Neutron Activation Analysis for Ecological State Assessment of Coastal Ecosystems of the Black Sea

26 slides

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"Neutron activation analysis for ecological state assessment of coastal ecosystems of the Black Sea".

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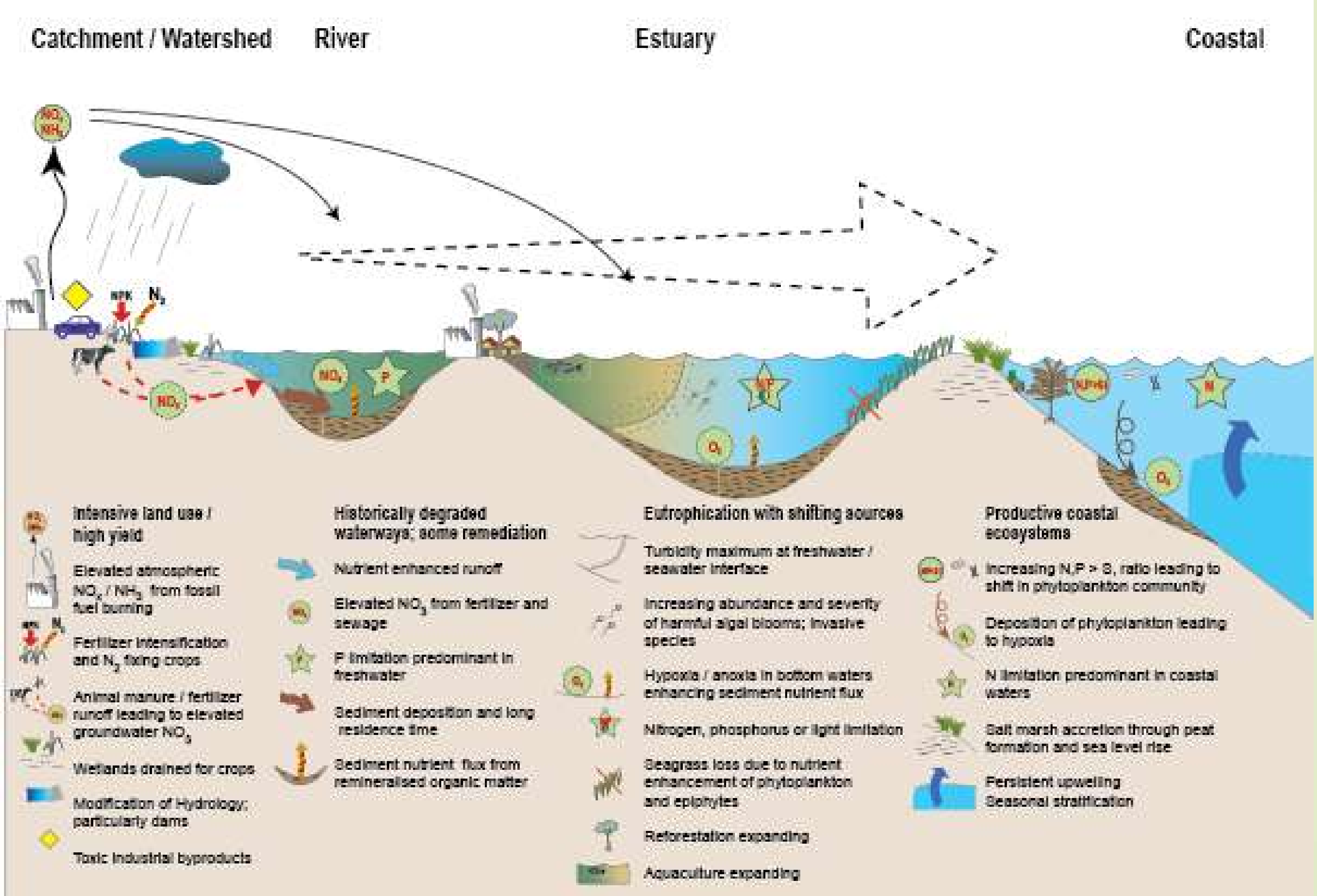
Plan

- General principles of development of coastal ecosystems
- Material and Methods: Neutron Activation Analysis
- Material and Methods: sampling
- Results: Substrates (Soils, BS, Water)
- Results: Objects (Aquatic Plants, Macrophytes, PHytoplankton)

Coastal ecosystems



Aim and tasks

to determine the ranges of variability of concentrations of different groups of elements in connection with affinity of pollution sources and properties of autotrophic biota

- Selection of model zones
- Determination (checking) of organisms-biomonitors
- Estimation of the levels of accumulation of elemental groups in these organisms by different zones
- The comparative analysis of data with reference values

Natural reserves

Recreational zones

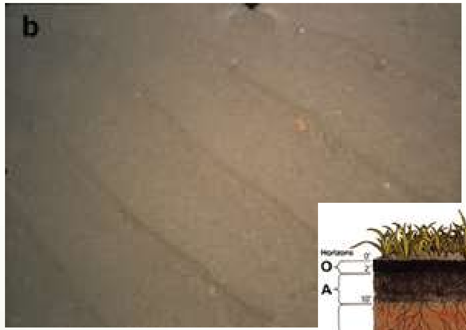
Industrial regions

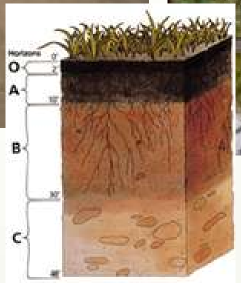
Neutron Activation Analysis

for assessment of elemental accumulation in coastal zones

Macrophytes

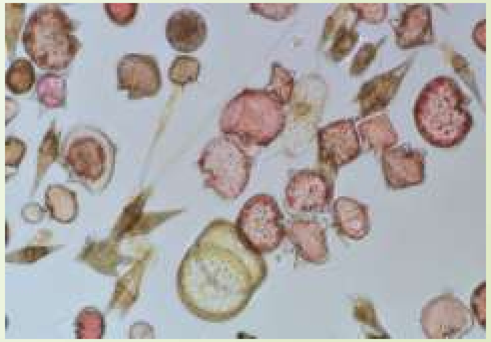
Sediments and soils





Aquatic vegetation

Phytoplankton



Neutron Activation Analysis

- Elemental contents of macroalgae, phytoplankton and aquatic plants were determined by means of neutron activation analysis performed at the reactor IBR-2 of the Frank Laboratory of Neutron Physics, Joint Institute for Nuclear Research, Dubna
- Macroalgae and aquatic plants were dried and prepared by using standards technique which was performed for vegetation
- The filters with phytoplankton were divided into two equal portions. The concentrations of elements in filter blanks were taken into account
- All samples were packed in plastic bags (to determine the short-lived isotopes) and into aluminum cups (to determine the long-lived isotopes).
- Quality control was provided by using standard reference materials of different origin : 433, 690CC, 1547, 1572, 1632b, 1633b, 2709, 2710

