The importance of understanding sediment dynamics to achieve a good chemical status in harbor environments.

J. Teuchies, A. Heylen, E. de Deckere, P. Meire & R. Blust

Port of Antwerp

Ecosystem Management Research Group (Ecobe)
University of Antwerp

sphere | Systemic Physiological & Ecotoxicological Research

SEDNET – 23/09/2015 - Krakow

University of Antwerp

EU Water Framework Directive

Background :

- **Achieve a good chemical status in aquatic systems.**

➡ **All European water bodies have to comply with the water quality standards of 45 priority substances.**

- **Multiple contaminant sources exist.**
- **Water bodies can be interdependent.**

➡ **River systems and contaminant dynamics complicated.**

➡ **Appropriate management calls for insight in emissions, transport and behavior of contaminants.**

Port of Antwerp: specific situation

- 80 km inland
- Connection with the Scheldt estuary via locks
- Freshwater inflow (canal) limited ($15\ m^3/s$)

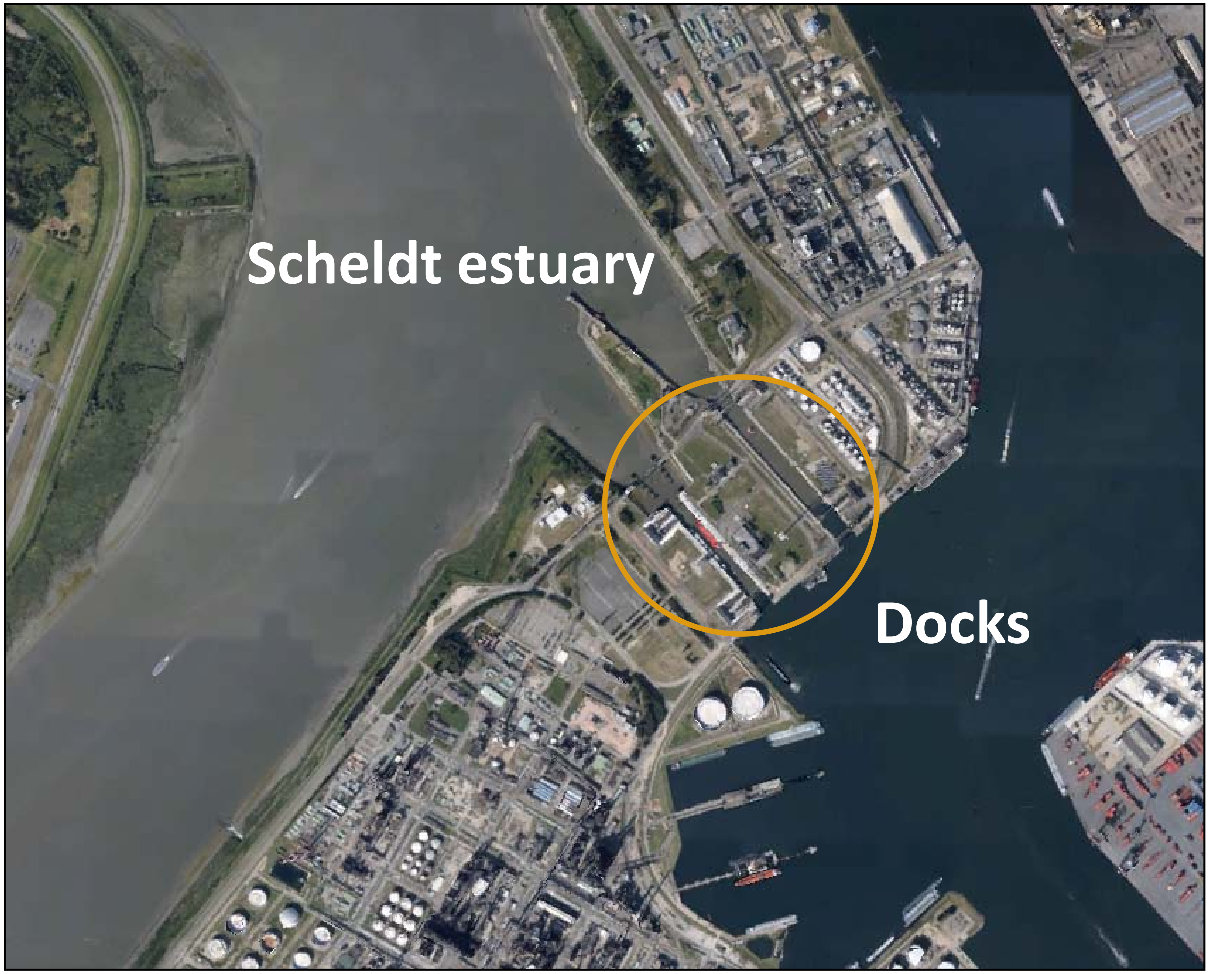
Port of Antwerp: specific situation

Scheldt estuary:

- Macrotidal
- Turbid
- High flow rate

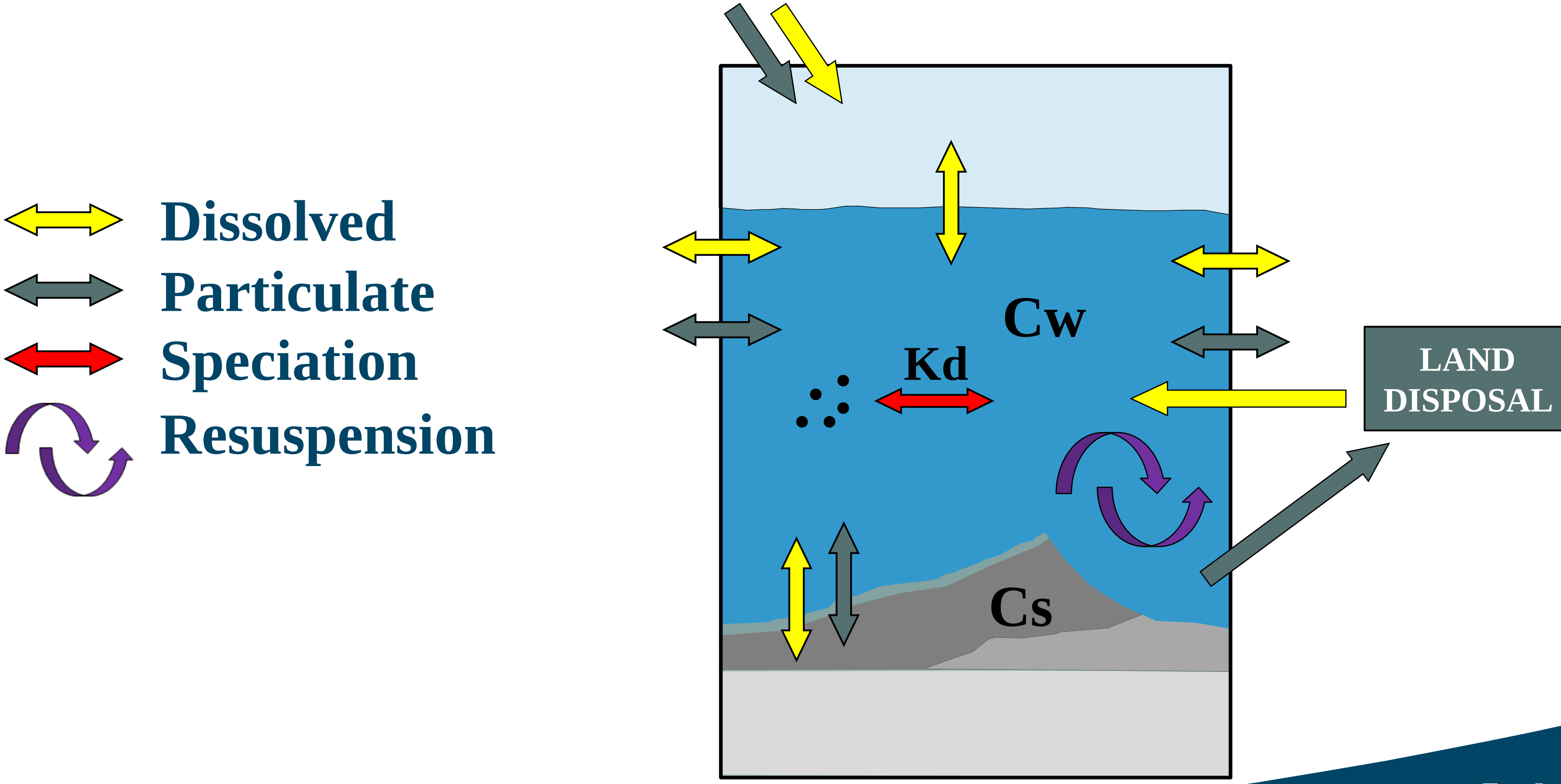
Harbor docks:

