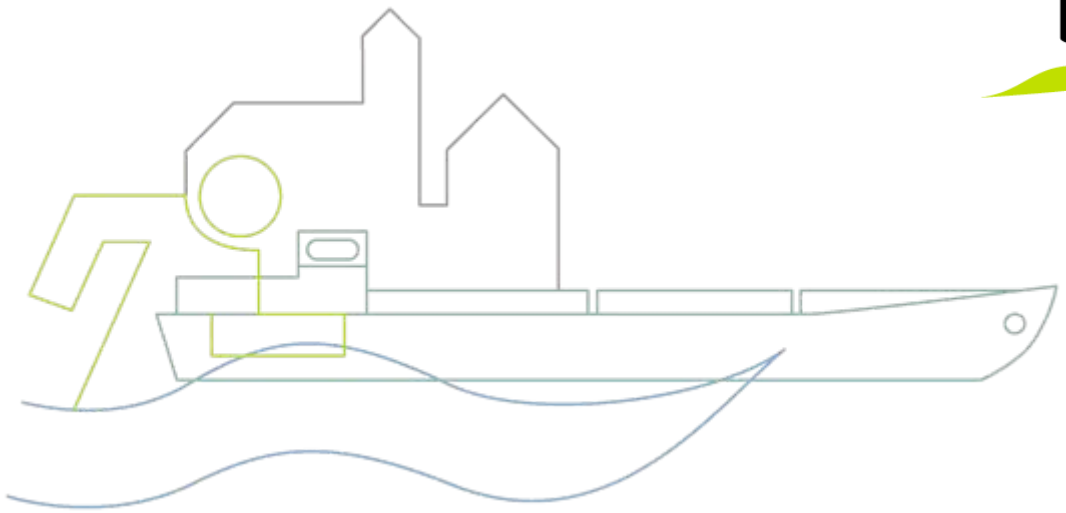


Chemical Monitoring in the Context of Sediment Management in Estuaries

Dr. B. Schubert, Dr. C. Pies, C. Heil
Department G1: General Water Quality Issues
Bundesanstalt für Gewässerkunde, Koblenz

6th International SedNet Conference, Hamburg, 7-8 October 2009

Objectives of monitoring contaminants in sediments and suspended particulate matter

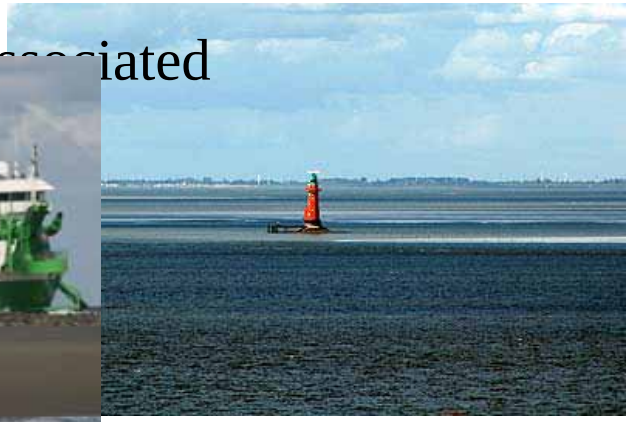
bfg Bundesanstalt für Gewässerkunde

- Assessment of sediment quality
  - Trend assessment, i.a. for the no-deterioration objective of the Water Framework Directive and the EQS-Directive 2008/105/EC
  - Derivation of criteria for the assessment of dredged material quality
  - Selection of disposal sites
- Contribution of contaminants as tracers to a better understanding of the transport of estuarine cohesive fine-grained solids

Contaminants as tracers for transport of fine-grained sediments in estuaries

- Estimation of the ratio marine/fluvial cohesive solids
- Evaluation of the impact of natural or anthropogenic changes on contaminant concentrations
- Medium to long-term destination of relocated dredged material
- Identification of areas of sediment accumulation, i.e. in wadden areas
  - Retention of (contaminated) cohesive particulate matter
  - potential secondary source for contaminants (remobilisation)
- Contribution to the estimation of input of particle-associated contaminants into the Germa

support for optimising dredged material and sediment management



Monitoring programme in German North Sea estuaries

- Investigations on and assessment of contaminants in sediments and suspended particulate matter
- Surface samples and sediment cores
- Spatial and temporal monitoring
- Analyses of grain size distribution, trace metals, organic contaminants, organotin compounds
- Assessment of contaminant concentrations in the **fine-grained fraction <20 µm**

Investigations

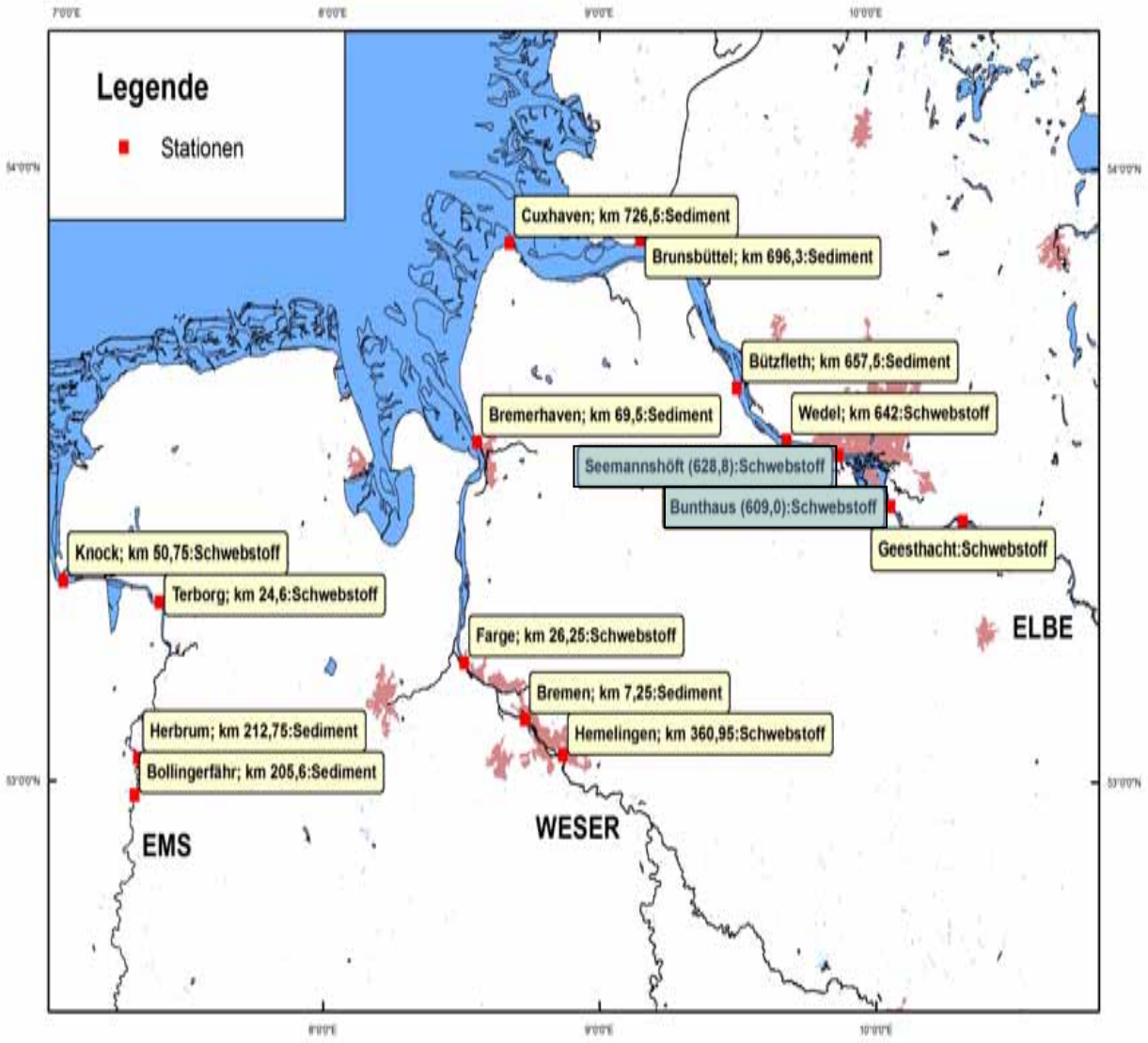
- Grain-size analysis, TOC, N, P, S

- Trace metals:
  cadmium, chromium, copper, mercury, nickel, lead, zinc, and arsenic

- organic contaminants:
  chloroenezenes, PCBs,
  hexachlorcyclohexanes, DDT and metabolites,
  PAHs, oil hydrocarbons, organo-tin compunds

- contaminant concentrations are measured in or normalised on the fine-grained fraction **<20 µm**

Long-term monitoring sites in estuaries: surface sediments, SPM



Bunthaus, Seemannshöft : ARGE Elbe

Other stations: BfG

- High frequency of 4–12 samples /a
- Sediments from sampling sites with high sedimentation rates
- Sampling of SPM 2 – 4 weeks

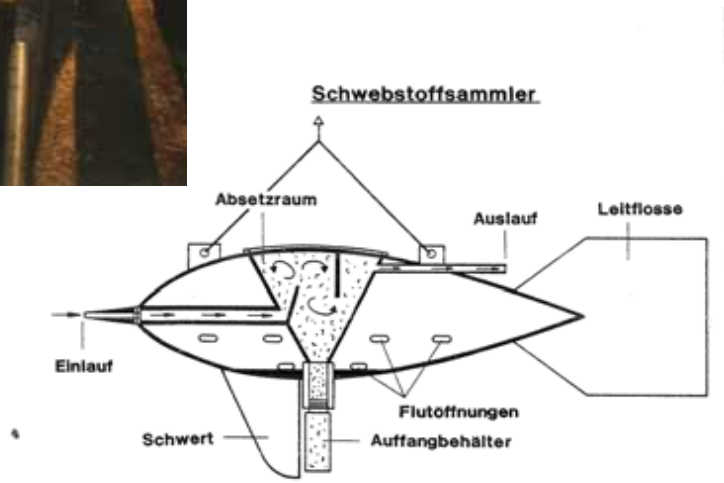
a) Long-term monitoring in the river:

