Deltares

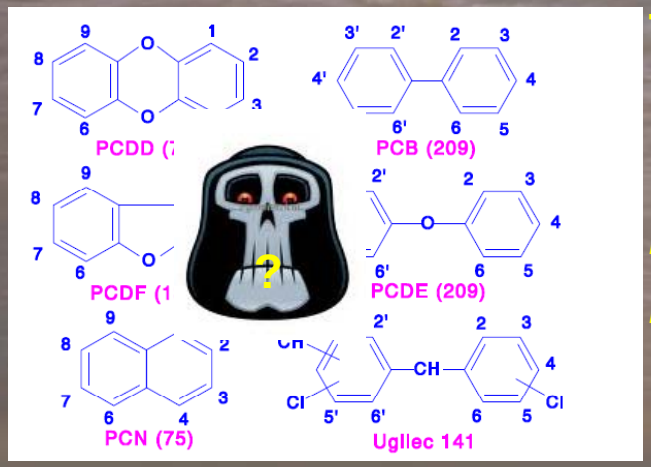
Enabling Delta Life

Assessment of effects of chemical contaminants in dredged material on marine ecosystems and human health

Dr. Cor Schipper

Environmental problems

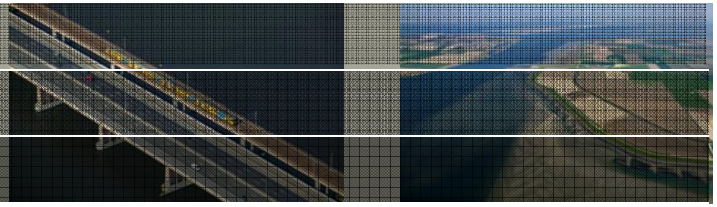
- Given the potential environemental consequencs of dumped dredged harbour sediment, it is vital to establish the potential risks from exposure before disposal at sea:



TBT - tributyltin
PCBs – polychlorinated biphenyls
PCDD/Fs– polychlorinated dibenzodioxins and furans
PCFs – polyfluorinated chemicals as PFOS and PFOA
PAKs - Polyhalogenated aromatic hydrocarbons

- How can we assess the risks of harmful substances in marine ecosystem?
- What is the health risk of toxic pollution on marine organisms?

Ecotoxicological risk assessment

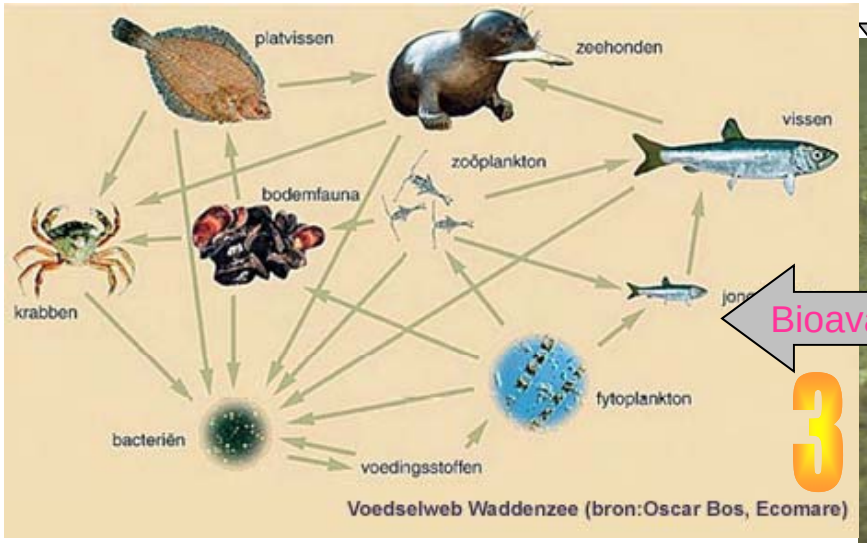


Hazard compounds

Rain, river

1

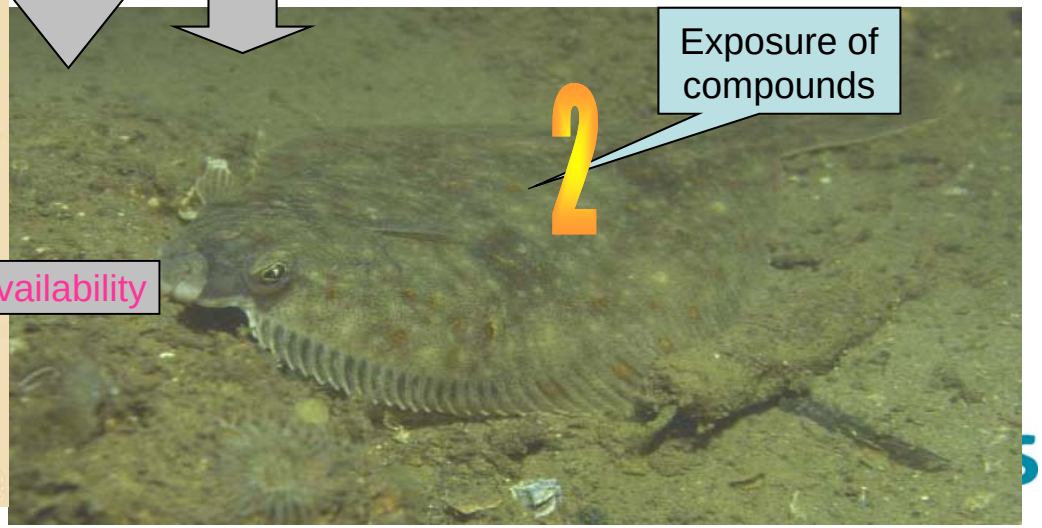
Stormwater runoff



Voedselweb Waddenzee (bron:Oscar Bos, Ecomare)

