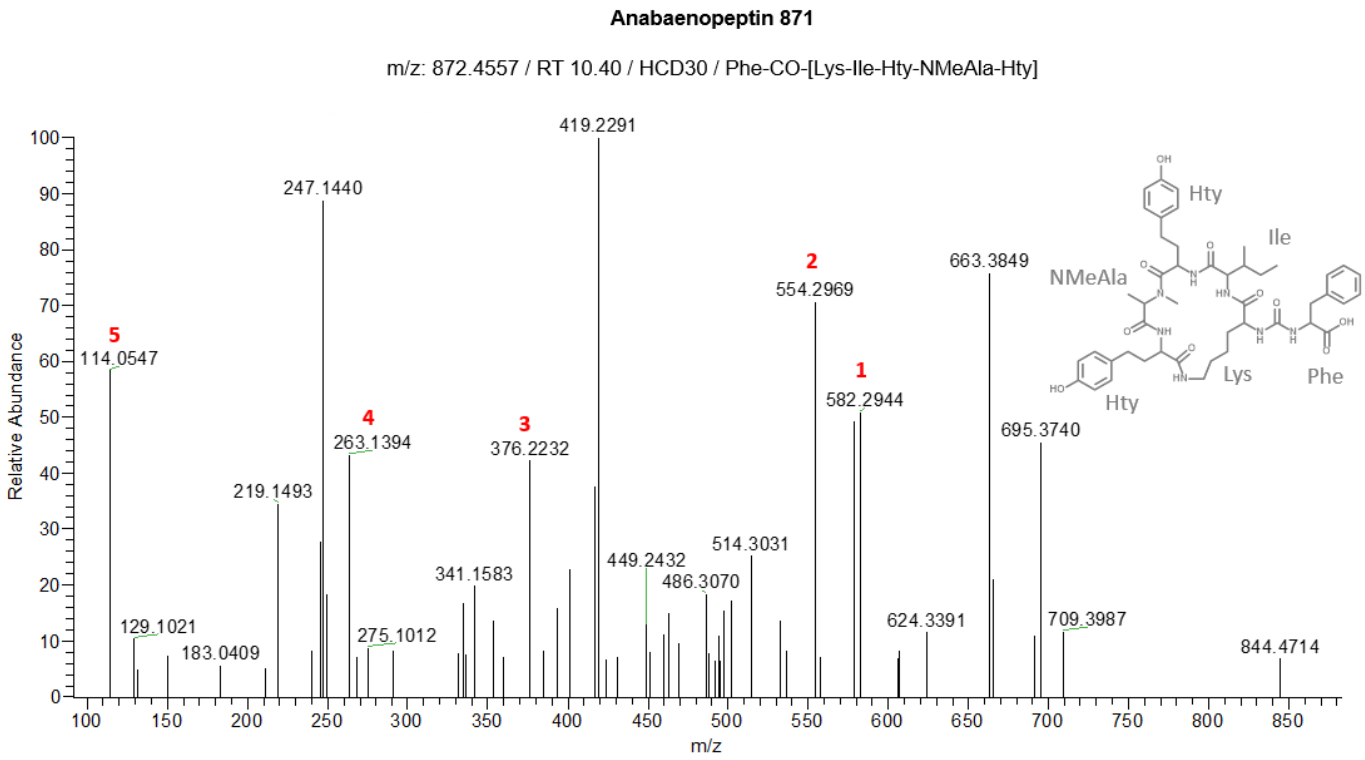
Fragment number	Calculated m/z	Peak m/z	Fragment
1	851.4761	851.4781	$[M + H]^+$
2	833.4657	833.4675	[Agma I OGluChoiHA I Leu – OH – NH3]$^+$

Figure S3. MS/MS annotation at HCD30 for compound with *m/z* 851.4779 and RT 5.92 and may correspond to either aeruginosin 850 (*m/z* 851.4761, $C_{41}H_{66}N_6O_{13}$) or anabaenopeptin F (*m/z* 851.4774, $C_{42}H_{62}N_{10}O_9$). The mass error of the parent ion for aeruginosin 850 is 1.5 ppm while it is only 0.1 ppm for anabaenopeptin F. The MS/MS fragments also shows a better match with anabaenopeptin F (compare Figure S2). The peaks at 201.0987 and 175.1194 are abundant and characteristic of an arginine moiety present in anabaenopeptin F but not representative of aeruginosin 850. By analyzing the mass error and the MS/MS fragments we conclude that this peak corresponds to anabaenopeptin F with level 2 identification confidence.



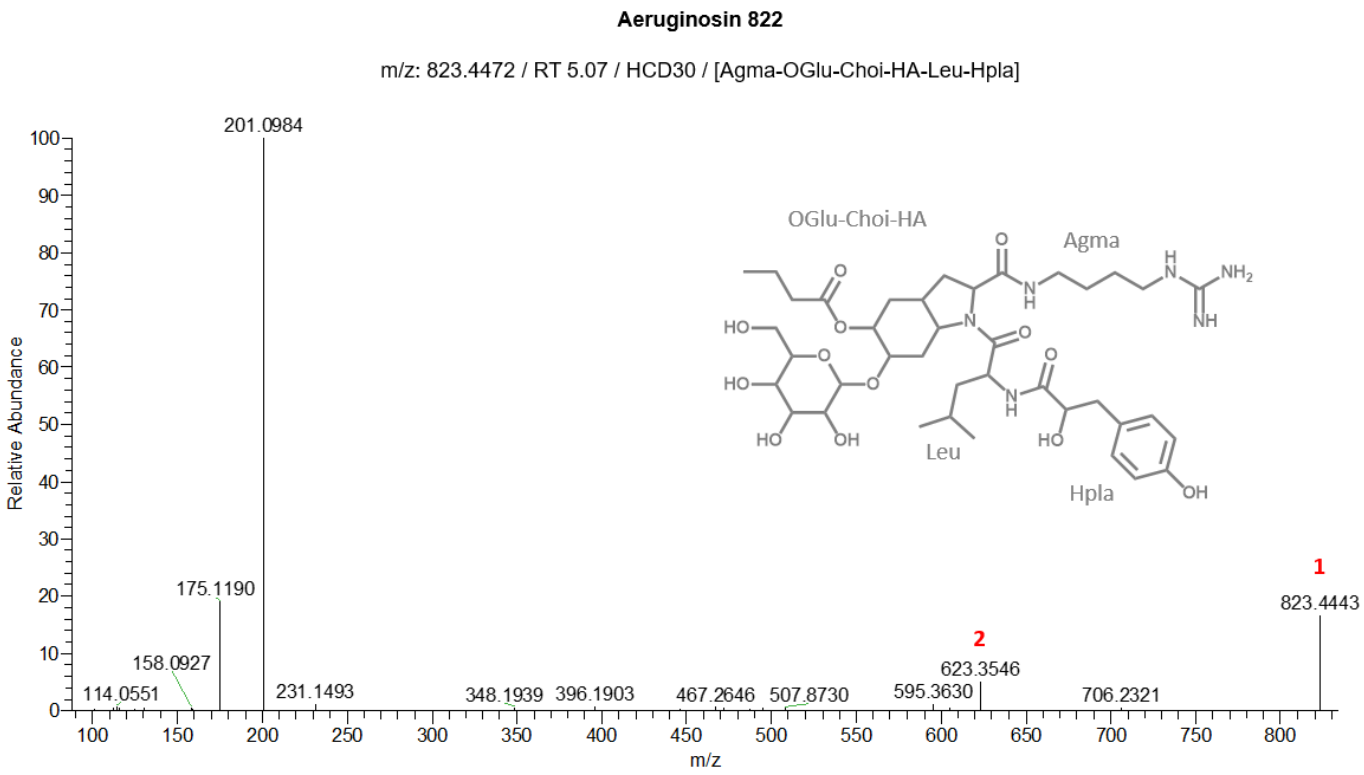
Fragment number	Calculated m/z	Peak m/z	Fragment
1	809.4556	809.4545	$[M + H]^+$
2	791.4453	791.4494	$[M - H_2O + H]^+$
3	724.4030	724.4039	[Hty | Val | Lys | CO | Lys | Phe + H]$^+$
4	710.3874	710.3882	[Lys | CO | Lys | Phe | NMeAla | Hty + H]$^+$
5	663.3502	663.3496	[Phe | NMeAla | Hty | Val | Lys | CO]$^+$
6	637.371	637.3716	[Lys | Phe | NMeAla | Hty | Val + 2H]$^+$
7	577.3346	577.3354	[Hty | Val | Lys | CO | Lys + H]$^+$
8	488.2869	488.2879	[Lys | Val | Hty | NMeAla]$^+$
9	362.2075	362.2086	[NMeAla | Hty | Val + H]$^+$
10	263.1391	263.1396	[NMeAla | Hty + H]$^+$
11	147.1129	147.1129	[Lys + H]$^+$

Figure S4. MS/MS annotation at HCD30 for Anabaenopeptin C.



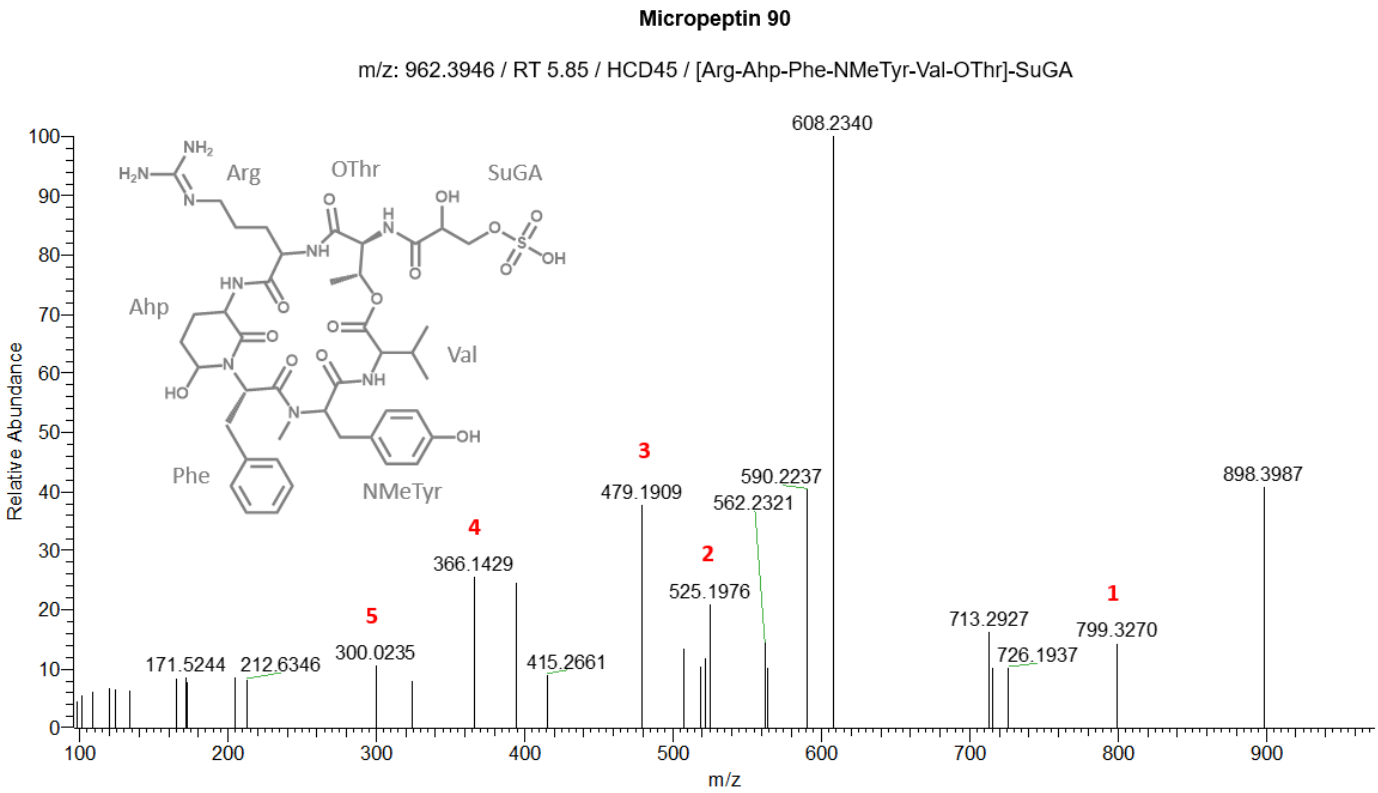
Fragment number	Calculated m/z	Peak m/z	Fragment
1	582.2924	582.2944	[Phe ǀ CO ǀ Lys ǀ Hty ǀ NMeAla + H]$^+$
2	554.2975	554.2969	[Phe ǀ CO ǀ Lys ǀ Hty ǀ NMeAla - CO + H]$^+$
3	376.2232	376.2232	[NMeAla ǀ Hty ǀ Ile + H]$^+$
4	263.1391	263.1394	[Hty ǀ NMeAla + H]$^+$
5	114.0550	114.0547	[MeAla + CO + H]$^+$

Figure S5. MS/MS annotation at HCD30 for Anabaenopeptin 871.



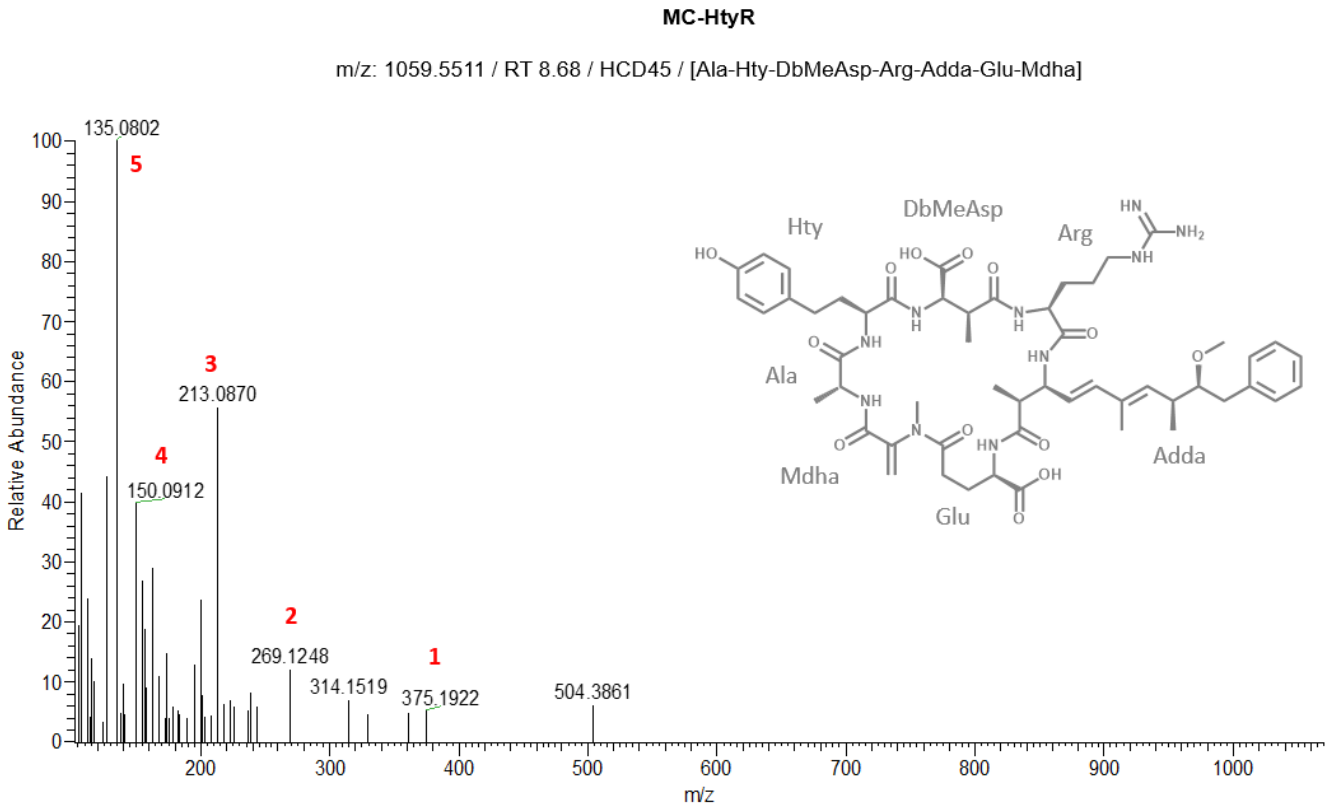
Fragment number	Calculated m/z	Peak m/z	Fragment
1	823.4448	823.4443	$[M + H]^+$
2	623.3527	623.3546	[Agma | OGluChoiHA | Leu – OH – NH3]$^+$

Figure S6. MS/MS annotation at HCD30 for compound with *m/z* 823.4472 and RT 5.07. Although the *m/z* of the precursor ion matches aeruginosin 822 ($C_{39}H_{62}N_6O_{13}$), by analyzing the MS/MS fragments we could confirm that the compound is not aeruginosin 822. The peaks at 201.0984 and 175.1190 are abundant and characteristic of an arginine moiety, which is not present in aeruginosin 822. We did not identify another cyanopeptide with this respective *m/z* in CyanoMetDB but suspect that this is a yet unidentified variant of an anabaenopeptin.