Contaminants in SPM and in recently deposited surface samples

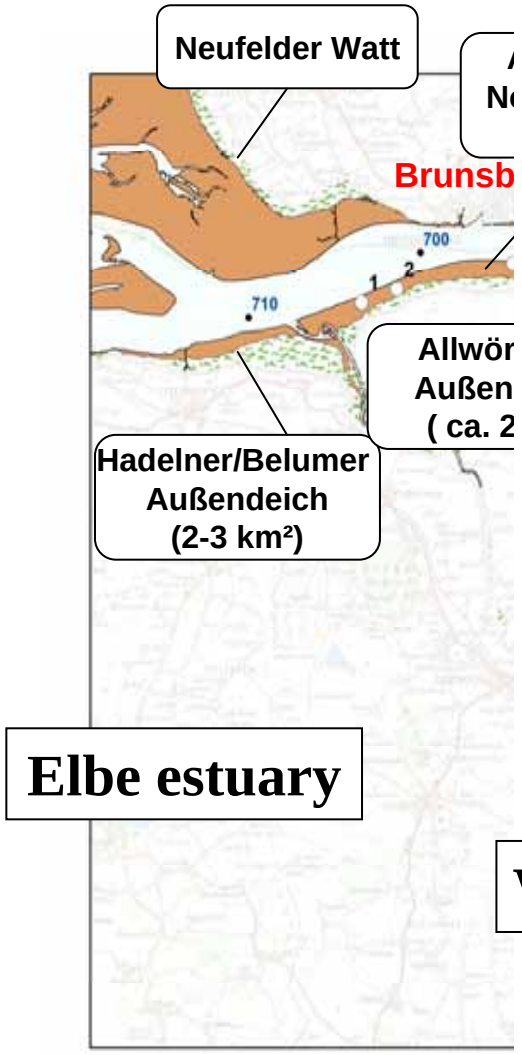
- High frequency of 4 – 12 samples/a

- Sampling of SPM 2 – 4 weeks

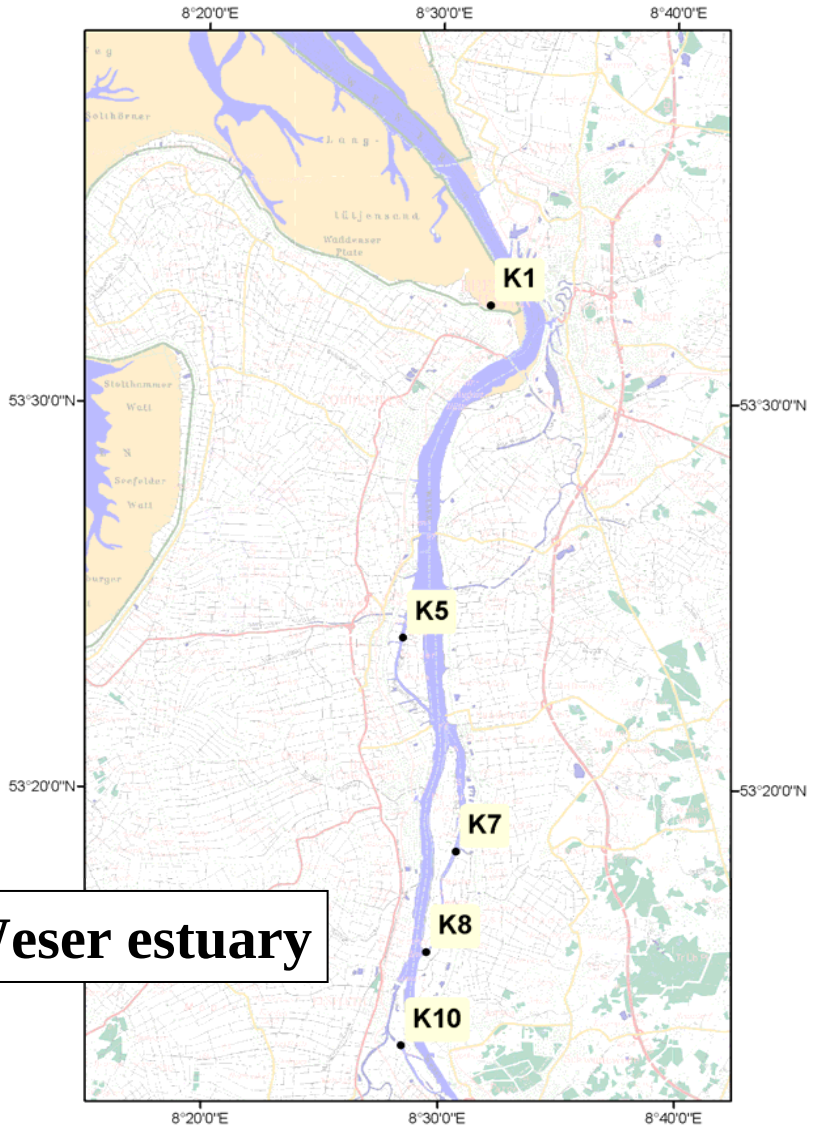
- Sediments from sampling sites with high sedimentation rates



Survey in sedimentation areas: sediment cores



Elbe estuary



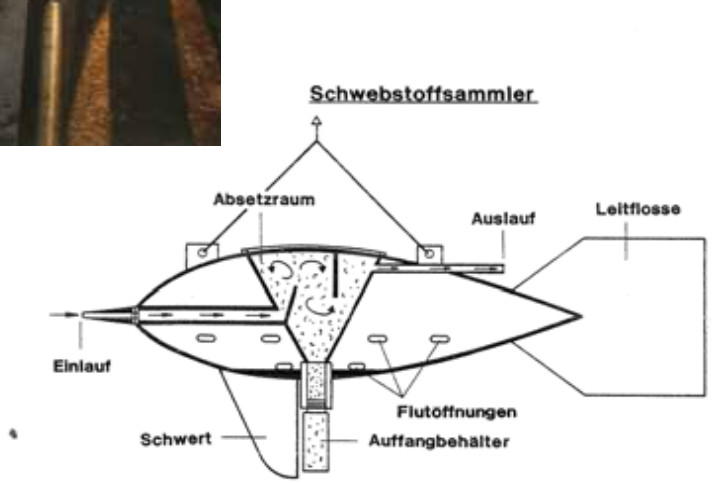
Weser estuary

Depth profiles,
surface layers

one-off studies or low frequency of sampling (several years)

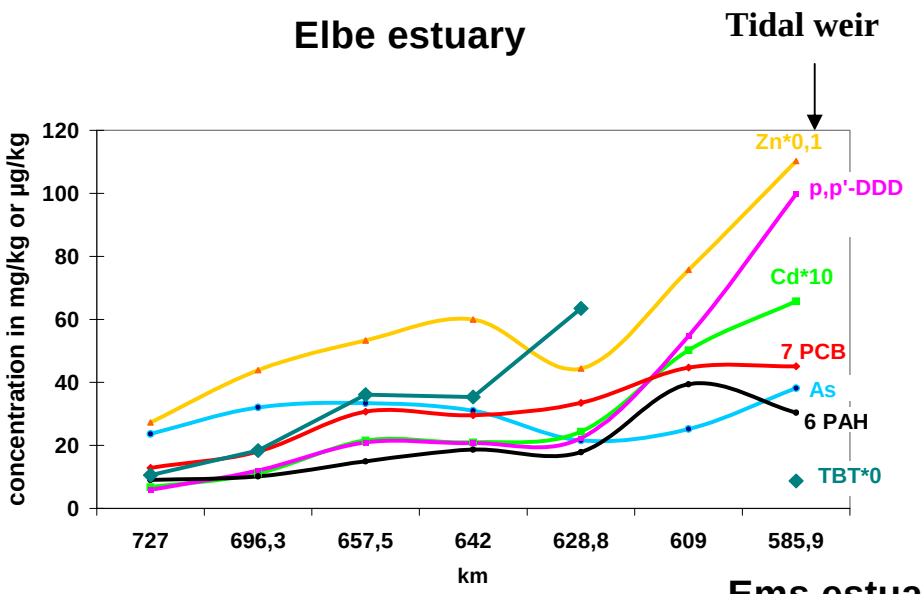
Results and assessment: Long-term monitoring in estuaries