Bioavailability

3



Exposure of compounds

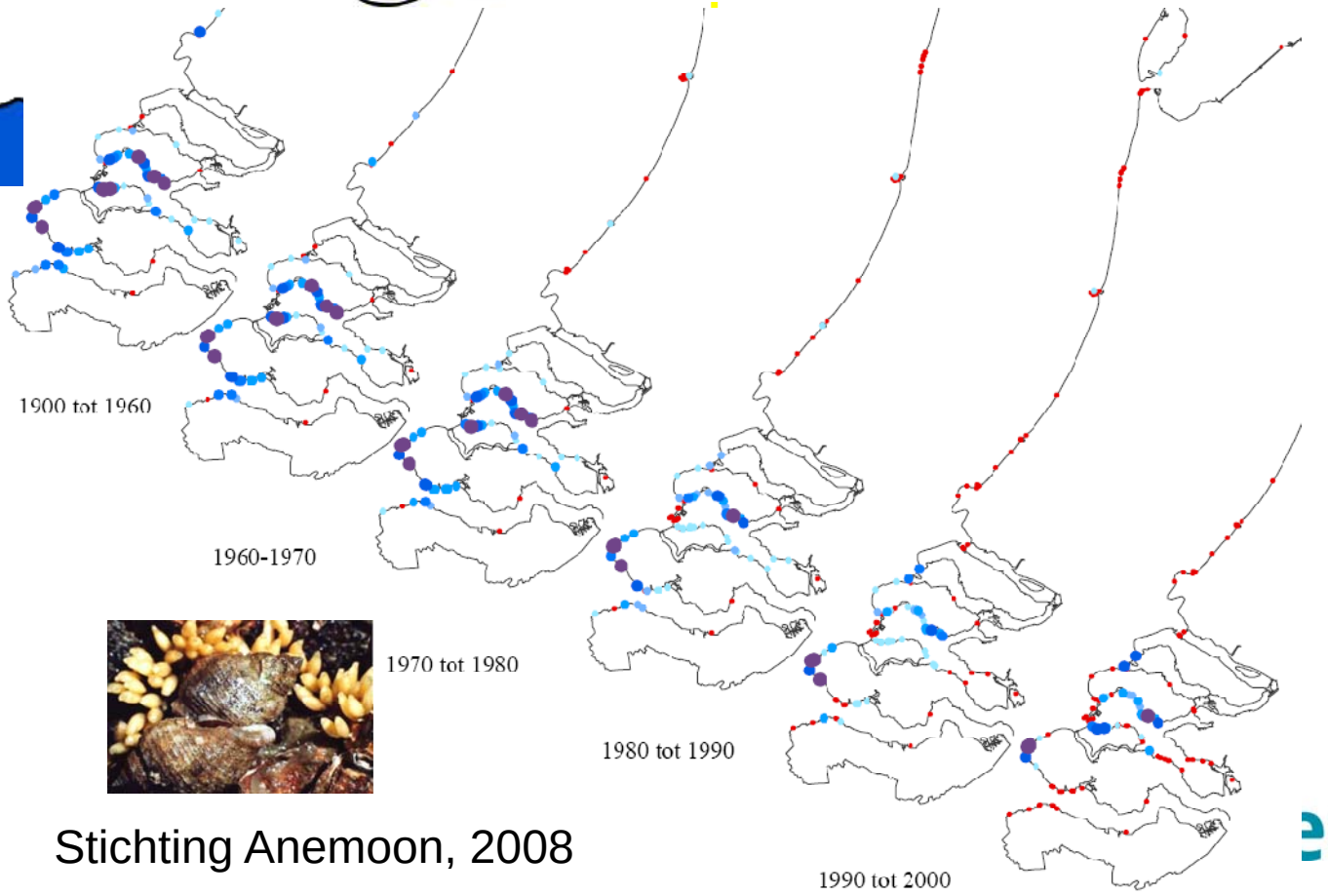
2

Ecological impact of organotin pollution

Chemical analyses

TBT

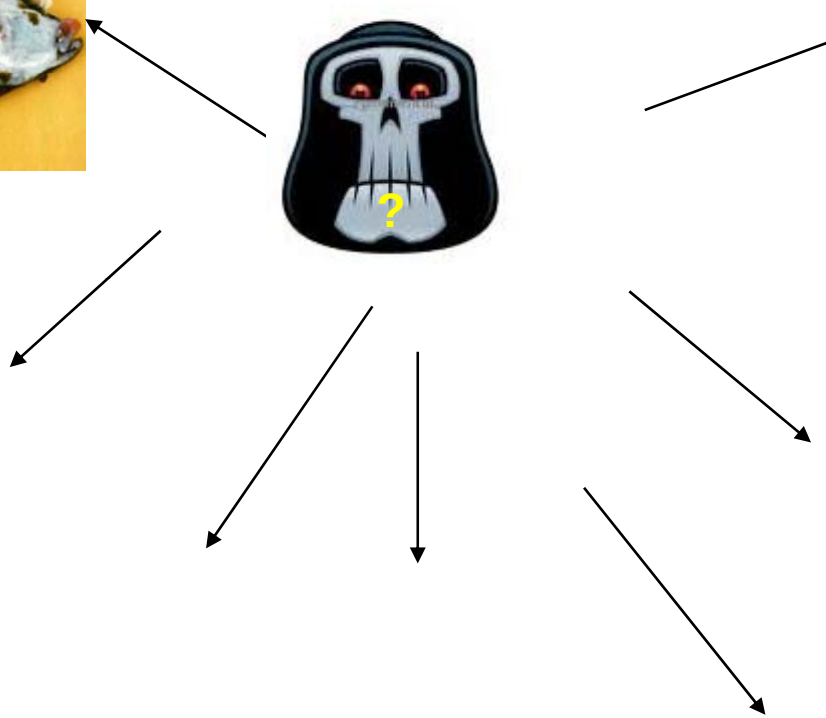
?