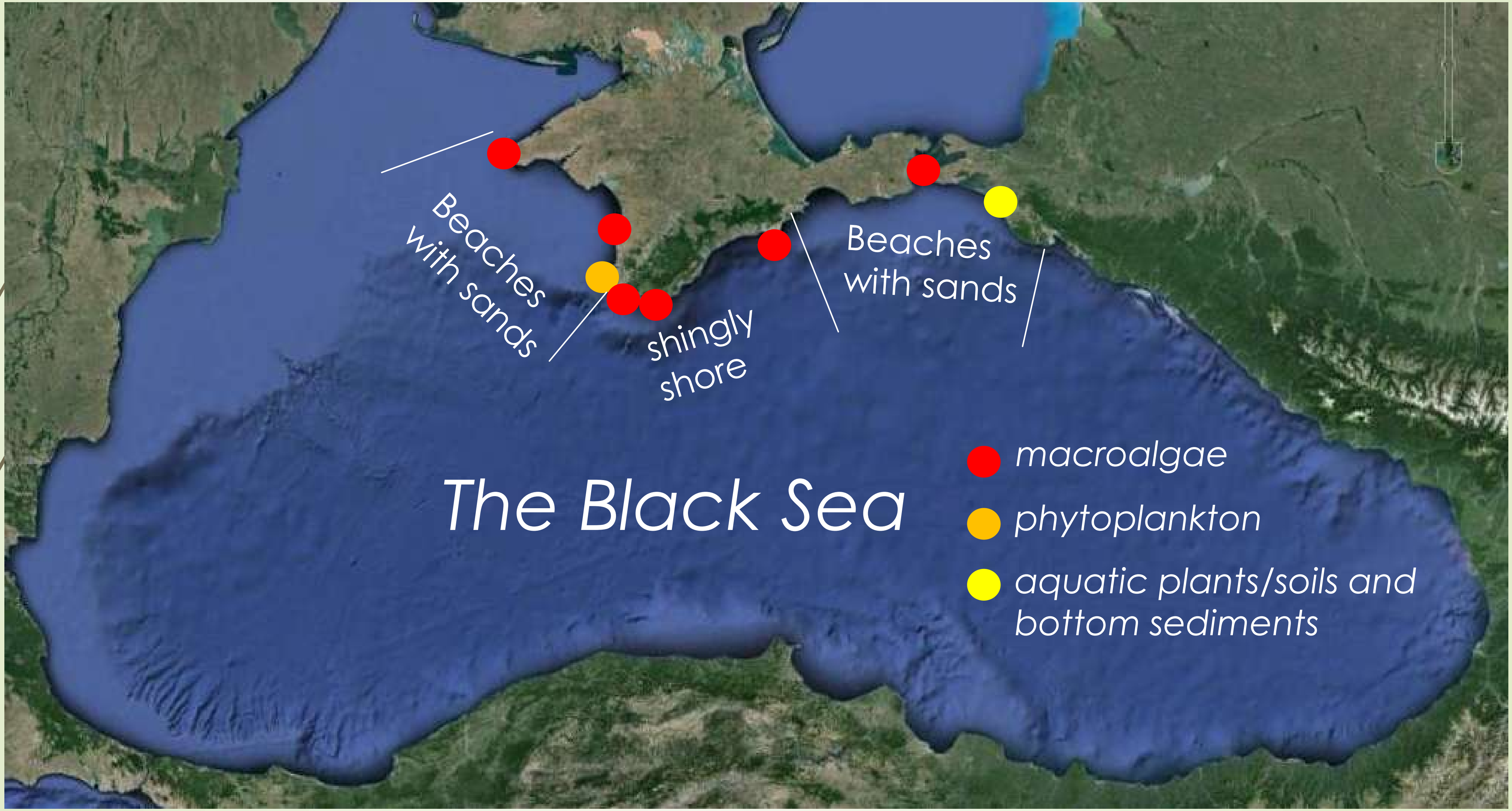
Elements, with the highest concentrations

Macroalgae: Cl, **Br**, **Sr**

Phytoplankton: Al, **Ca**, Cl

Aquatic plants: Al, **Mn**, Fe

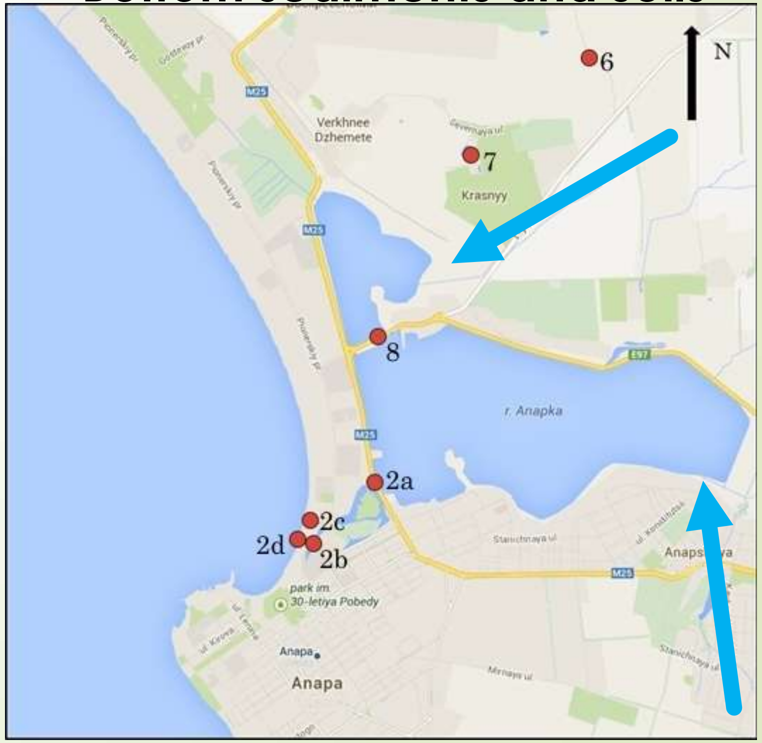
Model zones and Sampling



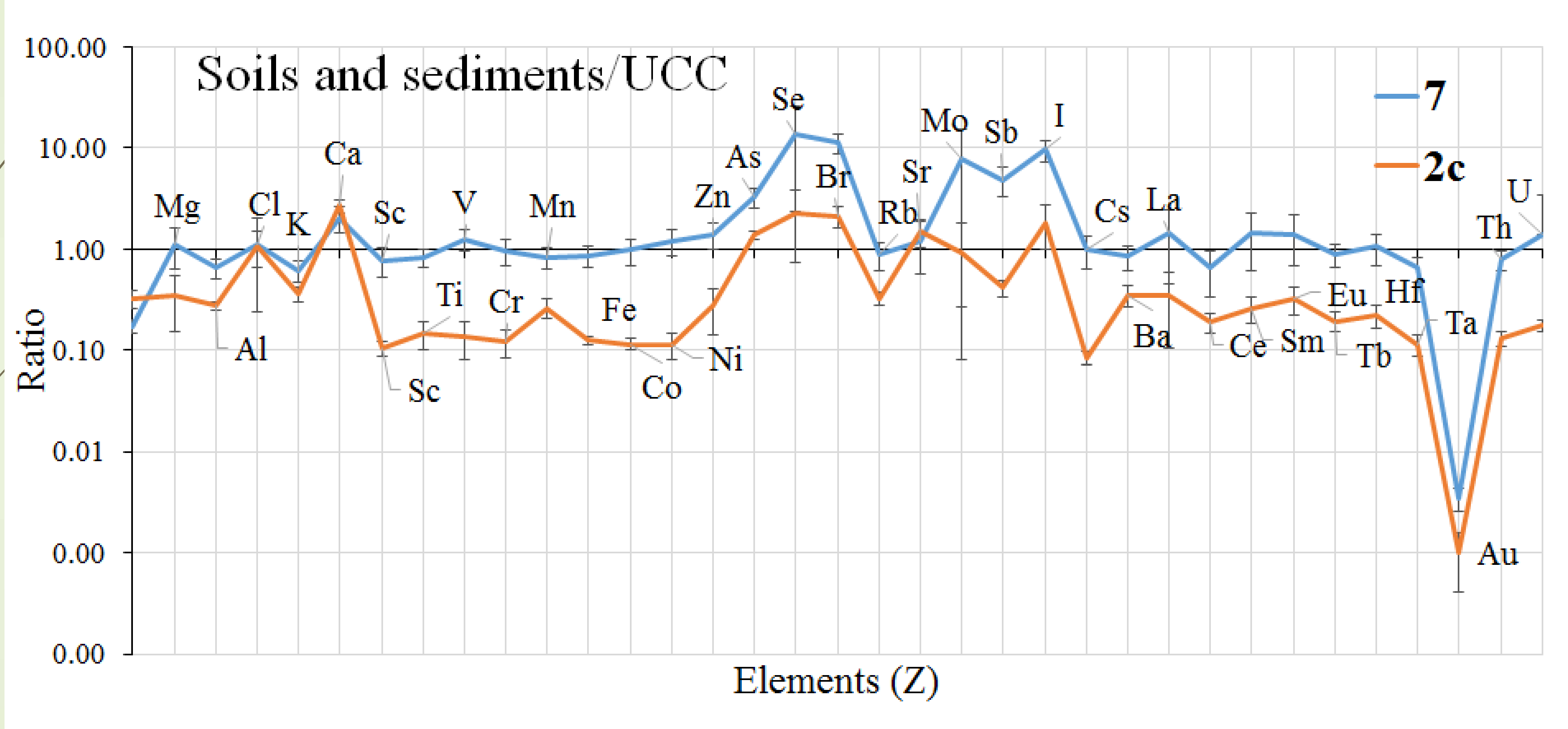
Anapa model recreational coastal zone

Coastal transect: from dump to beach

- ✓ **Aquatic plants:** *cane Phragmites australis, sedge Carex canescens*
- ✓ **Macroalgae:** *Cladophora sericea*
- ✓ **Bottom sediments and soils**