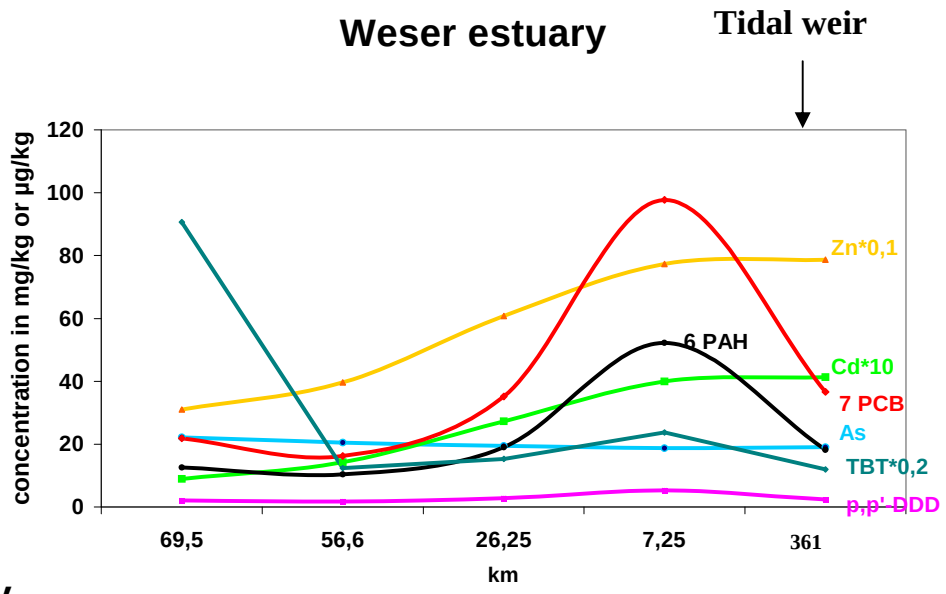
Surface sediments

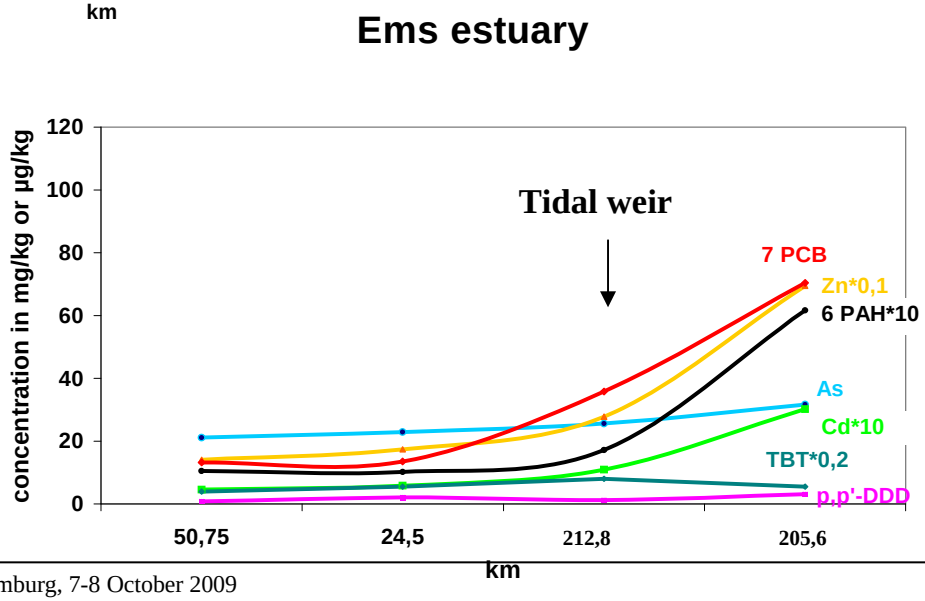


Suspended particulate matter

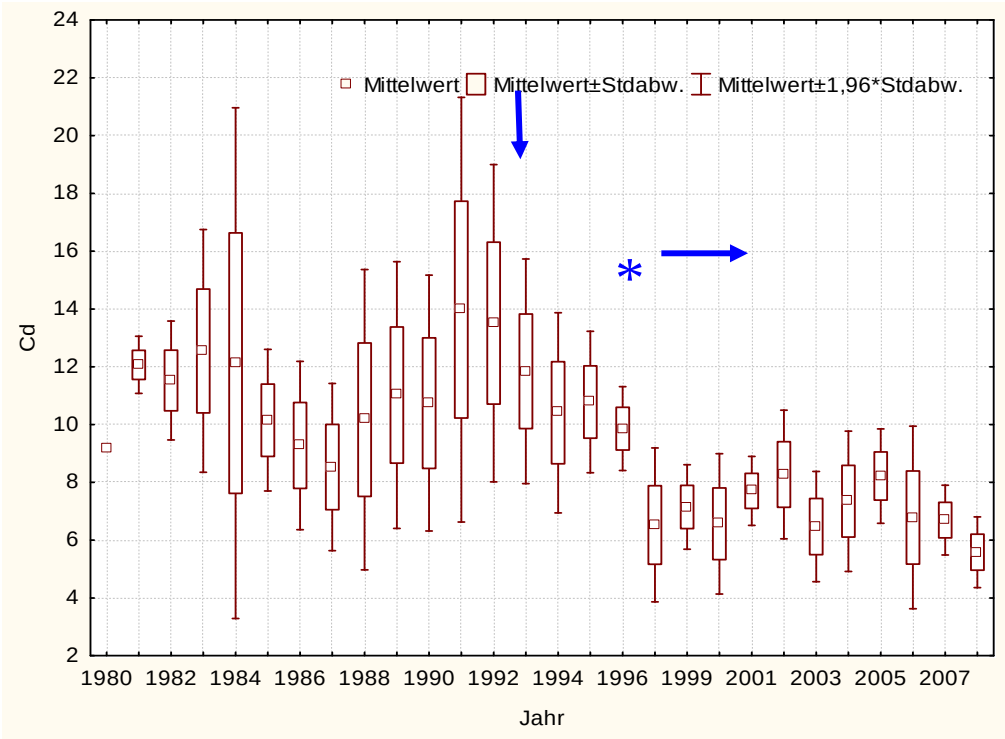
Contaminant concentrations in estuaries



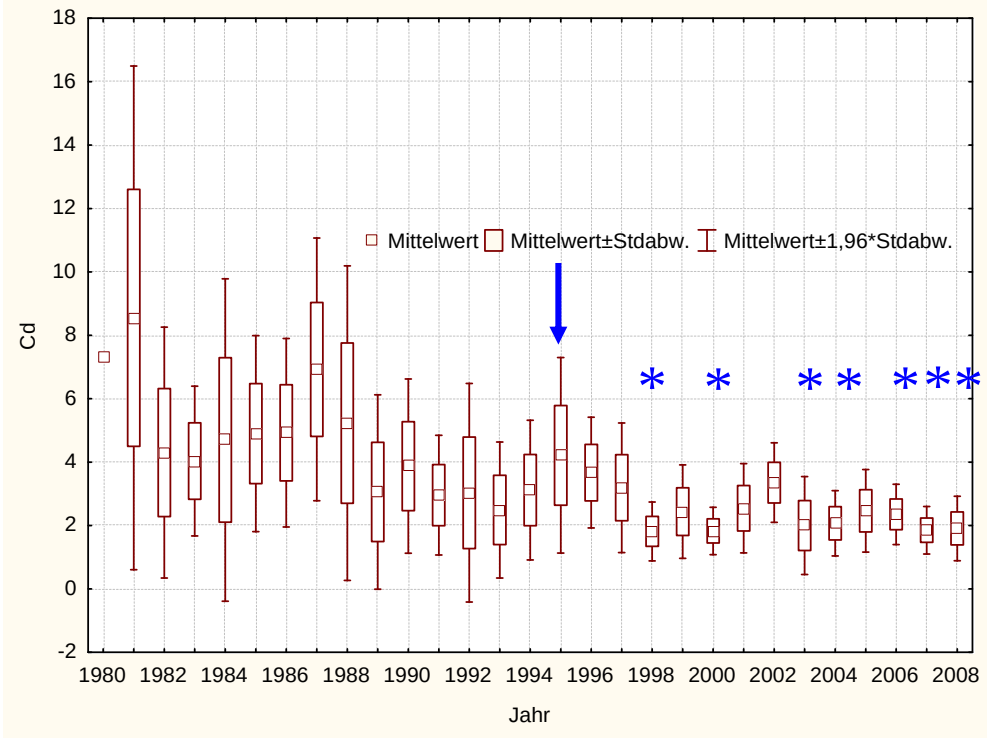




Temporal trend of Cd concentrations
Annual averages in spm in the Elbe estuary



Geesthacht (km 584)

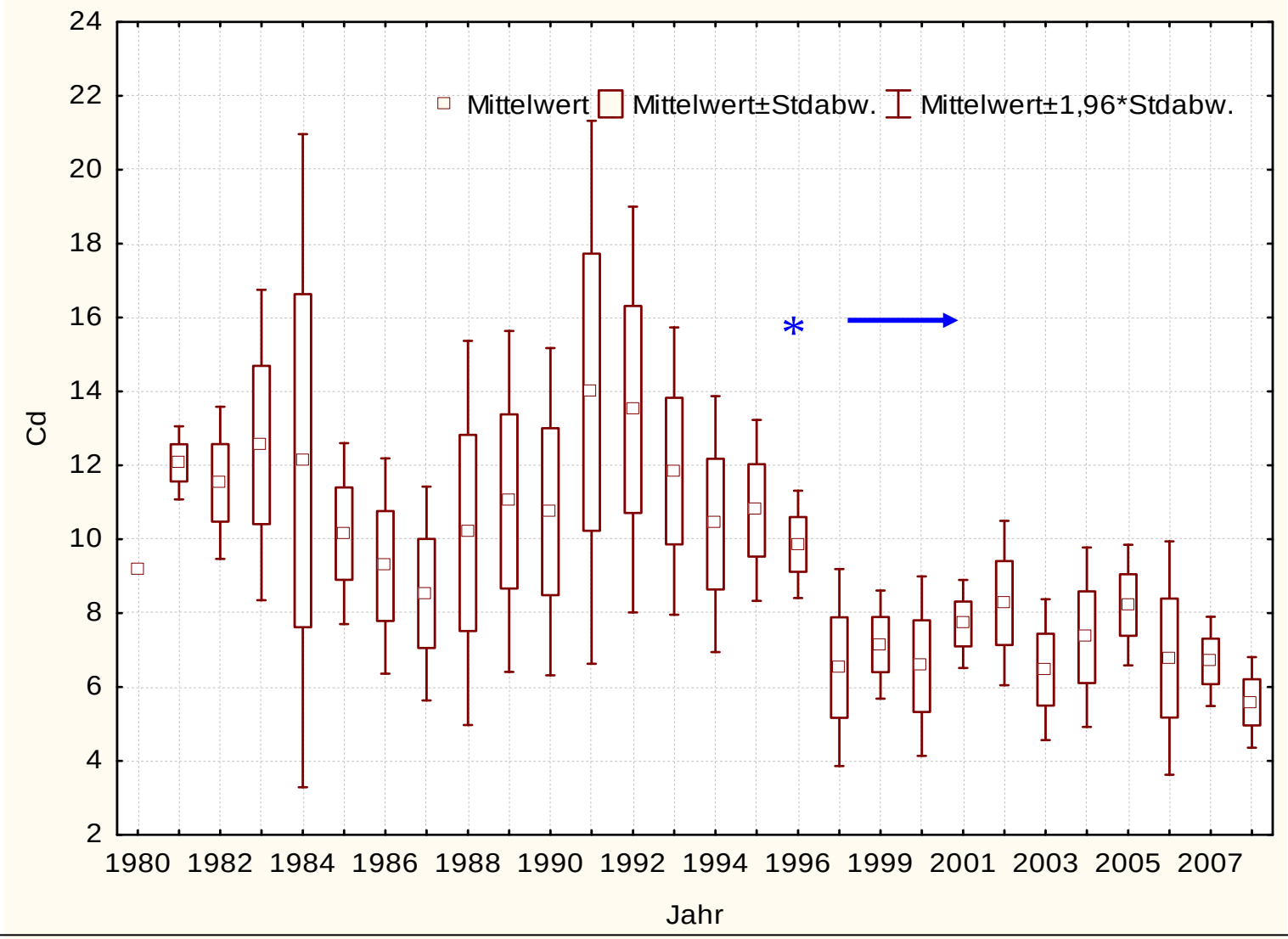


Wedel (km 642)

Scheffe-Test:

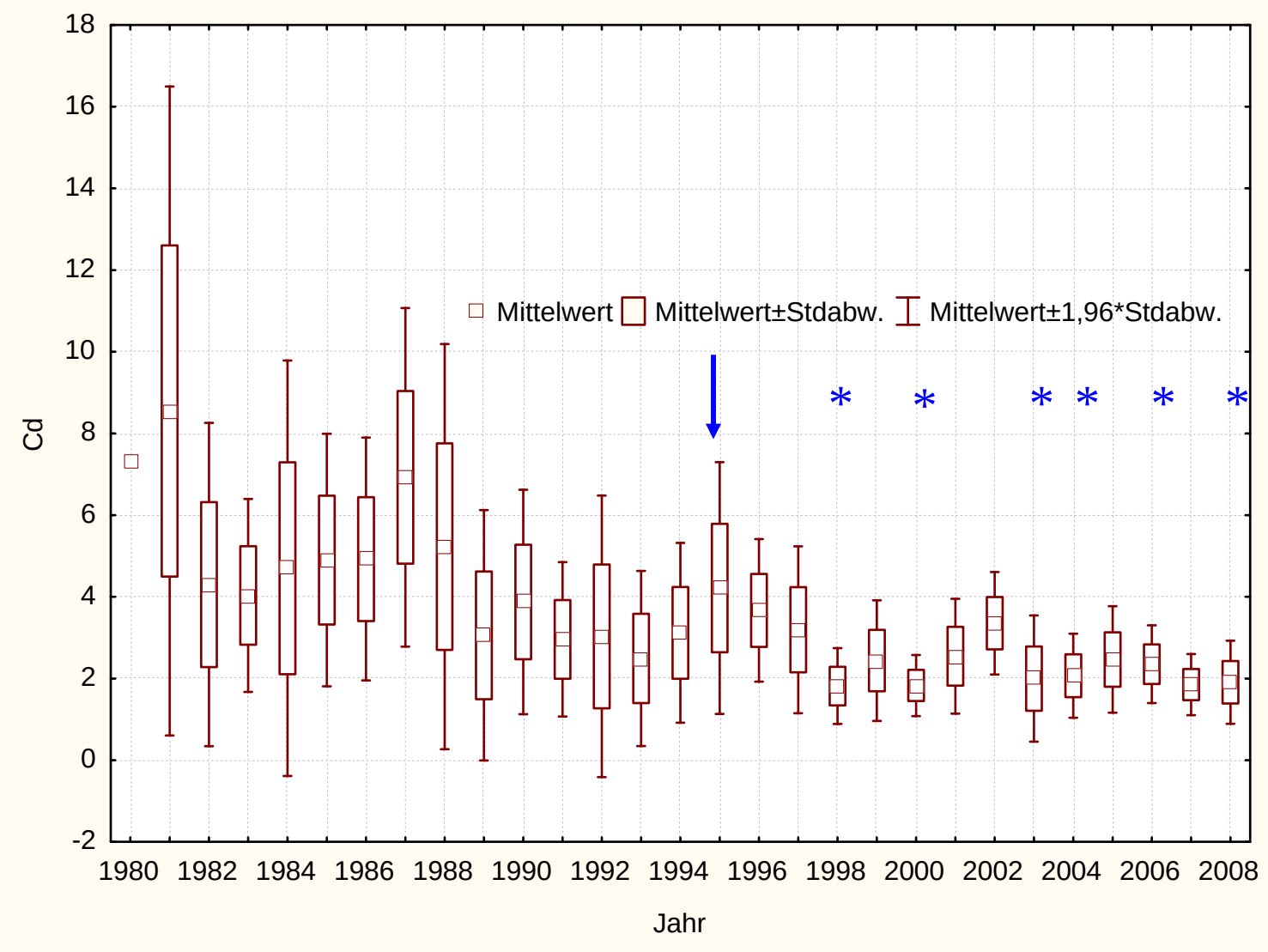
* statistically significant lower concentrations than in the reference year ( )