Stichting Anemoon, 2008

Ecological impact of compounds

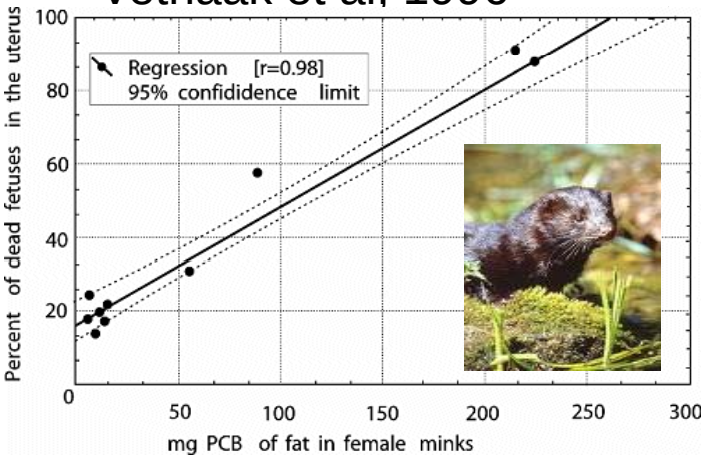
Vethaak et al, 1996



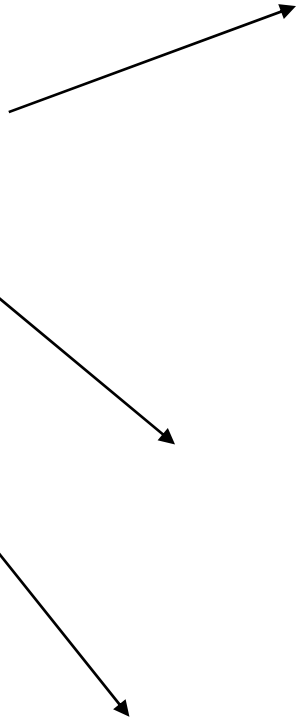
Deltares

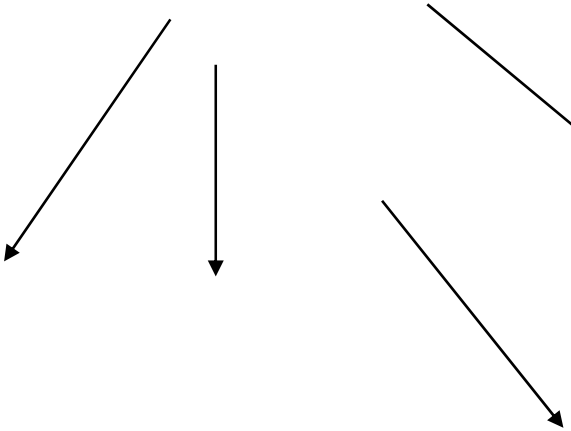
Ecological impact of compounds

Vethaak et al, 1996



Restum et al, 1998

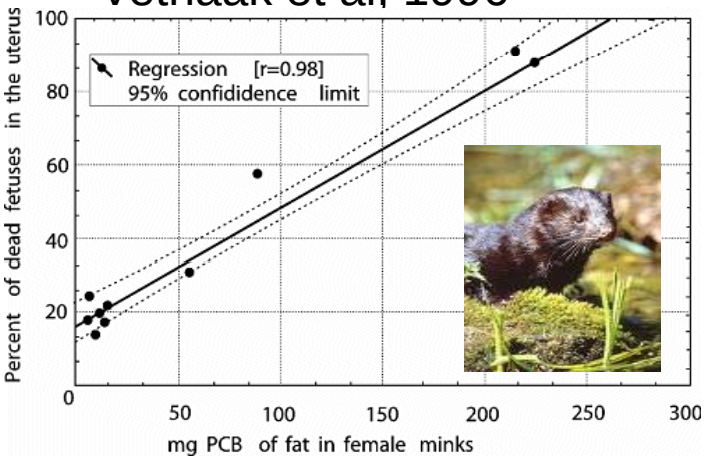




Deltares

Ecological impact of compounds

Vethaak et al, 1996



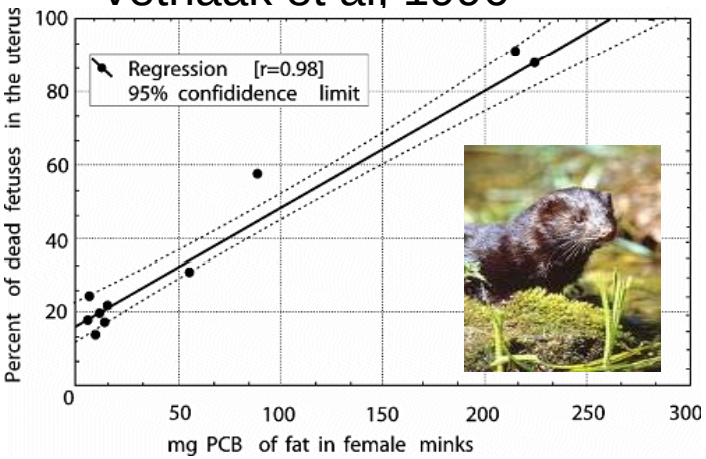
Restum et al, 1998

Schipper et al, 2008

Deltares

Ecological impact of compounds

Vethaak et al, 1996



Restum et al, 1998

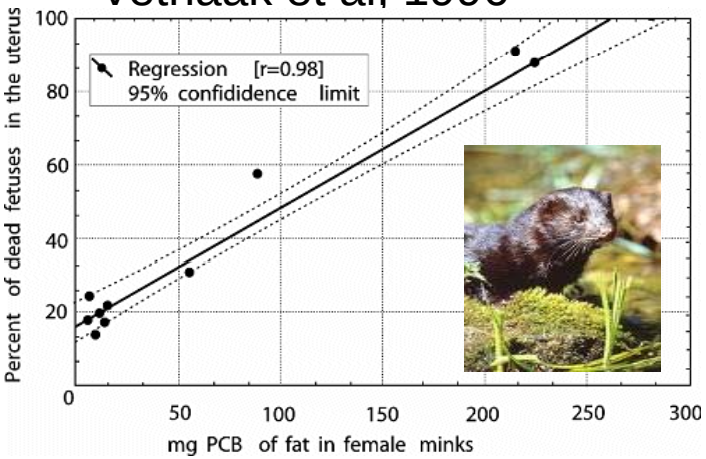
Schipper et al, 2008

Mees and Reijnders, 1994

Deltares

Ecological impact of compounds