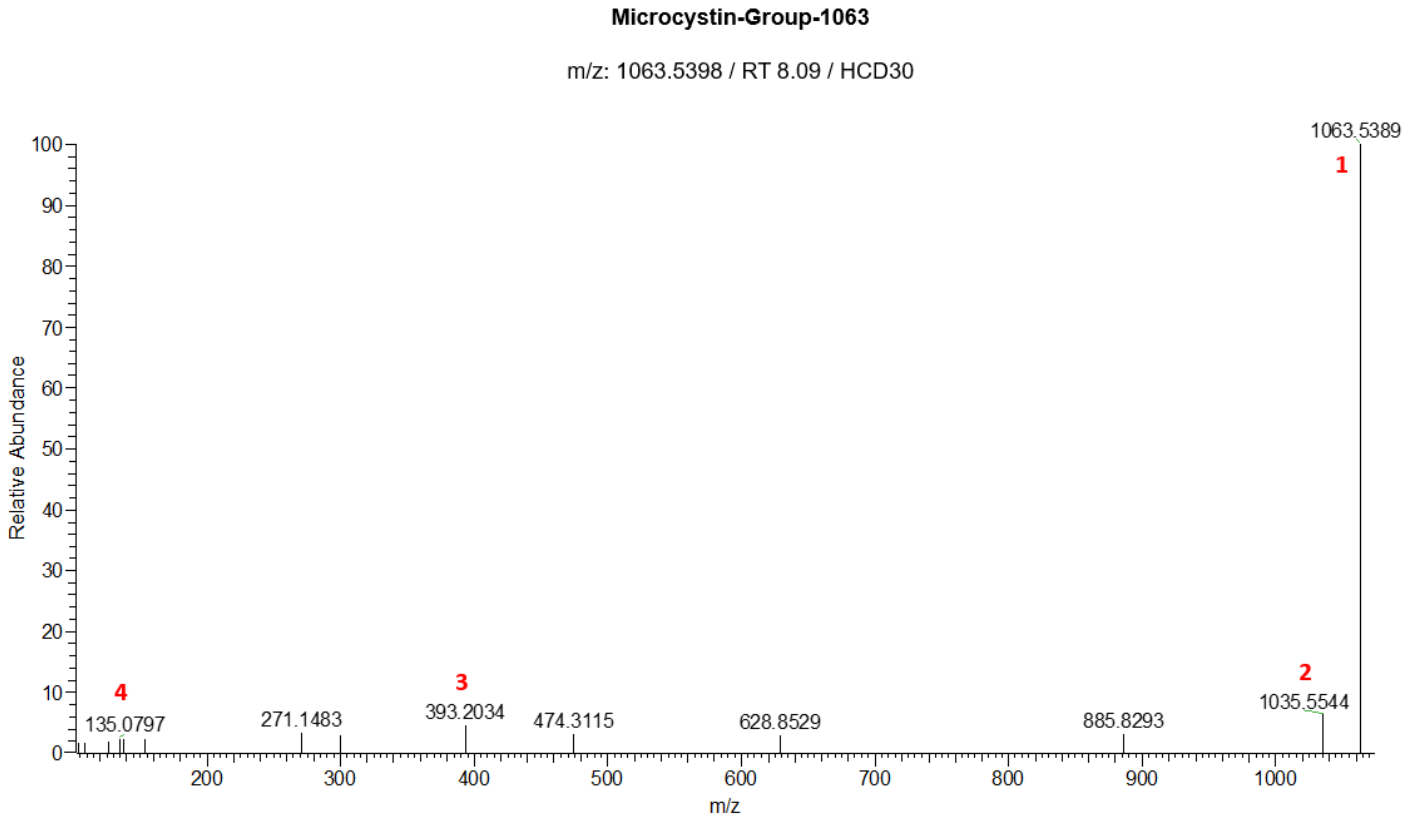
Fragment number	Calculated m/z	Peak m/z	Fragment
1	799.3292	799.3270	[Phe | Ahp | Arg | OThr | SuGA | Val + H]$^+$
2	525.1974	525.1976	[Arg | OThr | SuGA | Val + H]$^+$
3	479.1926	479.1909	[Ahp | Phe | NMeTyr – H]$^+$
4	366.1449	366.1429	[Phe | NMeTyr + NH + CO]$^+$
5	300.0258	300.0235	[OThr | SuGA + CO + H]$^+$

Figure S7. MS/MS annotation at HCD30 for Micropeptin 90.



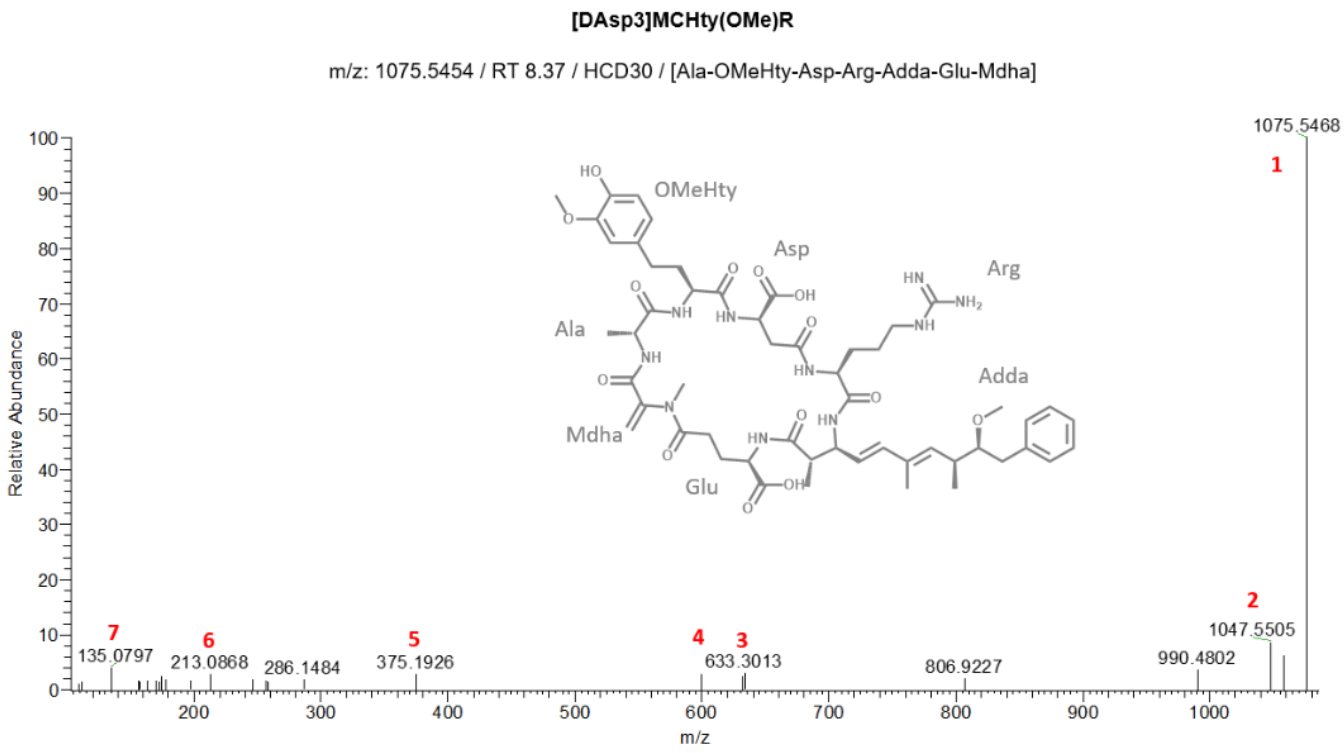
Fragment number	Calculated m/z	Peak m/z	Fragment
1	375.1915	375.1922	[Mdha | Glu | Adda - Addamoiety]$^+$
2	269.1245	269.1248	[DbMeAsp | Arg - H]$^+$
3	213.0870	213.0870	[Mdha | Glu + H]$^+$
4	150.0914	150.0912	[Hty - OH + H]$^+$
5	135.0805	135.0802	[Addamoiety]$^+$

Figure S8. MS/MS annotation at HCD30 for MC-HtyR. This compound belonged to an isobaric group.



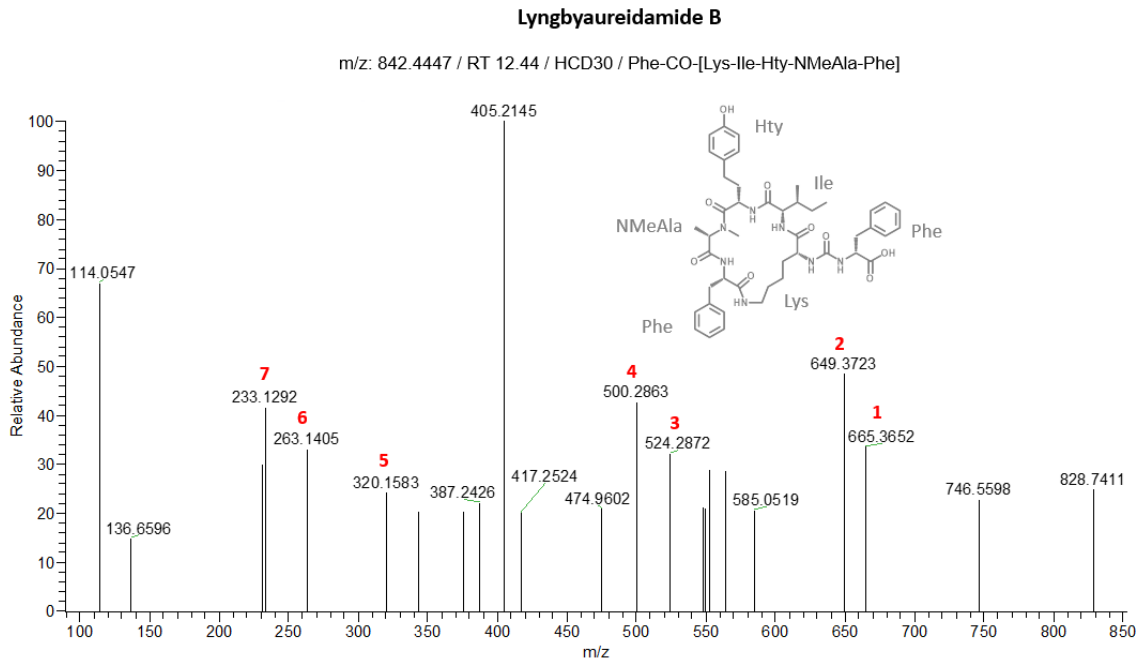
Fragment number	Calculated m/z	Peak m/z	Fragment
1		1063.5389	$[M + H]^+$
2		1035.5544	$[M - CO + H]^+$
3		393.2034	[Adda – Addamoiety – NH I Glu INMeSer]$^+$
4		135.0797	[Addamoiety]$^+$

Figure S9. MS/MS annotation at HCD30 for Microcystin-Group-1063. From the possible microcystins of the group due to the identified fragments, it could be the following compounds [NMeSer7]MCYR, [DAsp3, NMeSer7]MCHtyR, [NMeSer7]MCRY, [DAsp3, NMeSer7]MCYHar.



Fragment number	Calculated m/z	Peak m/z	Fragment
1		1075.5468	$[M + H]^+$
2		1047.5505	$[M - CO + H]^+$
3		633.3013	[Arg | Asp | OMeHty | Ala | Mdha + H]$^+$
4		599.3550	[Arg | Adda | Glu + H]$^+$
5		375.1926	[Mdha | Glu | Adda – Addamoiety – NH]$^+$
6		213.0868	[Glu | Mdha + H]$^+$
7		135.0797	[Addamoiety]$^+$

Figure S10. MS/MS annotation at HCD30 for [DAsp3]MCHty(OMe)R. This compound belonged to an isobaric group.



Fragment number	Calculated m/z	Peak m/z	Fragment
1	665.3659	665.3652	$[M - Hty + H]^+$
2	649.371	649.3723	$[M - CO - Phe]^+$
3	524.2869	524.2872	$[M - Ile - Hty + H]^+$
4	500.2869	500.2863	$[M - Phe - Hty]^+$
5	320.1606	320.1583	$[Phe \mid CO \mid Lys + H]^+$
6	263.1391	263.1405	$[Hty \mid NMeAla + H]^+$
7	233.1285	233.1291	$[NMeAla \mid Phe + H]^+$

Figure S11. MS/MS annotation at HCD30 for Lyngbyaureidamide B. This compound belonged to an isobaric group.

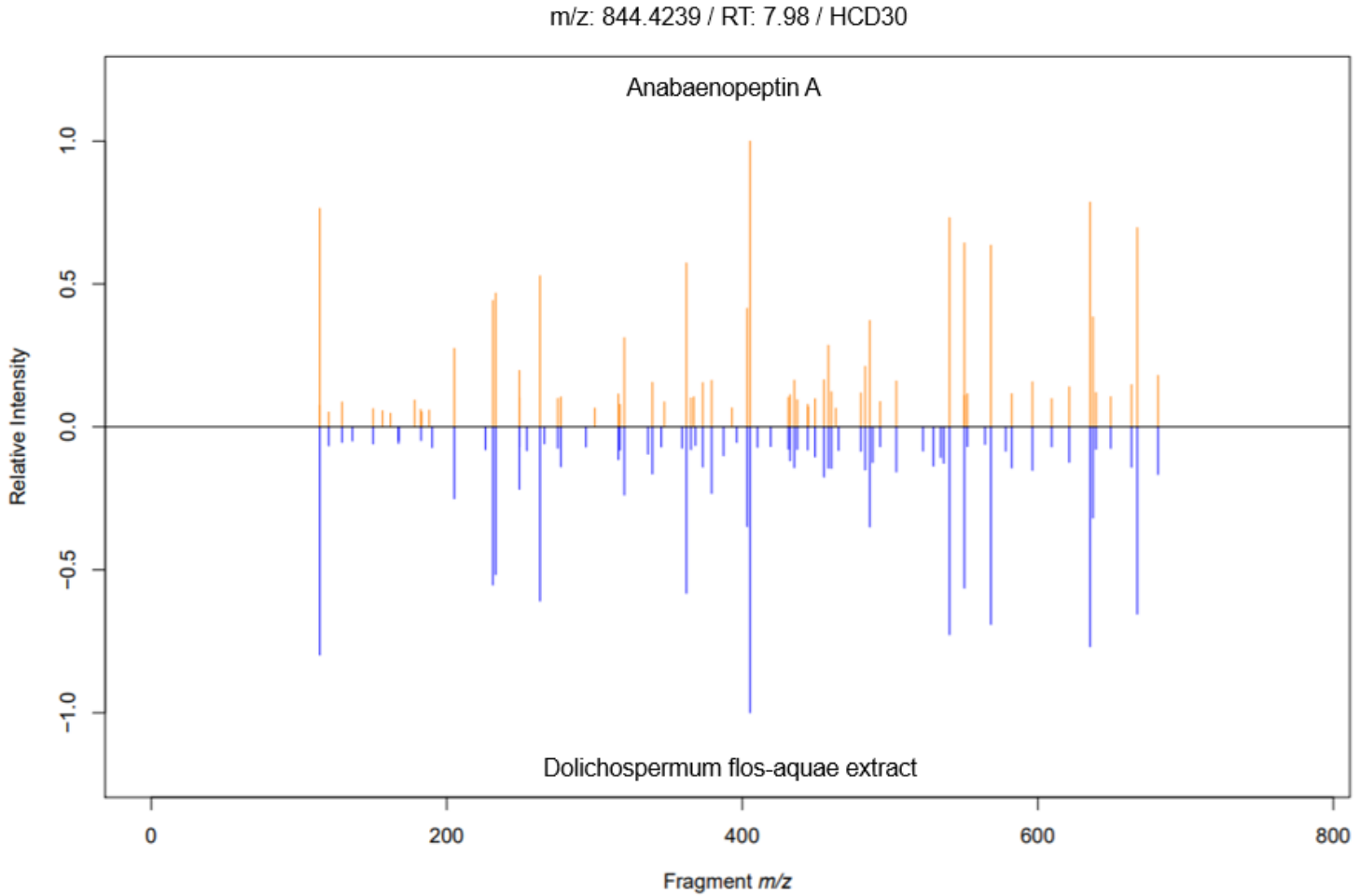


Figure S12. Comparison of relative intensity over *m/z* range for mass spectrometry fragmentation spectra between Anabaenopeptin A bioreagent (top, orange) and *Dolichospermum flos aquae* extract (bottom, blue) as head to tail plots. The *m/z* value, the retention time (RT in min) and the HCD collision energy are noted in the title line.