Temporal trend of Cd concentrations
Annual averages in spm in the Elbe estuary



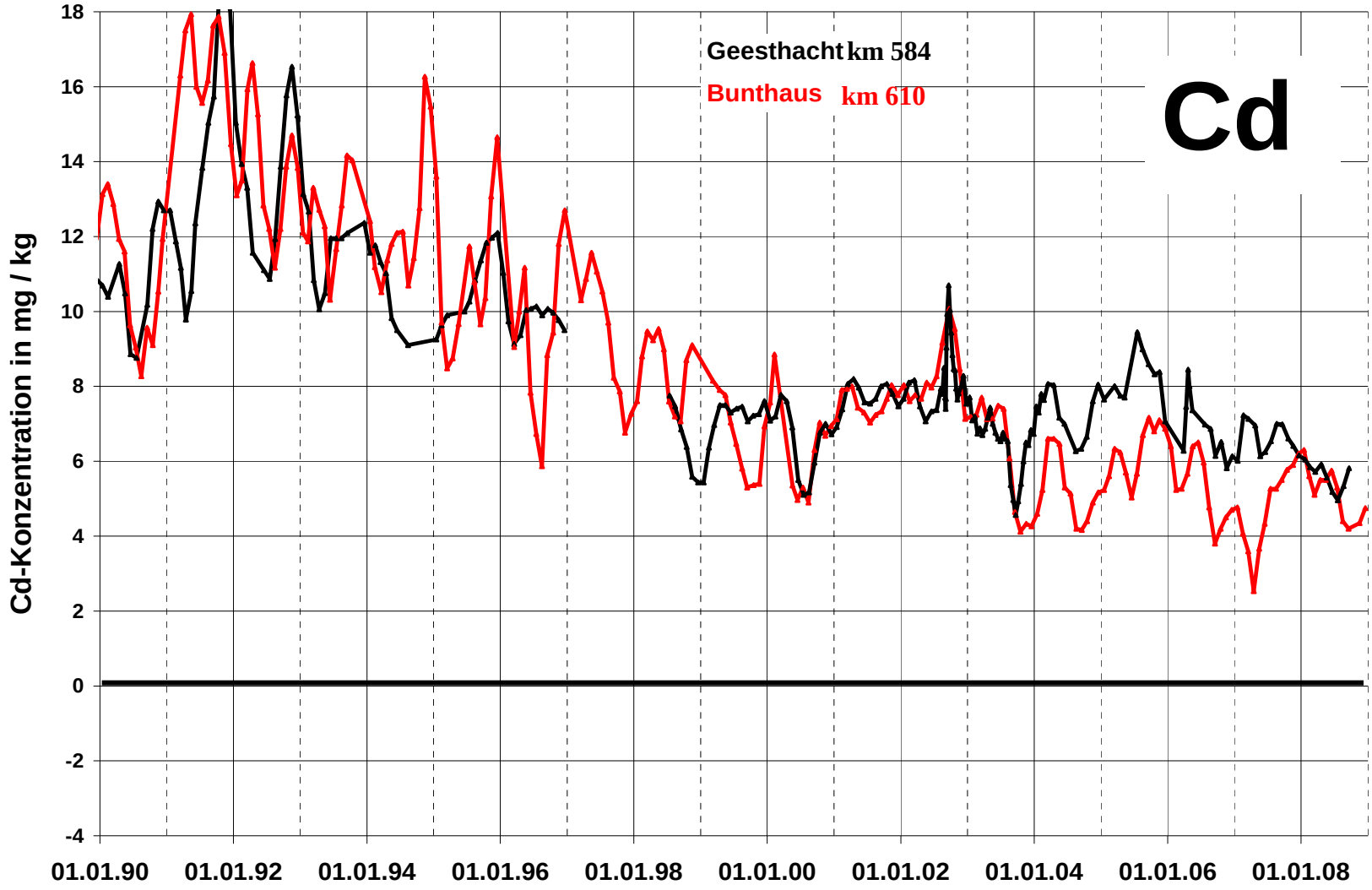
Geesthacht
Elbe-km 584

Temporal trend of Cd concentrations
Annual averages in spm in the Elbe estuary

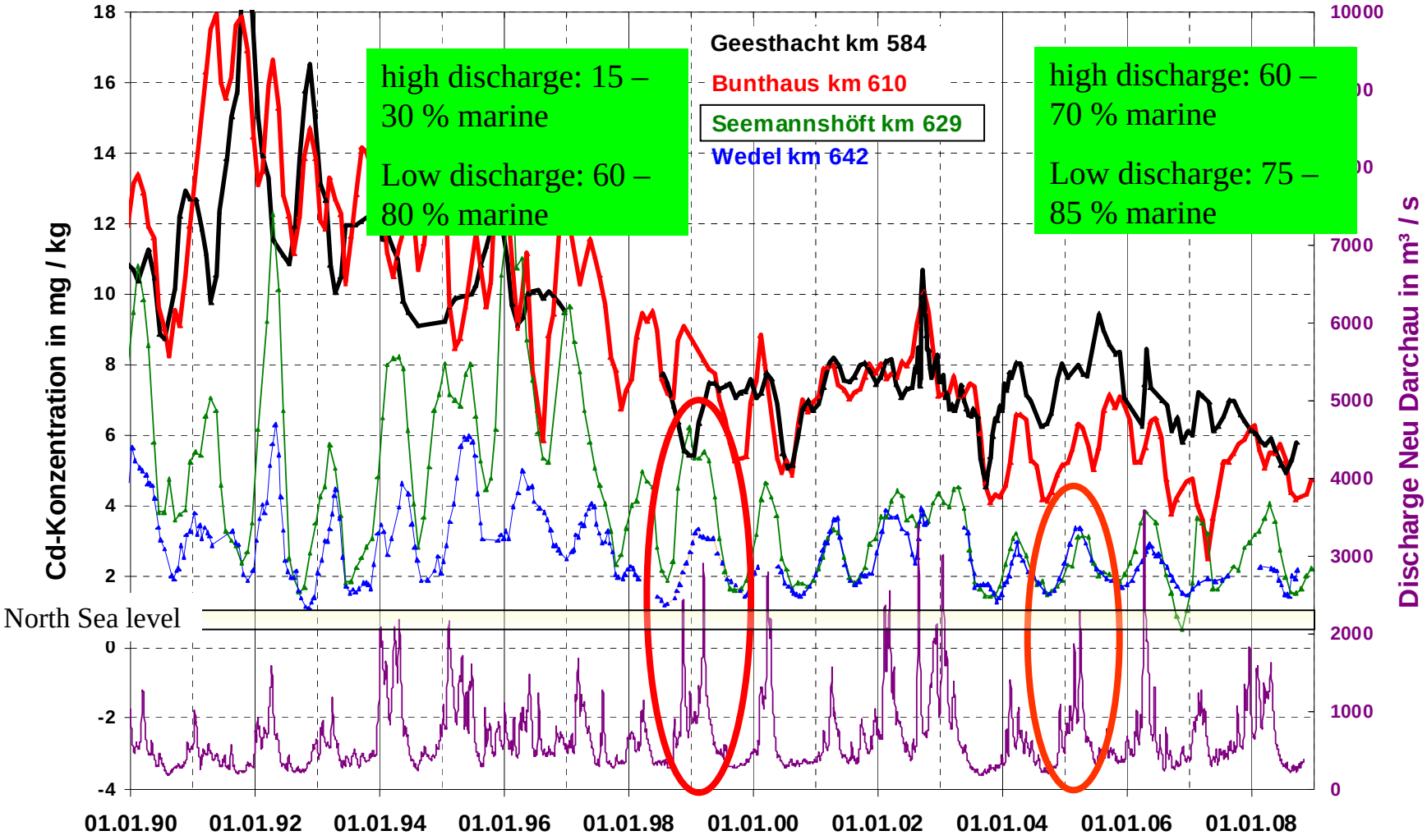


Wedel
Elbe-km
642

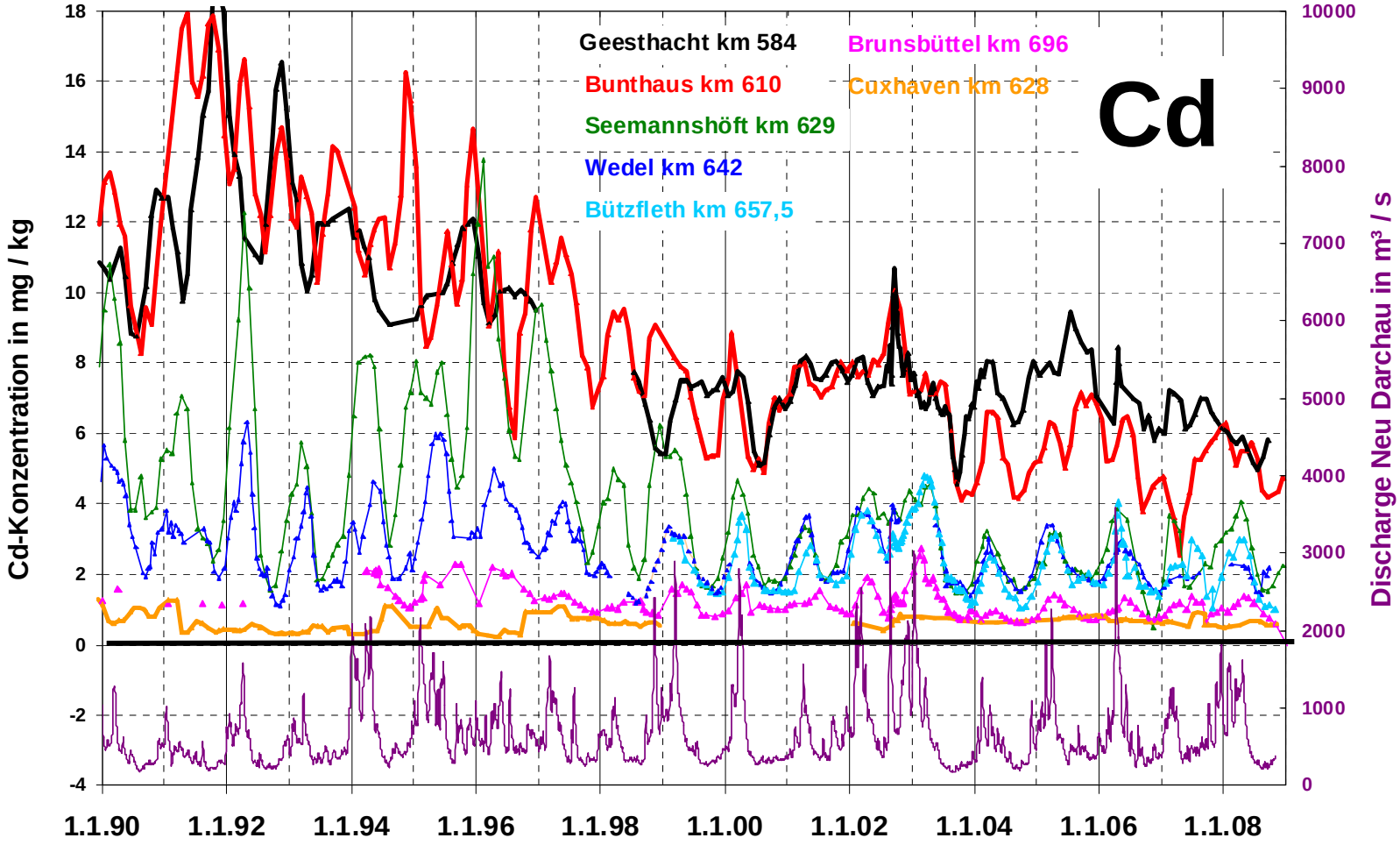
Spatial and temporal variations of contaminant concentrations (<20 µm) in the Elbe estuary



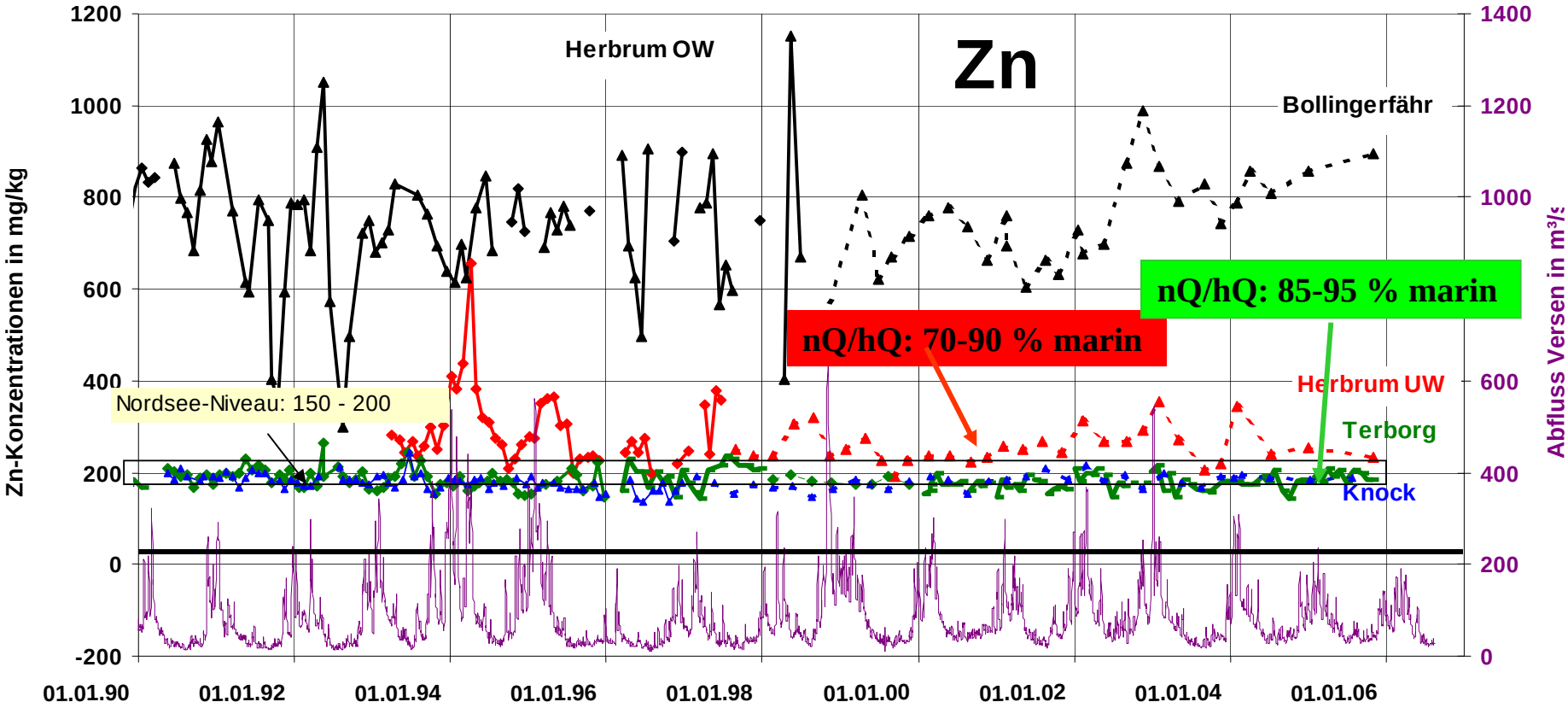
Spatial and temporal variations of contaminant concentrations (<20 µm) in the Elbe estuary