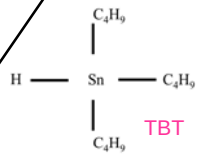
Vethaak et al, 1996

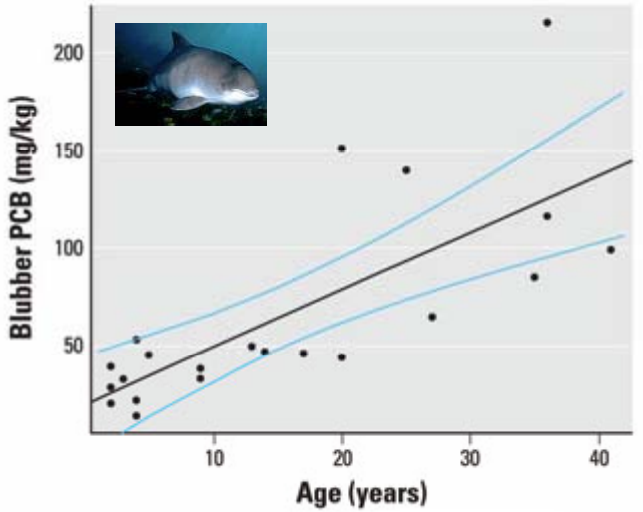


Restum et al, 1998

Schipper et al, 2008

Mees and Reijnders, 1994

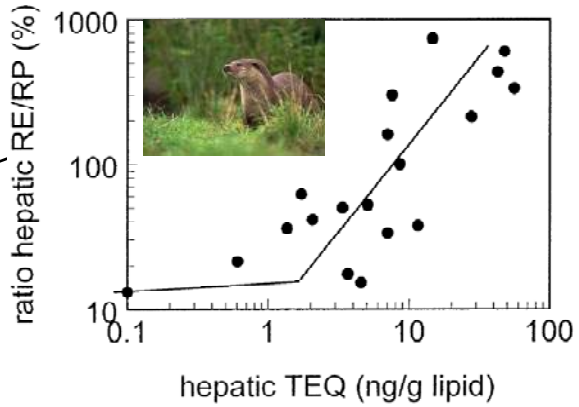




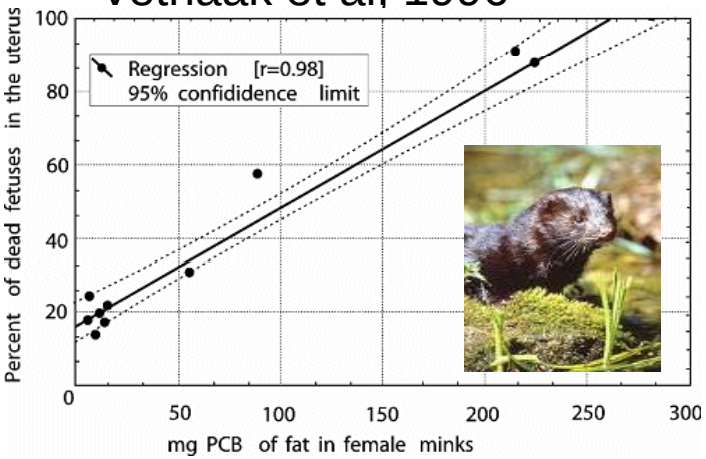
Hall et al, 2006

Ecological impact of compounds

Vethaak et al, 1996



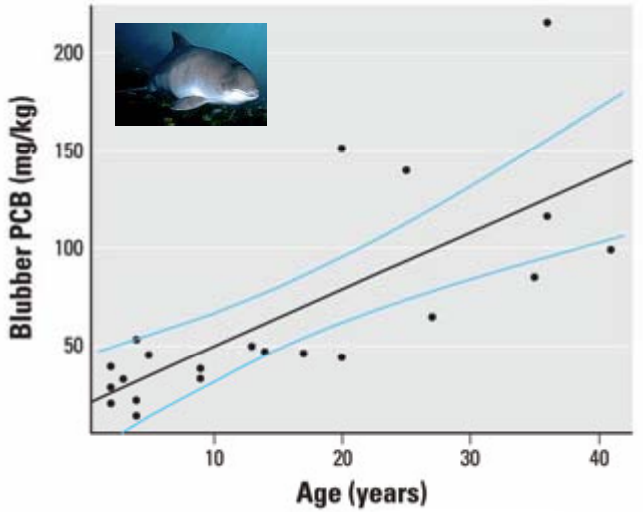
Murk et al, 1998



Restum et al, 1998

Schipper et al, 2008

Mees and Reijnders, 1994



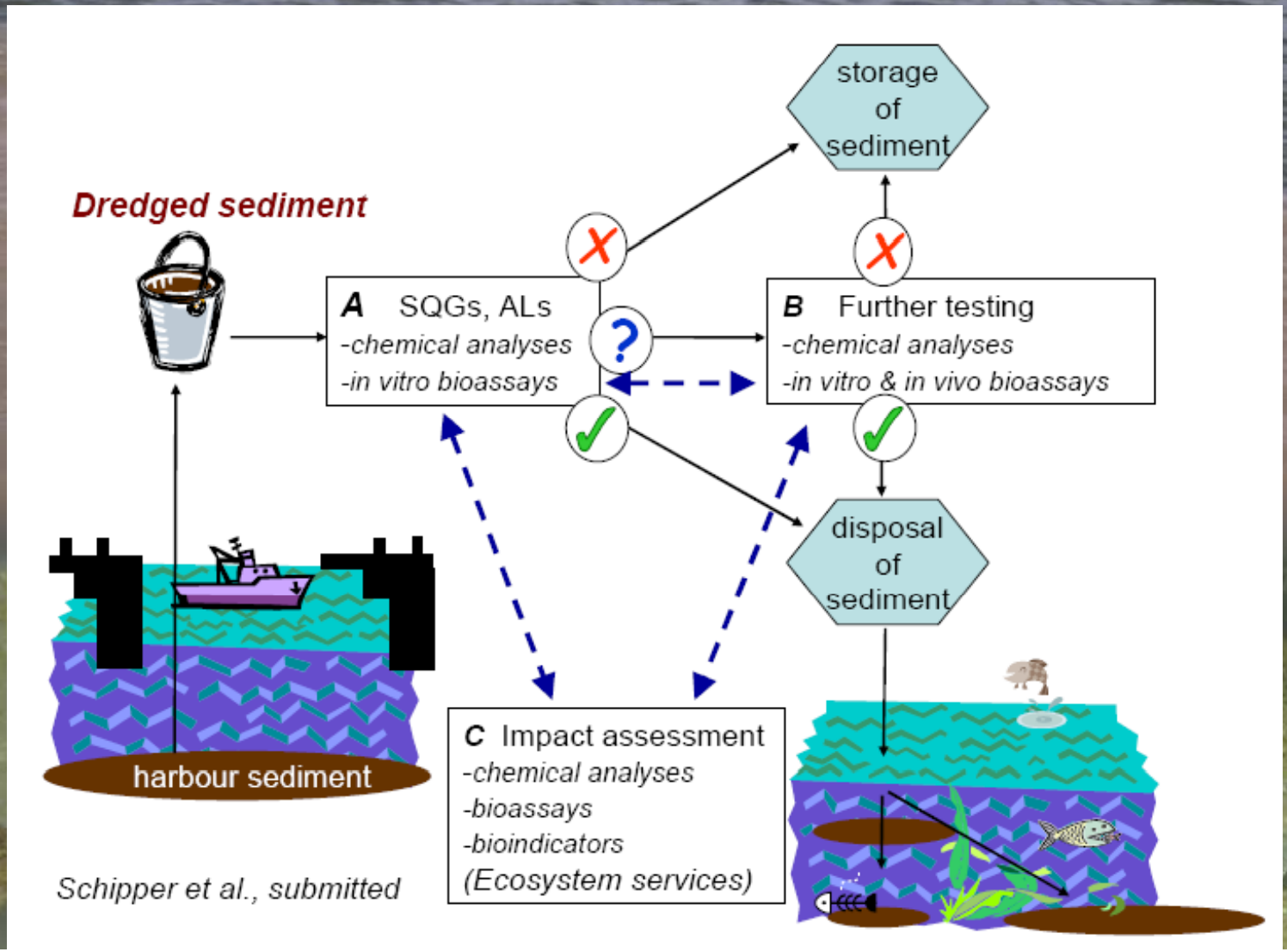
Hall et al, 2006

What is the applicability of bioassays for hazard, risk en local impact assessment?
The SO WHAT QUESTION?

- **Relationship between exposure studies of chemical contamination in dredged material on the health of marine organisms**