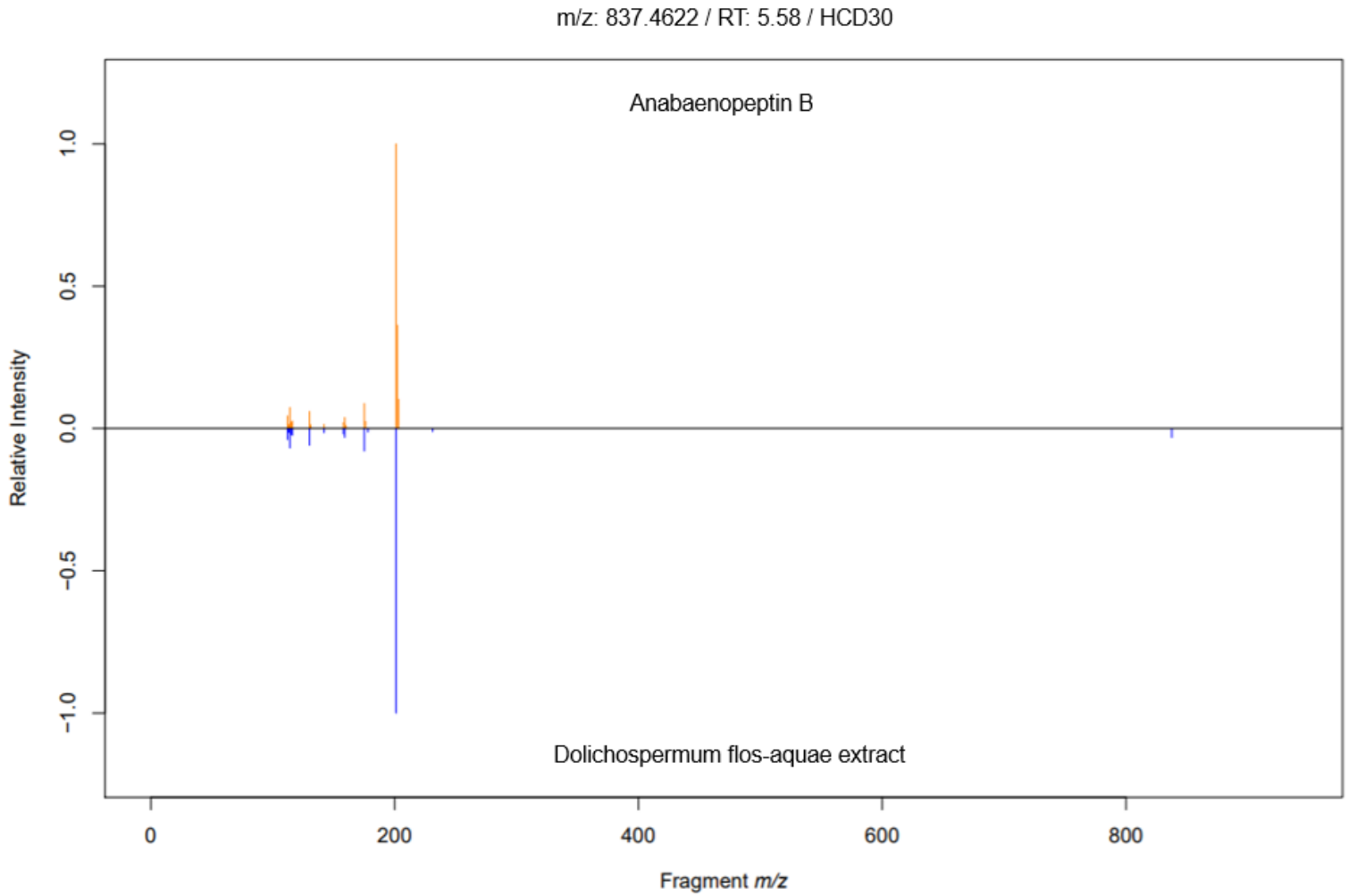


Figure S13. Comparison of relative intensity over *m/z* range for mass spectrometry fragmentation spectra between Anabaenopeptin B bioreagent (top, orange) and *Dolichospermum flos aquae* extract (bottom, blue) as head to tail plots. The *m/z* value, the retention time (RT in min) and the HCD collision energy are noted in the title line.

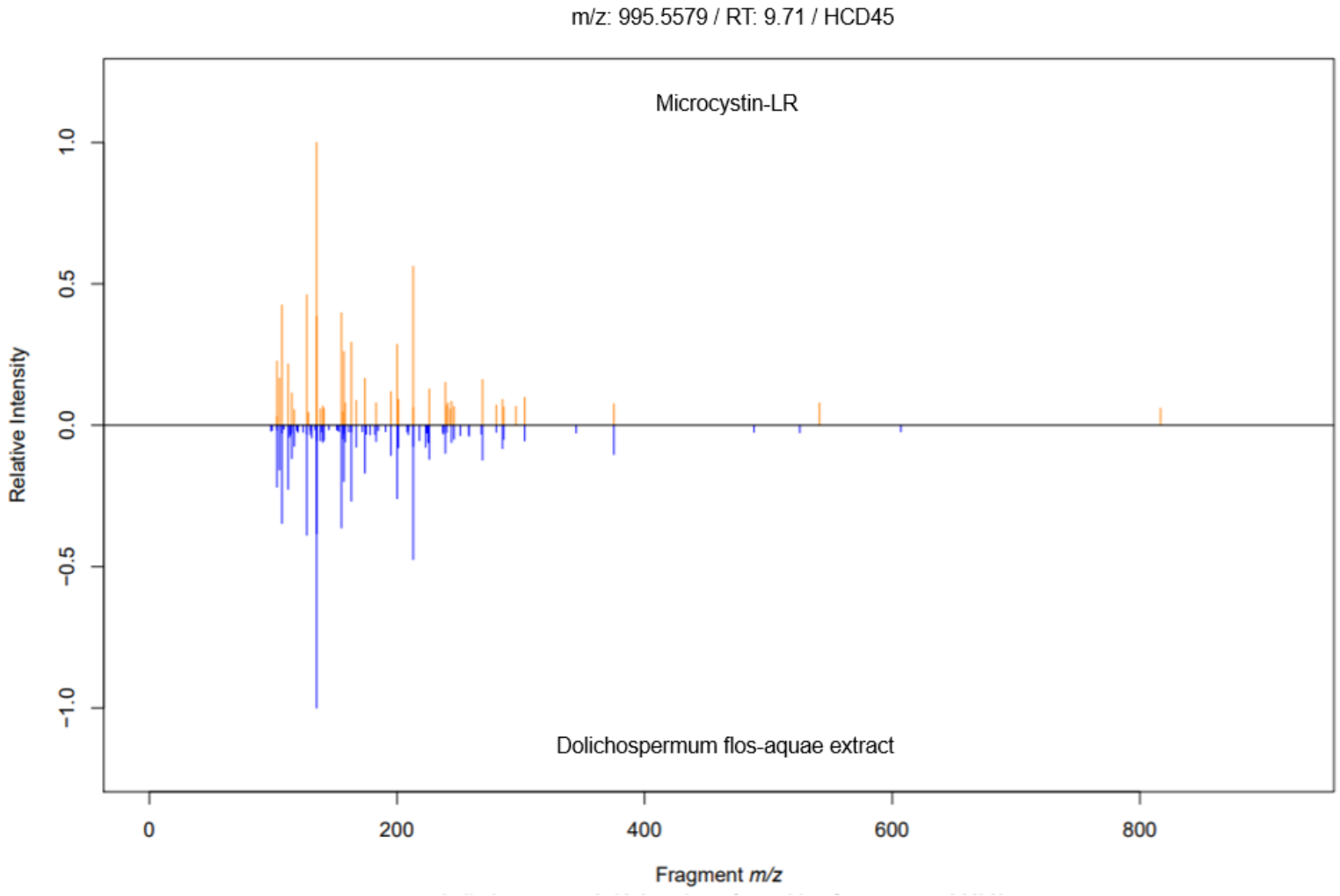


Figure S14. Comparison of relative intensity over *m/z* range for mass spectrometry fragmentation spectra between Microcystin-LR standard (top, orange) and *Dolichospermum flos aquae* extract (bottom, blue) as head to tail plots. The *m/z* value, the retention time (RT in min) and the HCD collision energy are noted in the title line.

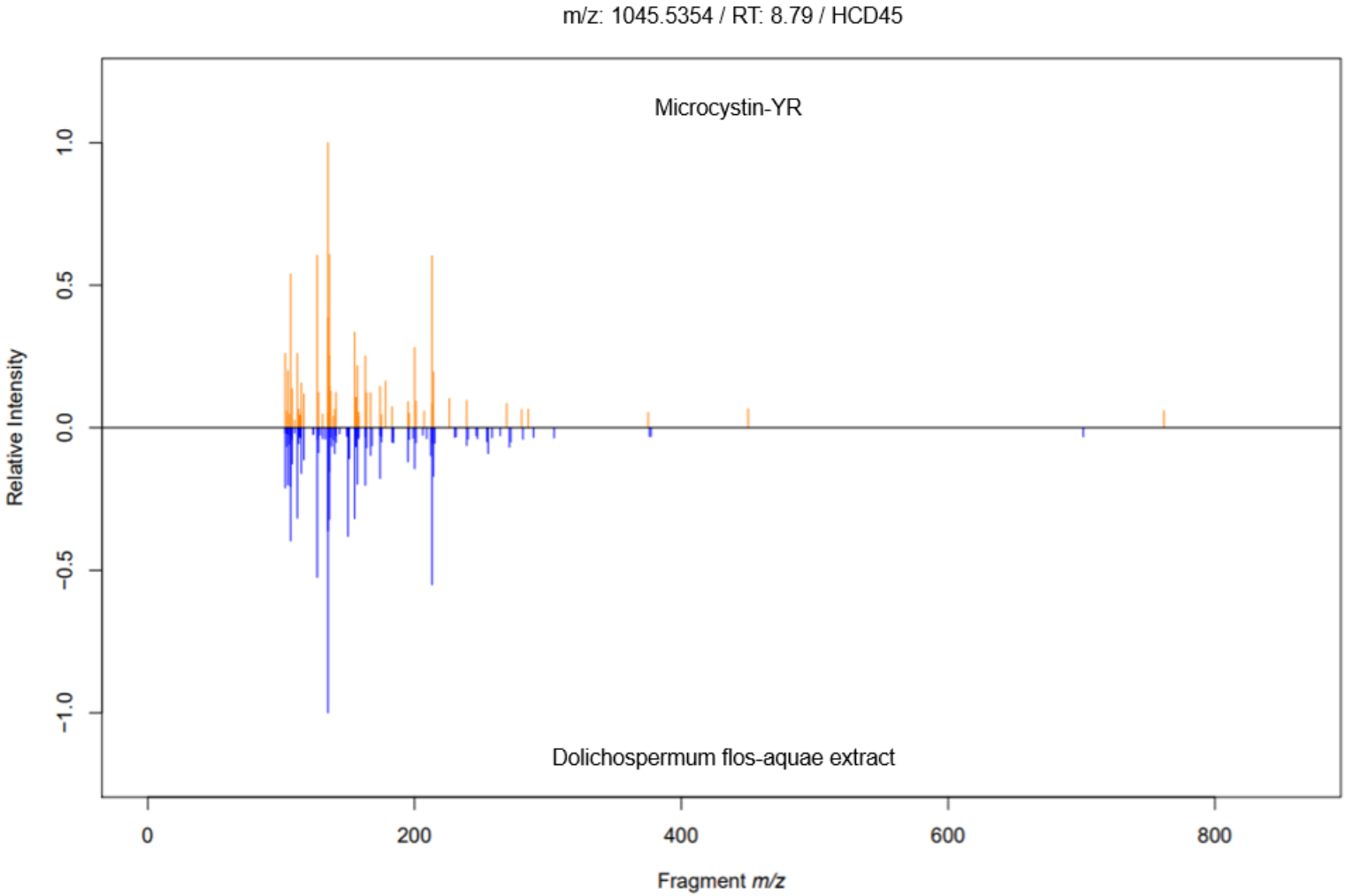


Figure S15. Comparison of relative intensity over *m/z* range for mass spectrometry fragmentation spectra between Microcystin-YR standard (top, orange) and *Dolichospermum flos aquae* extract (bottom, blue) as head to tail plots. The *m/z* value, the retention time (RT in min) and the HCD collision energy are noted in the title line.

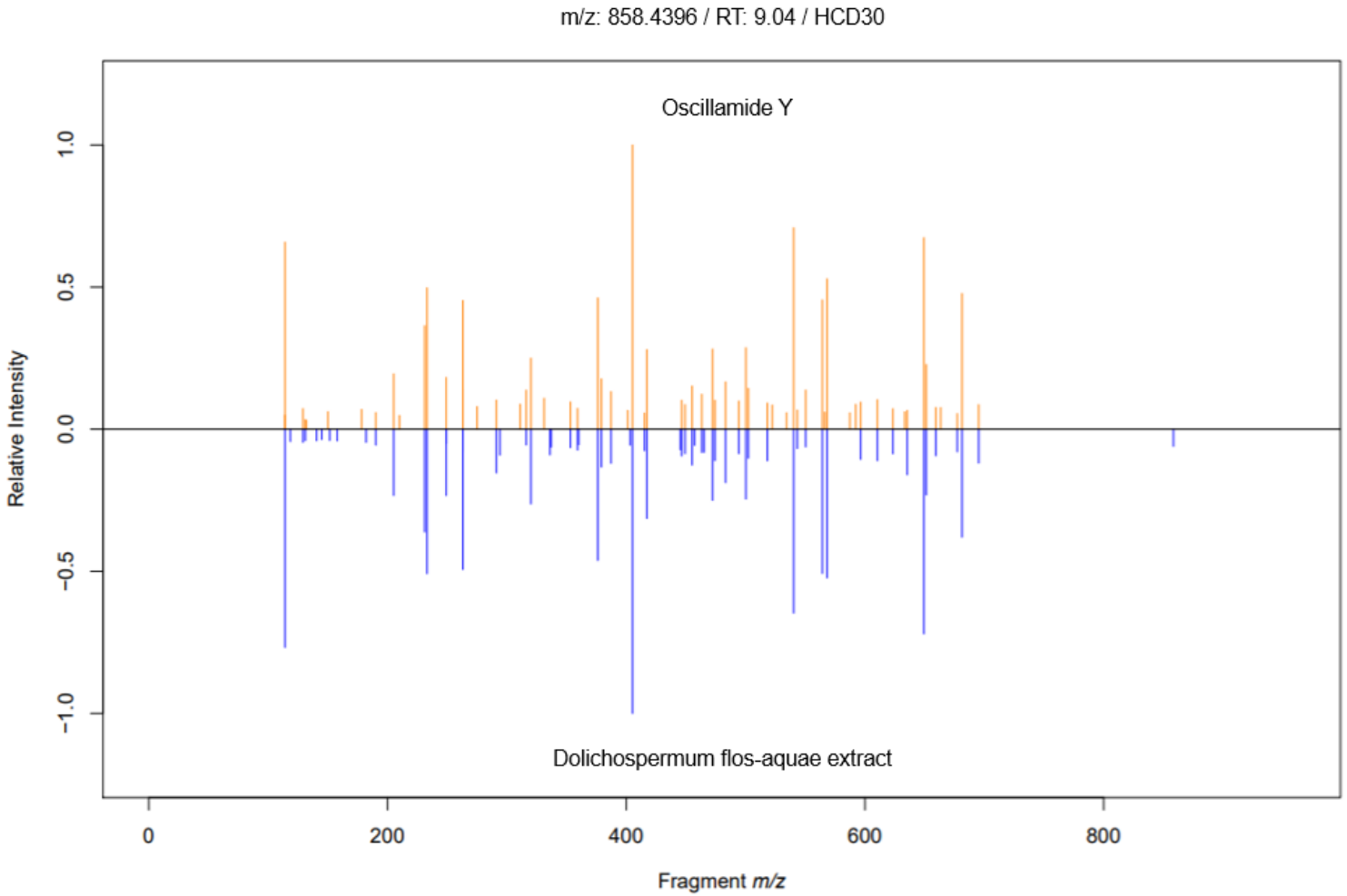


Figure S16. Comparison of relative intensity over *m/z* range for mass spectrometry fragmentation spectra between Oscillamide Y bioreagent (top, orange) and *Dolichospermum flos aquae* extract (bottom, blue) as head to tail plots. The *m/z* value, the retention time (RT in min) and the HCD collision energy are noted in the title line.

Table S4. Standard analytical information including: limit of detection (LOD) and limit of quantification (LOQ) for the reference standards and bioreagents for the data obtaind from the calibrations analysed along with data of the *D. flos aquae* profile and photochemical experiments with varying pH.

Experiment:	***D. flos aquae* profile**		**pH experiment**	
Cyanopeptide	**LOD (µg L^{-1})**	**LOQ (µg L^{-1})**	**LOD (µg L^{-1})**	**LOQ (µg L^{-1})**
Nodularin	0.57	1.89	0.68	2.28
MC-LY	0.42	1.41	0.48	1.62
MC-LR	0.29	0.96	0.66	2.20
MC-LF	0.70	2.34	0.76	2.54
MC-LA	0.34	1.13	0.61	2.02
MC-LW	0.37	1.23	0.64	2.15
MC-YR	0.45	1.50	0.77	2.58
MC-RR	0.30	1.01	0.71	2.36
[D-Asp^3,E-Dhb^7]-MCRR	0.34	1.13	0.65	2.17
Oscillamide Y	1.47	4.92	1.53	5.09
Anabaenopeptin A	0.37	1.23	0.55	1.84
Anabaenopeptin B	1.14	3.82	0.84	2.81
Aerucyclamide A	0.67	2.24	0.56	1.86
Aeruginosin 98B	0.76	2.53	2.97	9.89
Cyanopeptolin A	0.86	2.87	0.67	2.23
Cyanopeptolin D	0.86	2.88	0.84	2.79

Table S5. List of compounds and respective bioreagent or reference standard used for quantification as class equivalents by external calibration curves.

