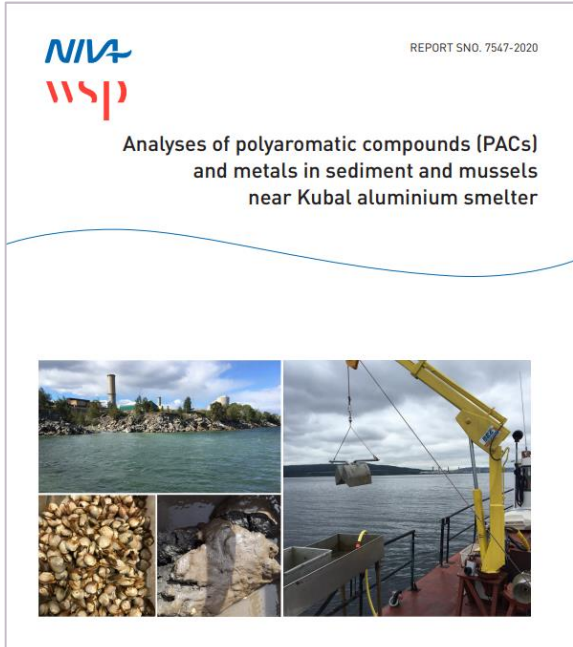
Utvidet analyse av flere PAH enn PAH16 gir et bedre bilde av toksiske effekter og kilder

Merete Grung[1], Alfhild Kringstad[1], Per Holmlund[2], Sondre Meland[1] and Ailbhe Macken[1]

[1] NIVA, Oslo, Norway

[2] WSP Environmental Sweden, Sundsvall, Sweden

E-mail: merete.grung@niva.no

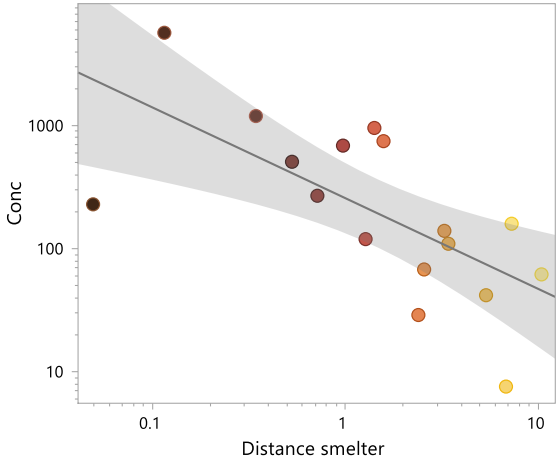


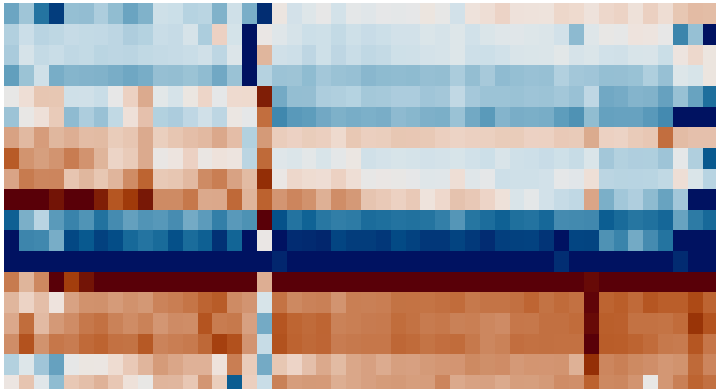
https://niva.brage.unit.no/niva-xmlui/handle/11250/2689453




Environmental class
(EU WFD + Norwegian classification system)

Background	Background levels	
Good	No toxic effects	
Moderate	Toxic effects upon chronic exposure	EQS AA
Poor	Toxic effect following short term exposure	EQS MAC
Bad	Severe acute toxic effects	MAC×5





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Analyses sediment/biota

PACs (54)

(ng/g dw or ng/ww)

PAH16

Alkylated PACs

- N (C1-C4)
- P/A (C1-C4)
- F (C1-C3)
- D (C1-C3)
- PY/FLA (C1-C2)
- C (C1-C2)

Other

- Large ring PACs

Metals (8)

(µg/g dw)