- **Argue why bio-analysis (with bioindicators en bioassays) are important in dredged material management for determining the health risks of pollution**

Bioanalysis in ecological risk assessment



Bioassays for hazard assessment (1)

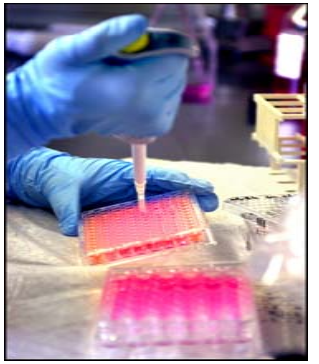
Box A: Aim is to establish whether chemicals are present at concentrations that too toxic to be disposed of the environment

Used for: Licensing disposal for rapid screening

Useful: Chemical analyses (PAHs, PCBs, toxic metals, TBT)

Examples: in-vitro bioassays

PCDDs
PCDFs
PCBs
TBT



Cartoons: www.cartoonstock.com

Deltares

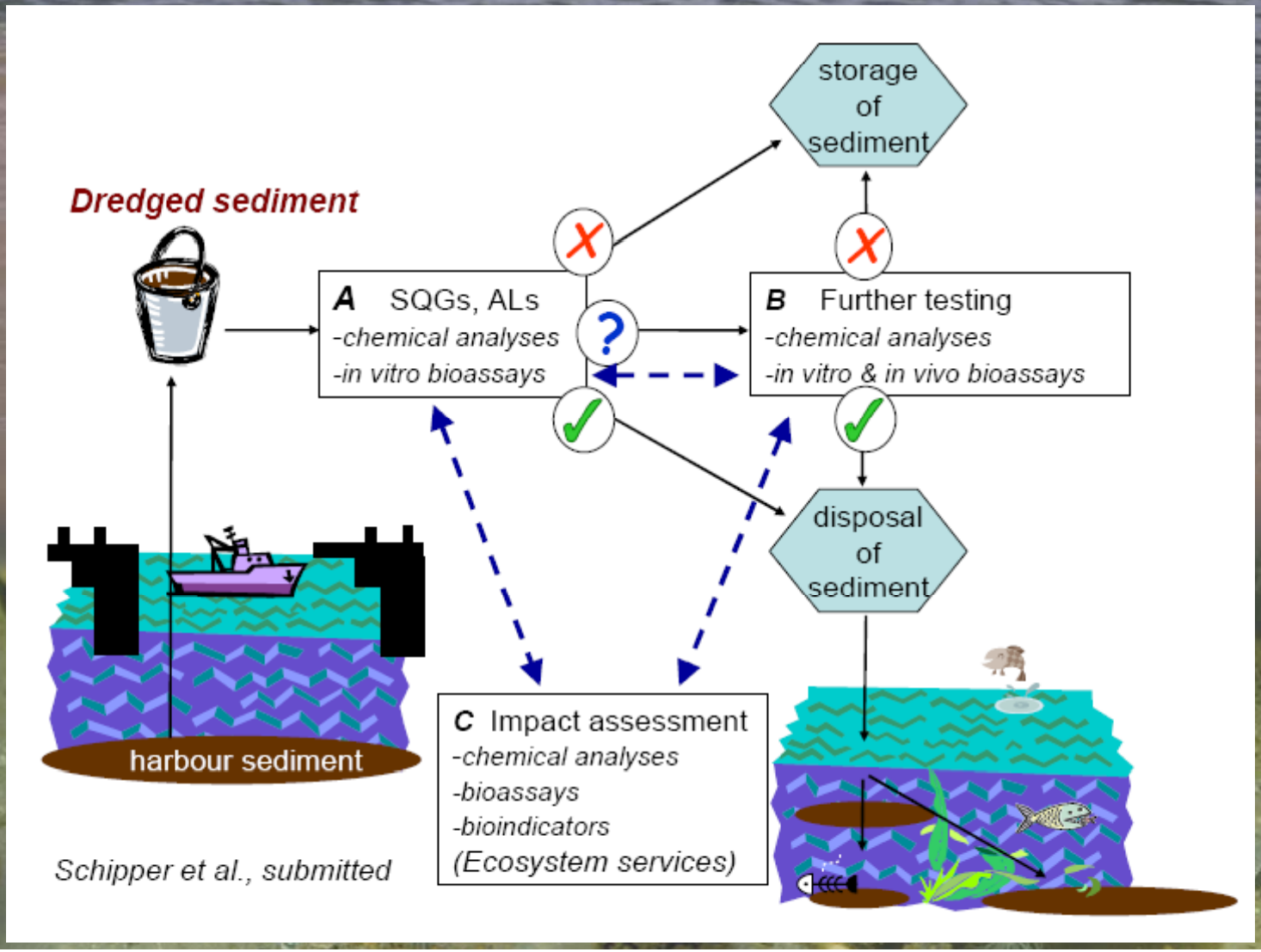
Bioassays for hazard assessment (2)