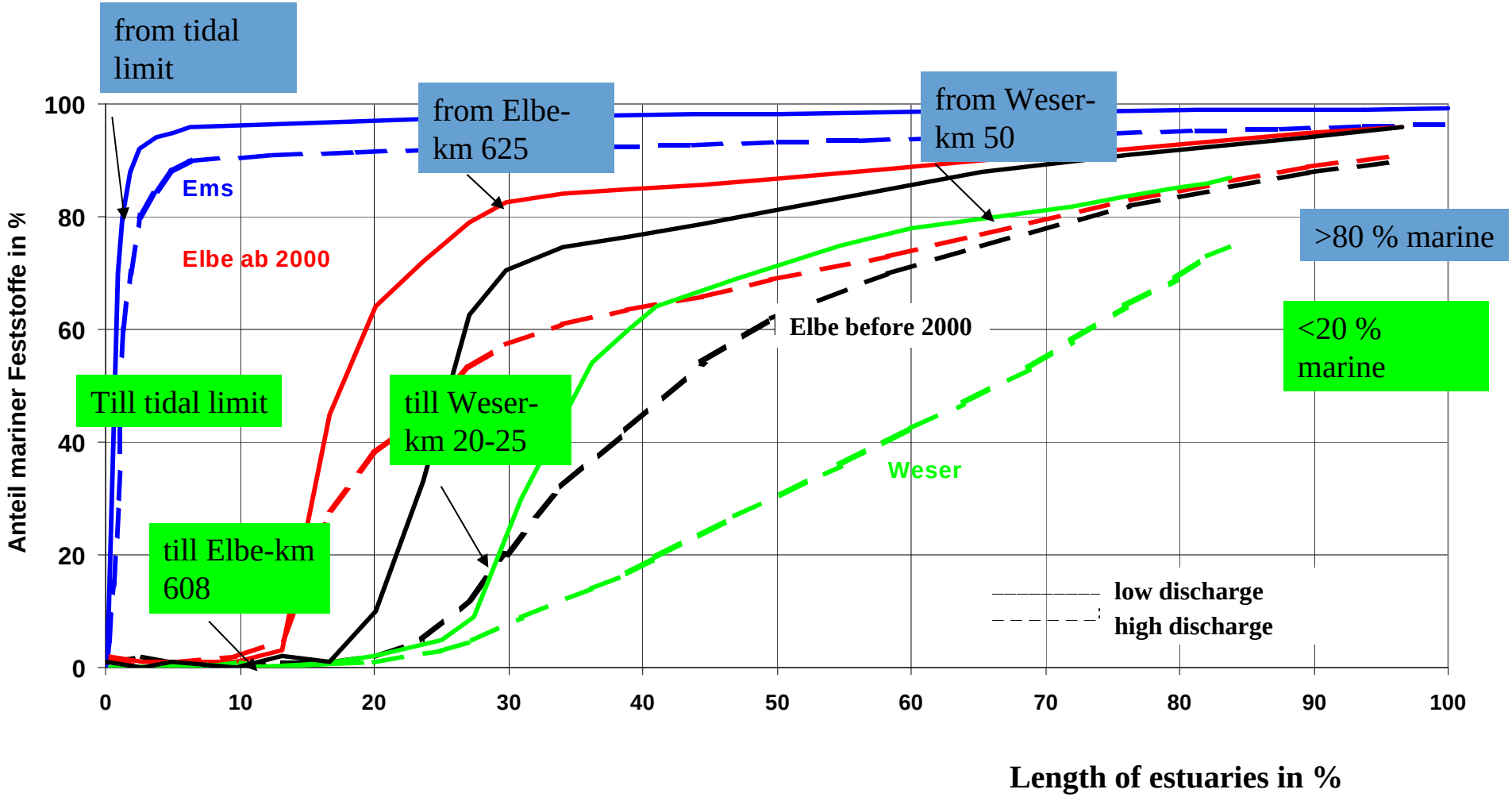
Räumliche und zeitliche Änderung der Schadstoffgehalte im Elbeästuar



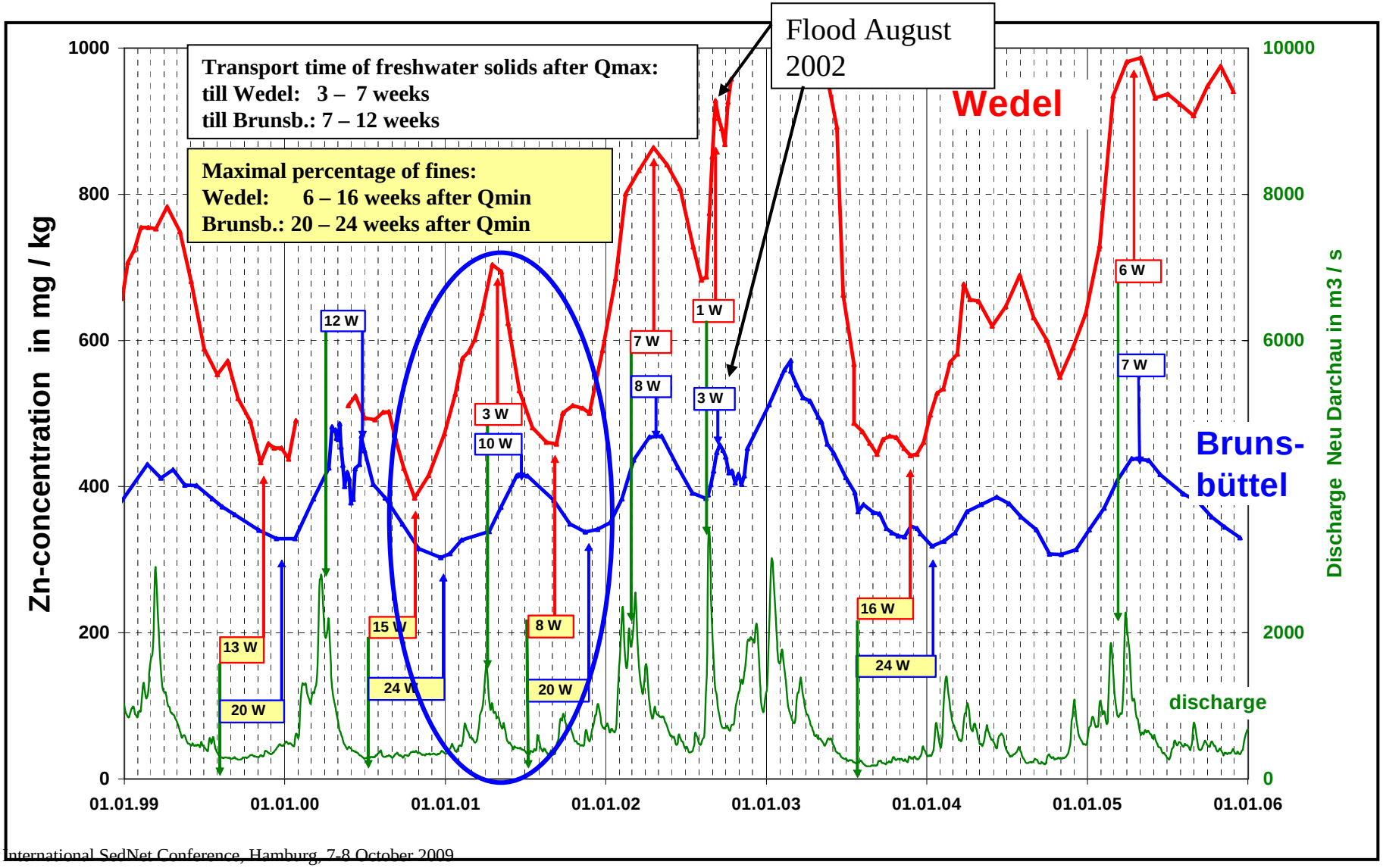
Variationen der Zinkgehalte in Schwebstoffen und Sedimenten (<20 µm) in der **Tideems**



Percentage of marine particulate matter in German North Sea estuaries



Transport times of fine-grained solids in the Elbe estuary



Transport times of particulate matter in estuaries

- Transport of freshwater solids towards the North Sea after Qmax:

  Elbe: till Wedel: 3 - 7 weeks
  till Brunsbüttel 8 - 12 weeks

  Weser: till Farge**:** 2 - 4 weeks

  ⇒ partially input to the German Bight

- Return of solids of marine origin at low river discharge (Q)

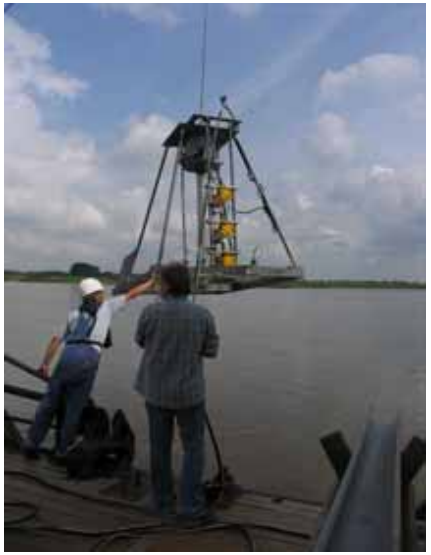
  Elbe: Wedel: till the next increase of Q (till 8 – 16 weeks after Qmin)
  Brunsbüttel: still during next increase of Q (till 20 – 24 Wochen after Qmin

  Weser: Farge: till 2 - 7 weeks after Qmin

b) Investigations in flat zones (wadden areas, branches)

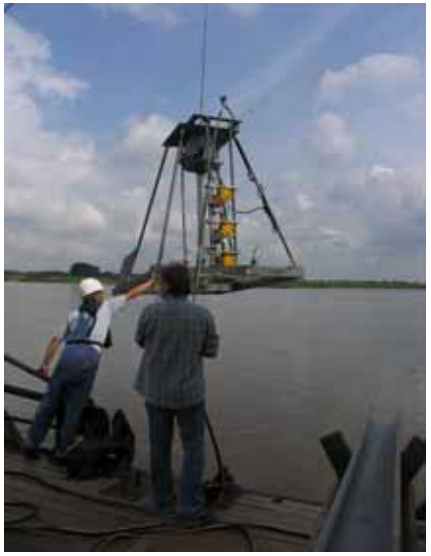
Sediment cores:

- Depth profiles, surface layers
- one-off studies or low frequency of sampling (several years)



