Environmental Quality Standards under the Water Framework Directive

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What I plan to cover

What are EQSs and how are they used?

How do we derive EQSs?

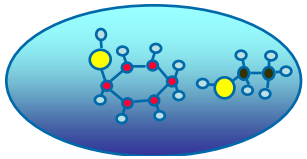
Focus on biota standards

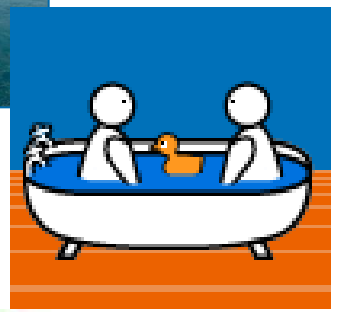
A role for passive samplers?

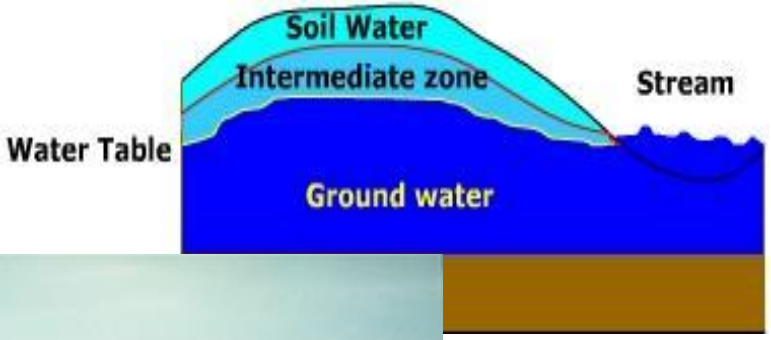
What are EQSs?

WFD - Purpose

- Prevent deterioration and enhance status of aquatic ecosystems & associated wetlands
- Promote sustainable water use
- Reduce pollution from priority substances
- Prevent deterioration/reduce pollution of groundwater
- Contribute to mitigating effects of floods/droughts

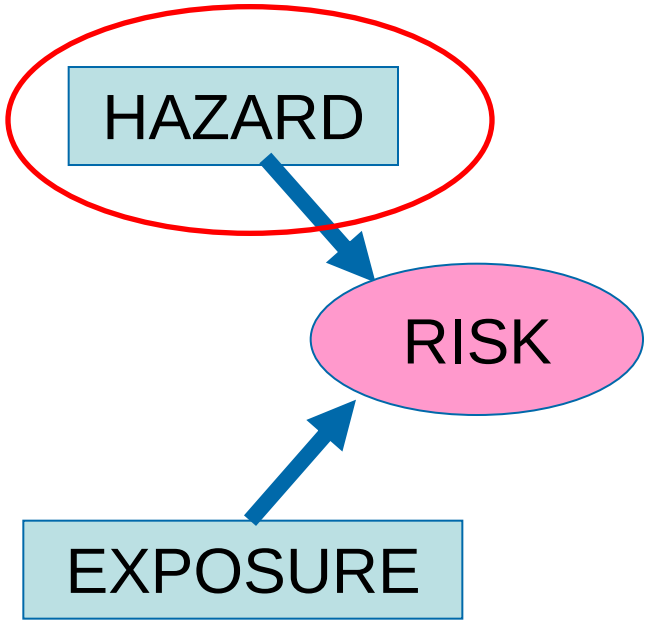






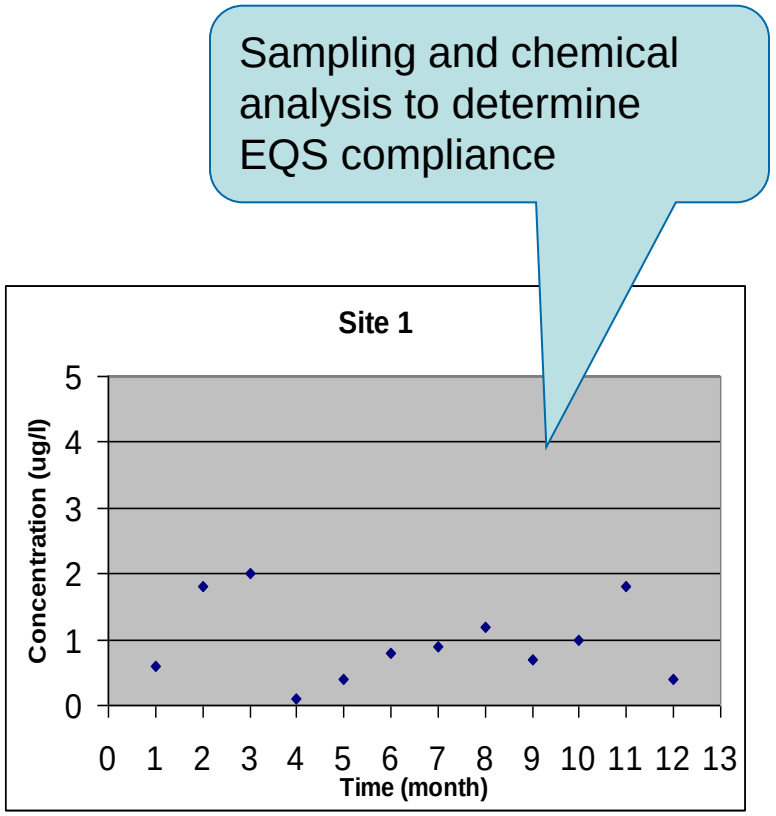
What are EQSs?