	Compound name	Chemical formula	Standard/bioreagent used to calculate class-equivalents
1	Bistratamide G	$C_{25}H_{32}N_6O_5S$	Aerucyclamide A
2	Bistratamide A	$C_{27}H_{34}N_6O_4S_2$	Aerucyclamide A
3	Spumigin G	$C_{31}H_{42}N_6O_6$	Aeruginosin 98B
4	Dysinosin C	$C_{25}H_{42}N_6O_{10}S$	Aeruginosin 98B
5	Dysinosin A	$C_{26}H_{44}N_6O_{10}S$	Aeruginosin 98B
6	Aeruginosin 103A	$C_{35}H_{48}N_6O_8$	Aeruginosin 98B
7	Aeruginosin 865	$C_{41}H_{64}N_6O_{14}$	Aeruginosin 98B
8	Aeruginosin-Group-878	$C_{42}H_{66}N_6O_{14}$	Aeruginosin 98B
9	Aeruginosin 892	$C_{43}H_{68}N_6O_{14}$	Aeruginosin 98B
10	Microginin 527 methyl ester	$C_{26}H_{43}N_3O_7S$	Aeruginosin 98B
11	Anabaenopeptin C	$C_{41}H_{60}N_8O_9$	Anabaenopeptin B
12	Anabaenopeptin 820	$C_{41}H_{60}N_{10}O_8$	Anabaenopeptin B
13	Anabaenopeptin D	$C_{44}H_{57}N_7O_9$	Anabaenopeptin A
14	Anabaenopeptin B	$C_{41}H_{60}N_{10}O_9$	Anabaenopeptin B
15	Nodulapeptin 839	$C_{42}H_{61}N_7O_9S$	Anabaenopeptin A
16	Lyngbyaureidamide B	$C_{45}H_{59}N_7O_9$	Oscillamide Y
17	Anabaenopeptin A	$C_{44}H_{57}N_7O_{10}$	Anabaenopeptin A
18	Anabaenopeptin F	$C_{42}H_{62}N_{10}O_9$	Anabaenopeptin B
19	Oscillamide Y	$C_{45}H_{59}N_7O_{10}$	Oscillamide Y
20	Anabaenopeptin 863	$C_{45}H_{66}N_8O_9$	Anabaenopeptin B
21	Anabaenopeptin KT864	$C_{43}H_{64}N_{10}O_9$	Anabaenopeptin B
22	Nodulapeptin 867	$C_{44}H_{65}N_7O_9S$	Anabaenopeptin A
23	Anabaenopeptin 871	$C_{46}H_{61}N_7O_{10}$	Oscillamide Y
24	Ferintoic acid B	$C_{47}H_{60}N_8O_9$	Oscillamide Y
25	Anabaenopeptin MM913	$C_{49}H_{67}N_7O_{10}$	Oscillamide Y
26	Micropeptin 90	$C_{42}H_{59}N_9O_{15}S$	Cyanopeptolin A
27	Anabaenopeptilide 90B	$C_{45}H_{61}ClN_8O_{14}$	Cyanopeptolin A
28	Micropeptin LH1021	$C_{50}H_{71}N_9O_{14}$	Cyanopeptolin A
29	A90720A	$C_{45}H_{72}N_{10}O_{16}S$	Cyanopeptolin A
30	Microcystin-Group-924	$C_{47}H_{69}N_7O_{12}$	MC-LA
31	Microcystin-Group-938	$C_{48}H_{71}N_7O_{12}$	MC-LA
32	Microcystin-Group-967	$C_{47}H_{70}N_{10}O_{12}$	MC-LR
33	Microcystin-Group-981	$C_{48}H_{72}N_{10}O_{12}$	MC-LR
34	[D-Asp^3,L-Ser^7]MC-LR	$C_{47}H_{72}N_{10}O_{13}$	MC-LR
35	MC-KynA	$C_{50}H_{66}N_8O_{13}$	MC-LW
36	MC-LR	$C_{49}H_{74}N_{10}O_{12}$	MC-LR
37	[D-Asp^3]MC-MR	$C_{47}H_{70}N_{10}O_{12}S$	MC-LR
38	Microcystin-Group-999.55	$C_{48}H_{74}N_{10}O_{13}$	MC-LR
39	[D-Asp^3,Dha^7]MC-FR	$C_{50}H_{68}N_{10}O_{12}$	MC-LR
40	Microcystin-Group-1009	$C_{50}H_{76}N_{10}O_{12}$	MC-LR
41	Microcystin-Group-1011	$C_{48}H_{70}N_{10}O_{14}$	MC-LR
42	[epoxyAdda^5]MC-LR	$C_{49}H_{74}N_{10}O_{13}$	MC-LR

43	Microcystin-Group-1013.51	$C_{48}H_{72}N_{10}O_{12}S$	MC-LR
44	Microcystin-Group-1013.56	$C_{49}H_{76}N_{10}O_{13}$	MC-LR
45	[D-Asp³]MC-M(O)R	$C_{47}H_{70}N_{10}O_{13}S$	MC-LR
46	Microcystin-Group-1015	$C_{51}H_{70}N_{10}O_{12}$	MC-LR
47	[D-Asp^3,ADMAdda^5,Thr^7]MC-LR	$C_{49}H_{74}N_{10}O_{14}$	MC-LR
48	[seco-1/2]MC-HilR	$C_{50}H_{78}N_{10}O_{13}$	MC-LR
49	MC-M(O)R	$C_{48}H_{72}N_{10}O_{13}S$	MC-LR
50	Microcystin-Group-1029	$C_{52}H_{72}N_{10}O_{12}$	MC-LR
51	[D-Asp³]MC-M(O2)R	$C_{47}H_{70}N_{10}O_{14}S$	MC-LR
52	Microcystin-Group-1031	$C_{51}H_{70}N_{10}O_{13}$	MC-YR
53	[D-Asp^3]MC-(H2)YR	$C_{51}H_{72}N_{10}O_{13}$	MC-YR
54	Microcystin-Group-1043	$C_{53}H_{74}N_{10}O_{12}$	MC-YR
55	MC-YR	$C_{52}H_{72}N_{10}O_{13}$	MC-YR
56	Microcystin-Group-1049	$C_{51}H_{72}N_{10}O_{14}$	MC-YR
57	MC-HtyR	$C_{53}H_{74}N_{10}O_{13}$	MC-YR
58	Microcystin-Group-1063	$C_{52}H_{74}N_{10}O_{14}$	MC-YR
59	MC-NMeHtyR	$C_{54}H_{76}N_{10}O_{13}$	MC-YR
60	[DAsp^3]MCHty(OMe)R	$C_{53}H_{74}N_{10}O_{14}$	MC-YR
61	Microcystin-Group-1077	$C_{53}H_{76}N_{10}O_{14}$	MC-YR

Table S6. List of all tentatively identified cyanopeptides in cell extracts of *Dolichopermum flos aquae*. Only the peptides that could be classified as tentative candidate (level 3), probable structure (level 2) or confirmed structure (level 1) are reported. Cyanopeptide references can be found at CyanometDB (Jones et al 2020) Only compounds above LOQ are reported. Photolabile amino acids are highlited in red.

Cyanopeptide	Cyanopeptide class	Molecular formula	m/z	Confidence Level	Amino acid building block
Aeruginosin 103A	Aeruginosin	$C_{35}H_{48}N_6O_8$	681.3606	3	Hpla-Tyr-Choi-EtArgal
Aeruginosin 865	Aeruginosin	$C_{41}H_{64}N_6O_{14}$	865.4553	3	Hpla-Leu-(Gluc,Hexan)-OHChoi-Agma
Aeruginosin-Group-878[a]	Aeruginosin	$C_{42}H_{66}N_6O_{14}$	879.4710	3	Hpla
Aeruginosin 892	Aeruginosin	$C_{43}H_{68}N_6O_{14}$	893.4866	3	Hpla-Leu-(Gluc,Oct)-OHChoi-Agma
Dysinosin A	Aeruginosin	$C_{26}H_{44}N_6O_{10}S$	633.2912	3	methoxy-PA-SO3-Leu-(Choi-5-OH-6-OH)-Aeap
Dysinosin C	Aeruginosin	$C_{25}H_{42}N_6O_{10}S$	619.2756	3	methoxy-PA-SO3-Leu-(Choi-5-OH-6-OH)-Aeap
Spumigin G	Aeruginosin	$C_{31}H_{42}N_6O_6$	595.3239	3	Hpla-Hph-MePro-Argal
Anabaenopeptin 820	Anabaenopeptin	$C_{41}H_{60}N_{10}O_8$	821.4668	3	Arg-CO-[Lys-Val-Hph-MeAla-Phe]
Anabaenopeptin 863	Anabaenopeptin	$C_{45}H_{66}N_8O_9$	863.5025	3	Leu-CO[Lys-Ile-EtHph-NMeAsn-Phe]
Anabaenopeptin 871[b]	Anabaenopeptin	$C_{46}H_{61}N_7O_{10}$	872.4553	2	Phe-CO[Lys-Ile-Hty-MeAla-Hty]
Anabaenopeptin A[b]	Anabaenopeptin	$C_{44}H_{57}N_7O_{10}$	844.4240	1	[(Phe)-(NMeAla)-(Hty)-(Val)-

					(D-Lys)]-(CO-Tyr)
Anabaenopeptin B[b]	Anabaenopeptin	$C_{41}H_{60}N_{10}O_9$	837.4617	1	[(Phe)-(NMeAla)-(Hty)-(Val)-(D-Lys)]-(CO-Arg)
Anabaenopeptin C[b]	Anabaenopeptin	$C_{41}H_{60}N_8O_9$	809.4556	2	[(Phe)-(NMeAla)-(Hty)-(Val)-(D-Lys)]-(CO-Lys)
Anabaenopeptin D	Anabaenopeptin	$C_{44}H_{57}N_7O_9$	828.4291	3	[(Phe)-(NMeAla)-(Hty)-(Val)-(Lys)]-(CO-Phe)
Anabaenopeptin F[b]	Anabaenopeptin	$C_{42}H_{62}N_{10}O_9$	851.4774	2	[(Lys)-(Arg)-(Ile)-(Hty)-(MeAla)]-(CO-Phe)
Anabaenopeptin MM913	Anabaenopeptin	$C_{49}H_{67}N_7O_{10}$	914.5022	3	[(Ile)-(NMeHty)-(Hphe)-(Ile)-(Lys)]-(CO-Tyr)
Lyngbyaureidamide B[b]	Anabaenopeptin	$C_{45}H_{59}N_7O_9$	842.4447	2	Hty
Anabaenopeptin KT864	Anabaenopeptin	$C_{43}H_{64}N_{10}O_9$	865.4930	3	Hty
Ferintoic acid B	Anabaenopeptin	$C_{47}H_{60}N_8O_9$	881.4556	3	[(L-Hty)-(alle)-[L-Trp]-(D-Lys)-(L-Phe)-(L-NMe-Ala)
Nodulapeptin 839	Anabaenopeptin	$C_{42}H_{61}N_7O_9S$	840.4324	3	Ile-CO-[Lys-Met-Hph-MeHph-Ser]
Nodulapeptin 867	Anabaenopeptin	$C_{44}H_{65}N_7O_9S$	868.4637	3	Ile-CO-[Lys-Val-Hph-MeHty-Met]
Oscillamide Y[b]	Anabaenopeptin	$C_{45}H_{59}N_7O_{10}$	858.4396	1	[(Phe)-(NMeAla)-(Hty)-(Ile)-(D-Lys)]-(CO-Tyr)

Anabaenopeptilide 90B	Cyanopeptolin	$C_{45}H_{61}ClN_8O_{14}$	973.4068	3	[(Hty)-(Ahp)-(Thr)-(N-Me-Tyr-Cl)-(Ile)-(O-Thr)]-N-formyl-Gln
A90720A	Cyanopeptolin	$C_{45}H_{72}N_{10}O_{16}S$	1041.4921	3	[(Arg)-(Ahp)-(Leu)-(N-Me-Tyr)-(Val)-(O-Thr)]-Leu-SuGA
Micropeptin 90[b]	Cyanopeptolin	$C_{42}H_{59}N_9O_{15}S$	962.3924	2	[(Arg)-(Ahp)-(Phe)-(MeTyr)-(Val)-(O-Thr)]-(SuGA)
Micropeptin LH1021	Cyanopeptolin	$C_{50}H_{71}N_9O_{14}$	1022.5193	3	[(L-Val)-(L-NMe-Tyr)-(L-Phe)-((3S, 6R)-Ahp)-(L-Gln)-(L-Thr-[(L-Thr)-(L-Gly)-(Hexanoic acid)])-]
Bistratamide A	Cyclamide	$C_{27}H_{34}N_6O_4S_2$	571.2156	3	
Bistratamide G	Cyclamide	$C_{25}H_{32}N_6O_5S$	529.2228	3	
[D-Asp^3, Dha^7]MC-FR	Microcystin	$C_{50}H_{68}N_{10}O_{12}$	1001.5091	3	[(D-Ala)-(Phe)-(D-Asp)-(Arg)-(Adda)-(D-Glu)-(Dha)]
MC-LR[b]	Microcystin	$C_{49}H_{74}N_{10}O_{12}$	995.5560	1	[(D-Ala)-(Leu)-(D-bMe-Asp)-(Arg)-(Adda)-(D-Glu)-(Mdha)]
[D-Asp^3]MC-M(O)R	Microcystin	$C_{47}H_{70}N_{10}O_{13}S$	1015.4917	3	[(D-Ala)-(O-Met)-(D-Asp)-(Arg)-(Adda)-(D-Glu)-(Mdha)]
[D-Asp^3]MC-MR	Microcystin	$C_{47}H_{70}N_{10}O_{12}S$	999.4968	3	[(D-Ala)-(Met)-(D-Asp)-(Arg)-(Adda)-(D-Glu)-(Mdha)]
MC-YR[b]	Microcystin	$C_{52}H_{72}N_{10}O_{13}$	1045.5353	1	[(D-Ala)-((4H)-Tyr)-(D-bMe-Asp)-(Arg)-(Adda)-

					(D-Glu)-(Mdha)]
Microcystin-Group-924 [a]	Microcystin	$C_{47}H_{69}N_7O_{12}$	924.5077	3	no obviously photolabile amino acid
Microcystin-Group-938 [a]	Microcystin	$C_{48}H_{71}N_7O_{12}$	938.5233	3	no obviously photolabile amino acid
Microcystin-Group-967 [a]	Microcystin	$C_{47}H_{70}N_{10}O_{12}$	967.5247	3	no obviously photolabile amino acid
Microcystin-Group-981 [a]	Microcystin	$C_{48}H_{72}N_{10}O_{12}$	981.5404	3	no obviously photolabile amino acid
Microcystin-Group-999.55 [a]	Microcystin	$C_{48}H_{74}N_{10}O_{13}$	999.5510	3	no obviously photolabile amino acid
Microcystin-Group-1009 [a]	Microcystin	$C_{50}H_{76}N_{10}O_{12}$	1009.5717	3	no obviously photolabile amino acid
Microcystin-Group-1013.51[a]	Microcystin	$C_{48}H_{72}N_{10}O_{12}S$	1013.5125	3	Met
Microcystin-Group-1013.56 [a]	Microcystin	$C_{49}H_{76}N_{10}O_{13}$	1013.5666	3	no obviously photolabile amino acid
Microcystin-Group-1015 [a]	Microcystin	$C_{51}H_{70}N_{10}O_{12}$	1015.5247	3	no obviously photolabile amino acid
Microcystin-Group-1029 [a]	Microcystin	$C_{52}H_{72}N_{10}O_{12}$	1029.5404	3	no obviously photolabile amino acid
Microcystin-Group-1031 [a]	Microcystin	$C_{51}H_{70}N_{10}O_{13}$	1031.5197	3	Tyr or Hty
Microcystin-Group-1043[a]	Microcystin	$C_{53}H_{74}N_{10}O_{12}$	1043.5560	3	no obviously photolabile amino acid
[D-Asp^3,L-Ser^7]MC-LR	Microcystin	$C_{47}H_{72}N_{10}O_{13}$	985.5353	3	cyclo[(D-Ala)-(Leu)-(D-Asp)-(Arg)-(Adda)-(D-Glu)-(L-Ser)]
MC-KynA	Microcystin	$C_{50}H_{66}N_8O_{13}$	987.4822	3	cyclo[(D-Ala)-(Kyn)-(D-bMe-Asp)-(Arg)-(Adda)-(D-Glu)-(Mdha)]
Microcystin-Group-1011[a]	Microcystin	$C_{48}H_{70}N_{10}O_{14}$	1011.5146	3	no obviously photolabile amino acid
[epoxyAdda^5]MC-LR	Microcystin	$C_{49}H_{74}N_{10}O_{13}$	1011.5510	3	cyclo[(D-Ala)-(Leu)-(D-bMe-Asp)-(Arg)-(epoxyAdda)-

					(D-Glu)-(Mdha)]
[D-Asp^3,ADMAdda^5,Thr^7]MC-LR	Microcystin	$C_{49}H_{74}N_{10}O_{14}$	1027.5459	3	cyclo[(D-Ala)-(Leu)-(D-Asp)-(Arg)-(ADMAdda)-(D-Glu)-(Thr)]
[seco-1/2]MC-HilR	Microcystin	$C_{50}H_{78}N_{10}O_{13}$	1027.5823	3	[(NH2-Hil)-(D-bMe-Asp)-(Arg)-(Adda)-(D-Glu)-(Mdha)-(D-Ala-OH)]
MC-M(O)R	Microcystin	$C_{48}H_{72}N_{10}O_{13}S$	1029.5074	3	cyclo[(D-Ala)-(Met(=O))-(D-bMe-Asp)-(Arg)-(Adda)-(D-Glu)-(Mdha)]
[D-Asp^3]MC-M(O2)R	Microcystin	$C_{47}H_{70}N_{10}O_{14}S$	1031.4866	3	cyclo[(D-Ala)-(O2-Met)-(D-Asp)-(Arg)-(Adda)-(D-Glu)-(Mdha)]
[D-Asp^3]MC-(H2)YR	Microcystin	$C_{51}H_{72}N_{10}O_{13}$	1033.5353	3	cyclo[(D-Ala)-((H2)Y)-(D-bMe-Asp)--(Arg)-(Adda)-(D-Glu)-(Mdha)]
Microcystin-Group-1049[a]	Microcystin	$C_{51}H_{72}N_{10}O_{14}$	1049.5302	3	Tyr or Hty
MC-HtyR[b]	Microcystin	$C_{53}H_{74}N_{10}O_{13}$	1059.5510	2	Hty
Microcystin-Group-1063[a,b]	Microcystin	$C_{52}H_{74}N_{10}O_{14}$	1063.5459	3	Tyr, Hty or (H4)Tyr
MC-NMeHtyR	Microcystin	$C_{54}H_{76}N_{10}O_{13}$	1073.5666	3	cyclo[(D-Ala)-(Me-Hty)-(D-bMe-Asp)-(Arg)-(Adda)-(D-Glu)-(Mdha)]
[DAsp^3]MCHty(OMe)R[b]	Microcystin	$C_{53}H_{74}N_{10}O_{14}$	1075.5459	2	MeO-Hty
Microcystin-Group-1077[a]	Microcystin	$C_{53}H_{76}N_{10}O_{14}$	1077.5615	3	Hty or (H4)Tyr
Microginin 527 methyl ester	Microginin	$C_{26}H_{43}N_3O_7S$	542.2822	3	(Ahda)-(MeMet(O))-(OMe-Tyr)

[a]isobaric compounds, see Table S7; [b]see MS/MS anotation in Figures S2 – S16; Jones, M.R., et al., CyanoMetDB, a comprehensive public database of secondary metabolites from cyanobacteria.Water Res 2021, 196, 117017.