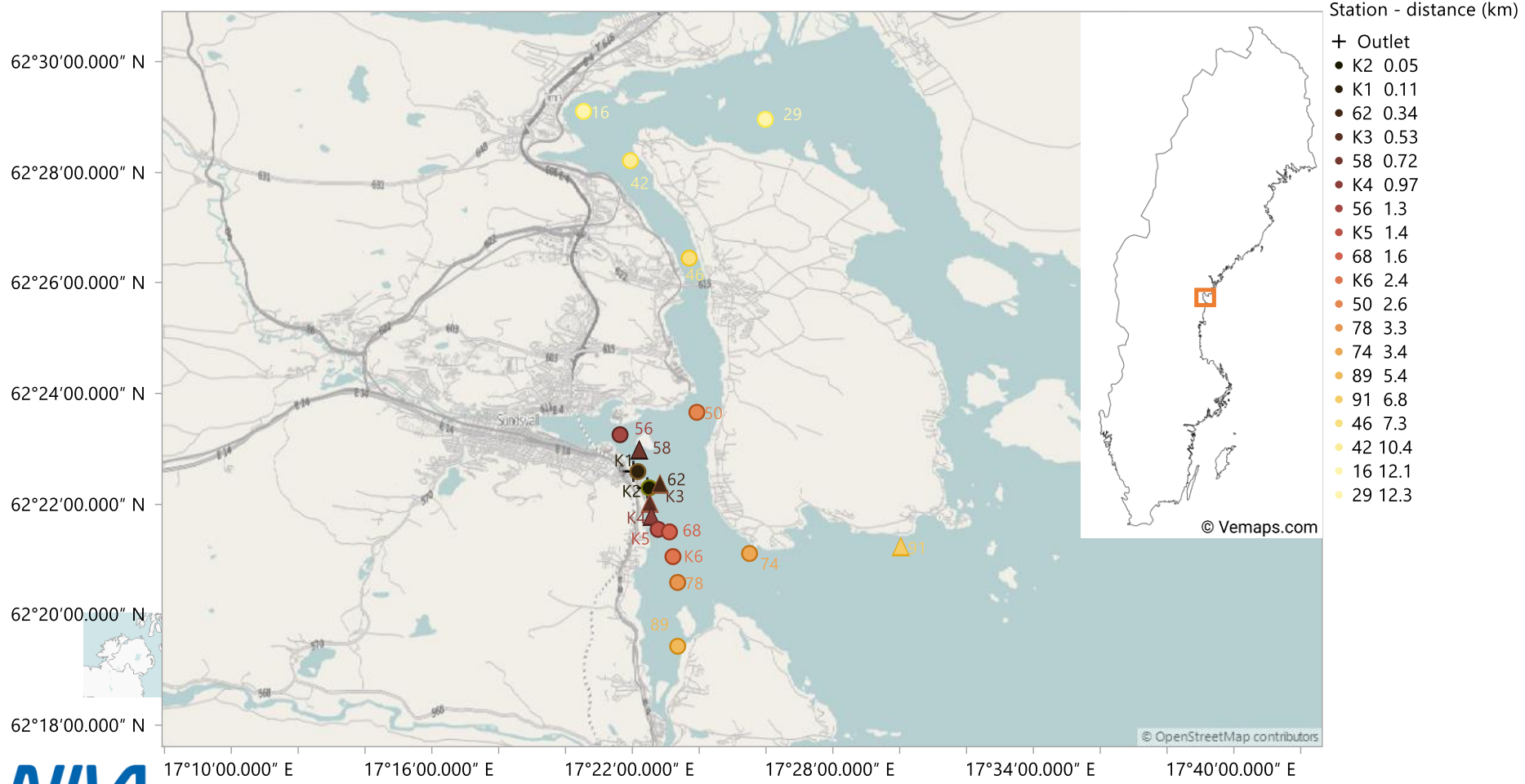
As
Cd
Cr
Cu
Hg
Pb
Ni
Zn

NIVA

Andersson and Achten 2015,
https://doi.org/10.1080/10406638.2014.991042

Compound	Abbr.	*m/z*	*WFD* sediment	WFD biota
Naphthalene	N	128	PS	PS
C1-Naphthalenes	N_C1	142		
C2-Naphthalenes	N_C2	156		
C3-Naphthalene	N_C3	170		
C4-Naphthalenes	N_C4	184		
Acenaphthylene	ACY	152	N-RBSP	
Acenaphthene	ACN	154	N-RBSP	
Fluorene	F	166	N-RBSP	
C1-Fluorenes	F_C1	180		
C2-Fluorenes	F_C2	194		
C3-Fluorenes	F_C3	208		
Anthracene	A	178	PS	PS
Phenanthrene	P	178	N-RBSP	
C1-Phenanthrenes	PA_C1	192		
C2-Phenanthrenes	PA_C2	206		
C3-Phenanthrenes	PA_C3	220		
C4-Phenanthrenes	PA_C4	234		
Retene	R	234		
Dibenzothiophene	D	184		
C1-Dibenzothiophenes	D_C1	198		
C2-Dibenzothiophenes	D_C2	212		
C3-Dibenzothiophenes	D_C3	226		
Fluoranthene	FLA	202	PS	PS
Pyrene	PY	202	N-RBSP	
C1-Pyrene/Fluoranthene	PY_C1	216		
C2-Pyrene/Fluoranthene	PY_C2	230		
Benzo(a)anthracene	BaA	228	N-RBSP	
6-methylbenz(a)anthracene	BaA_C1	242		
7,12-dimethylbenz(a)a.	BaA_C2	256		
3-methylcholanthrene	CA_C1	268		

Compound	Abbr.	*m/z*	*WFD* sediment	WFD biota
Chrysene	C	228	N-RBSP	
C1-Chrysenes	C_C1	242		
C2-Chrysenes	C_C2	256		
Benzo(b,j)fluoranthene	BbjF	252	PS (b)	
Benzo(k)fluoranthene	BkF	252	PS	
Benzo(a)pyrene	BaP	252	PS	PS
6-methylbenzo(a)pyrene	BaP_C1	266		
Indeno(1,2,3-cd)pyrene	IP	276	PS	
Benzo(ghi)perylene	BgP	276	PS	
Dibenz(ac/ah)anthracene	DahA	278	N-RBSP	
7H-benzo(c)fluorene	BcF	216		
cyclopenta(cd)pyrene	CcP	226		
benzo(ghi)fluoranthene	BgF	226		
benz(c)phenanthrene	BcP	228		
benzo(e)pyrene	BeP	252		
benzo(j)fluoranthene	BjF	252		
Perylene	PER	252		
benzo[j]aceanthrylene	BjeAA	252		
Anthanthrene	ANE	276		
dibenzo(a,e)fluoranthene	DaeF	302		
dibenzo(a,l)pyrene	DalP	302		
dibenzo(a,e)pyrene	DaeP	302		
dibenzo(a,i)pyrene	DaiP	302		
dibenzo(a,h)pyrene	DahP	302		
PAH16	PAH16		N-RBSP	