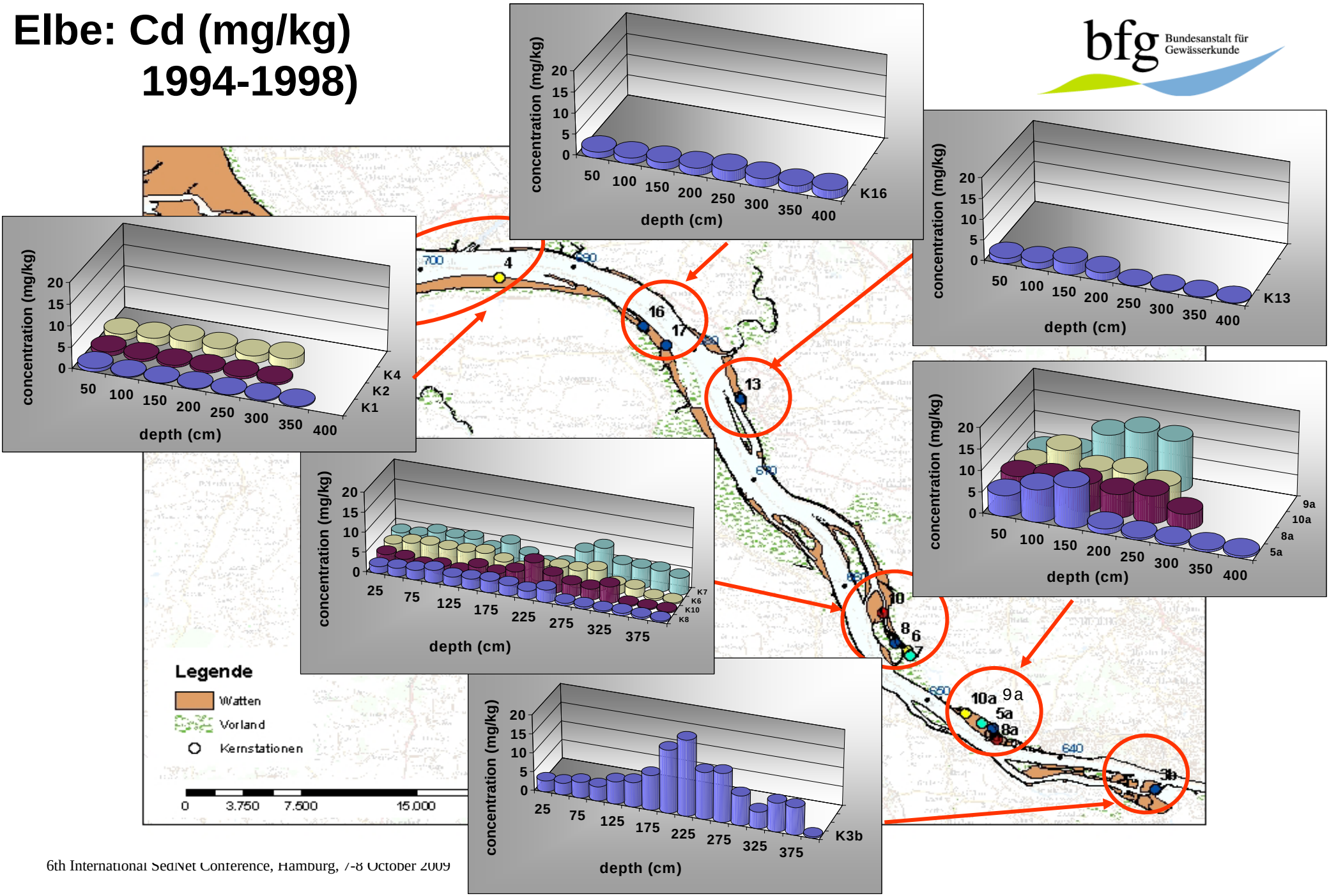
Results and assessment: Investigations in flat zones

box corer



vibrocorer

Elbe: Cd (mg/kg) 1994-1998)



Elbe: Cd (mg/kg) (2008)

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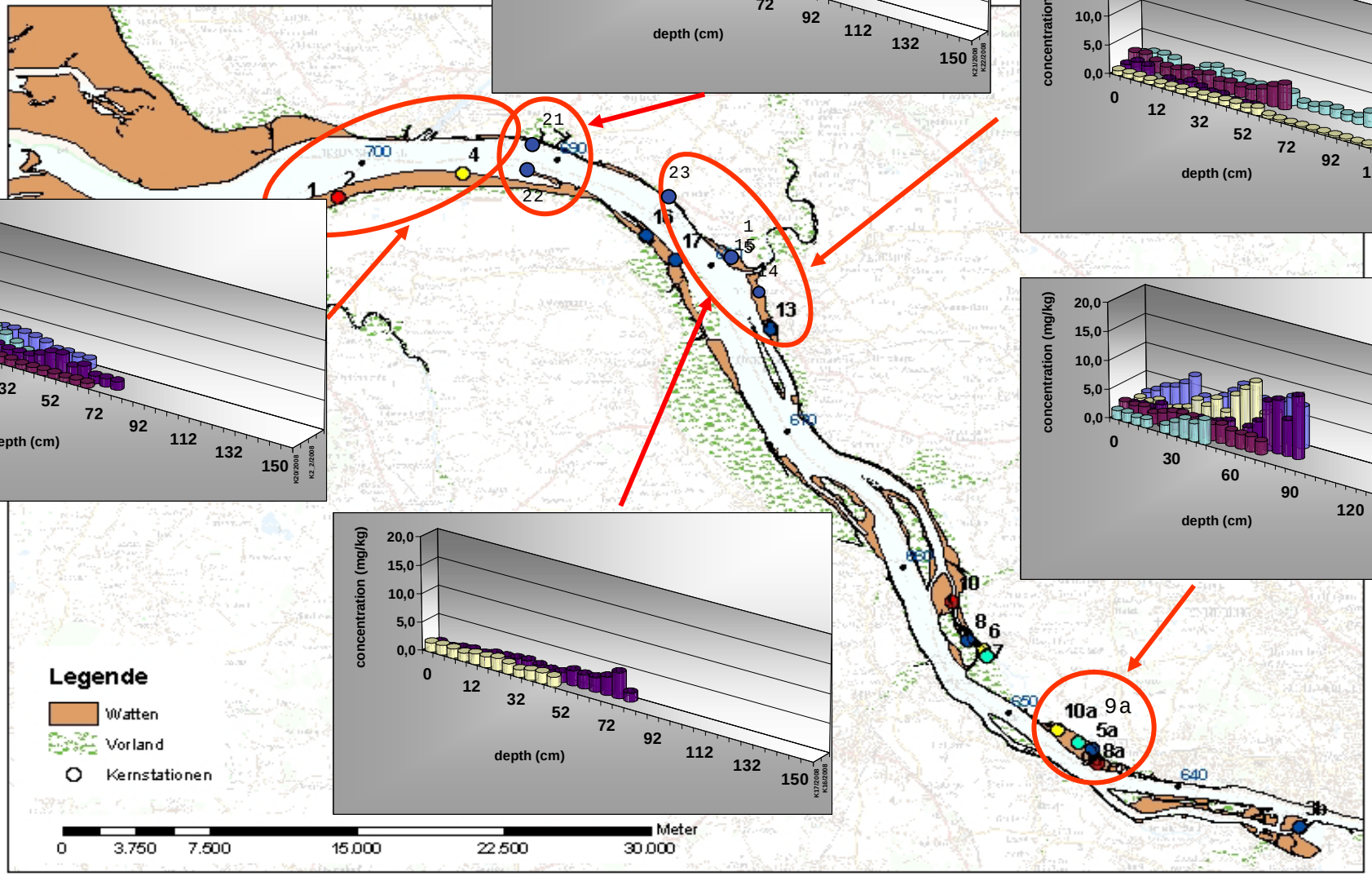
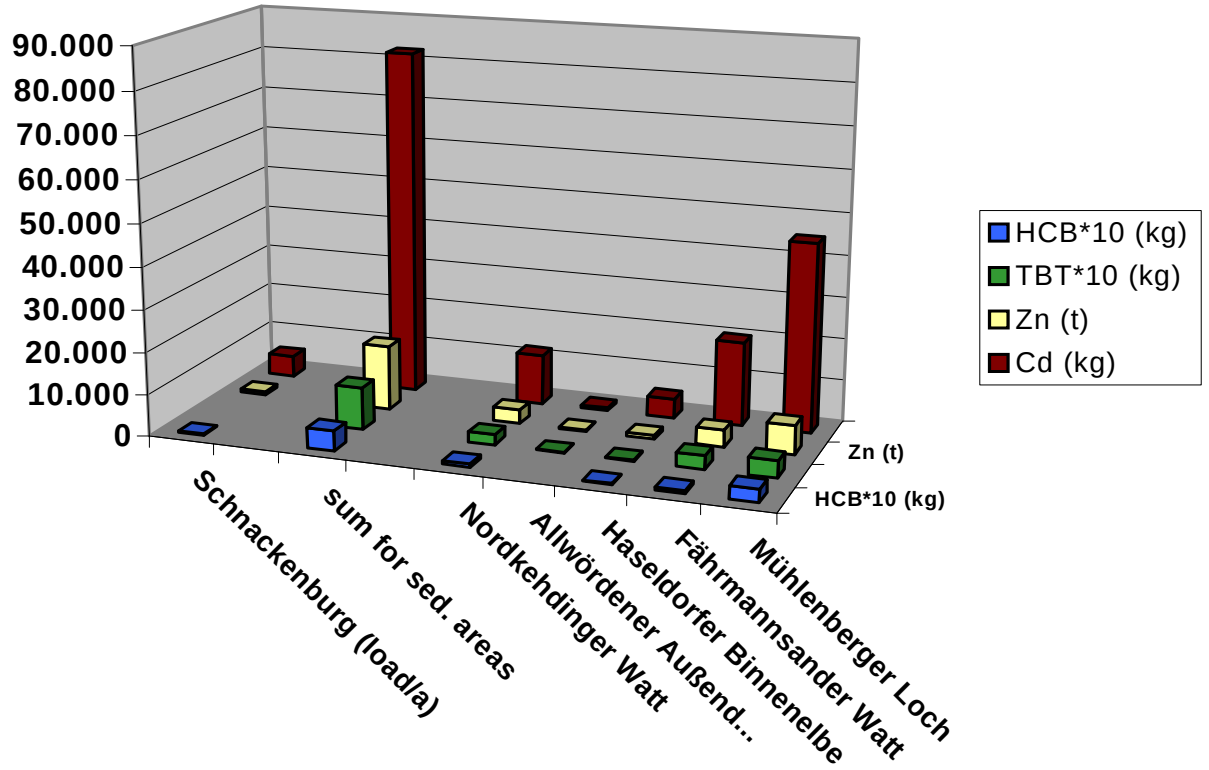
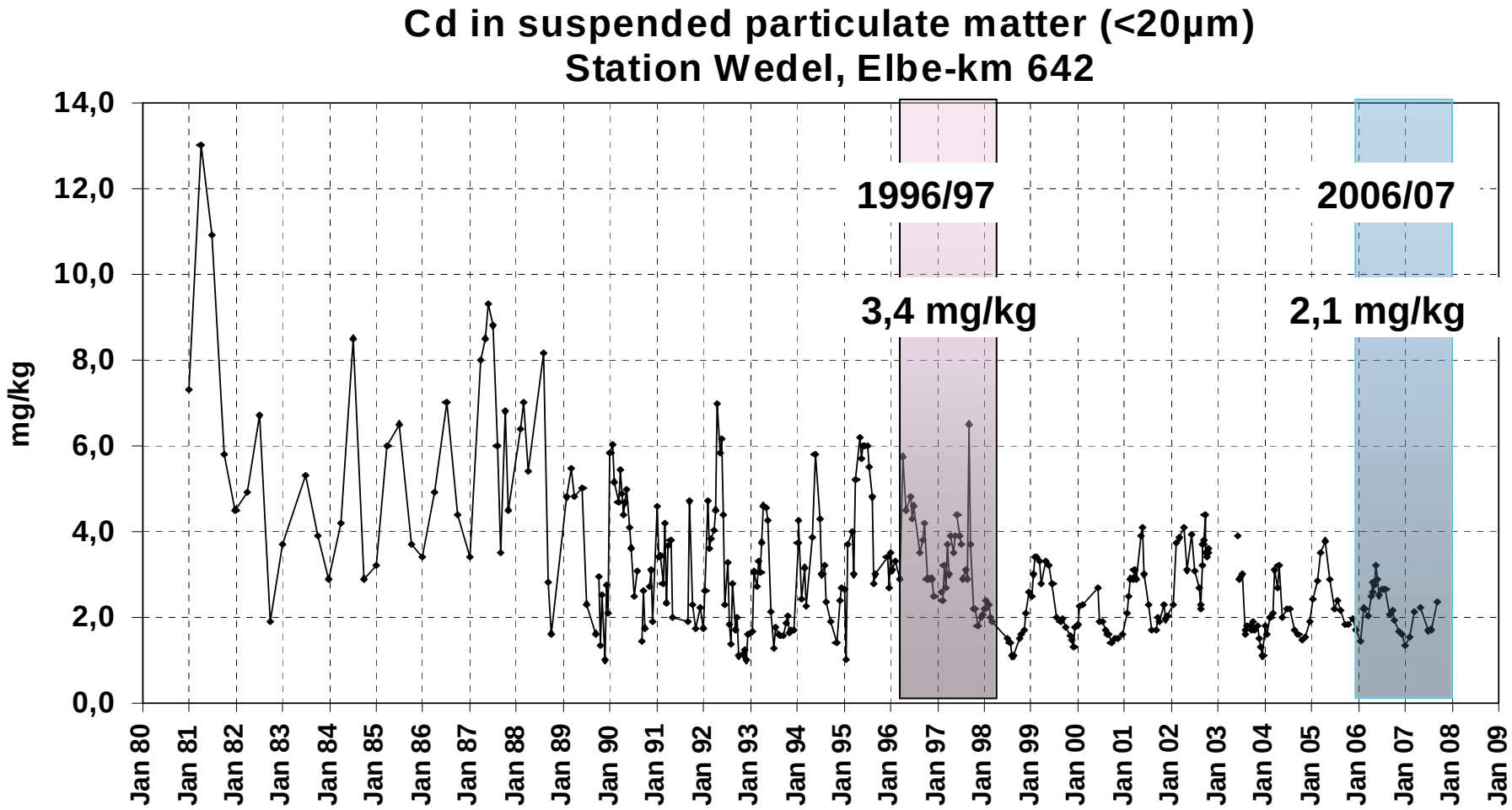