Table S7. Isobaric compound group name (cyanopeptide class-group-MW) and individual compounds within each group with the same molecular formula. Only compounds above LOQ are reported.

Cyanopeptide Group name	Cyanopeptide	Molecular formula	Amino acid building block
Aeruginosin-Group-878	Aeruginosin 878A	$C_{42}H_{66}N_6O_{14}$	Hpla-NMeLeu-(Gluc,Hexan)-OHChoi-Agma
	Aeruginosin 878B		Hpla-Leu-(Gluc,Hep)-OHChoi-Agma
Microcystin-Group-924	[D-Asp^3]MC-LV	$C_{47}H_{69}N_7O_{12}$	[(D-Ala)-(Leu)-(D-Asp)-(Val)-(Adda)-(D-Glu)-(Mdha)]
	MC-LAba		[(D-Ala)-(Leu)-(D-bMe-Asp)-(Aba)-(Adda)-(D-Glu)-(Mdha)]
	[D-Asp^3,D-MeO-Glu^6]MC-LAba		[(D-Ala)-(Leu)-(D-Asp)-(Aba)-(Adda)-(D-MeO1-Glu)-(Mdha)]
	MC-HilA		[(D-Ala)-(Hil)-(D-bMe-Asp)-(Ala)-(Adda)-(D-Glu)-(Mdha)]
Microcystin-Group-938	[D-Asp^3]MC-LL	$C_{48}H_{71}N_7O_{12}$	[(D-Ala)-(Leu)-(D-Asp)-(Leu)-(Adda)-(D-Glu)-(Mdha)]
	MC-LV		[(D-Ala)-(Leu)-(D-bMe-Asp)-(Val)-(Adda)-(D-Glu)-(Mdha)]
	MC-HilAbu		[(D-Ala)-(Hil)-(D-bMe-Asp)-(Abu)-(Adda)-(D-Glu)-(Mdha)]
Microcystin-Group-967	MC-AHar	$C_{47}H_{70}N_{10}O_{12}$	[(D-Ala)-(Ala)-(D-bMe-Asp)-(Har)-(Adda)-(D-Glu)-(Mdha)]
	[D-Asp^3,DMAdda^5]MC-LR		[(D-Ala)-(Leu)-(D-Asp)-(Arg)-(DMAdda)-(D-Glu)-(Mdha)]
	[Asp^3,DMAdda^5,Dhb^7]MC-LR		[(D-Ala)-(Leu)-(D-Asp)-(Arg)-(DMAdda)-(D-Glu)-(Dhb)]
	[Gly^1,D-Asp^3,Dhb^7]MC-LR		[(Gly)-(Leu)-(D-Asp)-(Arg)-(Adda)-(D-Glu)-(Dhb)]

	[D-Asp^{3}]MC-HarAba		[(D-Ala)-(Har)-(D-Asp)-(Aba)-(Adda)-(D-Glu)-(Mdha)]
	[Gly^{1},D-Asp^{3}]MC-LR		[(Gly)-(Leu)-(D-Asp)-(Arg)-(Adda)-(D-Glu)-(Mdha)]
	MC-Raba		[(D-Ala)-(Arg)-(D-bMe-Asp)-(Aba)-(Adda)-(D-Glu)-(Mdha)]
	[D-Asp^{3},Dha^{7}]MC-LR		[(D-Ala)-(Leu)-(D-Asp)-(Arg)-(Adda)-(D-Glu)-(Dha)]
Microcystin-Group-981	[DMAdda^{5}]MC-LR	$C_{48}H_{72}N_{10}O_{12}$	[(D-Ala)-(Leu)-(D-bMe-Asp)-(Arg)-(DMAdda)-(D-Glu)-(Mdha)]
	[Gly^{1},D-Asp^{3}]MC-LHar		[(Gly)-(Leu)-(D-Asp)-(Har)-(Adda)-(D-Glu)-(Mdha)]
	[D-Asp^{3},(E)-Dhb^{7}]MC-LR		[(D-Ala)-(Leu)-(D-Asp)-(Arg)-(Adda)-(D-Glu)-((E)-Dhb)]
	[D-Asp^{3},(Z)-Dhb^{7}]MC-LR		[(D-Ala)-(Leu)-(D-Asp)-(Arg)-(Adda)-(D-Glu)-((Z)-Dhb)]
	[Gly^{1},D-Asp^{3},Dhb^{7}]MC-LHar		[(Gly)-(Leu)-(D-Asp)-(Har)-(Adda)-(D-Glu)-(Dhb)]
	MC-Rapa		[(D-Ala)-(Arg)-(D-bMe-Asp)-(Apa)-(Adda)-(D-Glu)-(Mdha)]
	MC-VR		[(D-Ala)-(Val)-(D-bMe-Asp)-(Arg)-(Adda)-(D-Glu)-(Mdha)]
	[Dha^{7}]MC-LR		[(D-Ala)-(Leu)-(D-bMe-Asp)-(Arg)-(Adda)-(D-Glu)-(Dha)]
	[D-Asp^{3}]MC-LR		[(D-Ala)-(Leu)-(D-Asp)-(Arg)-(Adda)-(D-Glu)-(Mdha)]
Microcystin-Group-999.55	[Ser^{7}]MC-LR	$C_{48}H_{74}N_{10}O_{13}$	[(D-Ala)-(Leu)-(D-bMe-Asp)-(Arg)-(Adda)-(D-Glu)-(Ser)]
	[seco-4/5][D-Asp^{3}]MC-LR		[(NH2-Adda)-(D-Glu)-(Mdha)-(D-Ala)-(Leu)-(D-Asp)-(Arg-OH)]

	[D-Asp^{3},Mser^{7}]MC-LR		[(D-Ala)-(Leu)-(D-Asp)-(Arg)-(Adda)-(D-Glu)-(NMe-Ser)]
Microcystin-Group-1009	[D-MeO-Glu^{6}]MC-LR	$C_{50}H_{76}N_{10}O_{12}$	[(D-Ala)-(Leu)-(D-bMe-Asp)-(Arg)-(Adda)-(D-MeO1-Glu)-(Mdha)]
	[MDhb^{7}]MC-LR		[(D-Ala)-(Leu)-(D-bMe-Asp)-(Arg)-(Adda)-(D-Glu)-(Mdhb)]
	MC-HilR		[(D-Ala)-(Hil)-(D-bMe-Asp)-(Arg)-(Adda)-(D-Glu)-(Mdha)]
	MC-LHar		[(D-Ala)-(Leu)-(D-bMe-Asp)-(Har)-(Adda)-(D-Glu)-(Mdha)]
	[Me-Ala^{1}]MC-LR		[(Me-Ala)-(Leu)-(D-bMe-Asp)-(Arg)-(Adda)-(D-Glu)-(Mdha)]
	[D-Leu^{1},D-Asp^{3},DMAdda^{5}]MC-LR		[(D-Leu)-(Leu)-(D-Asp)-(Arg)-(DMAdda)-(D-Glu)-(Mdha)]
Microcystin-Group-1011	MC-ER	$C_{48}H_{70}N_{10}O_{14}$	cyclo[(D-Ala)-(Glu)-(D-bMe-Asp)-(Arg)-(Adda)-(D-Glu)-(Mdha)]
	MC-RE		cyclo[(D-Ala)-(Arg)-(D-bMe-Asp)-(Glu)-(Adda)-(D-Glu)-(Mdha)]
Microcystin-Group-1013.51	MC-MR	$C_{48}H_{72}N_{10}O_{12}S$	[(D-Ala)-(Met)-(D-bMe-Asp)-(Arg)-(Adda)-(D-Glu)-(Mdha)]
	MC-RM		[(D-Ala)-(Arg)-(D-bMe-Asp)-(Met)-(Adda)-(D-Glu)-(Mdha)]
Microcystin-Group-1013.56	[NMe-Ser^{7}]MC-LR	$C_{49}H_{76}N_{10}O_{13}$	[(D-Ala)-(Leu)-(D-bMe-Asp)-(Arg)-(Adda)-(D-Glu)-(NMe-Ser)]
	[seco-4/5]MC-LR		[(NH2-Adda)-(D-Glu)-(Mdha)-(D-Ala)-(Leu)-(D-bMe-Asp)-(Arg-OH)]
	[seco-1/2]MC-LR		[(NH2-Leu)-(D-bMe-Asp)-(Arg)-(Adda)-(D-Glu)-(Mdha)-(D-Ala-OH)]
Microcystin-Group-1015	[D-Asp^{3}]MC-FR	$C_{51}H_{70}N_{10}O_{12}$	[(D-Ala)-(Phe)-(D-Asp)-(Arg)-(Adda)-(D-Glu)-(Mdha)]

	[Dha^{7}]MC-FR		[(D-Ala)-(Phe)-(D-bMe-Asp)-(Arg)-(Adda)-(D-Glu)-(Dha)]
	[D-Asp^{3},Dha^{7}]MC-HphR		[(D-Ala)-(Hph)-(D-Asp)-(Arg)-(Adda)-(D-Glu)-(Dha)]
	[DMAdda^{5}]MC-FR		[(D-Ala)-(Phe)-(D-bMe-Asp)-(Arg)-(DMAdda)-(D-Glu)-(Mdha)]
	[D-Asp^{3}]MC-RF		[(D-Ala)-(Arg)-(D-Asp)-(Phe)-(Adda)-(D-Glu)-(Mdha)]
Microcystin-Group-1029	MC-FR	$C_{52}H_{72}N_{10}O_{12}$	[(D-Ala)-(Phe)-(D-bMe-Asp)-(Arg)-(Adda)-(D-Glu)-(Mdha)]
	[D-Asp^{3},(E)-Dhb^{7}]MC-HphR		[(D-Ala)-(Hph)-(D-Asp)-(Arg)-(Adda)-(D-Glu)-(Dhb)]
	[D-Asp^{3}]MC-HphR		[(D-Ala)-(Hph)-(D-Asp)-(Arg)-(Adda)-(D-Glu)-(Mdha)]
	[Dha^{7}]MC-HphR		[(D-Ala)-(Hph)-(D-bMe-Asp)-(Arg)-(Adda)-(D-Glu)-(Dha)]
	MC-RF		[(D-Ala)-(Arg)-(D-bMe-Asp)-(Phe)-(Adda)-(D-Glu)-(Mdha)]
Microcystin-Group-1031	[D-Asp^{3}]MC-RY	$C_{51}H_{70}N_{10}O_{13}$	[(D-Ala)-(Arg)-(D-Asp)-(Tyr)-(Adda)-(D-Glu)-(Dha)]
	[D-Asp^{3},Dha^{7}]MC-HtyR		[(D-Ala)-(Hty)-(D-Asp)-(Arg)-(Adda)-(D-Glu)-(Dha)]
	[D-Asp^{3}]MC-YR		[(D-Ala)-(Tyr)-(D-Asp)-(Arg)-(Adda)-(D-Glu)-(Mdha)]
	[Dha^{7}]MC-YR		[(D-Ala)-(Tyr)-(D-bMe-Asp)-(Arg)-(Adda)-(D-Glu)-(Dha)]
	[DMAdda^{5}]MC-YR		[(D-Ala)-(Tyr)-(D-bMe-Asp)-(Arg)-(DMAdda)-(D-Glu)-(Mdha)]
	[D-Asp^{3},DMAdda^{5}]MC-HtyR		[(D-Ala)-(Hty)-(D-Asp)-(Arg)-(DMAdda)-(D-Glu)-(Mdha)]

	[Dha^{7}]MC-RY		[(D-Ala)-(Arg)-(D-bMe-Asp)-(Tyr)-(Adda)-(D-Glu)-(Dha)]
	[D-Asp^{3},Dhb^{7}]MC-RY		[(D-Ala)-(Arg)-(D-Asp)-(Tyr)-(Adda)-(D-Glu)-(Dhb)]
	[D-Asp^{3},(E)-Dhb^{7}]MC-YR		[(D-Ala)-(Tyr)-(D-Asp)-(Arg)-(Adda)-(D-Glu)-(Dhb)]
Microcystin-Group-1043	MC-HphR	$C_{53}H_{74}N_{10}O_{12}$	[(D-Ala)-(Hph)-(D-bMe-Asp)-(Arg)-(Adda)-(D-Glu)-(Mdha)]
	[D-MeO-Glu^{6}]MC-FR		[(D-Ala)-(Phe)-(D-bMe-Asp)-(Arg)-(Adda)-(D-MeO-Glu)-(Mdha)]
Microcystin-Group-1049	[D-Asp^{3},Ser^{7}]MC-HtyR	$C_{51}H_{72}N_{10}O_{14}$	cyclo[(D-Ala)-(Hty)-(D-Asp)-(Arg)-(Adda)-(D-Glu)-(Ser)]
	[D-Asp^{3},Mser^{7}]MC-RY		cyclo[(D-Ala)-(Arg)-(D-Asp)-(Tyr)-(Adda)-(D-Glu)-(Mser)]
	[Ser^{7}]MC-YR		cyclo[(D-Ala)-(Tyr)-(D-bMe-Asp)-(Arg)-(Adda)-(D-Glu)-(Ser)]
Microcystin-Group-1061	[D-Ser^{1},D-Asp^{3}]MC-HtyR	$C_{52}H_{72}N_{10}O_{14}$	[(D-Ser)-(Hty)-(D-Asp)-(Arg)-(Adda)-(D-Glu)-(Mdha)]
	[D-Asp^{3}]MC-Y(OMe)R		[(D-Ala)-(MeO-Tyr)-(D-Asp)-(Arg)-(Adda)-(D-Glu)-(Mdha)]
	[DMAdda^{5}]MC-Y(OMe)R		[(D-Ala)-(MeO-Tyr)-(D-bMe-Asp)-(Arg)-(DMAdda)-(D-Glu)-(Mdha)]
Microcystin-Group-1063	[NMe-Ser^{7}]MC-YR	$C_{52}H_{74}N_{10}O_{14}$	cyclo[(D-Ala)-(Tyr)-(D-bMe-Asp)-(Arg)-(Adda)-(D-Glu)-(NMe-Ser)]
	[Ser^{7}]MC-HtyR		cyclo[(D-Ala)-(Hty)-(D-bMe-Asp)-(Arg)-(Adda)-(D-Glu)-(Ser)]
	[D-Asp^{3},Mser^{7}]MC-HtyR		cyclo[(D-Ala)-(Hty)-(D-Asp)-(Arg)-(Adda)-(D-Glu)-(NMe-Ser)]
	[seco-4/5][D-Asp^{3}]MC-HtyR		[(NH2-Adda)-(D-Glu)-(Mdha)-(D-Ala)-(Hty)-(D-Asp)-(Arg)]
	[D-Asp^{3},ADMAdda^{5}]MC-(H4)YR		cyclo[(D-Ala)-((H4)Tyr)-(D-Asp)-(Arg)-(ADMAdda)-(D-Glu)-(Mdha)]

	[NMeSer^{7}]MC-RY		cyclo[(D-Ala)-(Arg)-(D-bMe-Asp)-(Tyr)-(Adda)-(D-Glu)-(NMeSer)]
	[D-Asp^{3},Mser^{7}]MC-YHar		cyclo[(D-Ala)-(Tyr)-(D-Asp)-(Har)-(Adda)-(D-Glu)-(Mser)]
Microcystin-Group-1077	[seco-4/5]MC-HtyR	$C_{53}H_{76}N_{10}O_{14}$	[(NH2-Adda)-(D-Glu)-(Mdha)-(D-Ala)-(Hty)-(D-bMe-Asp)-(Arg)]
	[ADMAdda^{5}]MC-(H4)YR		cyclo[(D-Ala)-((H4)Tyr)-(D-bMe-Asp)-(Arg)-(ADMAdda)-(D-Glu)-(Mdha)]
	[Mser^{7}]MC-HtyR		cyclo[(D-Ala)-(Hty)-(D-bMe-Asp)-(Arg)-(Adda)-(D-Glu)-(Mser)]

Table S8. *Dolichospermum flos aquae* cyanopeptide profile with concentrations (µg mg^{-1} dry wt) and relative abundance (%) of each class (sum of indivudial compounds per class).