Soil or BS milieu (substrate) in coastal zone



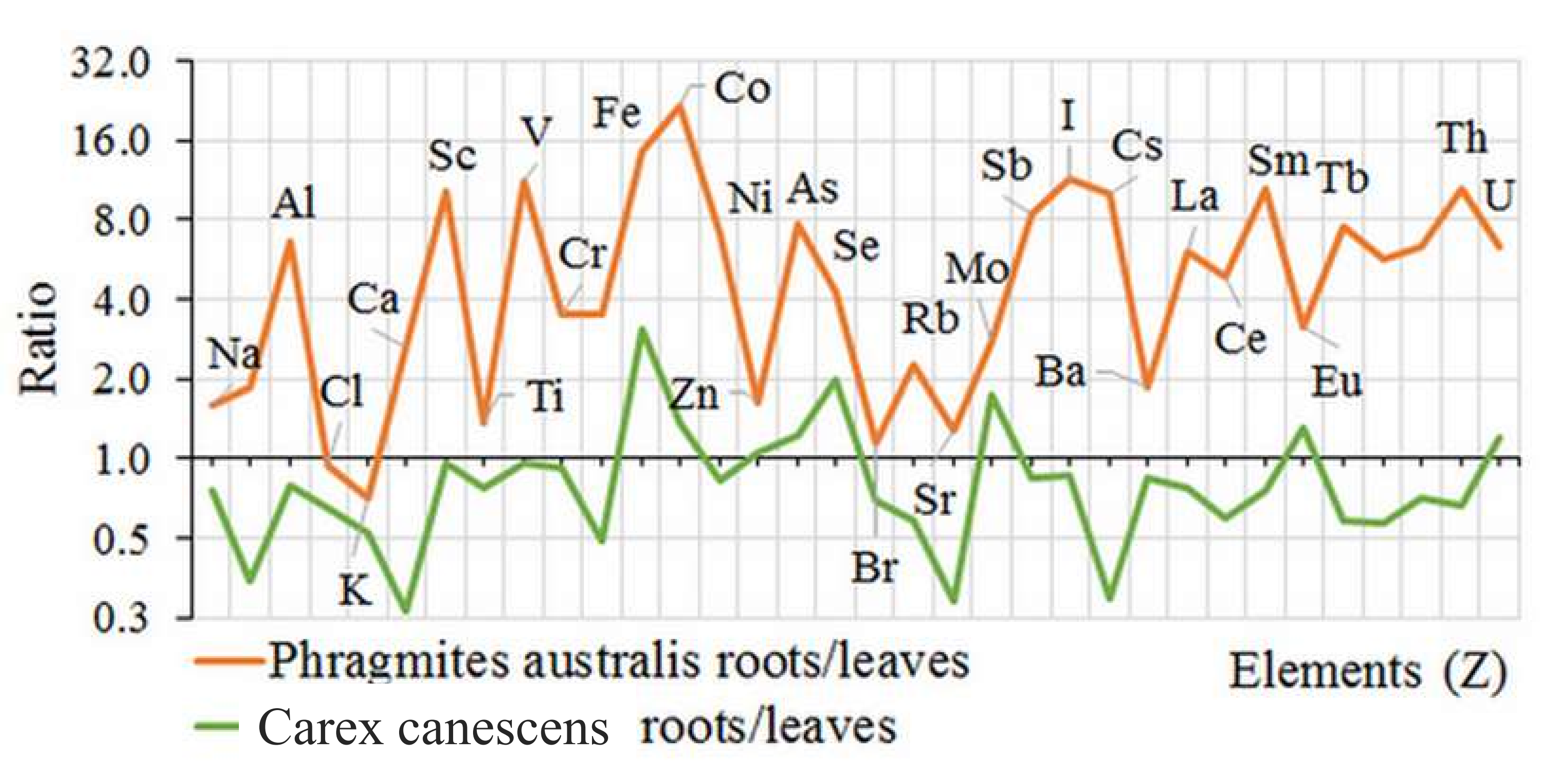
Enrichment of elements (concentrations/upper continental crust) at the polluted station (7) and station on the beach (2c):

- Se, Br and I: feature of accumulation of marine elements in coastal area
- As, Mo and Sb: anthropogenic origin, pesticides, oil refining

Maximum permissible levels of elements in soils established in different countries

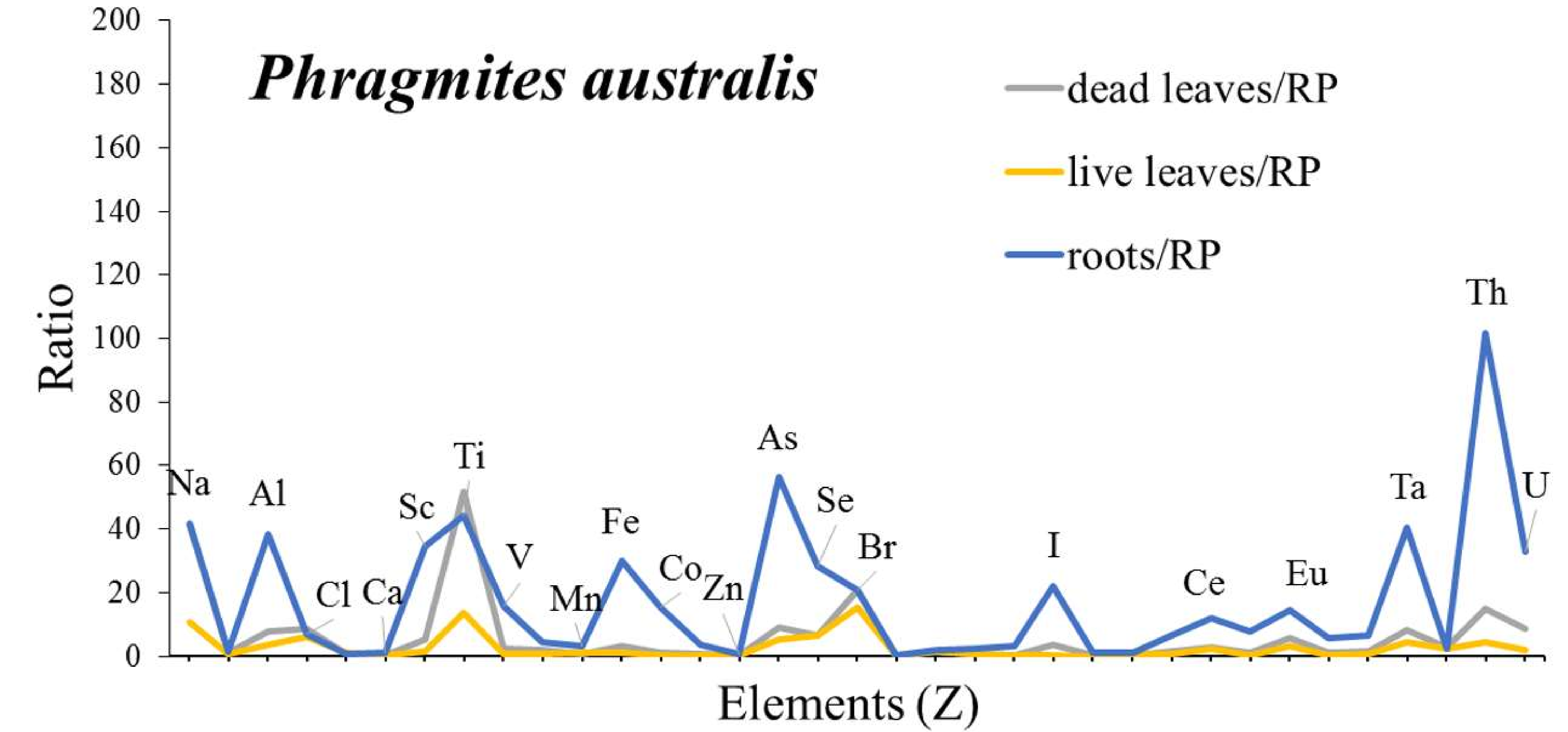
Element	Original data (*n=40*)			Russia	Germany	Netherlands	USA	Finland
	min	max	median	(Kolesnikov et al., 2012)		(Mynbayeva et al., 2013)		
V	10	150	30	150	-	-	-	100
Cr	6	105	30	90	100	250	1000	100
Mn	150	900	370	1500	-	-	-	-
Co	1.6	24	4	-	50	50	-	20
Ni	3	80	12	85	100	100	-	50
Zn	6	270	50	100	300	500	2500	200
As	3	36.8	7	2	50	30	30	5
Se	0.06	2.31	0.25	-	10	-	-	-
Mo	0.2	15.7	1.1	-	10	40	-	-
Sb	0.1	2.1	0.6	4.5	-	-	-	2
Ba	150	690	250	-	-	400	-	-