62°30'00.000" N
62°28'00.000" N
62°26'00.000" N
62°24'00.000" N
62°22'00.000" N
62°20'00.000" N
62°18'00.000" N
17°10'00.000" E
17°16'00.000" E
17°22'00.000" E
17°28'00.000" E
17°34'00.000" E
17°40'00.000" E
Sundsvall
16
29
42
46
50
56
58
K1
62
K2
K3
K4
68
K5
K6
74
78
89
91
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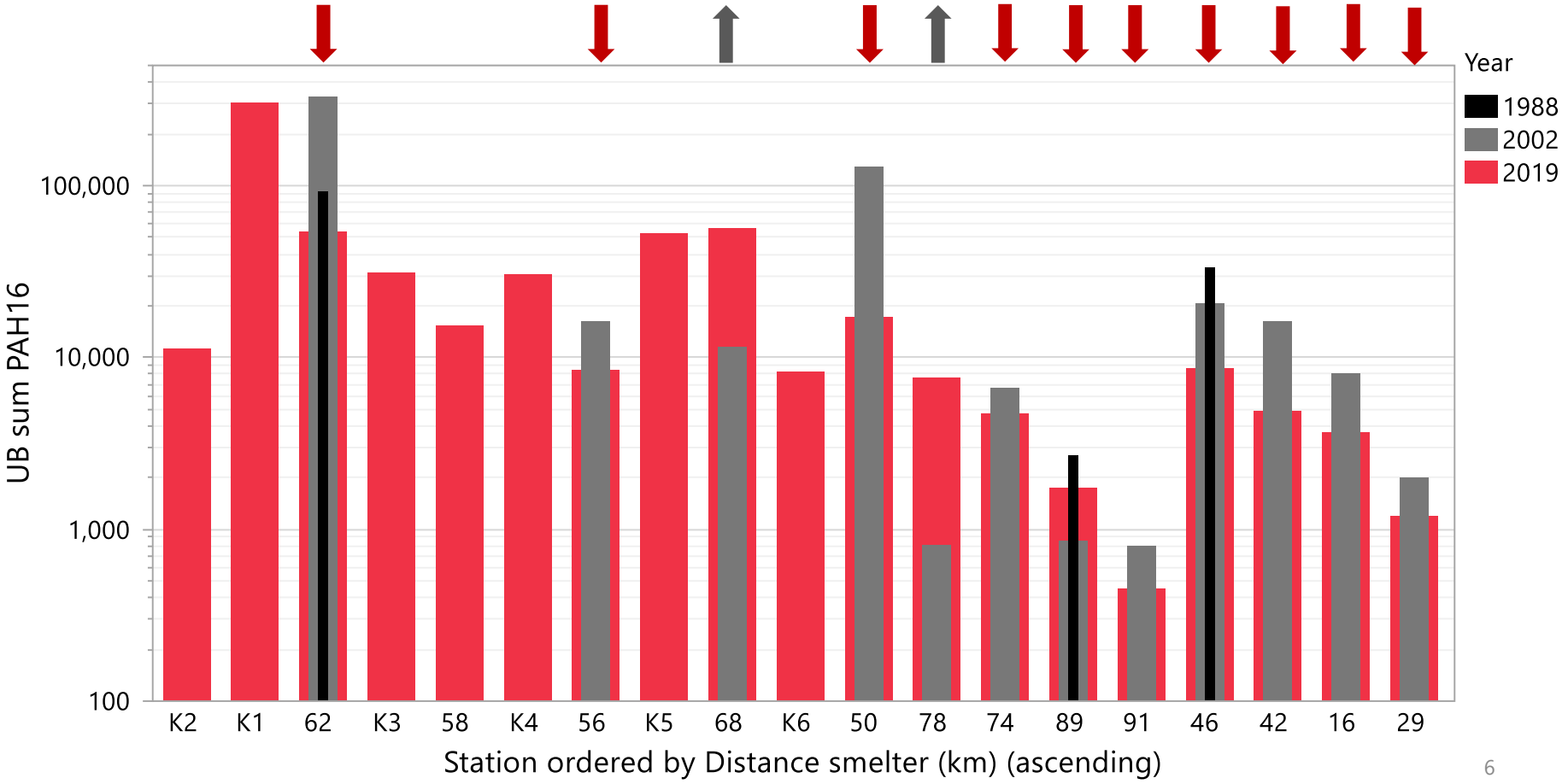
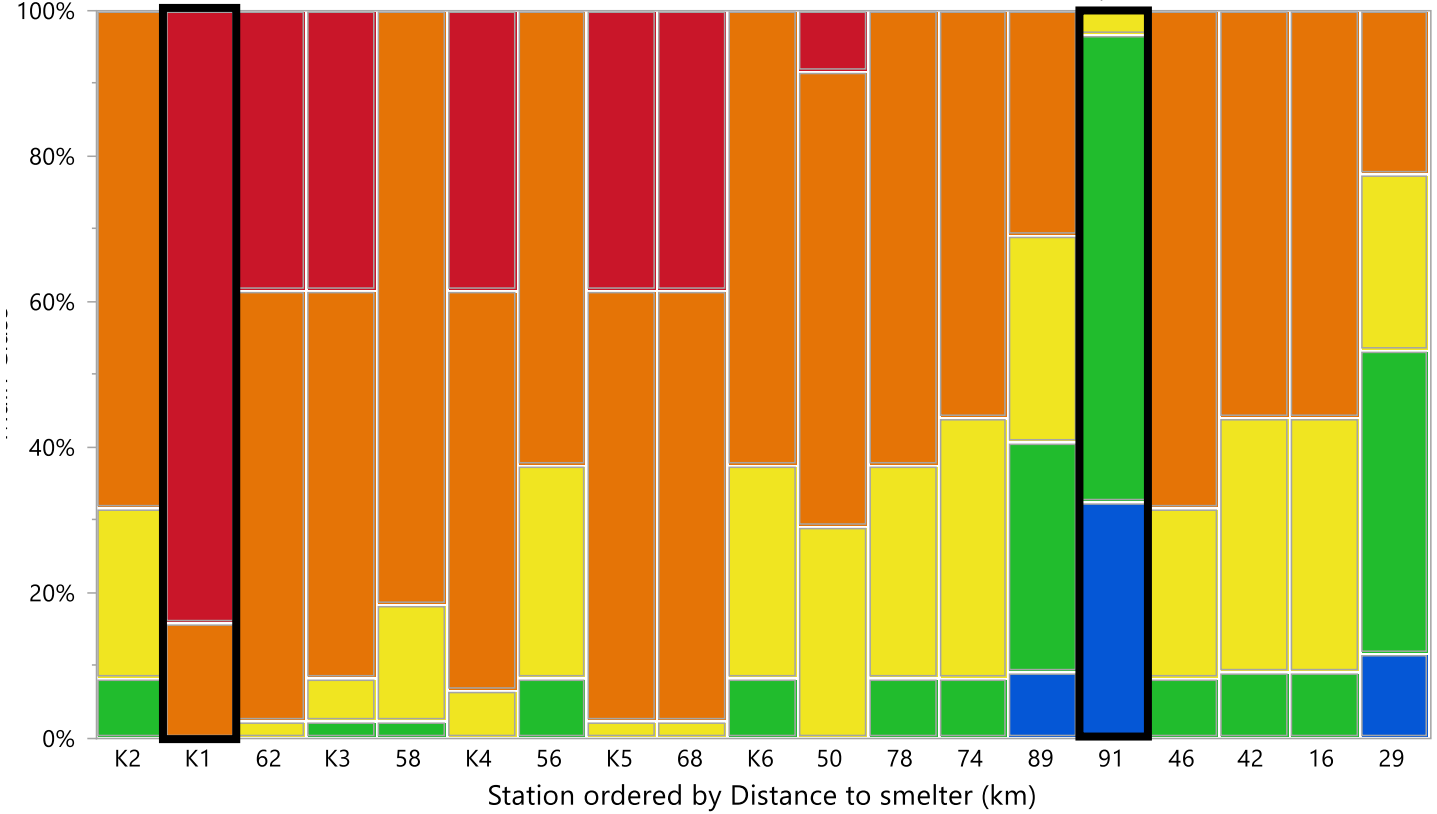
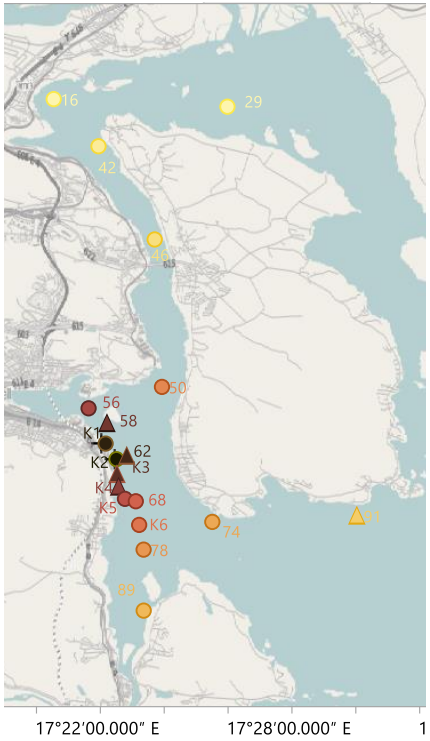
Station - distance (km)
Outlet
K2 0.05
K1 0.11
62 0.34
K3 0.53
58 0.72
K4 0.97
56 1.3
K5 1.4
68 1.6
K6 2.4
50 2.6
78 3.3
74 3.4
89 5.4
91 6.8
46 7.3
42 10.4
16 12.1
29 12.3

PAH16 in sediments (1988, 2002, 2019)