Contaminant loads in sedimentation areas of the Elbe estuary (1994-1998)

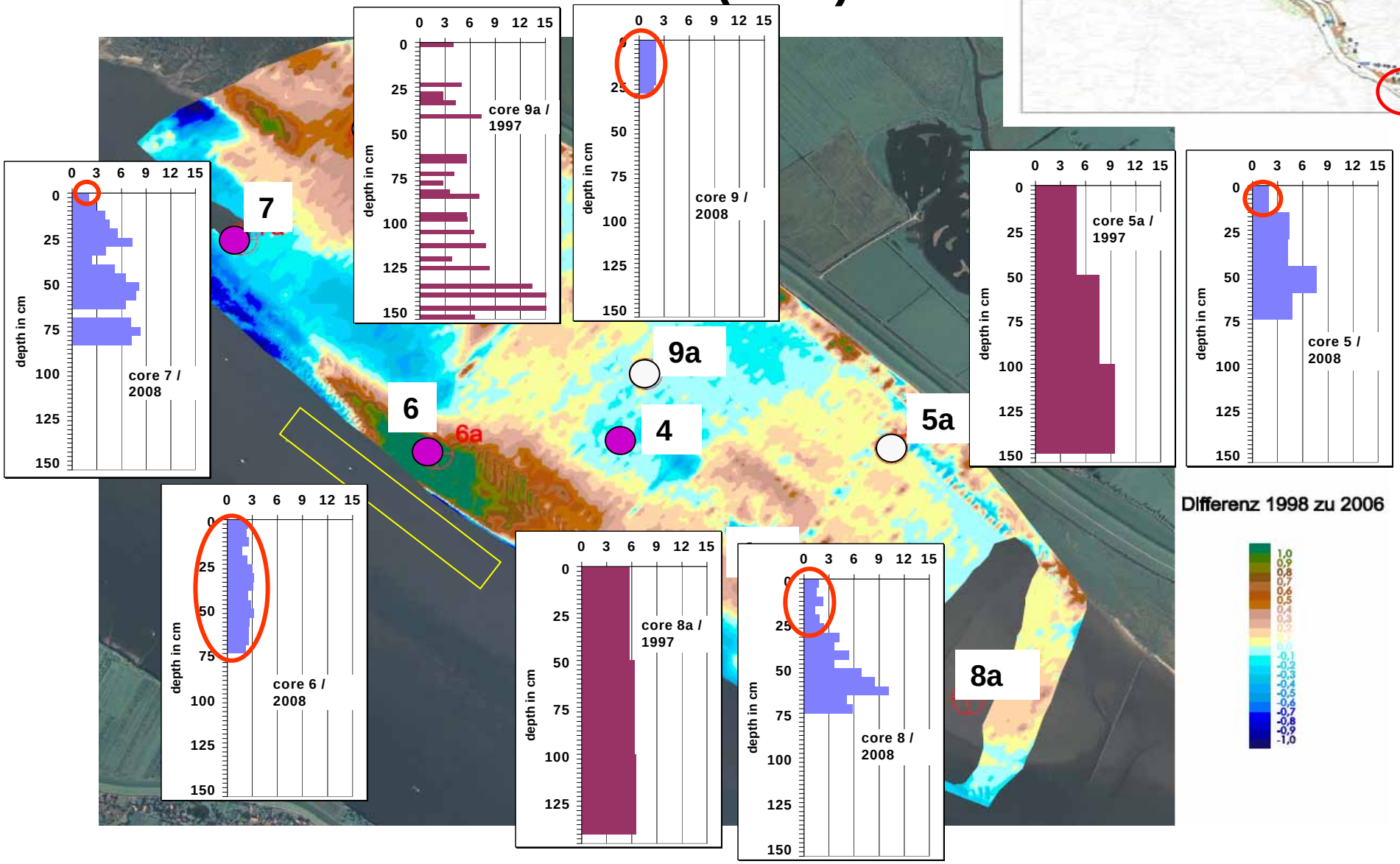


Schnackenburg: average annual load (2004 – 2006), ARGE Elbe

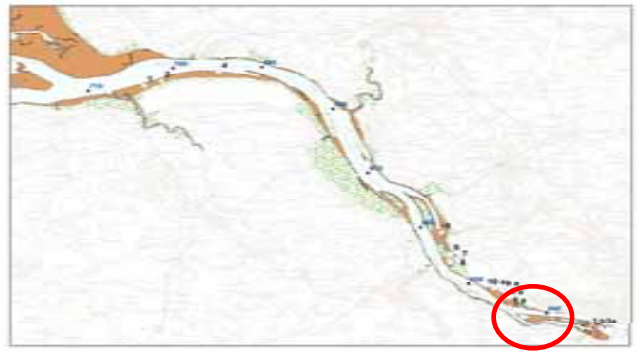
Temporal development of Cd concentrations in spm at Wedel, Elbe-km 642

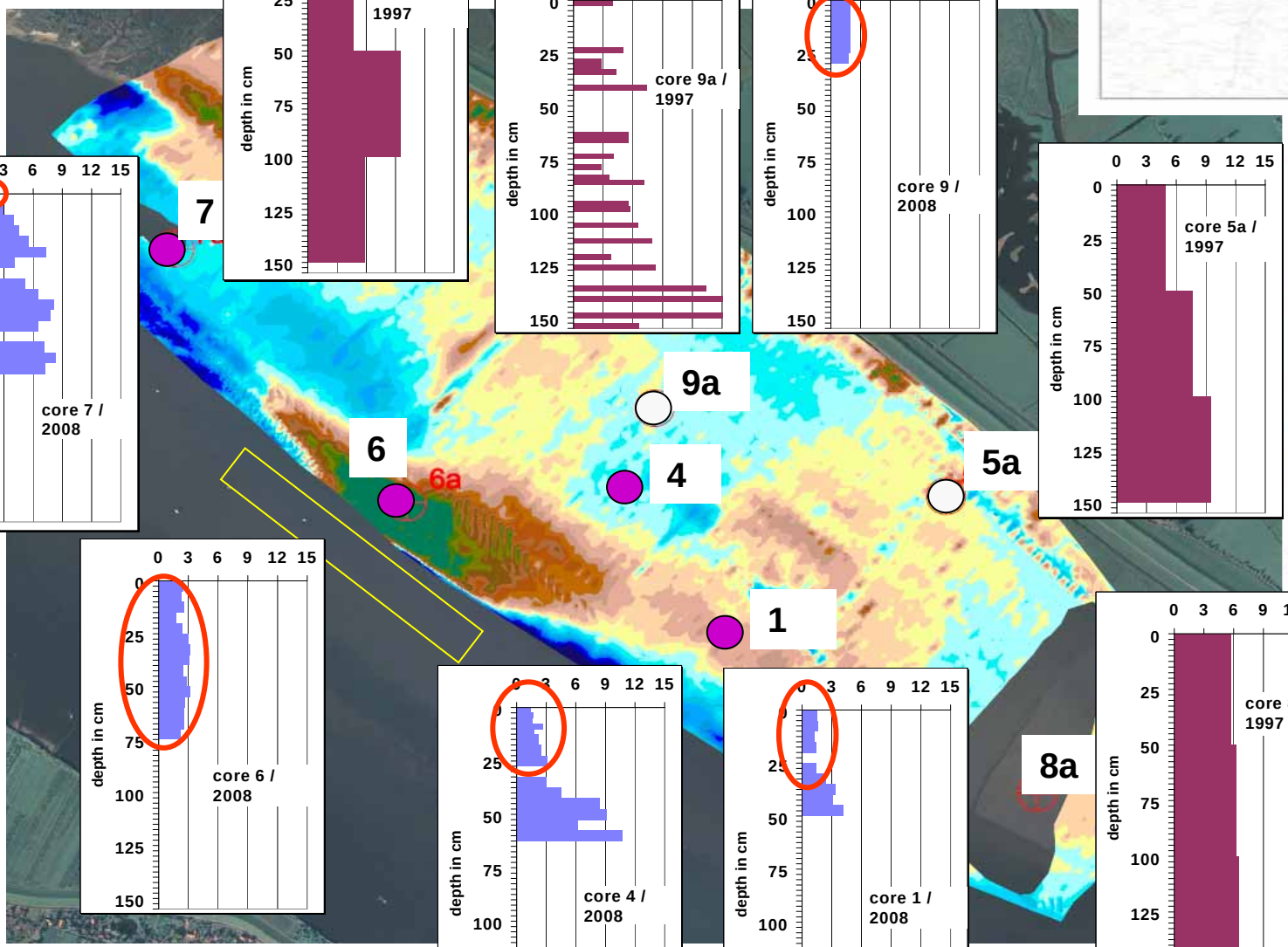


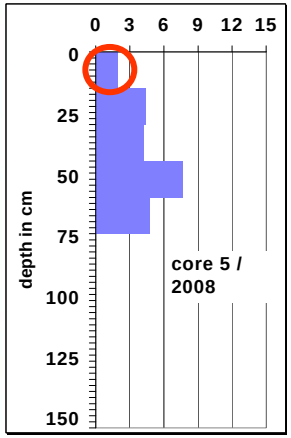
Cd (mg/kg) in sediment cores 1997 and 2008 - Fährmannsander Watt (Elbe)



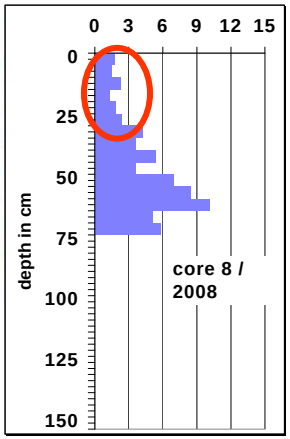
Cd (mg/kg) in sediment cores 1997 and 2008