- Low flow rate
- Low turbidity
- High vessel activity
- Large dredging volumes



Objective

Understanding contaminant dynamics in order to establish appropriate management to achieve water quality targets: ***Mathematical risk model (EcoDocks)*****.**



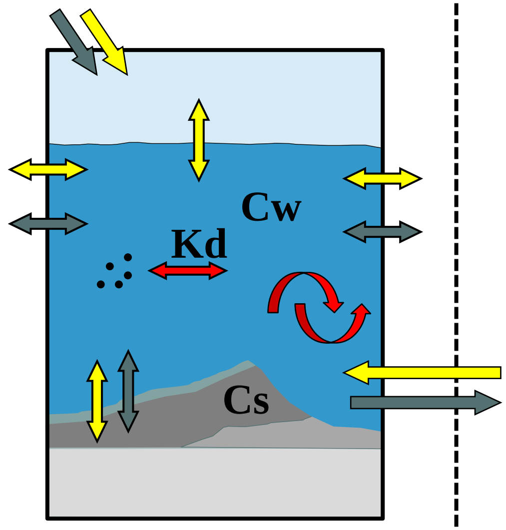
Mass balance calculations: *processes*

Scheldt estuary

Harbor docks

Freshwater canal

Emissions:
diffusive/point



Freshwater inflow

Advection-diffusion:
sediment/water exchange

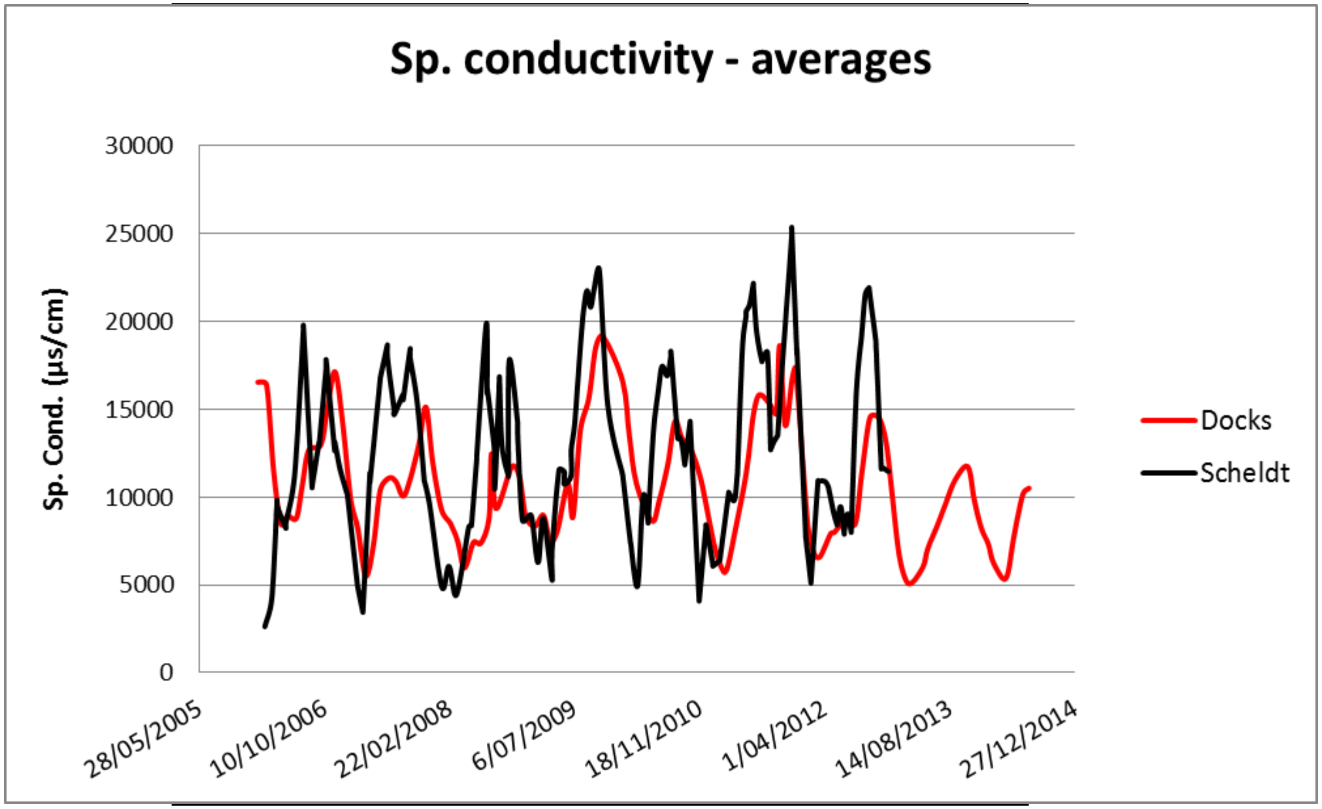
Land disposal
dredged sediment

Diffusive flux
Sediment-water

Resuspension:
navigation/dredging

Large fluxes

Exchange with the estuary: *effect of locks?*



- **Brackish water originating from the Scheldt estuary penetrates the docks against the freshwater flow.**