Aquatic vegetation: accumulation features



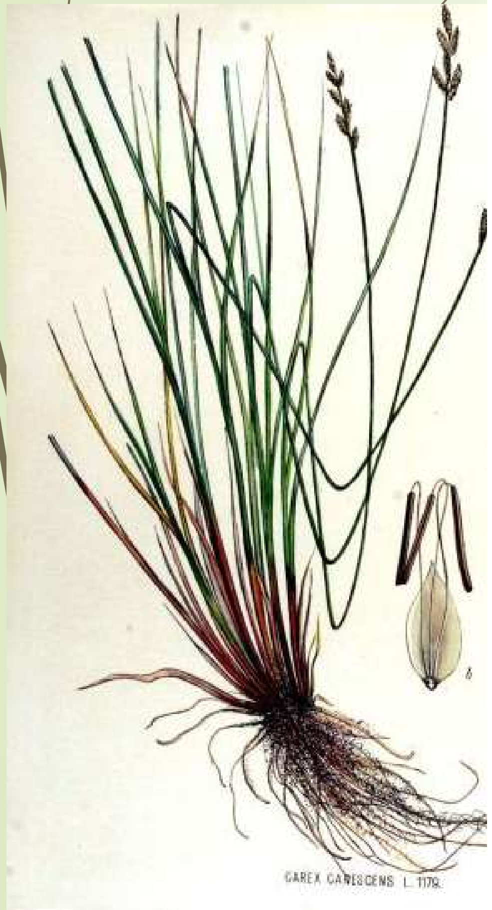
Traits of the two types of biomonitors:
Cane – root-biomonitor,
Sedge – leave-biomonitor

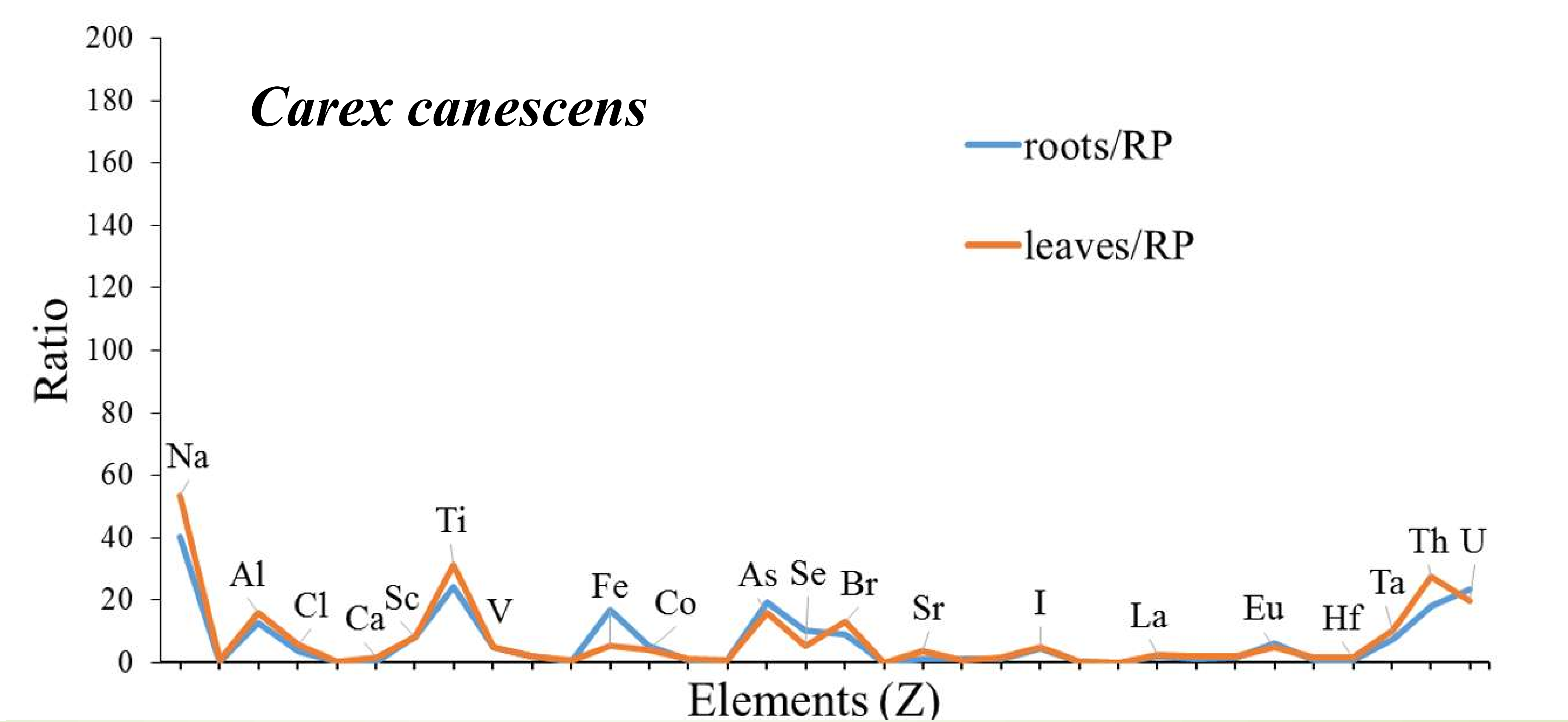
Special "biochemical signature" of aquatic vegetation in recreational coastal zone



RP – reference plant by B. Markert (1992)

Special "biochemical signature" of aquatic vegetation in recreational coastal zone