Class	Cyanopeptide concentration (µg mg^{-1} dry wt)	Relative abundance (%)
Anabaenopeptins	46.55	85.54
Microcystins	7.79	14.32
Aeruginosins	0.05	0.09
Microginins	0.01	0.03
Cyanopeptolins	0.01	0.01
Cyclamides	0.01	0.01
Total	54.43	100.00

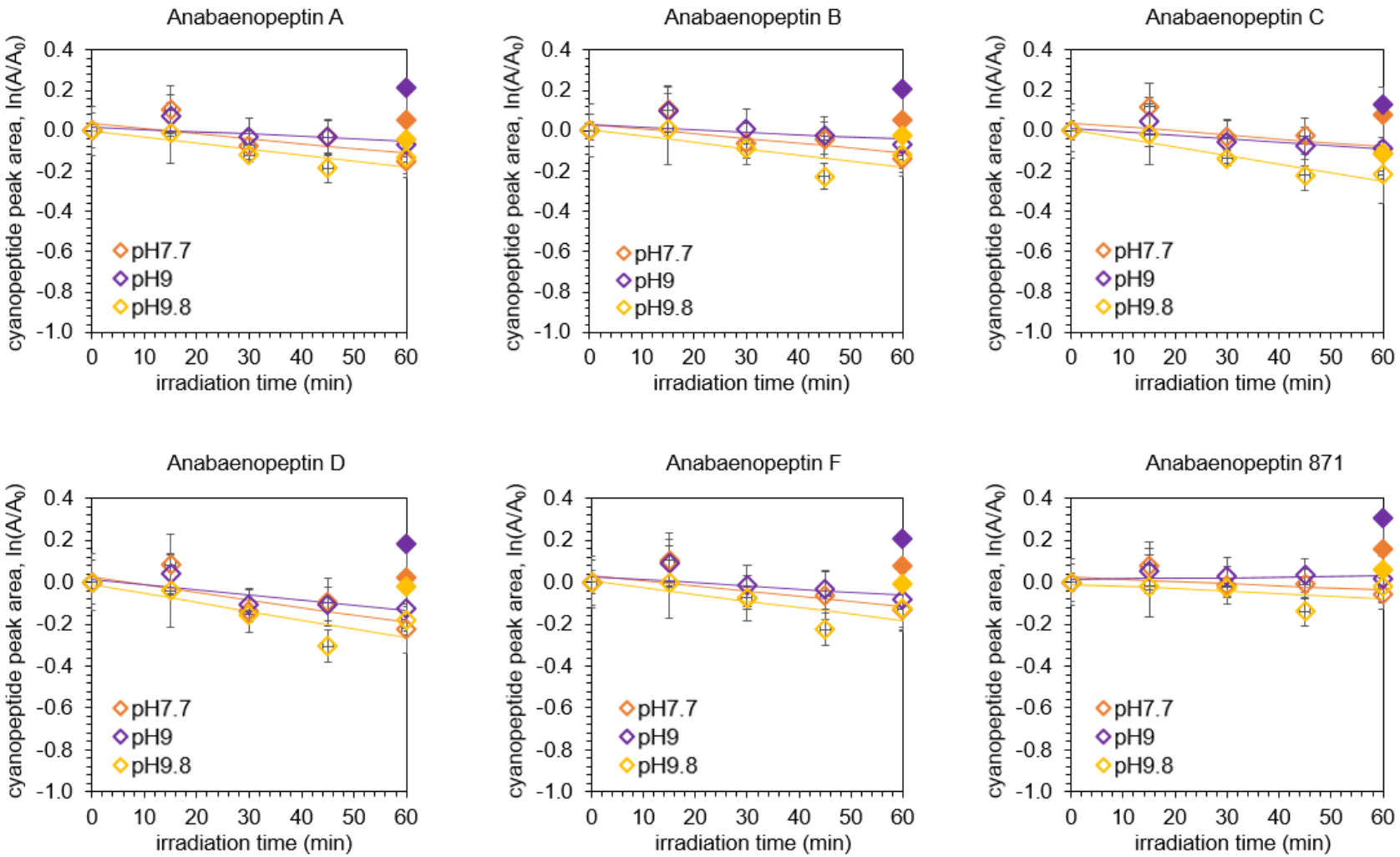


Figure S17. Irradiation in UVA light without sensitizer for anabaenopeptin A, anabaenopeptin B, anabaenopeptin C, anabaenopeptin D, anabaenopeptin F and anabaenopeptin 871 at pH 7.7-9.8. Filled symbols at 60min present the stable dark controls.

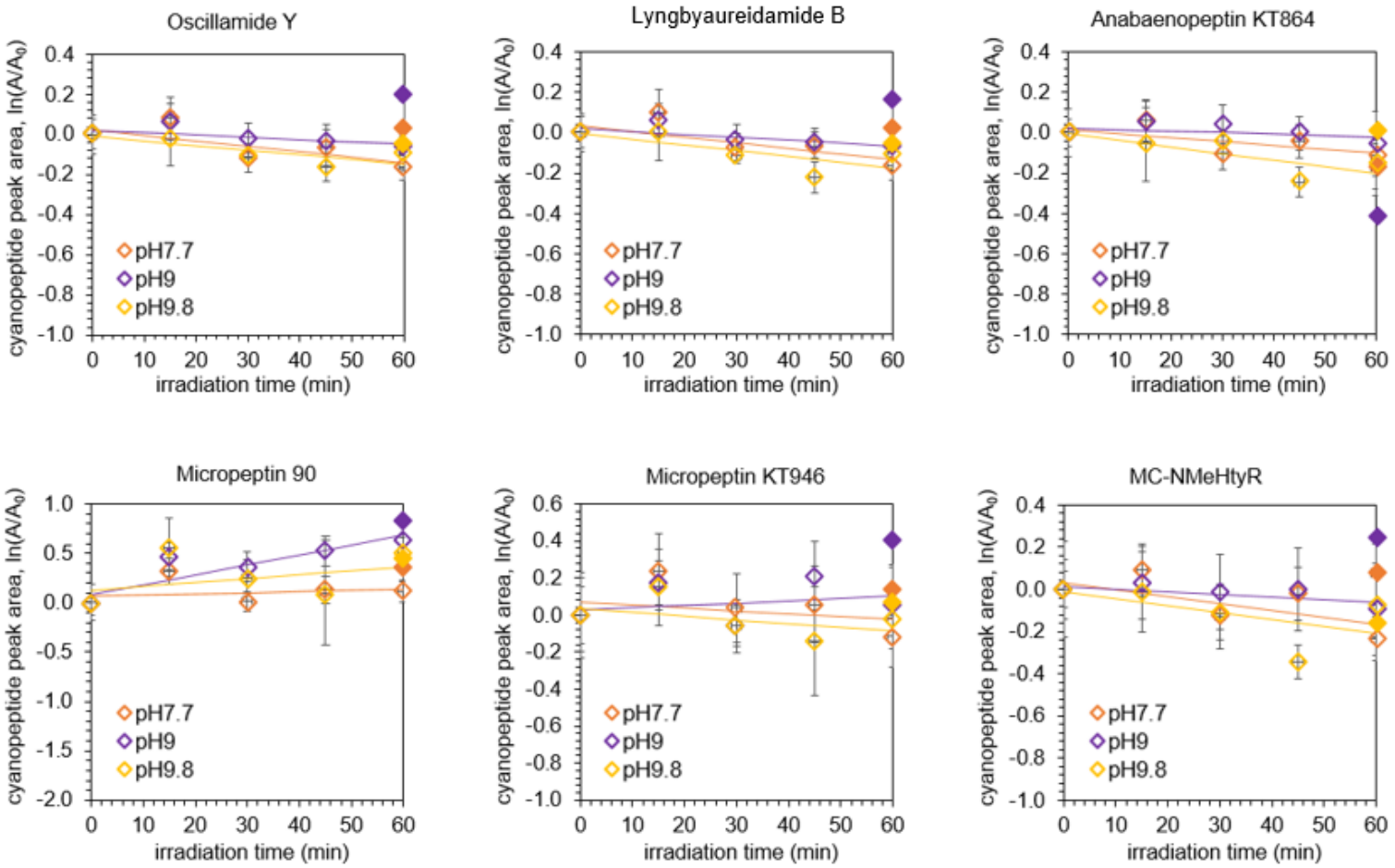


Figure S18. Irradiation in UVA light without sensitizer for oscillamide Y, lyngbyaureidamide B, anabaenopeptin KT864, micropeptin 90, micropeptin KT946 and MC-NMeHtyR at pH 7.7-9.8. Filled symbols at 60min present the stable dark controls.

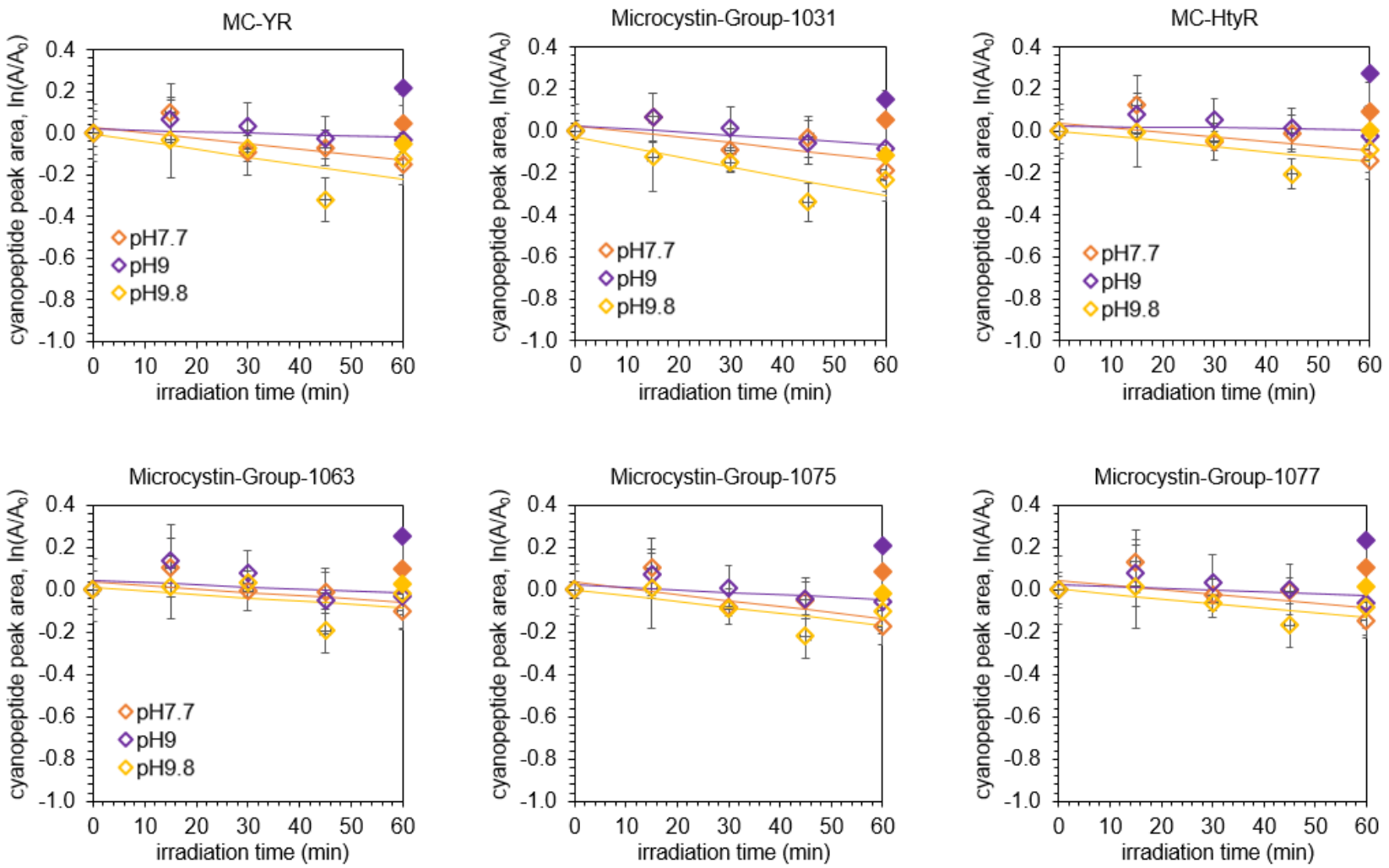


Figure S19. Irradiation in UVA light without sensitizer for MC-YR, microcystin-group-1031, MC-HtyR, microcystin-group-1063, microcystin-

group-1075 and microcystin-group-1077 at pH 7.7-9.8. Filled symbols at 60min present the stable dark control

Table S9. Observed degradation rates (k_{obs}) for 30 cyanopeptides in buffered solutions at pH 7-11.6 in H_2O and at pH 11.6 in D_2O.

	Compound	pH 7.0 kobs ± stdev (s^{-1})	pH 8.0 kobs ± stdev (s^{-1})	pH 9.0 kobs ± stdev (s^{-1})	pH 10.0 kobs ± stdev (s^{-1})	pH 11.6 kobs ± stdev (s^{-1})	pH 11.6 D_2O kobs ± stdev (s^{-1})
1	Anabaenopeptin A	n.f.k	1.54E-04 ± 1.23E-05	2.66E-04 ± 1.60E-05	5.62E-04 ± 4.56E-05	2.02E-03 ± 3.56E-05	5.76E-03 ± 2.85E-04
2	Anabaenopeptin B	n.d	n.f.k	1.76E-04 ± 1.85E-05	3.93E-04 ± 1.72E-05	1.11E-03 ± 1.37E-05	2.59E-03 ± 8.41E-05
3	Anabaenopeptin C	n.d	n.f.k	2.79E-04 ± 1.75E-05	5.06E-04 ± 1.92E-05	1.09E-03 ± 1.29E-05	3.31E-03 ± 2.61E-04
4	Anabaenopeptin D	n.d	n.f.k	1.61E-04 ± 2.08E-05	3.31E-04 ± 2.05E-05	1.35E-03 ± 3.51E-05	n.f.k
5	Anabaenopeptin F	n.d	n.f.k	1.86E-04 ± 1.84E-05	4.09E-04 ± 1.83E-05	1.19E-03 ± 1.49E-05	2.62E-03 ± 6.70E-05
6	Anabaenopeptin 871	n.f.k	1.12E-04 ± 1.27E-05	2.25E-04 ± 1.67E-05	5.39E-04 ± 1.72E-05	1.88E-03 ± 7.88E-05	1.09E-02 ± 1.48E-03
7	Oscillamide Y	n.f.k	1.35E-04 ±1.12E-05	2.47E-04 ± 1.57E-05	5.91E-04 ± 1.61E-05	2.15E-03 ± 2.36E-05	4.77E-03 ± 3.20E-04
8	Lyngbyaureidamide B	n.d	n.f.k	1.62E-04 ± 1.54E-05	3.40E-04 ± 1.57E-05	1.29E-03 ± 2.94E-05	2.87E-03 ± 5.81E-04
9	Anabaenopeptin KT864	n.d	n.d	n.d	3.19E-04 ± 1.57E-05	1.03E-03 ± 2.87E-05	n.d
10	Micropeptin 90	n.d	n.d	n.d	4.53E-04 ± 2.92E-05	2.89E-03 ± 1.30E-05	n.a
11	Micropeptin KT946	n.d	n.d	2.35E-04 ± 2.27E-05	5.15E-04 ± 2.78E-05	n.a	n.a
12	MC-YR	n.d	1.21E-04 ± 1.42E-05	2.07E-04 ± 1.87E-05	4.45E-04 ± 1.81E-05	1.74E-03 ± 9.83E-05	3.30E-03 ± 4.00E-04
13	MC-HtyR	n.f.k	n.f.k	1.67E-04 ± 1.82E-05	3.71E-04 ± 1.70E-05	1.48E-03 ± 3.84E-05	3.04E-03 ± 1.36E-04
14	Microcystin-Group-1063	n.f.k	1.27E-04 ± 1.41E-05	1.97E-04 ± 1.68E-05	4.18E-04 ± 1.70E-05	2.00E-03 ± 4.87E-05	n.f.k
15	Microcystin-Group-1031	n.f.k	1.10E-04 ± 1.48E-05	1.14E-04 ± 1.48E-05	3.04E-04 ± 2.26E-05	n.a	n.a