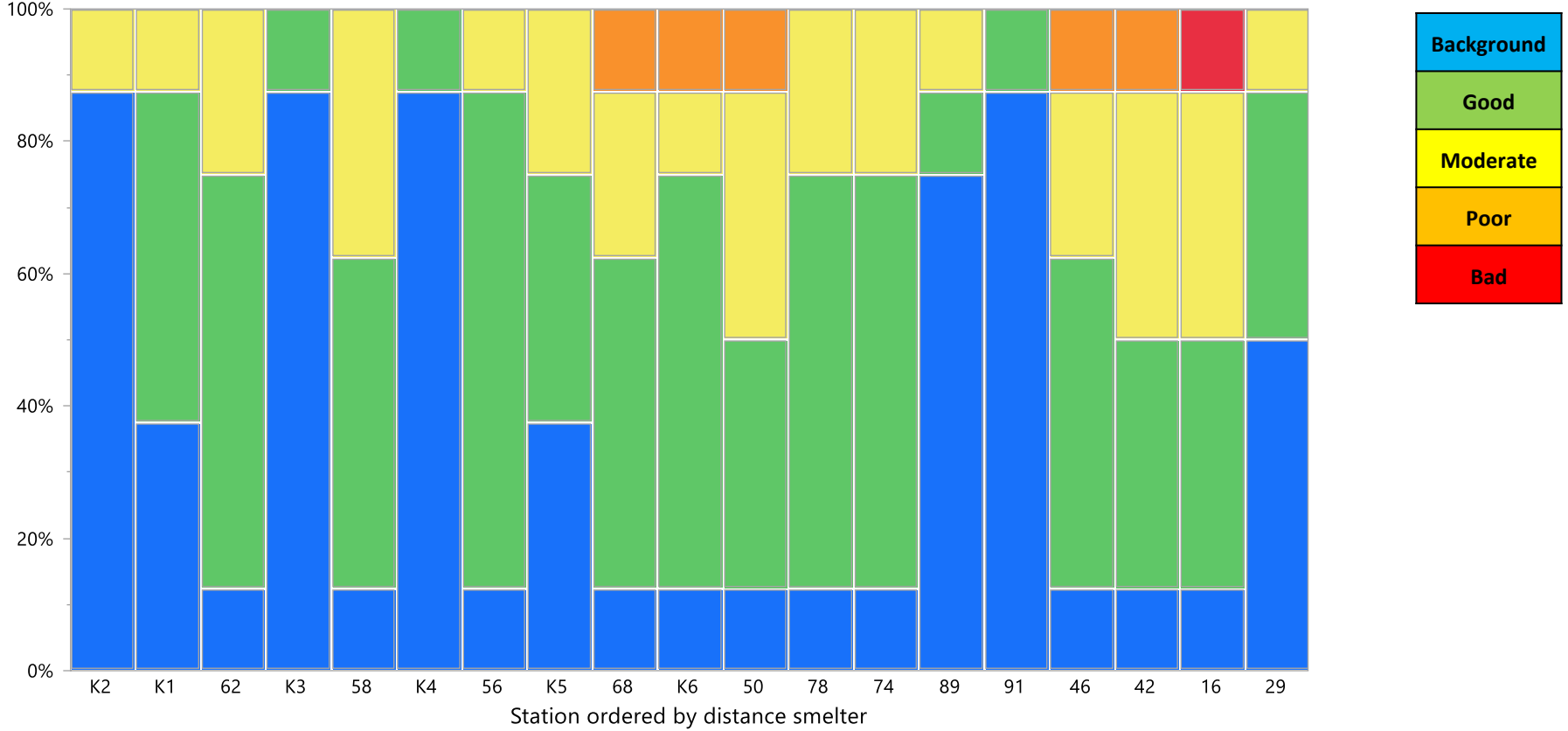


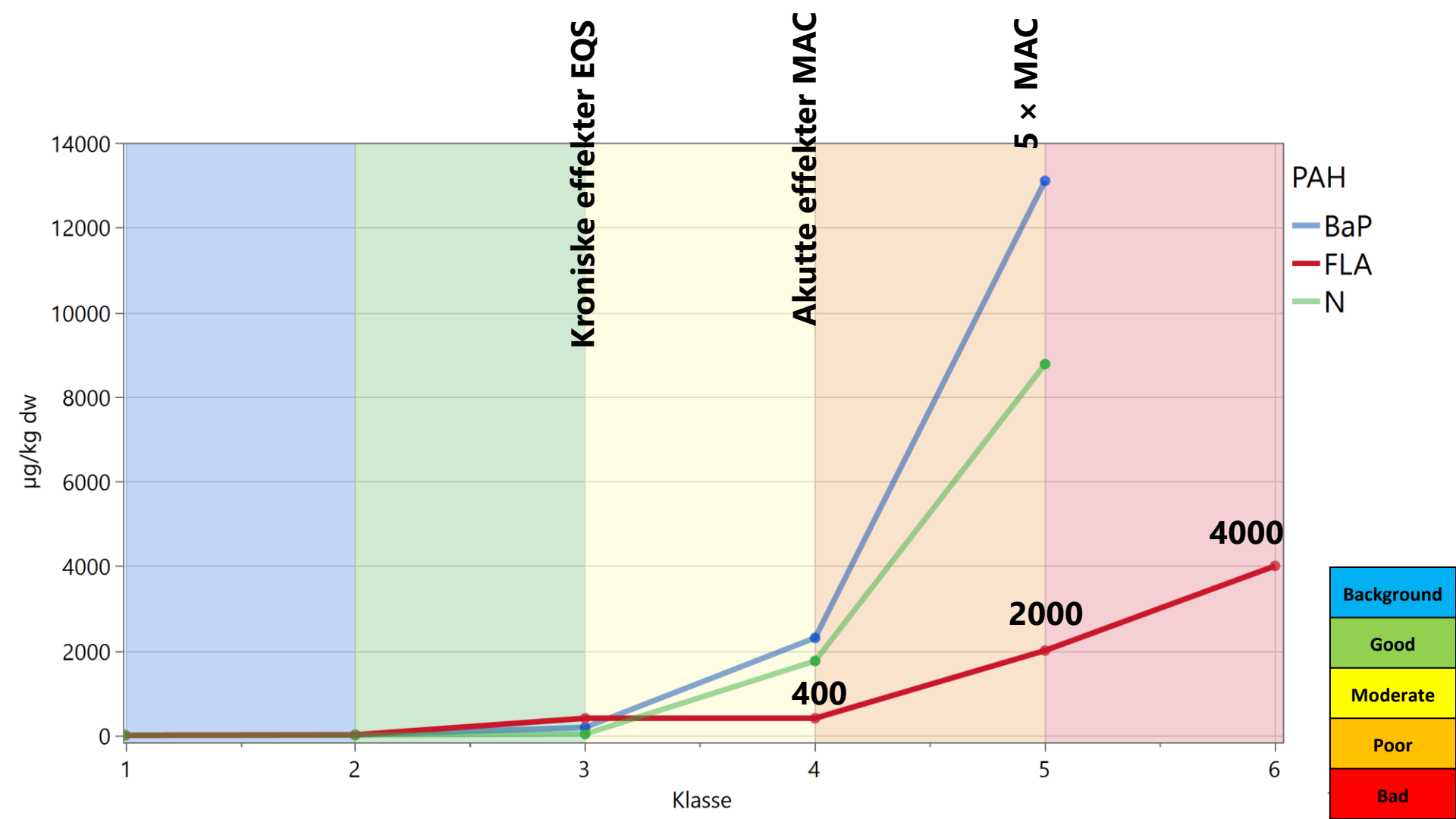
Environmental class 16 PAH (sediments)



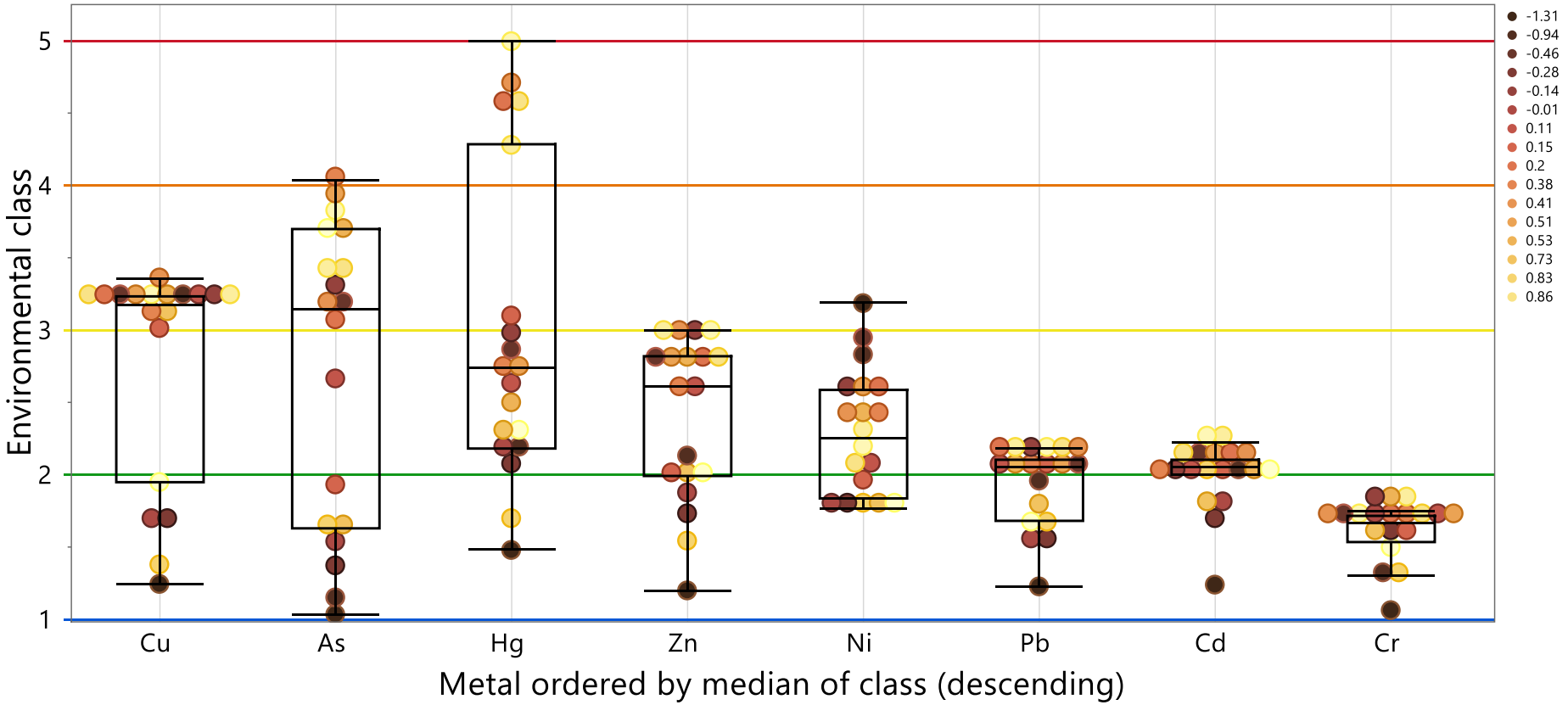


Environmental class metals (sediments)