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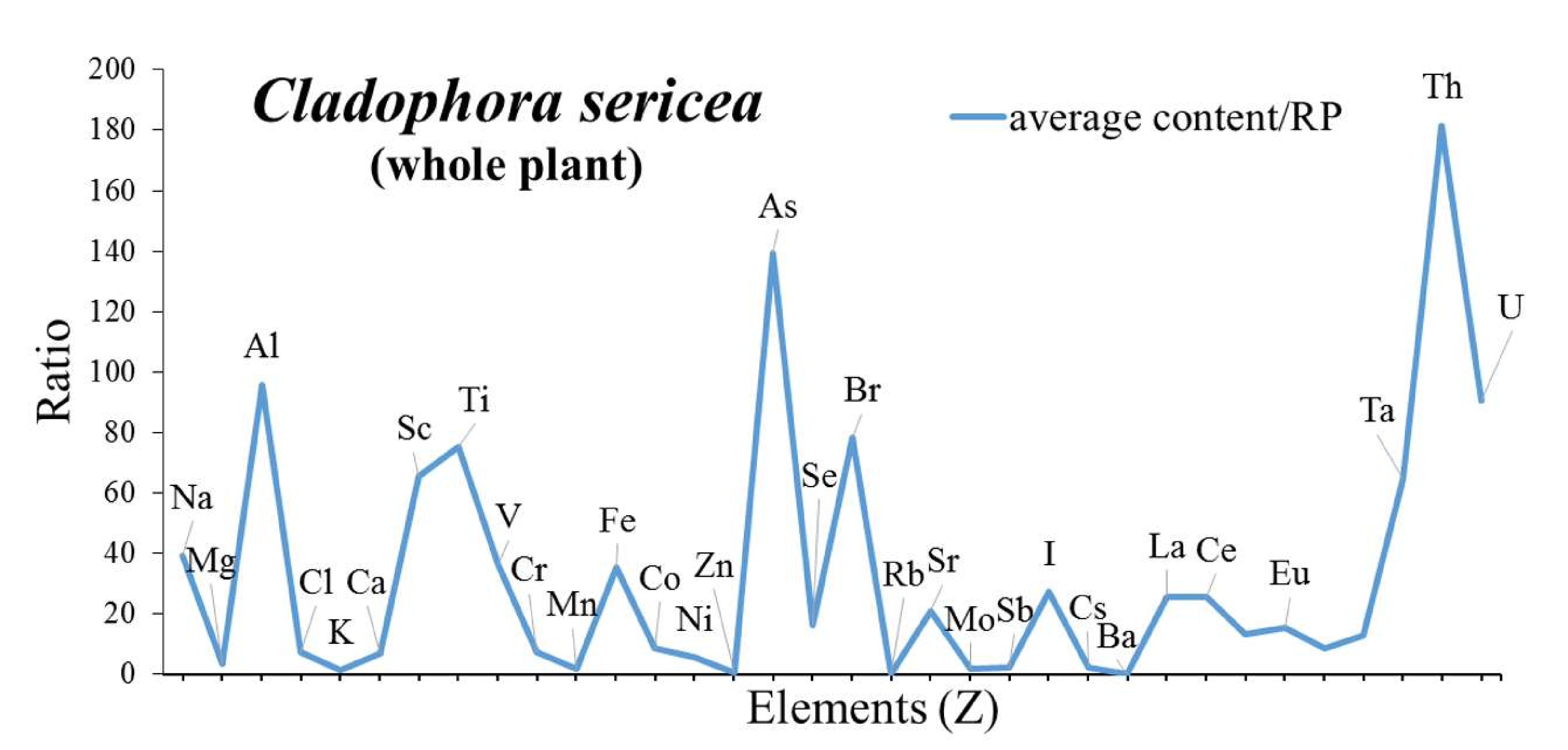


RP – reference plant by B. Markert (1992)

Macroalgae

Macroalgae – marine plants without roots

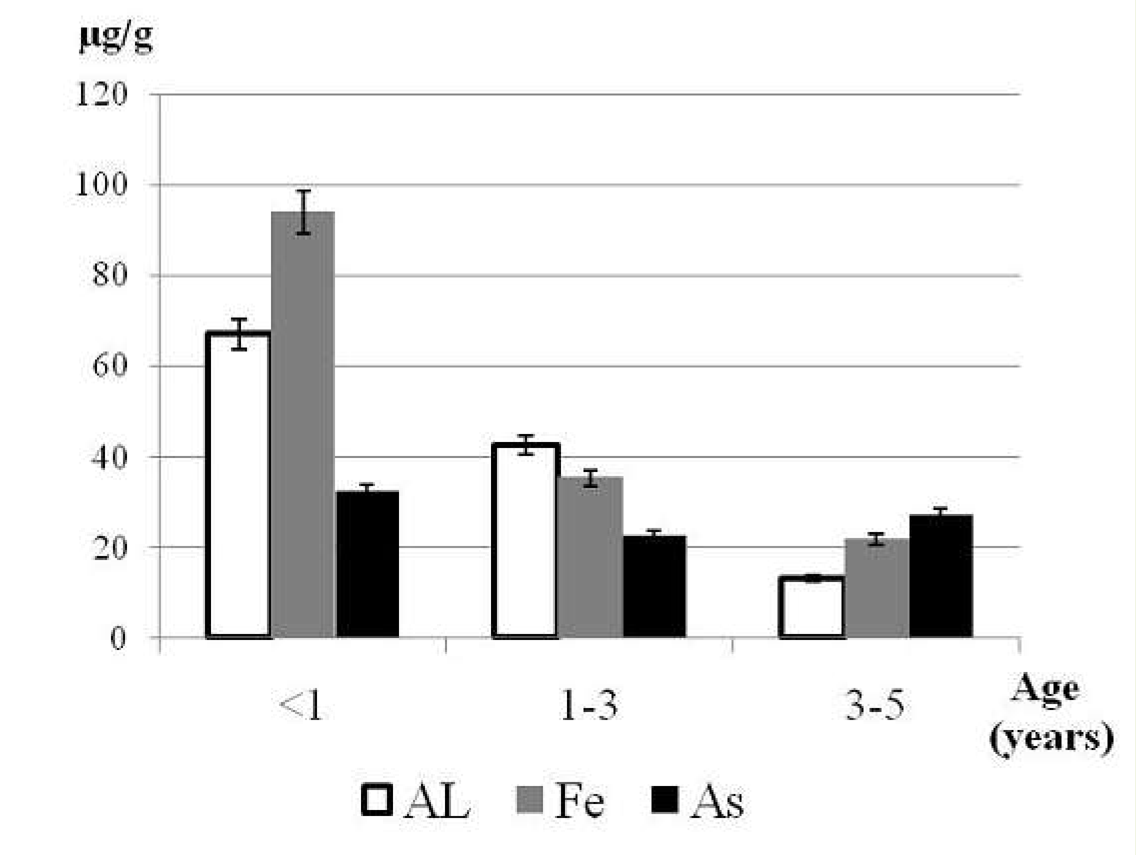
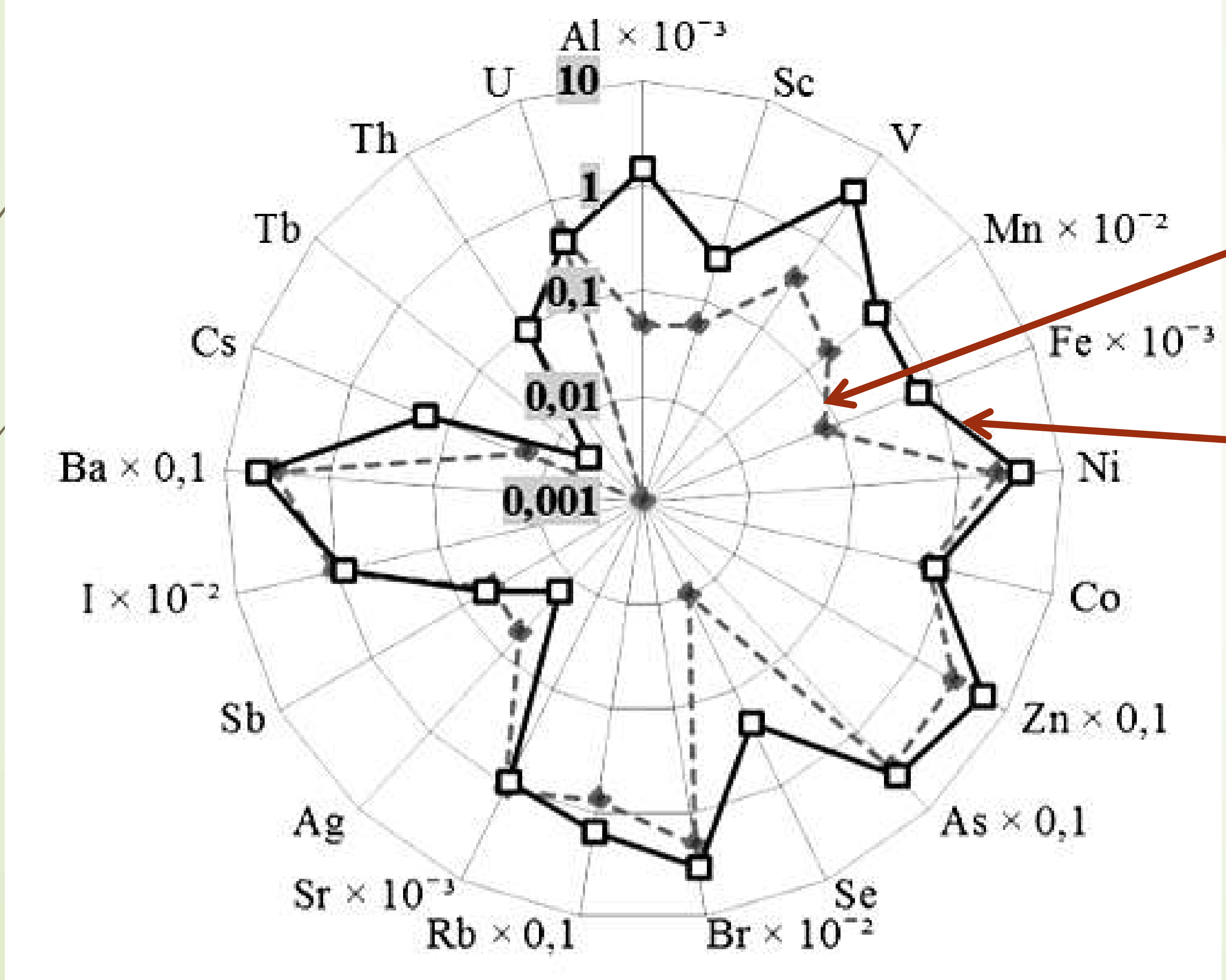