- **Specific conductivity used to calculate the bulk dispersion coefficient: D = 100 m³/s.**

➡ **Large dispersion coefficient and large exchange of water and sediments despite the presence of locks.**

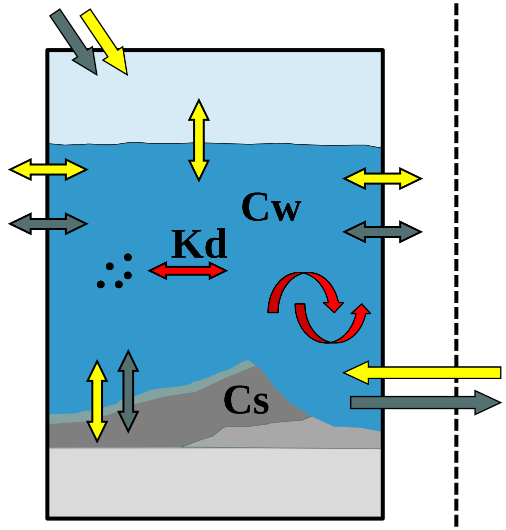
Mass balance calculations: *processes*

Scheldt estuary

Harbor docks

Freshwater canal

Input from emissions: diffusive/point



Advection-diffusion: sediment/water exchange

Freshwater inflow 15 m³/s

Land disposal dredged sediment

Speciation: Kp - Koc

Diffusive flux Sediment-water

Resuspension: navigation/dredging

Large fluxes

Dredging: *land disposal (AMORAS)*

- Processing most of the sediments dredged in the docks
- On land storage of sediments after dewatering

➡ Removal of large volumes of sediments and associated contaminants.