Location	Years of sampling	ng TEQ//kg dw (min-max)	Reference
Marine sediment			
North Sea	1996	2-10	Stronkhorst et al. (2003a)
North Sea	2000	6-27	Klamer et al. (2004)
North Sea	2002	20	Sanctorum et al (2007)
North Sea	2003	13-33	Åkerman et al. (2004)
Western Scheldt estuary outflow	2000	15	Klamer et al. (2005)
Western Scheldt estuary outflow	2003	15-17	Åkerman et al (2004)
Western Scheldt	2003	10-42	Sanctorum et al (2007)
Western Scheldt	2005	4-29	Van den Heuvel-Greve et al. (200
Suspended matter			
North Sea	2003	16-46	Åkerman et al. (2004)
Western Scheldt	2003	20-40	Åkerman et al. (2004)
Wadden Sea	2003	18-29	Åkerman et al. (2004)
Harbours			
Delfzijl	1999-2005	2 - 65	own results
Harlingen	1999-2005	1 - 47	own results
Den Helder	1999-2005	1 - 53	own results
IJmuiden	1999-2005	1 – 61	own results
Scheveningen	1999-2005	8 – 192	own results
Rotterdam Rijnmond	1999-2005	0 – 689	own results
Vlissingen	1999-2005	0 - 23	own results
Eemshaven	1999-2005	1 – 16	own results

Schipper et al., 2010

Deltares

Bioanalysis in ecological risk assessment in dredged material



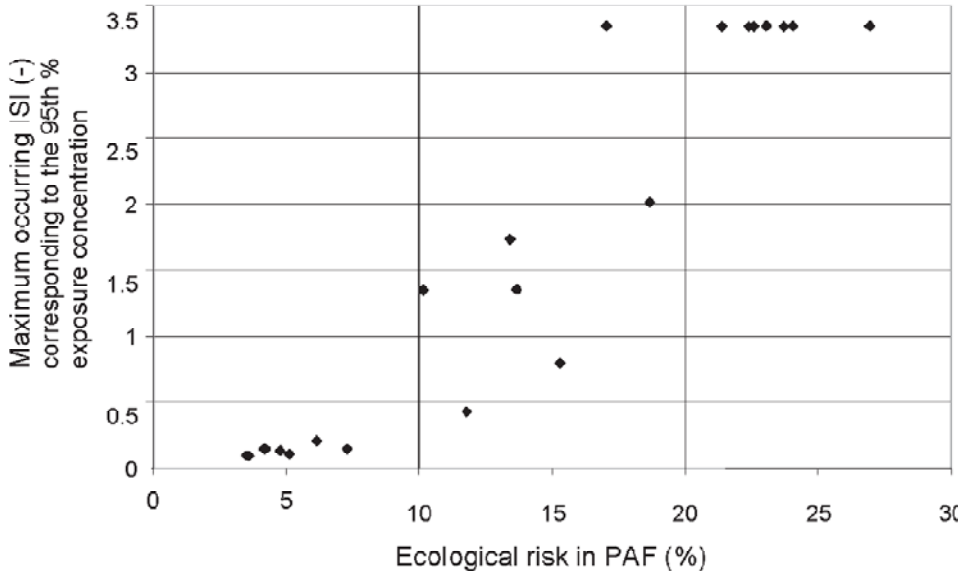
Use of bioassays in Ecotoxicological risk assessment

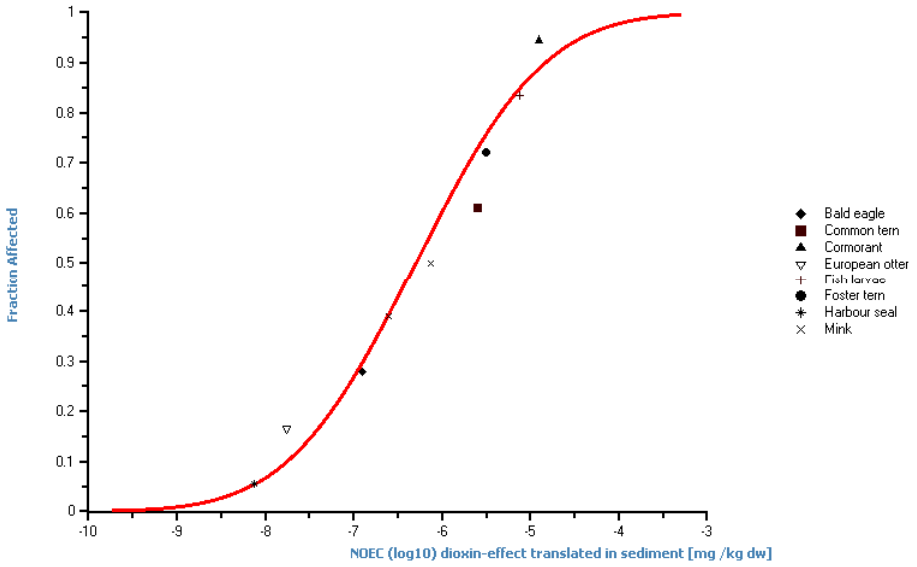
Box B: Advanced risk assessment DM before disposal

Used for: Indications of relevance and bioavailability

Useful: Bioassays with ecological relevant endpoints (reproduction survival). Calculation of Potential Affected Fraction (msPAF).