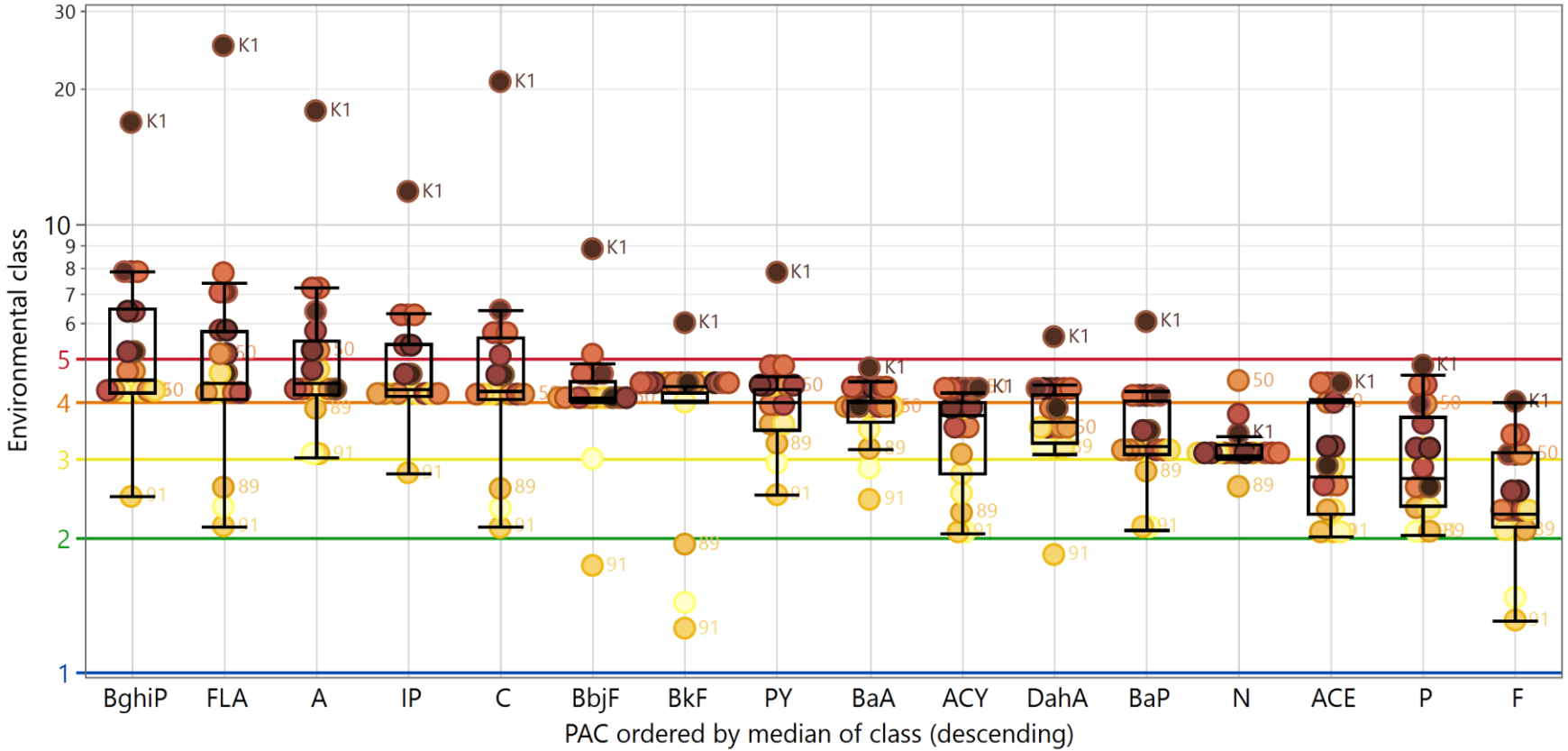



Kroniske effekter EQS
Akutte effekter MAC
5 × MAC
PAH
BaP
FLA
N
µg/kg dw
14000
12000
10000
8000
6000
4000
2000
0
1
2
3
4
5
6
Klasse
400
2000
4000
Background
Good
Moderate
Poor
Bad