16	Microcystin-Group-1077	n.f.k	1.23E-04 ± 1.43E-05	2.18E-04 ± 1.95E-05	4.47E-04 ± 2.00E-05	1.65E-03 ± 3.92E-05	n.f.k
17	MC-NMeHtyR	n.f.k	n.f.k	2.46E-04 ± 2.51E-05	5.78E-04 ± 3.89E-05	n.a	n.a
18	[DAsp^{3}]MC-(OMe)HtyR	n.f.k	9.68E-05 ± 1.25E-05	1.79E-04 ± 1.79E-05	3.72E-04 ± 1.98E-05	8.70E-04 ± 1.18E-05	n.a
19	Microcystin-Group-1043	n.d	n.d	n.d	n.d	n.d	n.d
20	Bistratamide G	n.d	n.d	n.d	n.d	n.d	n.a
21	[D-Asp^{3},Dha7]MC-FR	n.d	n.d	n.d	n.d	n.d	n.d
22	Microcystin-Group-1029	n.d	n.d	n.d	n.d	n.d	n.d
23	[D-Asp^{3}]MC-(H2)YR	n.d	n.d	n.d	n.d	n.d	n.d
24	Microcystin-Group-1009	n.d	n.d	n.d	n.d	n.d	n.d
25	[epoxyAdda^{5}]MC-LR	n.d	n.d	n.d	n.d	n.d	n.d
26	MC-LR	n.d	n.d	n.d	n.d	n.d	n.f.k
27	Microcystin-Group-981	n.d	n.d	n.d	n.d	n.d	n.d
28	Microcystin-Group-999.55	n.d	n.d	n.d	n.d	n.d	n.d
29	Microcystin-Group-1013.56	n.d	n.d	n.d	n.d	n.d	n.d
30	Microcystin-Group-1015	n.d	n.d	n.d	n.d	n.d	n.d

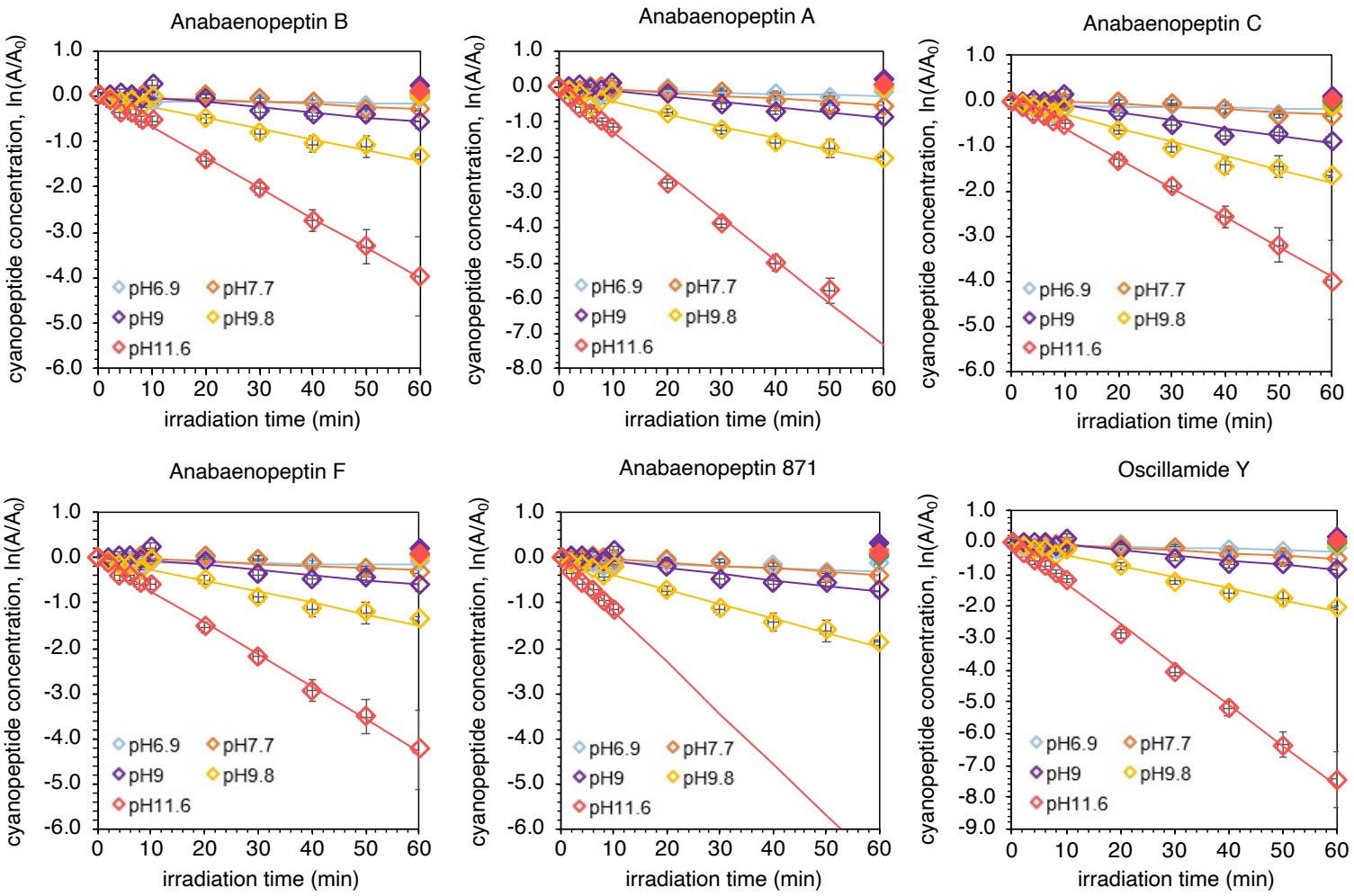


Figure S20. Irradiation in UVA light in the presence of photosensitizer perinaphthenone for anabaenopeptin B, anabaenopeptin A, anabaenopeptin C, anabaenopeptin F, anabaenopeptin 871 and oscillamide Y at pH 6.9-11.6. Filled symbols at 60min present the stable dark controls.

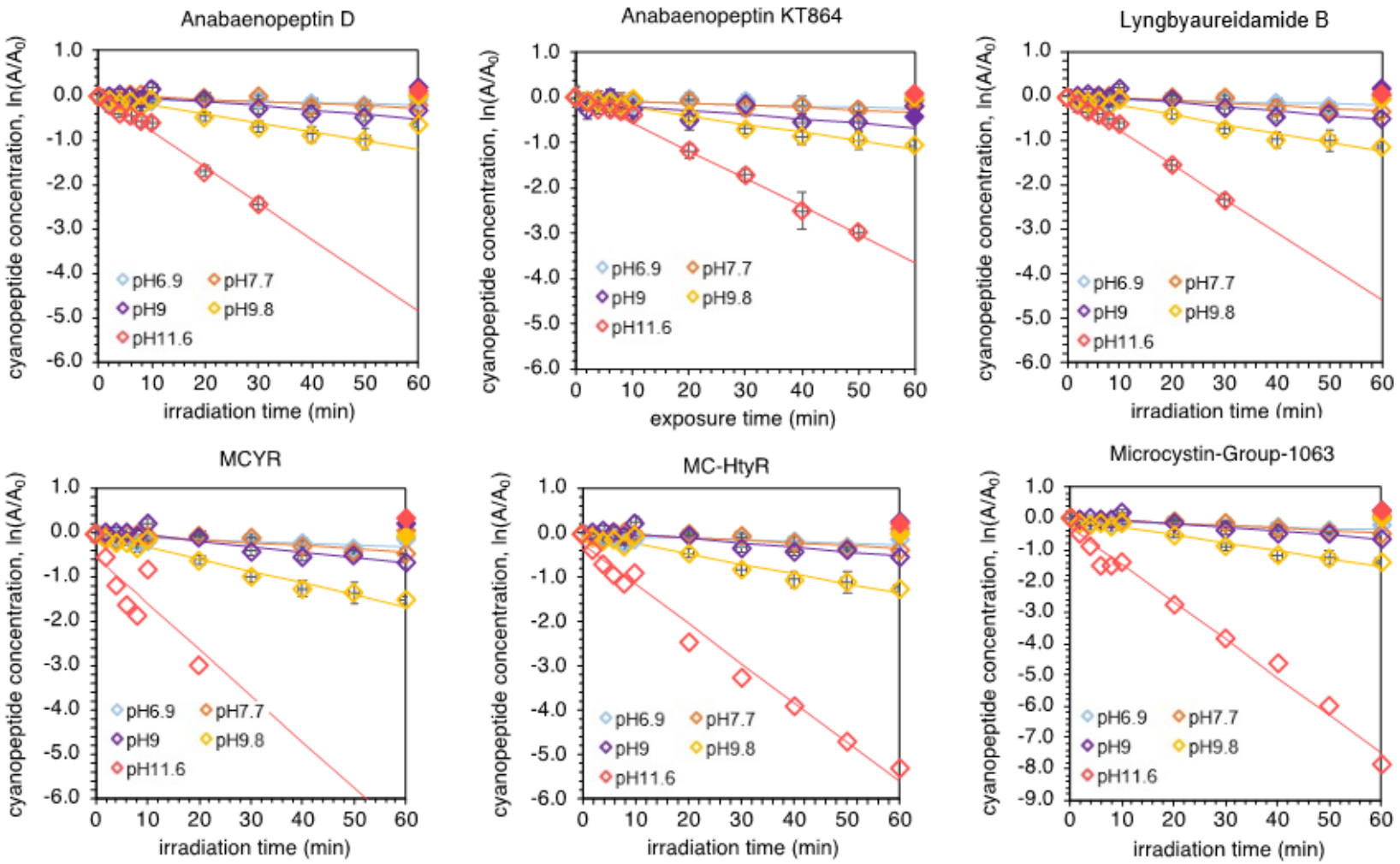


Figure S21. Irradiation in UVA light in the presence of photosensitizer perinaphthenone for anabaenopeptin D, anabaenopeptin KT864, lyngbyaureidamide B, microcystin YR (MC-YR), microcystin HtyR (MC-HTyR) and microcystin group 1063 at pH 6.9-11.6. Filled symbols at 60min present the stable dark controls.

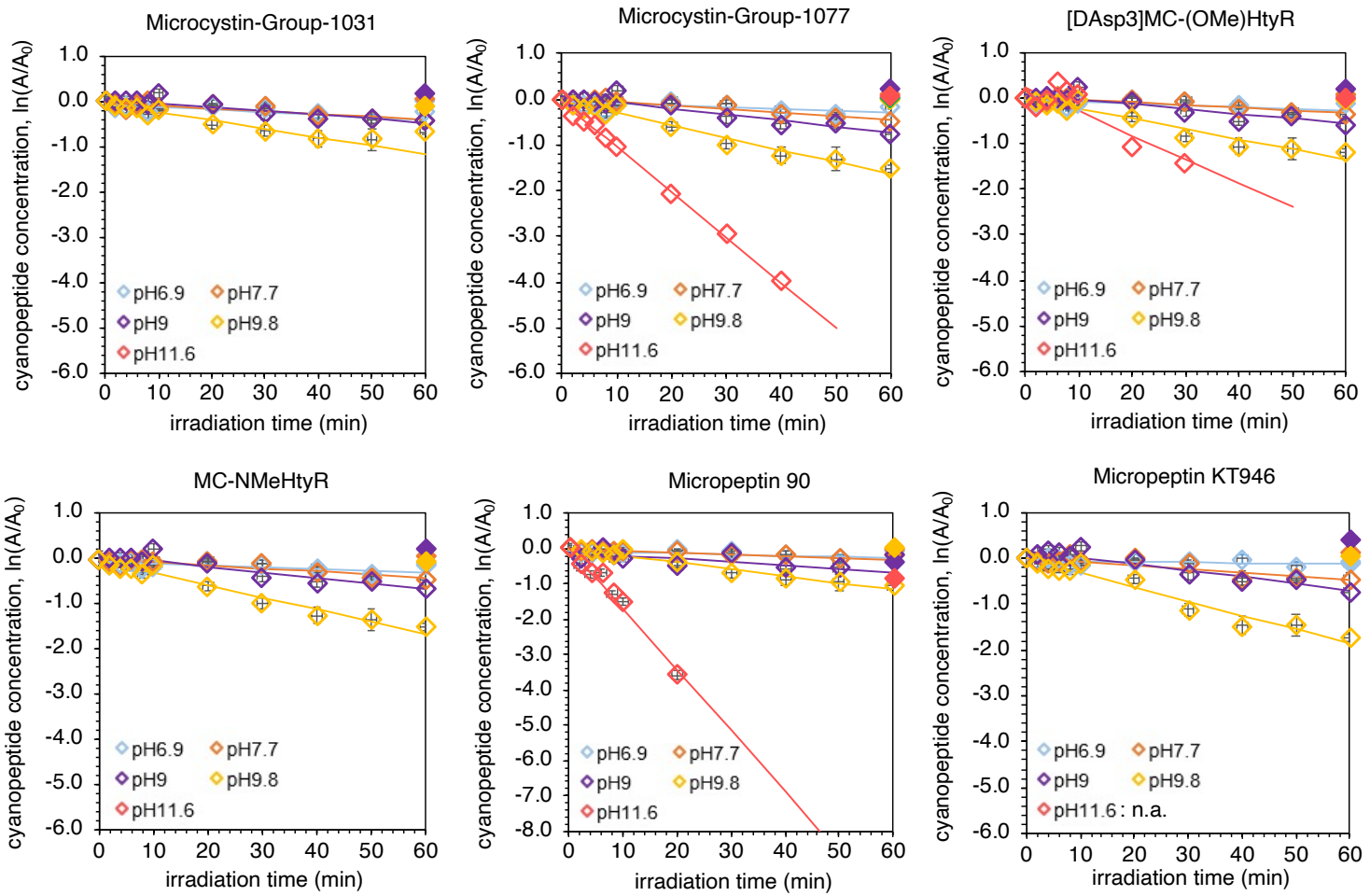


Figure S22. Irradiation in UVA light in the presence of photosensitizer perinaphthenone for microcystin group1031, microcystin group1077, [D-Asp^3]MC-(OMe)HtyR, MC-NMeHtyR, micropeptin 90, micropeptin KT946 at pH 6.9-11.6. Filled symbols at 60min present the stable dark controls. No data available at pH 11.6 for microcystin group 1031 and MC-NMeHtyR.

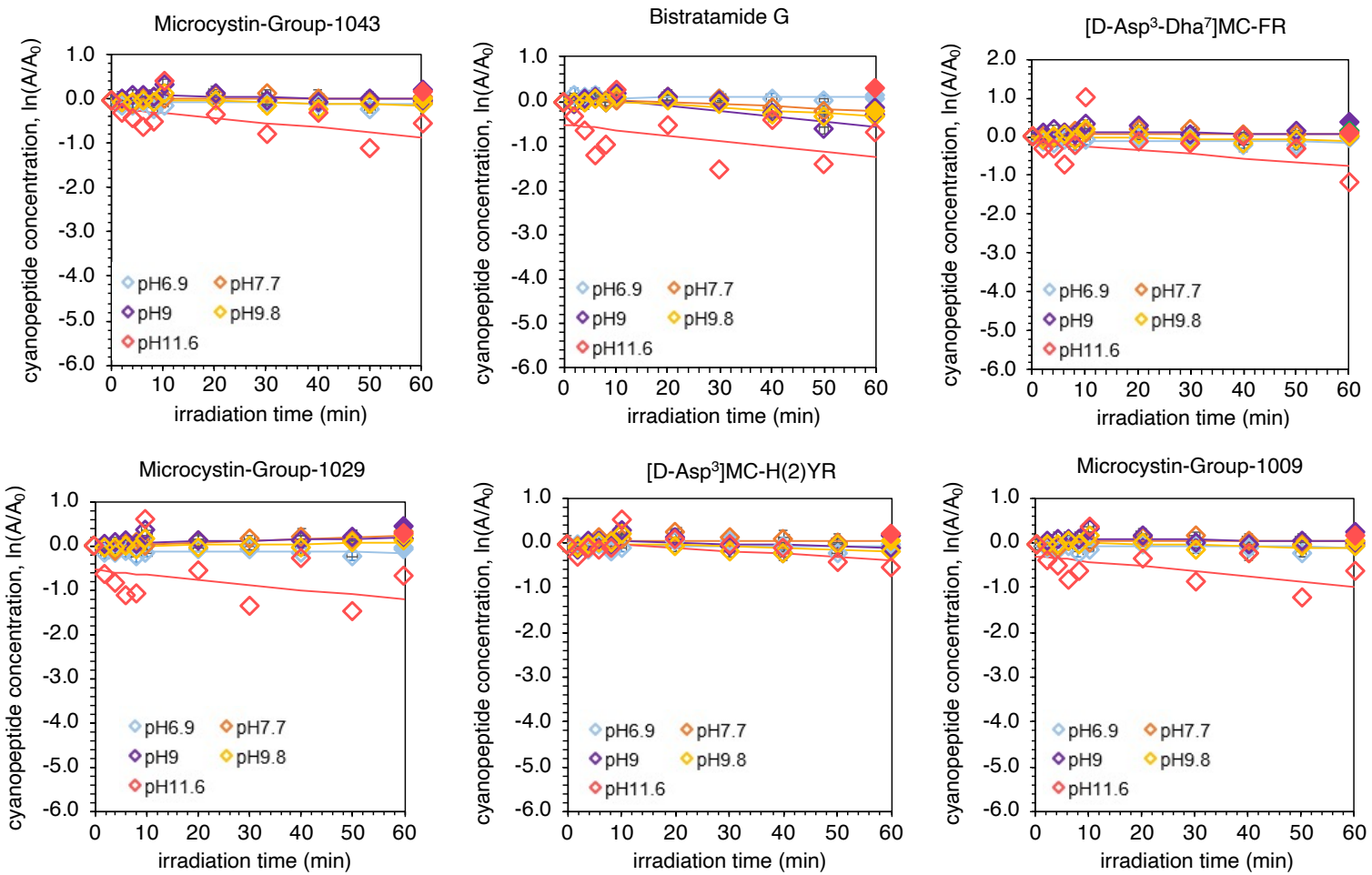


Figure S23. Irradiation in UVA light in the presence of photosensitizer perinaphthenone for microcystin group 1043 containing a singlet oxygen reactive methionine moiety, bistratamide G, [D-Asp^3-Dha^7]MC-FR, microcystin group 1029, [D-Asp^3]MC-H(2)YR, microcystin group 1009 at pH 6.9-11.6. Filled symbols at 60min present the stable dark controls.