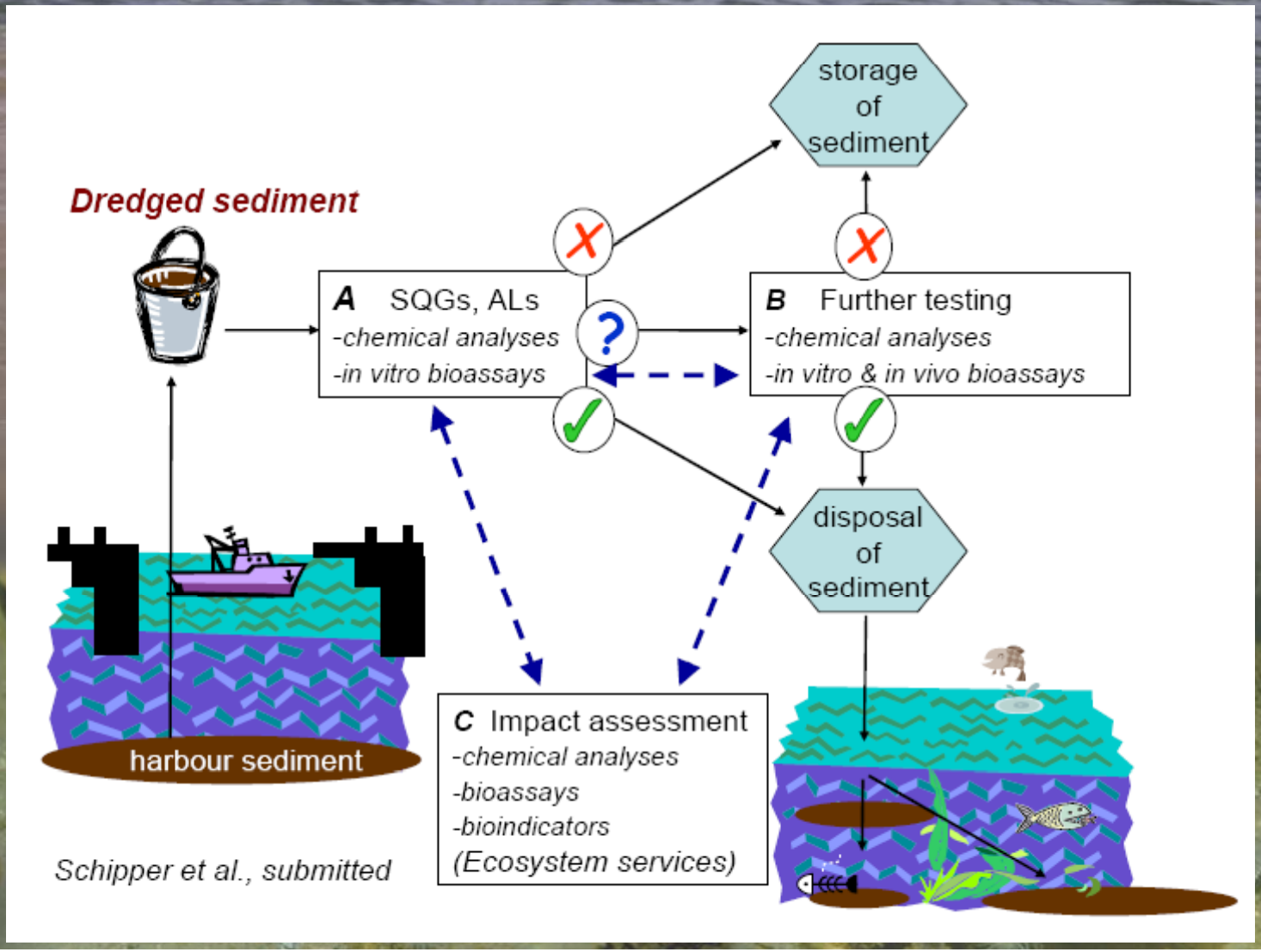
Examples: In vivo bioassays,o*nly relevant exposure conditions*