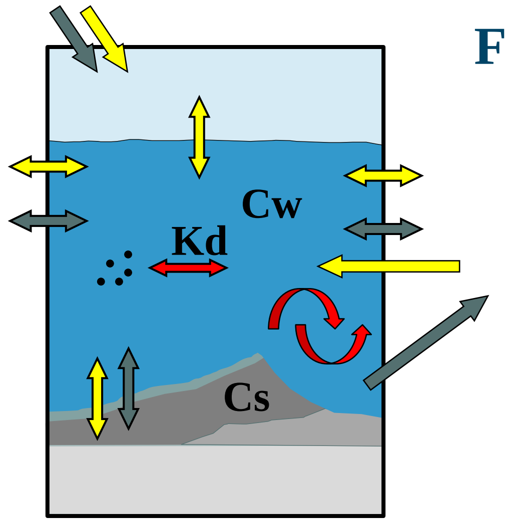
Mass balance calculations: *Zn (ton per year)*

Scheldt estuary **Harbor docks** **Freshwater canal**

Emissions:
+13 t/y

Advection
-17 t/y

Freshwater inflow
+22 t/y



Estuarine influx
+100 to +300 t/y

Land disposal dredged sediment
-350 t/y

Resuspension:
Discontinue/temporal

Diffusive flux
<1 t/y

➡ **Gradual improvement of the aquatic system.**

Large sediment-related Zn fluxes

Ecotoxicological risk: *Zn*

- **Uptake and toxicity depends on the dissolved fraction.**
- **Depends on multiple environmental factors.**

Acidity

Organic matter

Oxygen

Zn^{2+}

Water hardness

Temperature

Salinity

→ **Speciation (Zn part. / Zn diss.) as an important factor in risk assessment.**

Fate of contaminants: *speciation*

Scheldt estuary

SPM = 100 mg L^{-1}

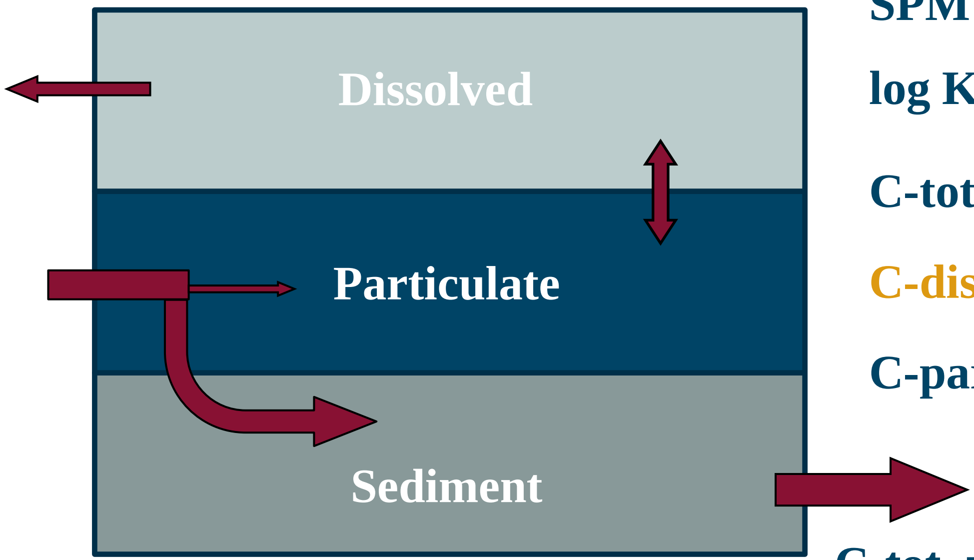
log Kd = 4.9 L kg^{-1}

C-tot. = 40 µg L^{-1}

C-dis. = 5 µg L^{-1}

C-part. = 350 mg kg^{-1}

Harbor docks



SPM = 15 mg L^{-1}

log Kd = 5.0 L kg^{-1}

C-tot. = 28 µg L^{-1}

C-dis. = 19 µg L^{-1}

C-part. = 600 mg kg^{-1}

C-tot. = 640 mg kg^{-1}

➡ **Large sediment related influx from the estuary. Low impact on dissolved Zn concentrations?**

EcoDocks: *dynamic risk model for the Antwerp Harbor docks*

Speciation

Mass balance calculations

Resuspension
Dredging - Navigation

EcoDocks

Bioaccumulation
Toxicity

Sediment
Toxicity

Sediment-water fluxes

Develop a site specific risk model in order to support policy decisions by the Antwerp Port Authority concerning environmental issues.

→ **Large effect of other waterbodies. Complex pollutant dynamics.**

Thank you for your attention!