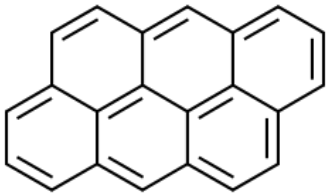
Risk of individual metals in sediment

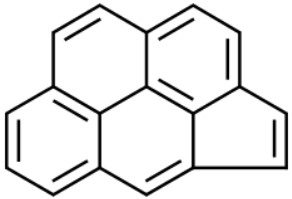


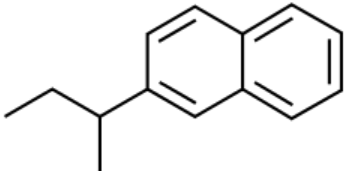
Risk of individual PAHs in sediment

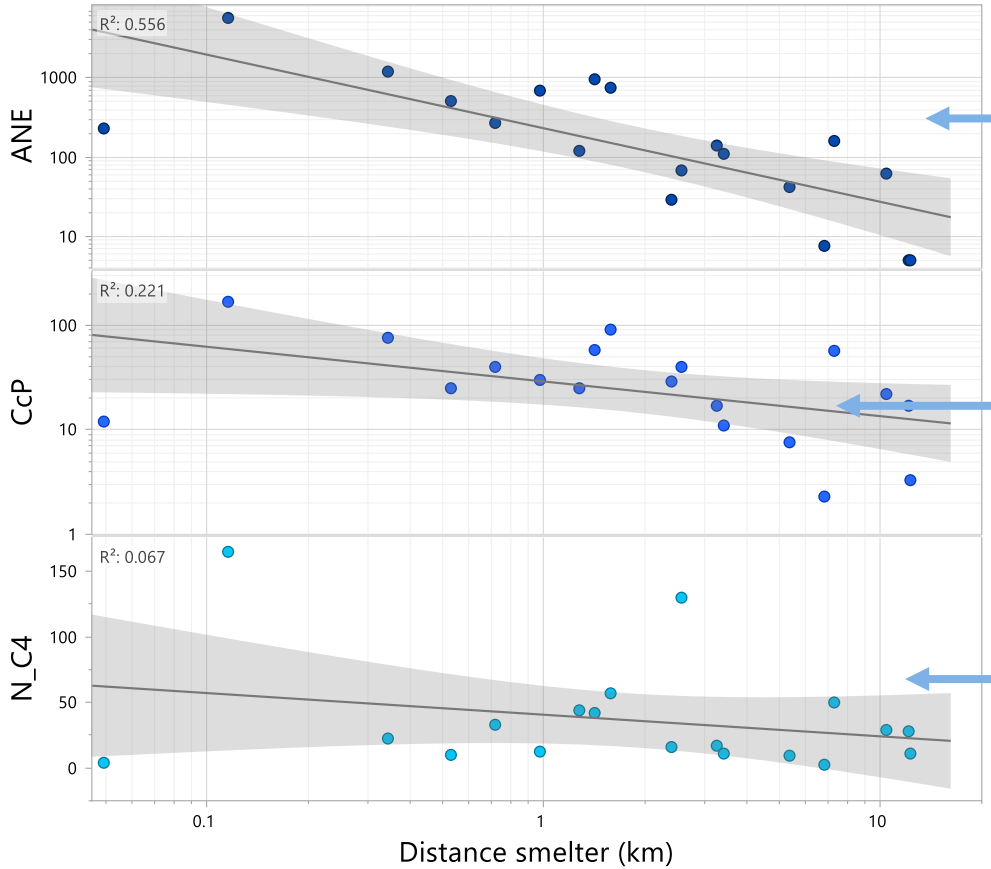


PACs in sediments correlate w. distance



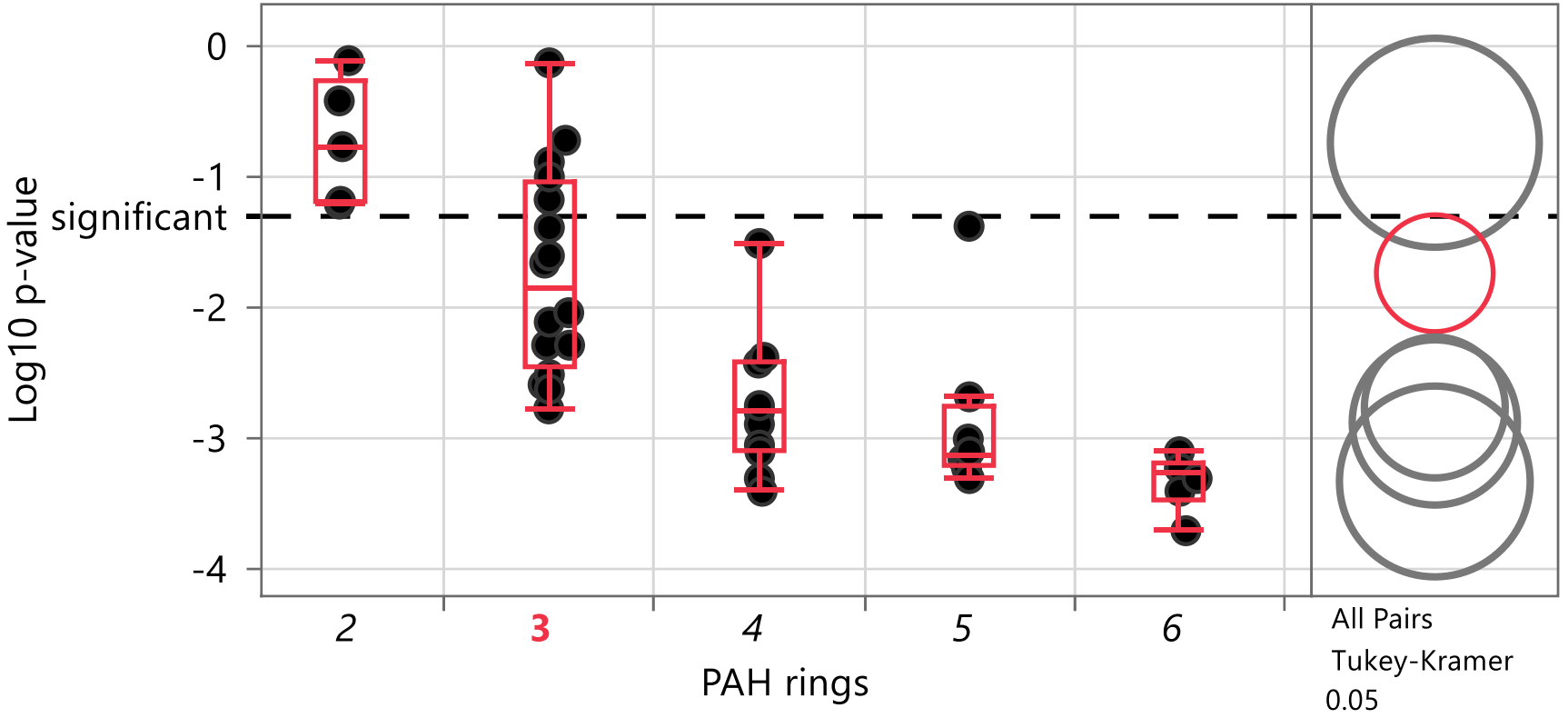




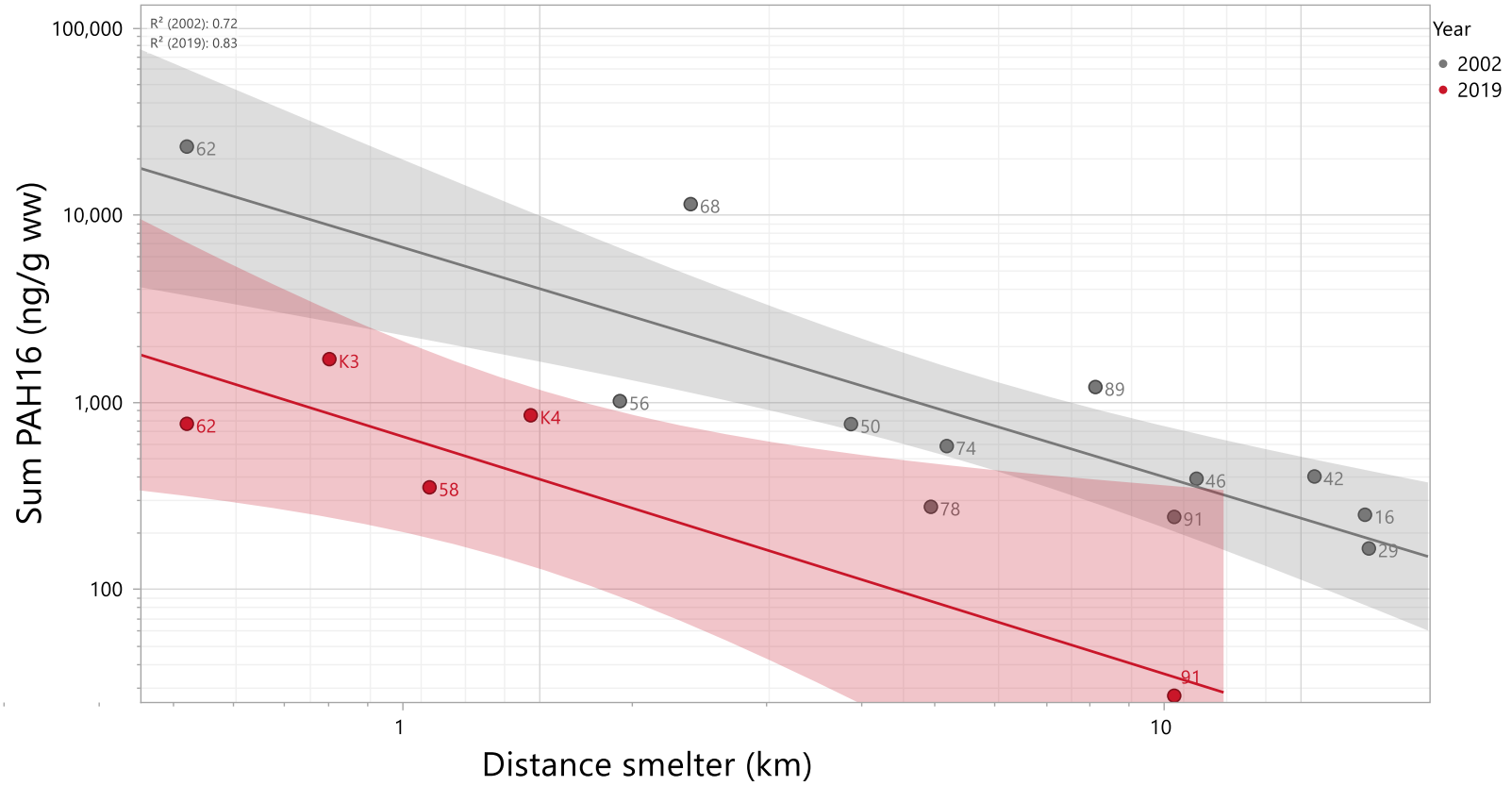


PAC	Slope	Prob>|t|
ANE	-0.93	0.00020
C	-0.81	0.00040
DaeP	-0.70	0.00040
BaP	-0.83	0.00050
BcF	-0.74	0.00050
DaeF	-0.63	0.00050
BgP	-0.67	0.00060
DahP	-0.79	0.00060
PER	-0.70	0.00060
BbjF	-0.73	0.00070
BeP	-0.73	0.00070
PY_C1	-0.73	0.00080
BkF	-0.72	0.00080