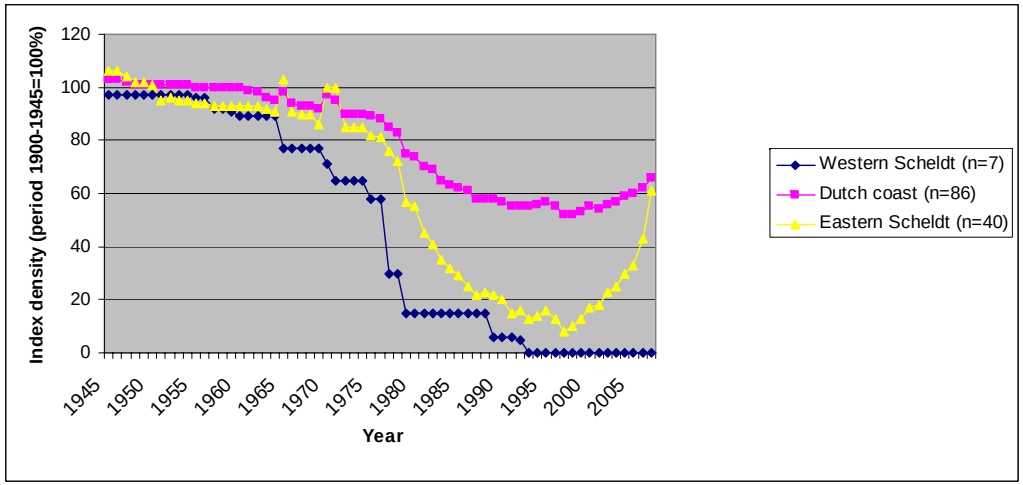
Schipper et al., 2008

Bioanalysis in ecological risk assessment in dredged material

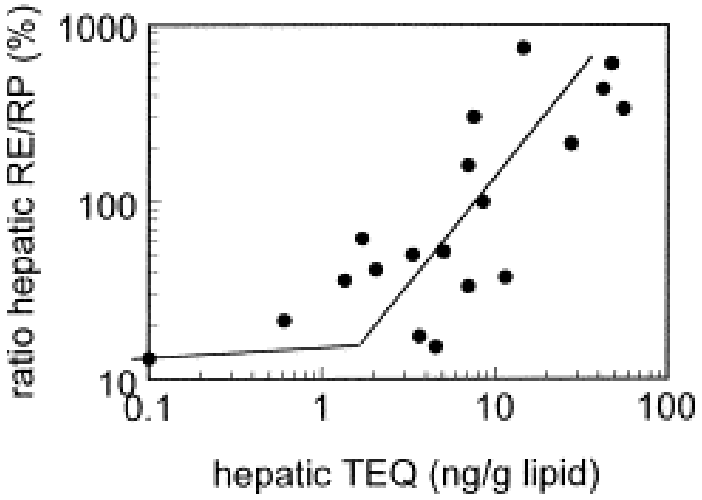


Use of bioassays to local impact assessment

- ***Box C:*** impact of dredged material on the receiving ecosystem
- **Used for:** Local sediments in cases of indications of relevance
- **Useful:** Bioaccumation and biomagnifications; population decline of local organisms; use of in vivo/in vitro bioassays, biomarkers and bioindicators
- **Examples:** gastropod population decline



Schipper et al., 2008; 2009



Murk et al., 1998;

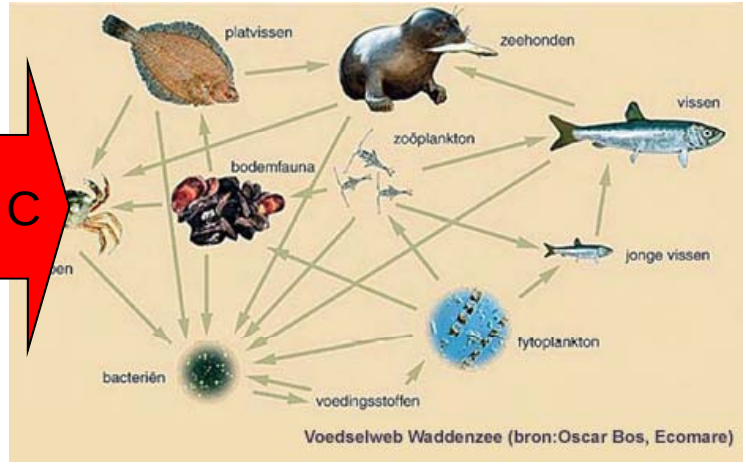
Deltares

Rational application of bioassays for hazard, risk and impact assessement for DM

Assessment of toxic compounds

Local impact assessment (dioxines)

Box C

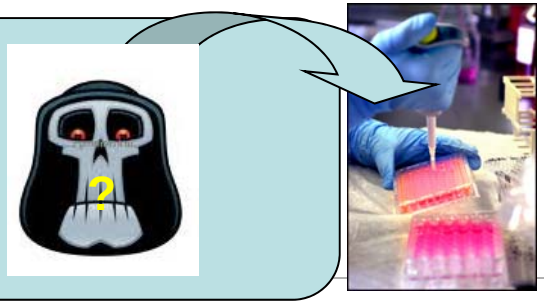


Ecotoxicological risk before disposal

Box B

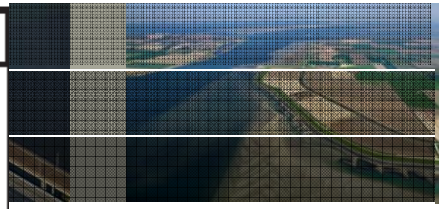
Hazard risk assessment

Box A



Schipper et al, 2009

Deltares



Box A	**Useful**
Currently used for: licensing disposal harbour sediment rapid screening	*In vitro* bioassay DR-Luc (purified extract) *Chemical analyses (PAHs, PCBs, toxic metals, TBT) chemical anal.)*
Possibly relevant to be added to data base	*in vitro* bioassay general toxicity (extract) *in vitro* bioassay thyroid hormone disruption (extract) (incl. bioactivation)
Box B	**Useful**
Currently Advanced risk assessment harbour sediment before disposal	*In vivo* bioassays with cultured species & ecologically relevant endpoints: growth Development, survival, reproduction PAF or msPAF
To be added in cases of indications for relevance and bioavailability	*In vivo* bioassays with relevant exposure conditions, routes and endpoints Prolonged ELS and metamorphosis *In vivo* bioassays with sediment extracts *In vitro* bioassays specific mechanisms *Internal effect levels* *Specific chemicals (e.g. PFACs, HBCDs, PBDEs)*
Box C	**Useful**
Currently Local sediments impact assessment	Bioaccumulation and biomagnifications Population decline of local organisms *In vivo* bioassays with local sediment *In vitro* bioassays with local sediment (extract) Bioindicators Biomarkers *Bioavailability of compounds*
To be added in cases of indications for relevance	Specific genomics biomarkers *In vitro* bioassays with bioactivation *In vivo* bioassays with local sediment extracts Local PAF or msPAF & validation *Body burden toxic compound* *Pharmaceuticals*

Deltares

Conclusions Assessment of effects of chemical contaminants in DM on marine ecosystems

- Rationally chosen bioassays can provide valuable contribution to hazard, risk and impact assessment
- Bioassays for risk assessment should be based on rational considerations, exposure routes and relevant endpoints
- For hazard assessment in licensing system chemical analysis to quantify the bioavailability does not need include, since the bioavailability will change after disposal of DM
- Mechanism- specific in-vitro bioassays can fill the gaps left open by chemical analysis
- When the outcome of the hazard assessment of DM does not convincingly demonstrate too polluted, further bioanalaysis can help the decision making process. The focus must include aspect of unknown chemicals, bioavailability and chronic toxicity.
- To validate the predicted risk, dedicated bioassays as well as bioindicators give the actual impact of DM in ecosystem
- Field effects can be used as an indicator for the local ecotoxicological health status

Deltares