Fig. 1. Al, Fe and As in *Cystoseira crinita* “stems” at various ages
From Kravtsova et al., 2014

Anthropogenic effects in coastal zones based on biomonitoring of macroalgae



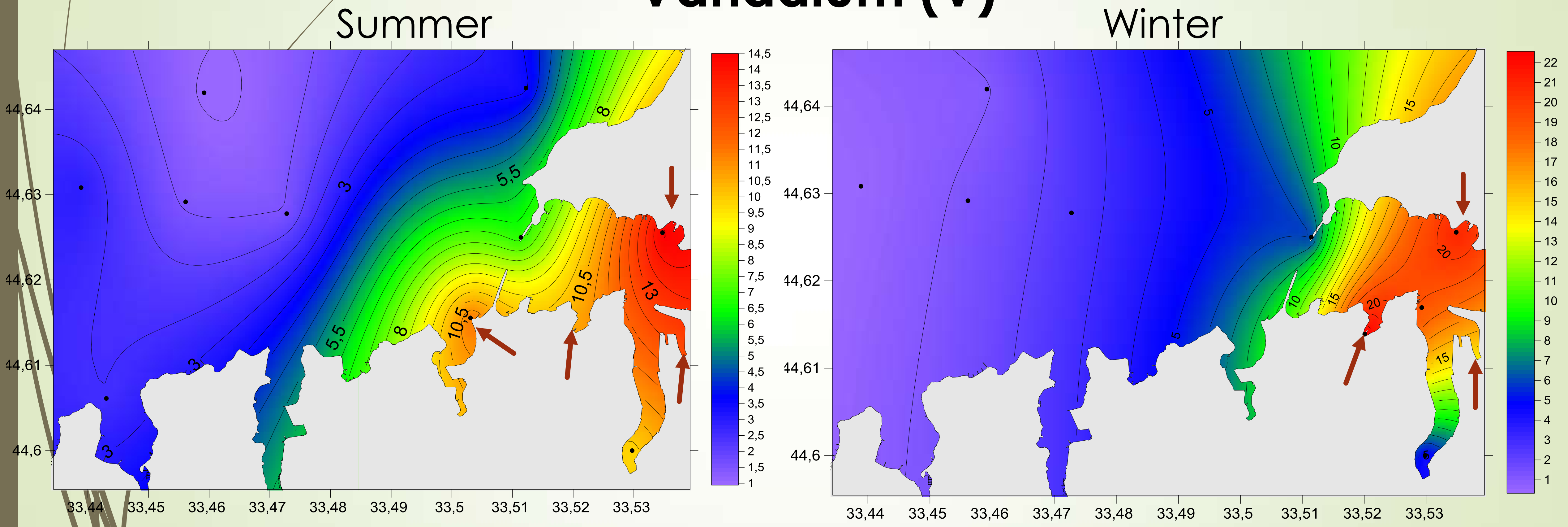
-aquatic natural reserve

-recreational zone (beach)

Biological accumulation of Al, Sc, V, Mn, Fe, Zn, Se

Peculiarities of elemental accumulation in phytoplankton

Vanadium (V)



✓Related to pollution in the bays (waste water, oil)

✓Related to terrigenous flows in shallow water areas

Maximal values in different coastal organisms of elements based on our data (in comparison with substrate)

Aquatic plants	Cl, V, Fe, Co, As, Se, Br, Sr, I
Phytoplankton	V, Cr, Mn, Br, Mo, I, Sb
Macroalgae	V, Mn, Fe, Zn, As, Sr, Se
Important elements	V, Cr, Fe, Mn, Co, Ni, As, Se, Cu, Zn, Mo, Sr, I,

Terrigenous	**Biologically important**	**Anthropogenic**
Al, K, Ca, Sc, Ti, Rb, Sr, Zr, Cs, Th, U	Co, Cr, Cu, Zn, Mn, Fe, Se, Mo, I	V, Co, Ni, Cu, Zn, As, Sr, Sb

Conclusions

- Neutron Activation Analysis fits well to assessment of elemental accumulation in organisms from coastal ecosystems. Coastal water objects could be analyzed by using NAA in complex study
- Roots and leaves of Phragmites australis are good accumulators of Na, Ti, and Br and, in contrast, contain lower levels of Zn, Rb, and Ba than in RP. In Carex canescens roots and leaves the levels of Na, Ti, As, Th, and U are one order of magnitude higher than in RP. In contrast, Mg, K, Mn, Zn, Rb, Cs, and Ba show lower levels in comparison to RP concentrations
- Cladophora sericea accumulated Cl in small relative amounts in comparison to Br and I. Phragmites australis in the major cases selected I and Cl regardless Br. In that sense the Carex canescens demonstrated the most flexible ability for accumulation of these halogens
- The environmental levels of the 19 TE in Cystoseira spp. From relatively clean waters from marine protected areas, determined in this study, could be used for the further biomonitoring objectives in the Black Sea region
- The revealed peculiarities of elemental accumulation in different morphostructural parts of Cystoseira spp. and the relationship between the concentrations of some TE in algae with geological composition of the coast (that is, the type of rocks) improved our knowledge regarding the use of Cystoseira spp. as a biomonitor of coastal waters pollution
- Using such organisms as phytoplankton, macroalgae and aquatic vegetation (as basic elements forming primary production) in biomonitoring studies the environmental states of coastal zones and special fingerprints in different regions could be analyzed