IP	-0.65	0.00080
BaA	-0.73	0.00090
DahA	-0.63	0.0010
C_C1	-0.69	0.0013
PY	-0.68	0.0016
FLA	-0.68	0.0017
ACY	-0.75	0.0017
BcP	-0.67	0.0018
BgF	-0.65	0.0021
PA_C1	-0.64	0.0024
A	-0.69	0.0026
P	-0.65	0.0031
C_C2	-0.57	0.0038
PY_C2	-0.56	0.0042
F_C1	-0.58	0.0052
F	-0.65	0.0052
PA_C2	-0.53	0.0078
F_C2	-0.52	0.0092
PA_C3	-0.48	0.022
D	-0.53	0.025
BaA_C2	-0.38	0.031
D_C1	-0.42	0.041
CcP	-0.33	0.042
N_C2	-0.39	0.062
N_C1	-0.46	0.065
F_C3	-0.35	0.067
R	0.32	0.10
D_C2	-0.29	0.13
N	-0.38	0.17
D_C3	-0.25	0.19
N_C3	-0.14	0.38
ACE	-0.06	0.74
N_C4	-0.05	0.77

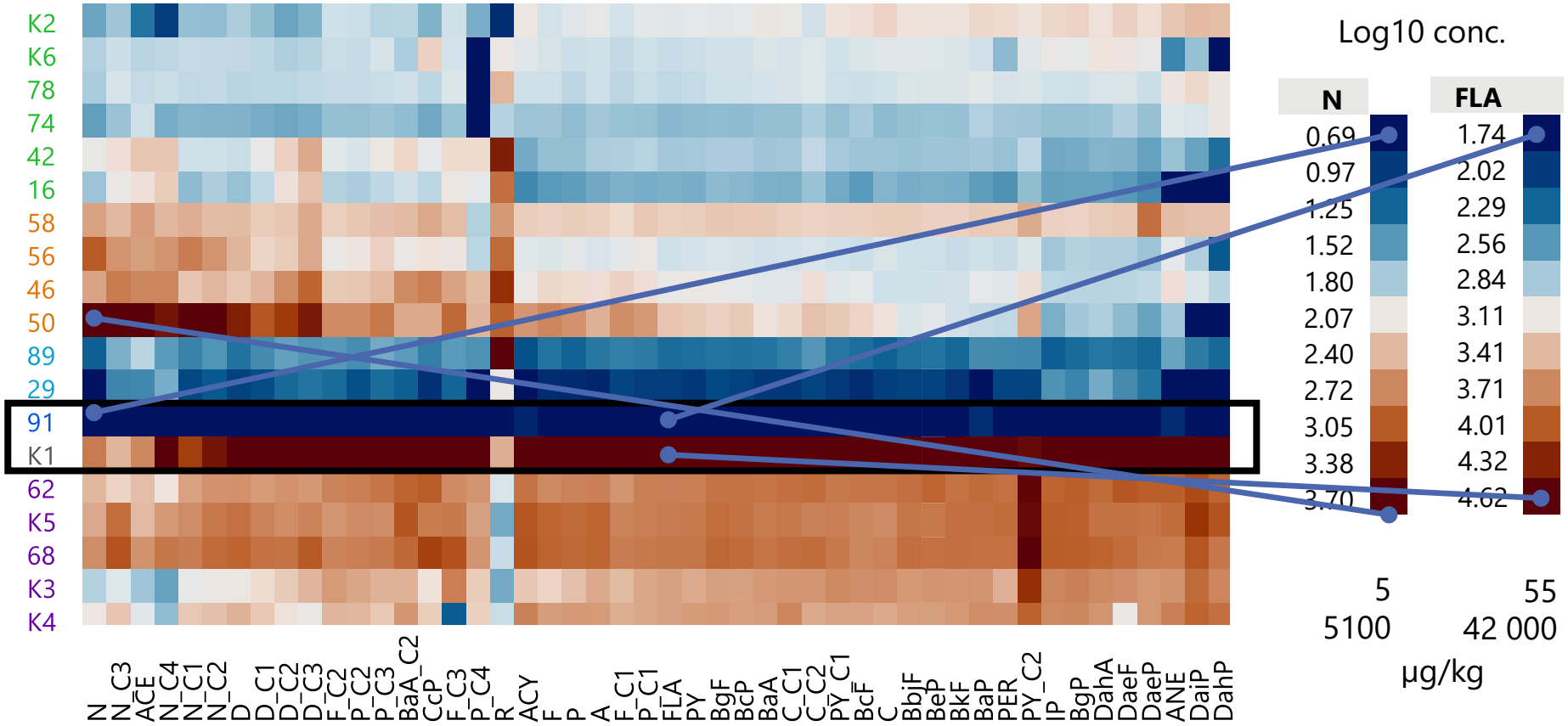
Larger PAC: more correlated with distance to smelter