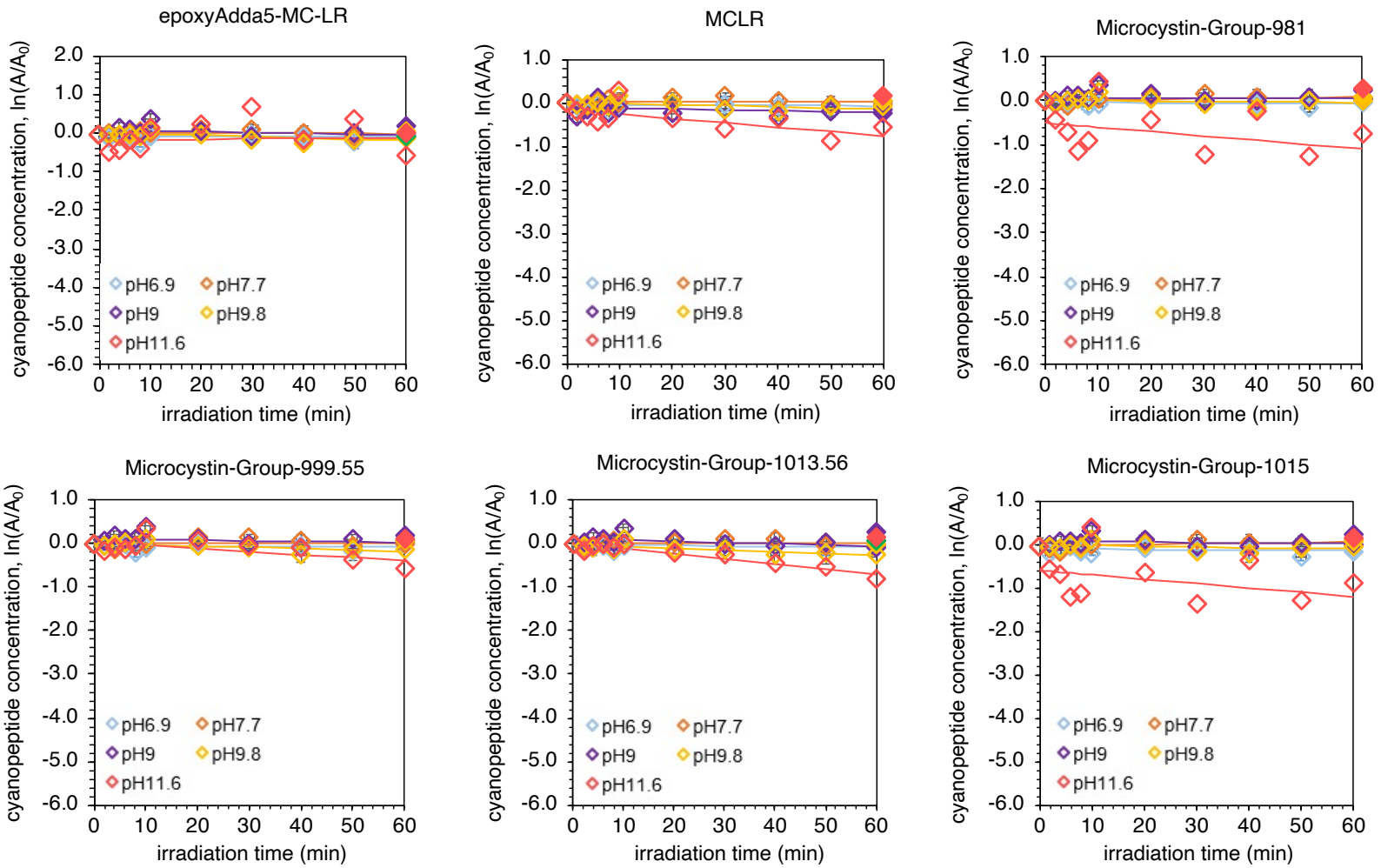


Figure S24. Irradiation in UVA light in the presence of photosensitizer perinaphthenone for epoxyAdda5-MC-LR, MCLR, microcystin group 981, microcystin group 999.55, microcystin group 1013.56, microcystin group 1015 at pH 6.9-11.6. Filled symbols at 60min present the stable dark controls.

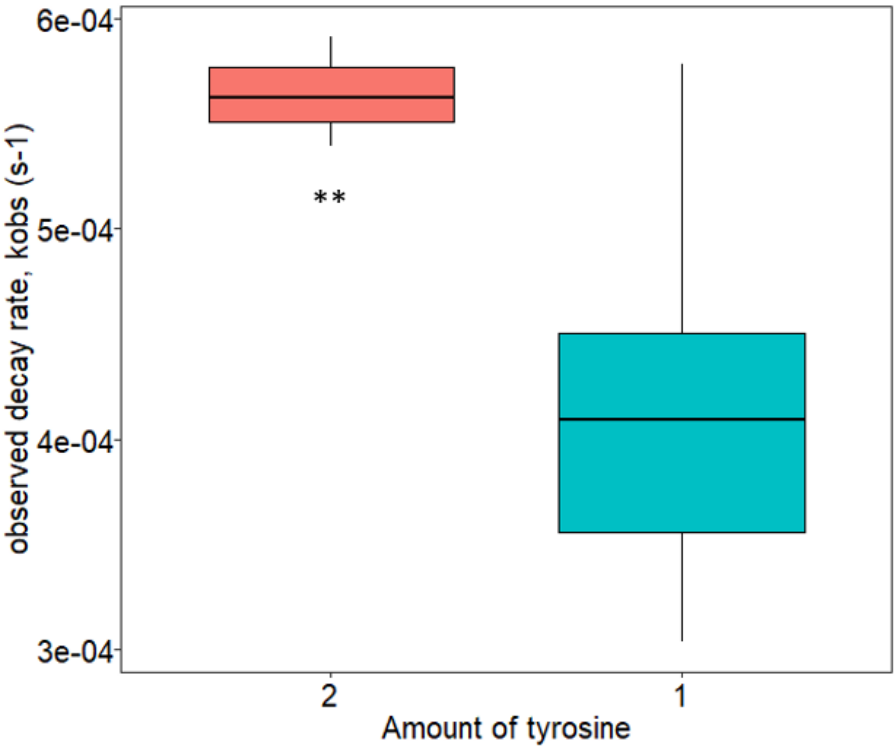


Figure S25. Boxplot of 18 tyrosine containing cyanopeptides comparing the k_{obs} (s^{-1}) of compounds containing one and two tyrosine moieties at pH 9.87 (One-way-Anova, ** p-value < 0.01).

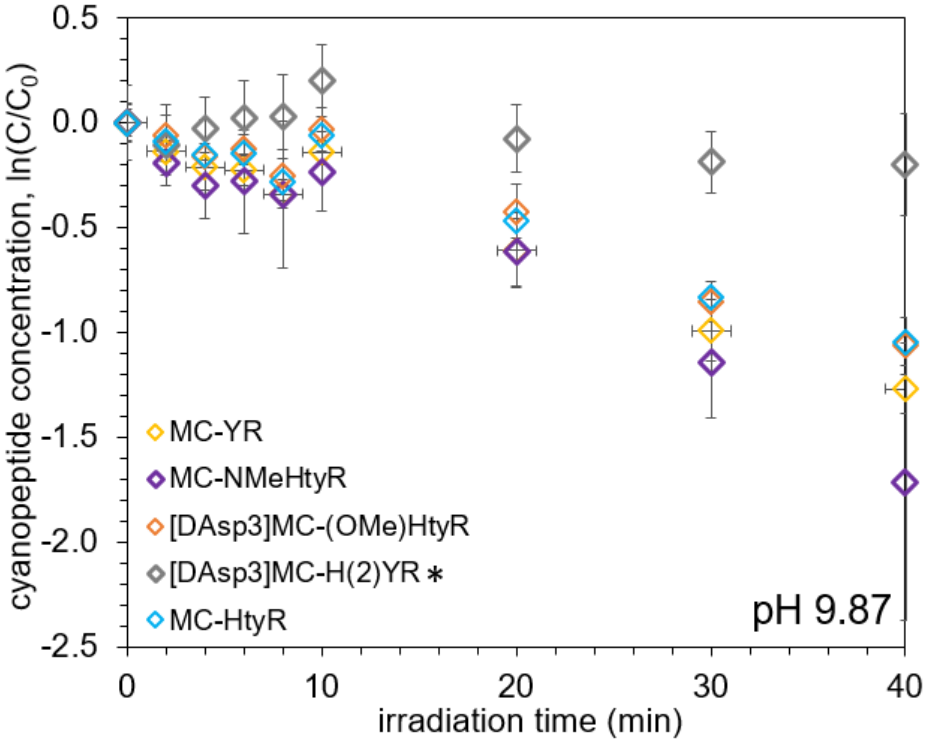


Figure S26. Decay in the presence of the sensitizer perinaphthenone, in UVA light and pH 9.8 for 1 microcystin that contains tyrosine (Y) and 4 additional microcystins with structurally related moieties: homotyrosine (MC-HtyR), N-methylated homotyrosine (MC-NMeHtyR), O-methylated tyrosine ([DAsp^3]MC-(OMe)HtyR), and cyclohexa-2,4-dien-1-ol ([D-Asp^3]MC-H(2)YR). Statistical analysis further confirmed that [D-Asp^3]MC-H(2)YR degradation is significantly different from the other microcystins (*Anova, p-value < 0.0001).

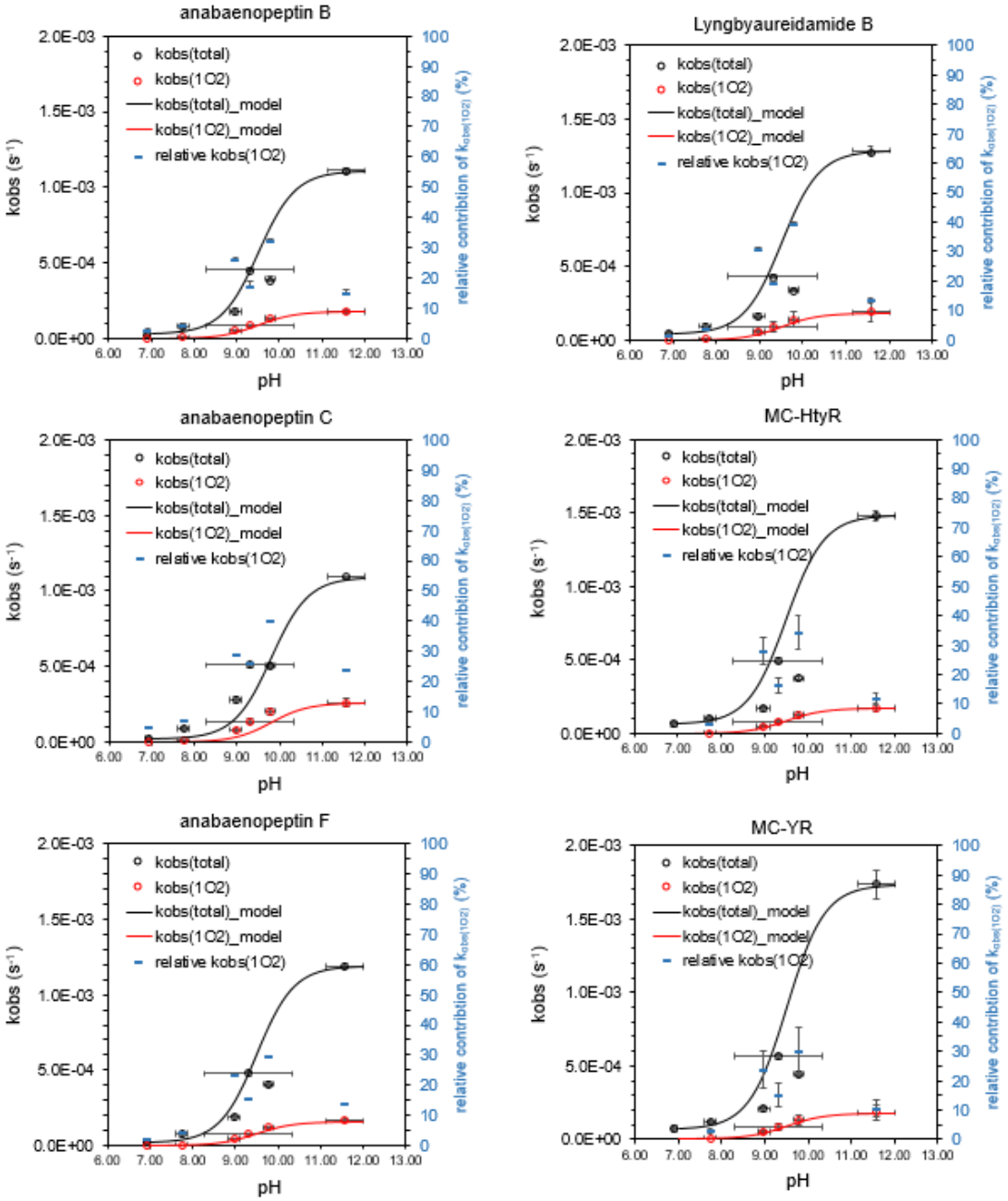


Figure S27. Observed reaction rate constant (k_{obs}) versus pH for the observed rates, $k_{obs,total}$ (black circles), and the contribution of the reaction with singlet oxygen, $k_{obs,1O2}$ (red circles), and the relative contribution of the singlet oxygen pathway on the secondary y-axis (blie bars) for anabaenopeptin B, lyngbyaureidamide B, anabaenopeptin C, anabaenopeptin F, MC-HtyR and MC-YR.

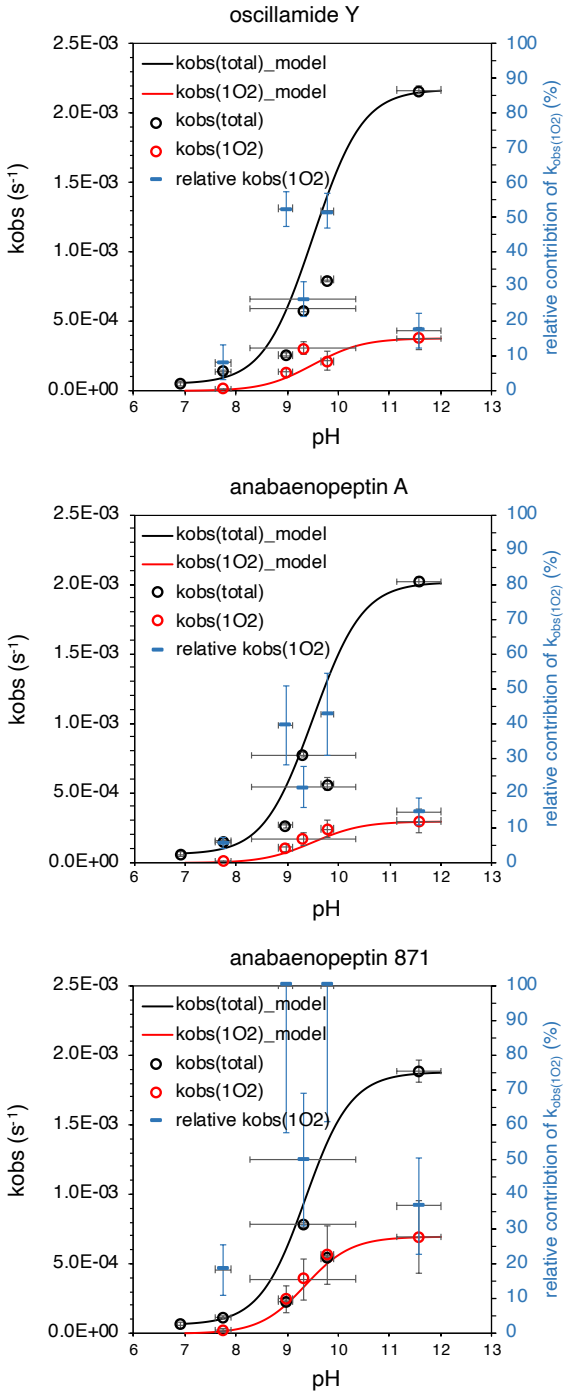


Figure S28. Observed reaction rate constant (k_{obs}) versus pH for the observed rates, $k_{obs,total}$ (black circles), and the contribution of the reaction with singlet oxygen, $k_{obs,1O2}$ (red circles), and the relative contribution of the singlet oxygen pathway on the secondary y-axis (blie bars) for oscillamide Y, anabaenopeptin A and anabaenopeptin 871.