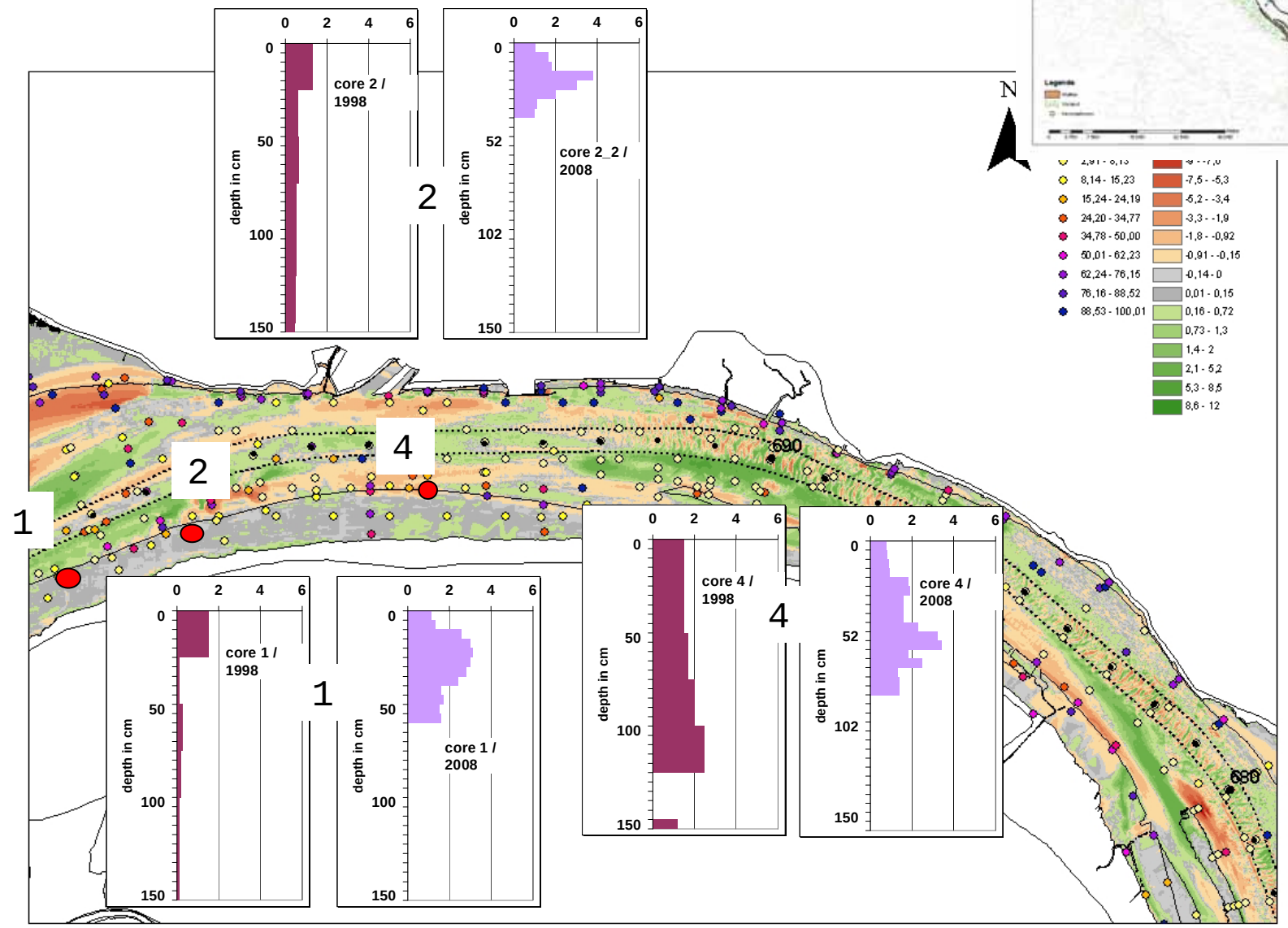




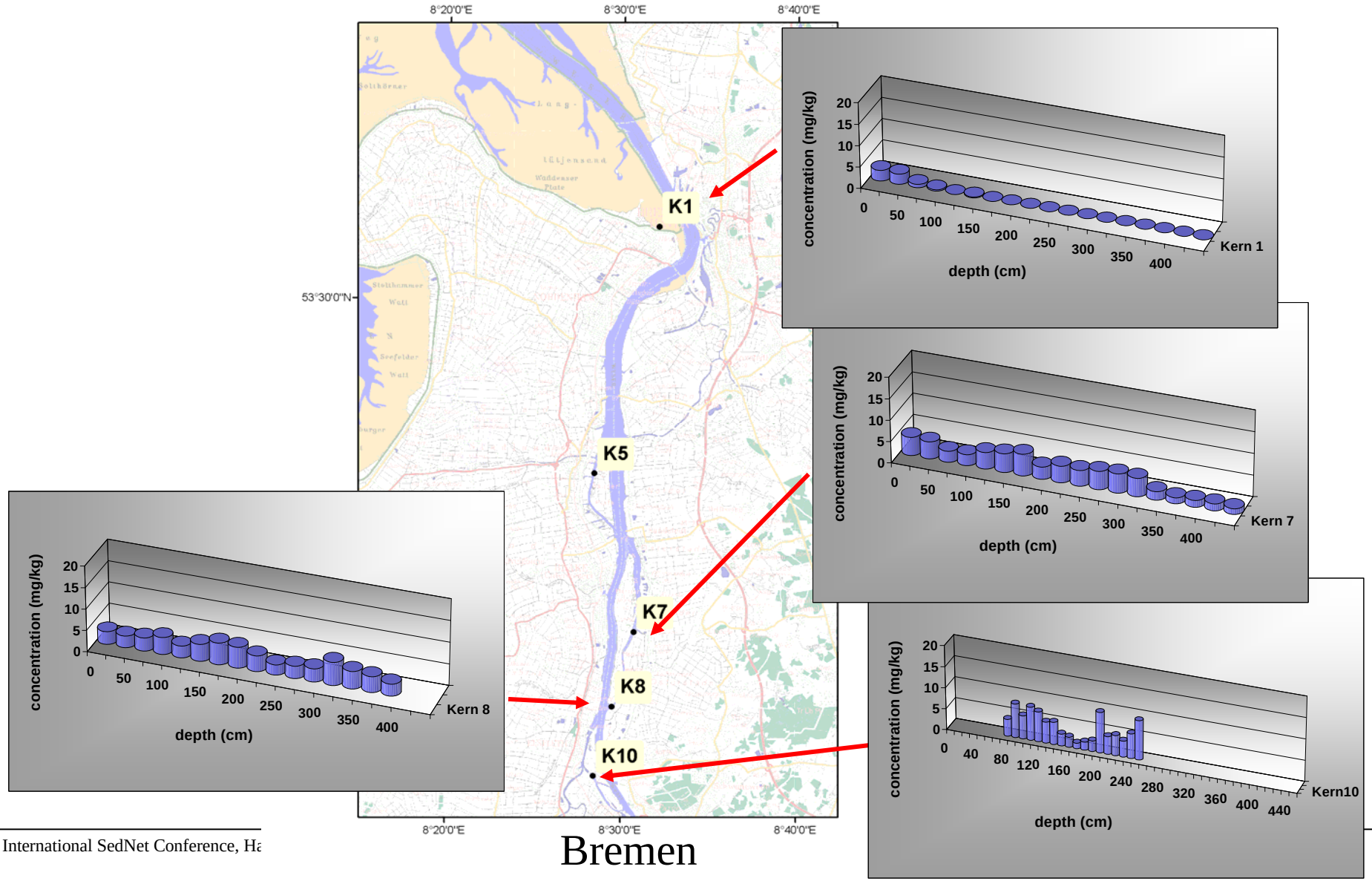
Differenz 1998 zu 2006



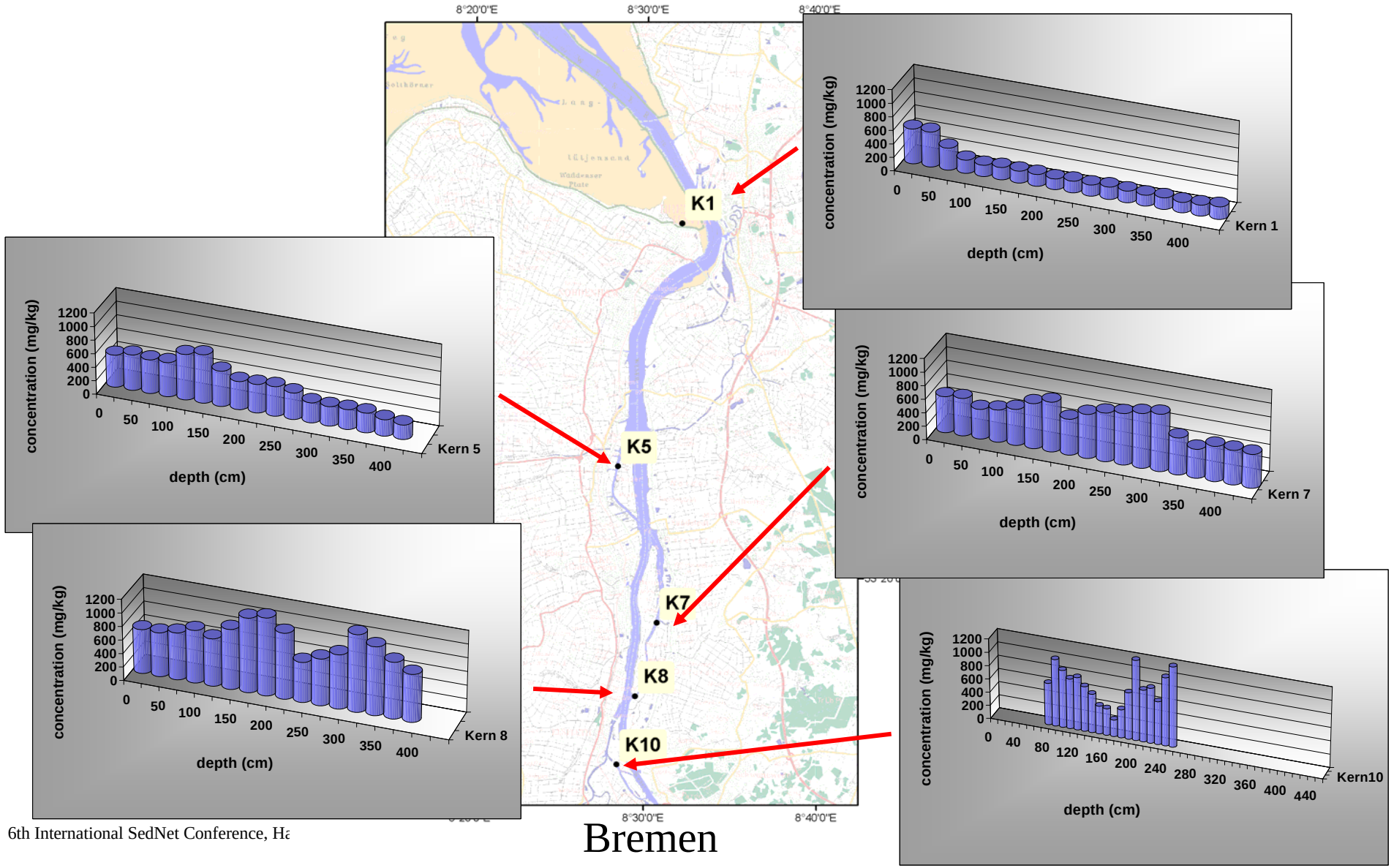
Cd (mg/kg) in sediment cores 1998 and 2008



Weser estuary: Cd concentrations in sediment cores (1999)



Weser estuary: Zn concentrations in sediment cores (1999)



Summary

- Results of long-term contaminant analyses
  - confirm the upstream transport of fine-grained solids as predicted by model calculations,
  - Indicate a larger extent of upstream transport in the river Elbe after the year 2000
  - how a different extent of upstream transport for the estuaries of Elbe, Weser and Ems
  - give an indication on transport time of fine-grained solids
- Results from depth profiles in wadden areas
  - Contaminated layers in tidal flats and branches of Elbe and Weser have a thickness of up to 3 m.
  - Contaminant quantities accumulated in sediments of tidal flats of the Elbe estuary amount to ca the 20-fold of loads entering the estuary annually.
  - Re-investigation of contaminants in tidal flats may give an indication of deposition rates.

Conclusions and perspective

- Results of chemical monitoring should be considered
  - In the planning of construction works, capital dredging, and sediment management meassures for navigation,
  - In the planning of measures for improving waterbodies in the implementation of the EC-Water Framwork Directive
  - In the estimation of particle-bound contaminant input to the North Sea

- Future planning
  - Use of trace metal data for veryfying numerical models for transport of fine-grained sediments
  - Re-investigation of wadden areas and branches
  - Investigations in further flat zones and floodplains

Thanks go to

the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) which provided essential funding

the Waterways and Shipping Agencies, facilitating the sampling programme

the colleagues in the laboratory of the BfG

Dr. Fridbert Ackermann, who initiated these investigations

Thank you for your attention