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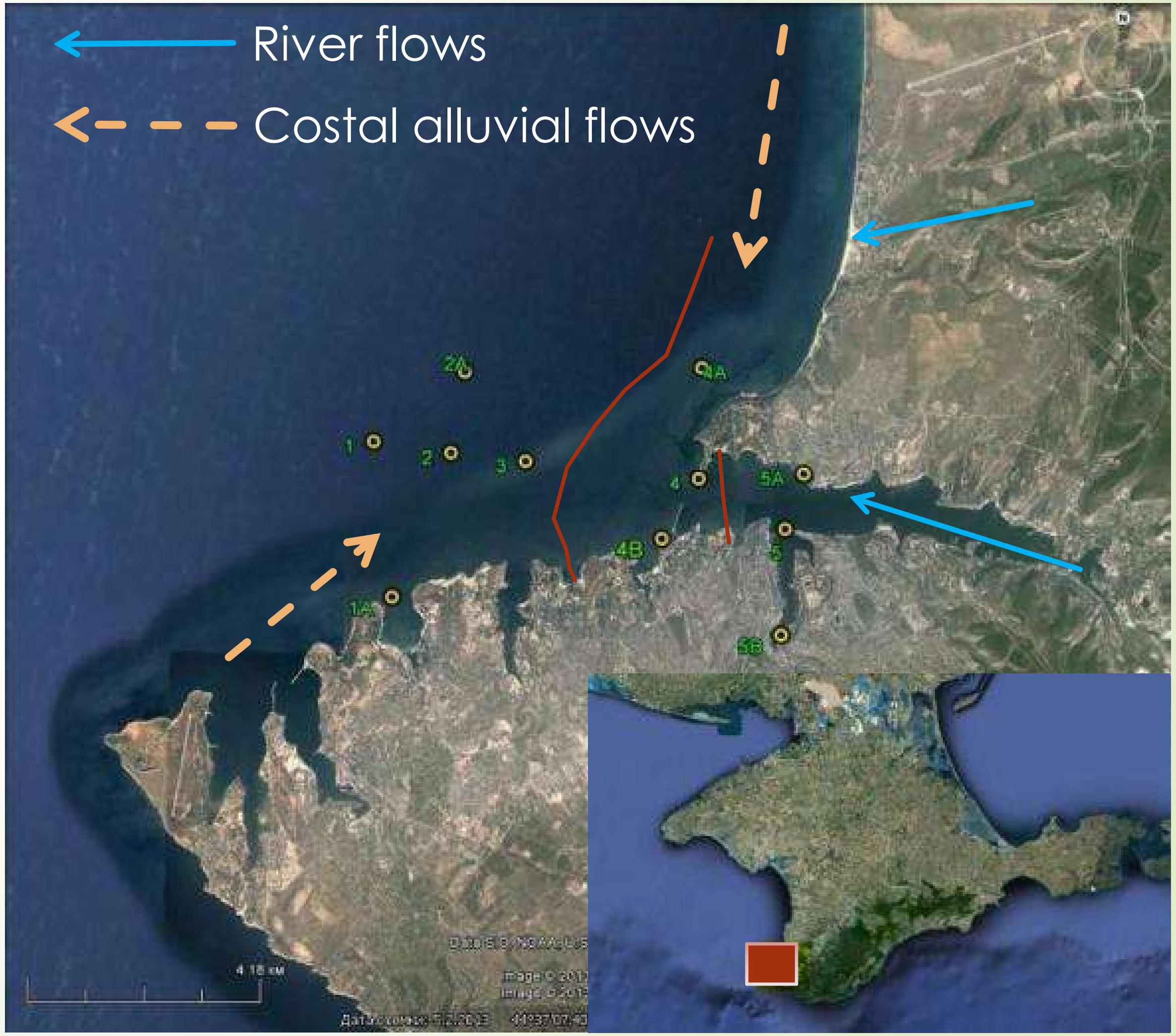
- To our colleagues from Moscow State University for sampling and information
- To all which were involved in this cycle of works


To you for your attention!

Spatial variability of elemental contents in coastal organisms (biota)

- Elemental Flows
  - Along coast
  - Storms and upwellings
  - River flows
  - Atmospheric deposition
- Terrigenous particles
- Transition zones



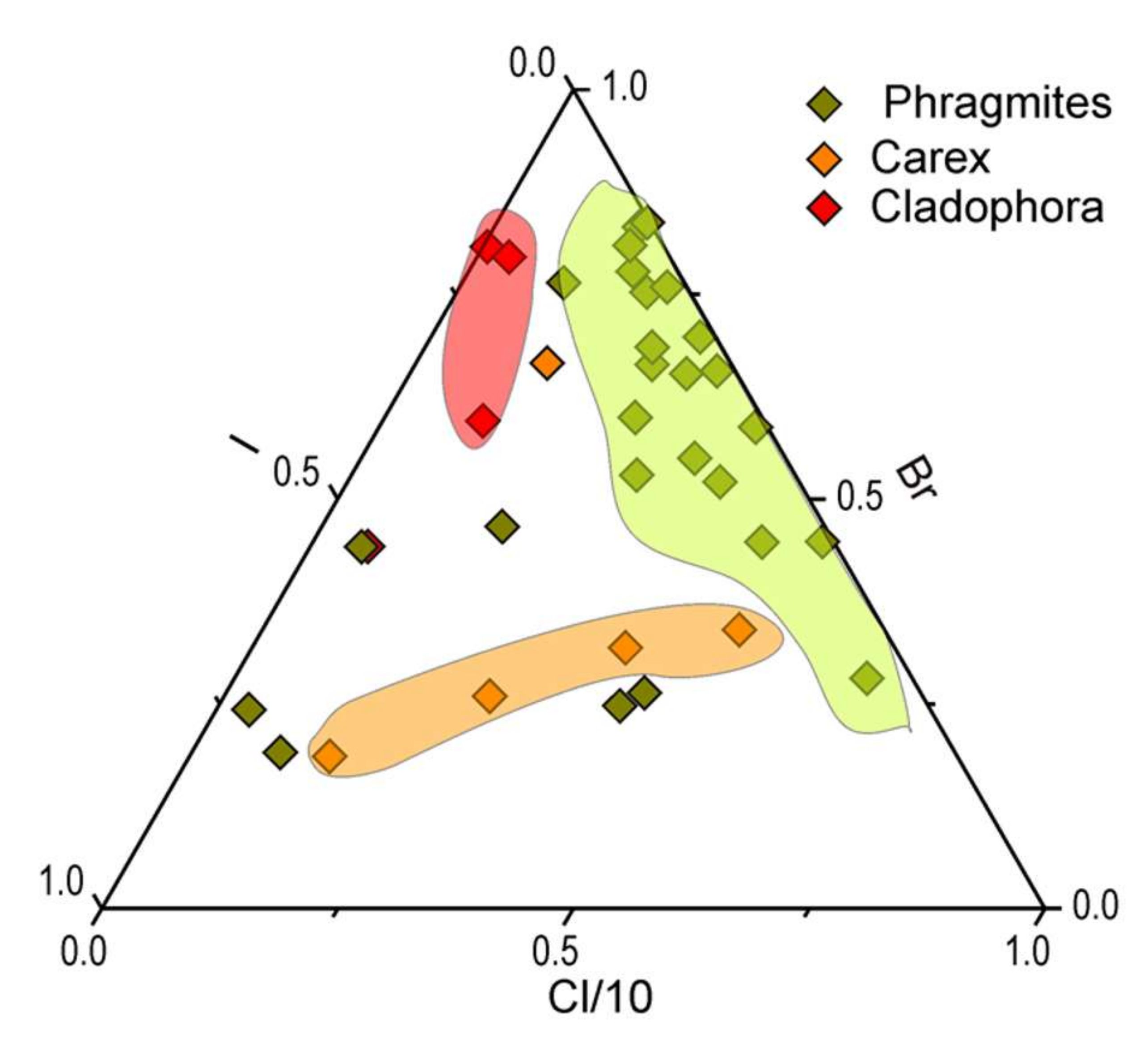
Shore – Transitional zone – buffer water area