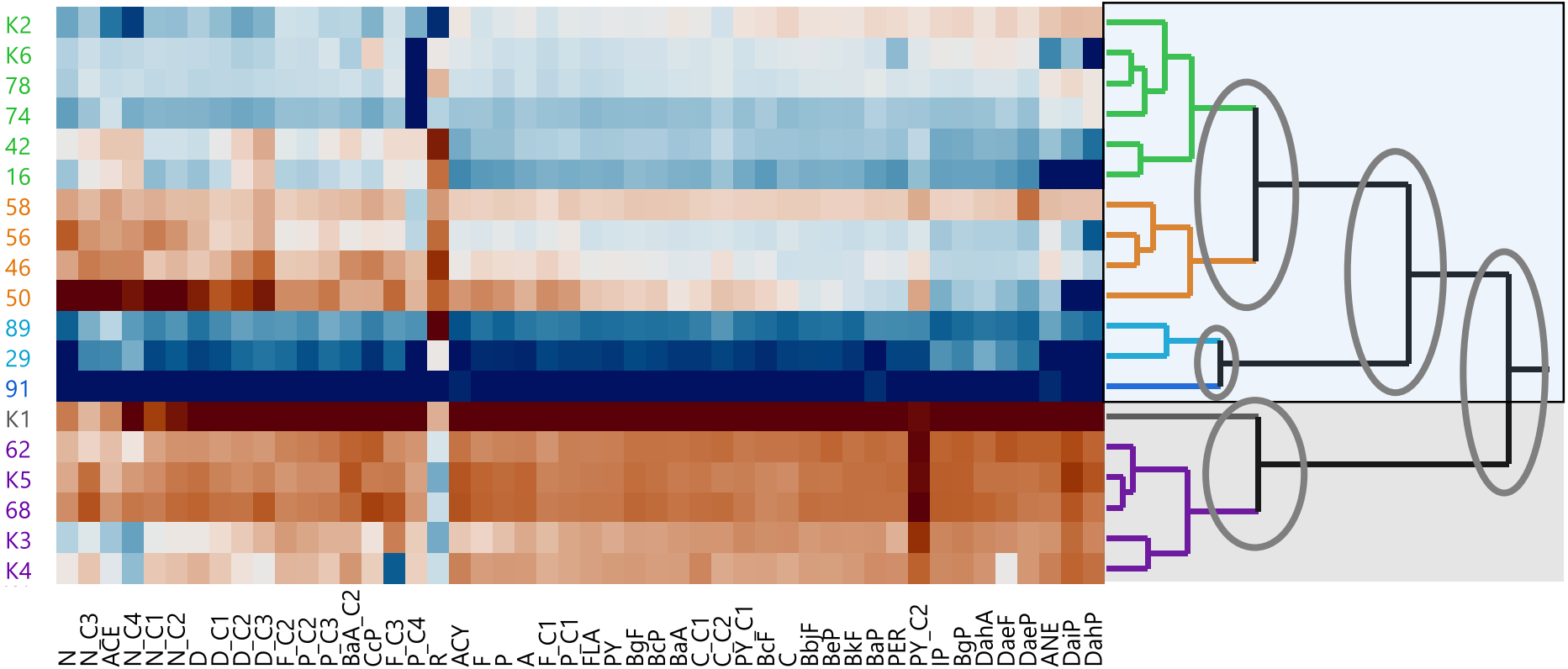


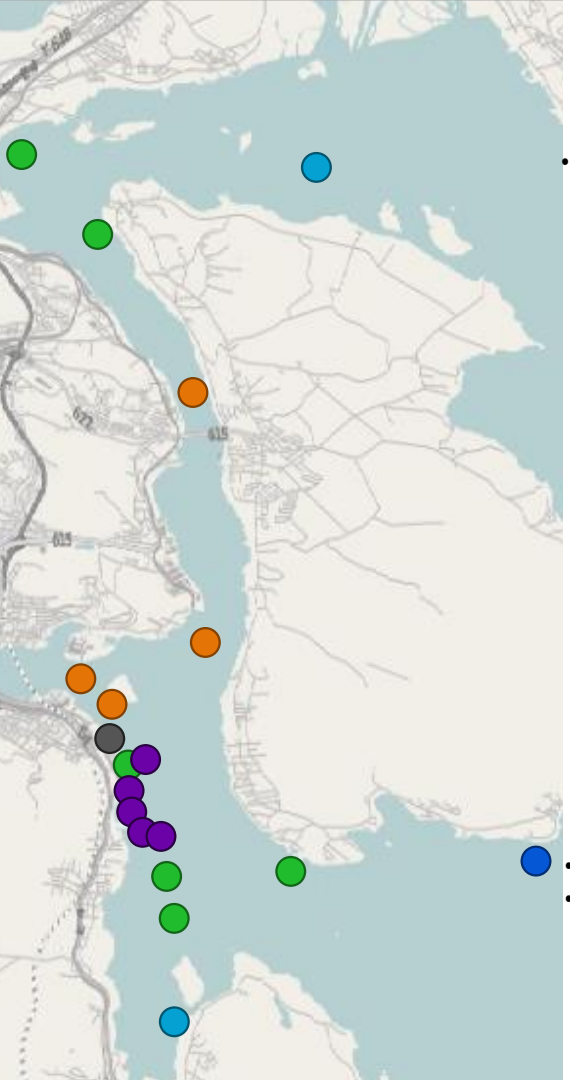
PAH16 in mussels vs distance (2002 vs 2019)

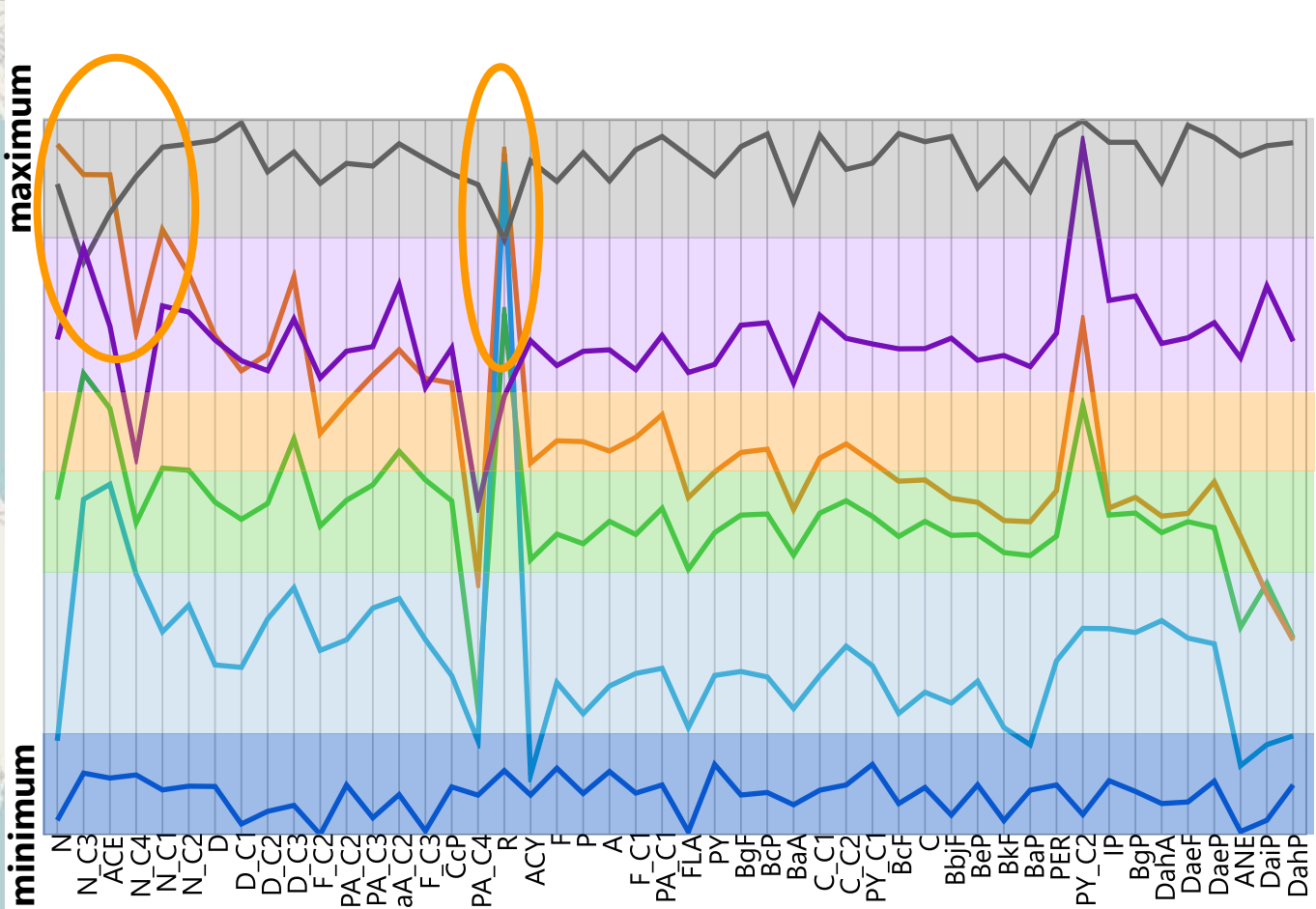


2-way hierarchichal cluster




K2
K6
78
74
42
16
58
56
46
50
89
29
91
K1
62
K5
68
K3
K4
N
N_C3
ACE
N_C4
N_C1
N_C2
D
D_C1
D_C2
D_C3
F_C2
P_C2
P_C3
BaA_C2
CcP
F_C3
P_C4
R
ACY
F
P
A
F_C1
P_C1
FLA
PY
BgF
BcP
BaA
C_C1
C_C2
PY_C1
BcF
C
BbjF
BeP
BkF
BaP
PER
PY_C2
IP
BgP
DahA
DaeF
DaeP
ANE
DaiP
DahP




maximum
minimum
N
N_C3
ACE
N_C4
N_C1
N_C2
D
D_C1
D_C2
D_C3
F_C2
PA_C2
PA_C3
BaA_C2
F_C3
CcP
PA_C4
R
ACY
F
P
A
F_C1
PA_C1
FLA
PY
BgF
BcP
BaA
C_C1
C_C2
PY_C1
BcF
C
BbjF
BeP
BkF
BaP
PER
PY_C2
IP
BgP
DahA
DaeF
DaeP
ANE
DaiP
DahP

Conclusions

PAC release from smelter has been reduced later years

PACs in sediment and biota correlated with distance to smelter

PACs in the area pose a higher risk to environment than metals

Multivariate statistics/extended PAC analyses revealed additional sources to PACs than smelter

Acknowledgements

https://www.ams-aluminium.net/

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Per Holmlund

https://rusal.ru/en/about/geography/kubikenborg-aluminium-ab-kubal/

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