Maximal and median elemental concentrations (µg/g dry weight) in soils from Anapa region (our data) and values for non-polluted and polluted soils from the Southern part of Russia

Elements	Soils in Anapa region (*n=40*)		Soils in the Southern part of Russia[1]		
	Max	Median	Non-polluted	Low polluted	Moderate polluted
V	150	30	<200	200-300	300-850
Cr	105	30	<70	70-90	90-170
Mn	900	370	<1000	1000-1600	1600-1800
Co	24	4	<18	18-36	36-250
Ni	80	12	<50	50-100	100-700
Zn	270	50	<125	125-200	200-850
As	36.8	7.1	<17	17-30	30-160
Se	2.31	0.25	<0.7	0.7-1.4	1.4-9
Sr	840	510	<250	240-450	450-3200
Mo	15.7	1.1	<8	8-400	>400
Sb	2.1	0.6	<5	5-12	12-200
Ba	690	250	<900	900-1500	1500-4000

[1] elements in soil according to (Kolesnikov et al., 2012)

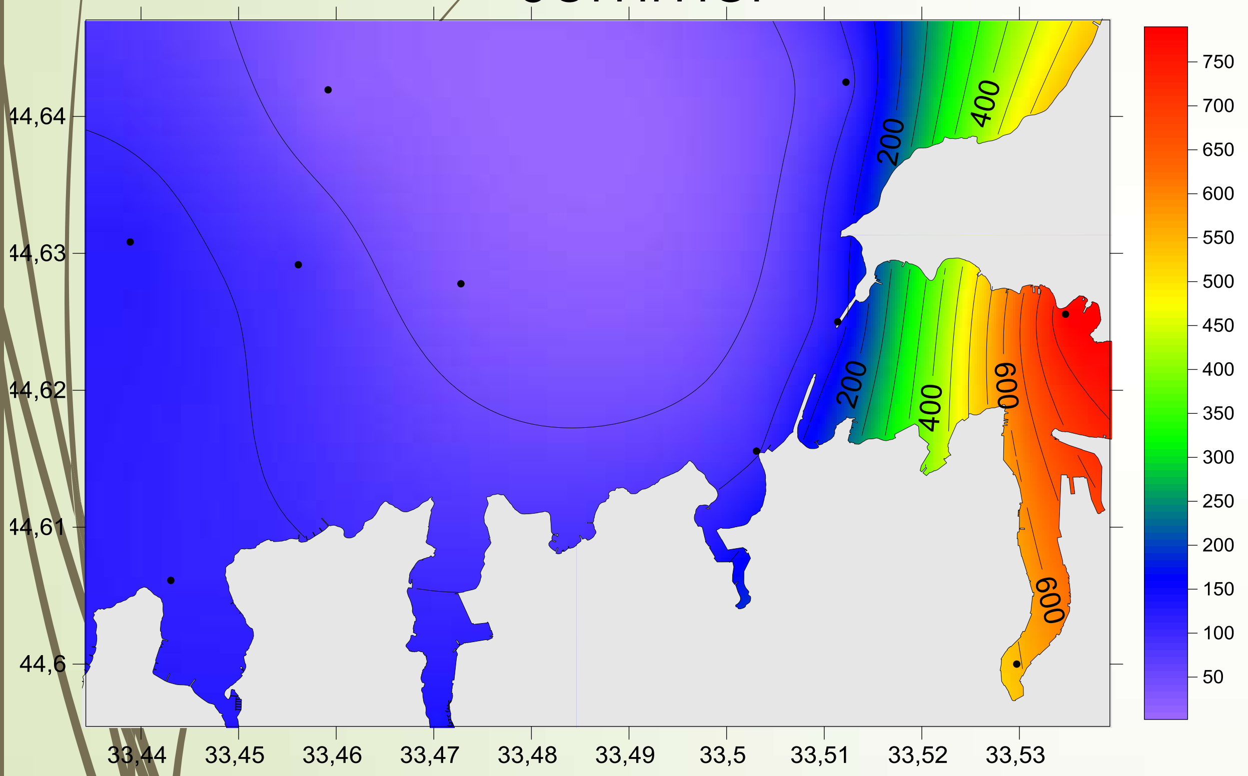
Special traits of halogens accumulation in aquatic plants



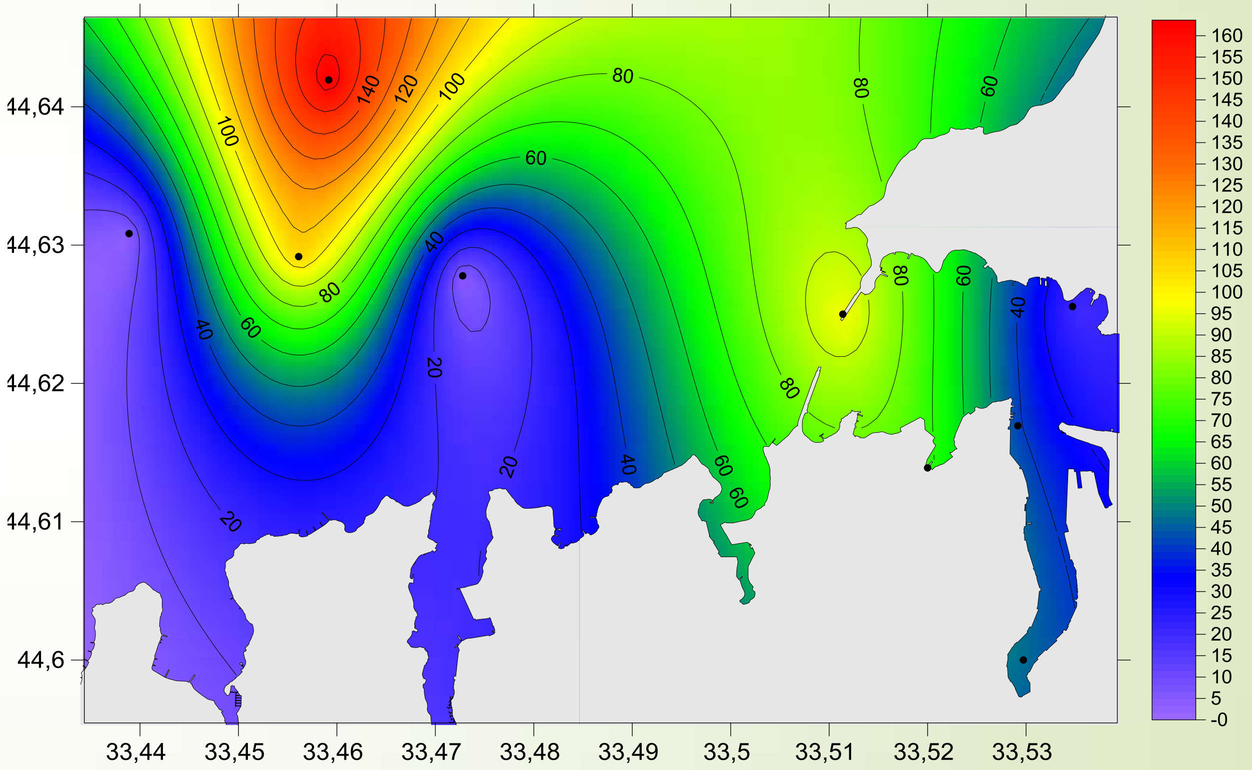
Peculiarities of elemental accumulation in phytoplankton

Zinc (Zn)

Summer



Winter



✓ Related to local source of pollution (nonferrous metallurgy, foundry, pesticides and herbicides)

✓ Related to deep water convection and resuspend of bottom sediments in the mouth area