- Environmental Quality Standard
- Threshold below which we do not expect adverse effects to occur
  - Hazard-based
  - Usually for individual chemicals
  - Only meaningful when we compare them to environmental concentrations (measured or predicted) → Risk

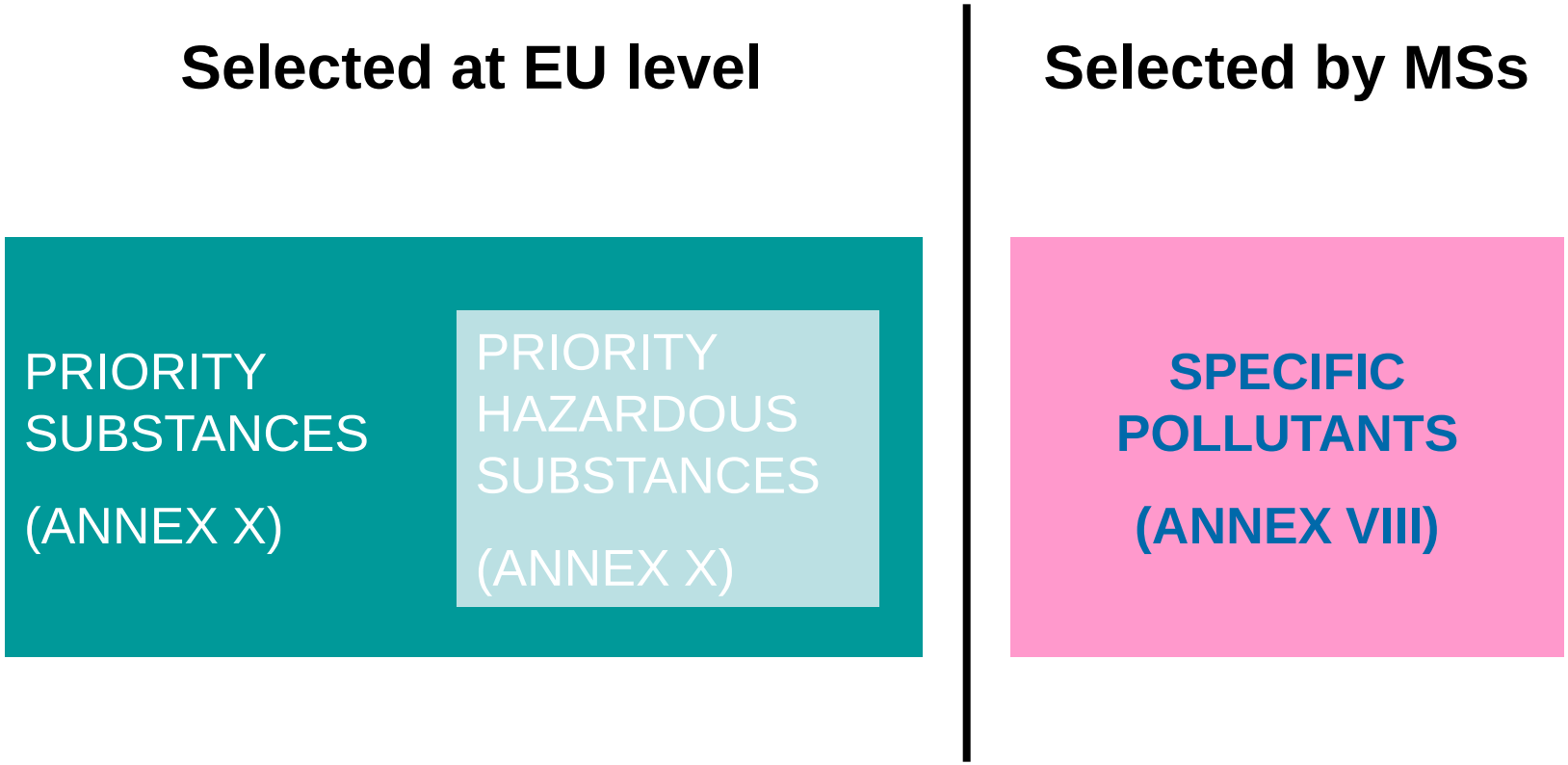


How are EQSs used?

- Controlling discharges to the environment
  - EQSs translated into discharge limits
  - Assess compliance - sampling and chemical analysis
- Monitor ‘state of the environment’
  - Benchmark e.g. trends in exceedances
- Classification
  - ‘Good’ status requires compliance with EQSs for Specific Pollutants
  - EQS exceedances trigger further investigation or remediation

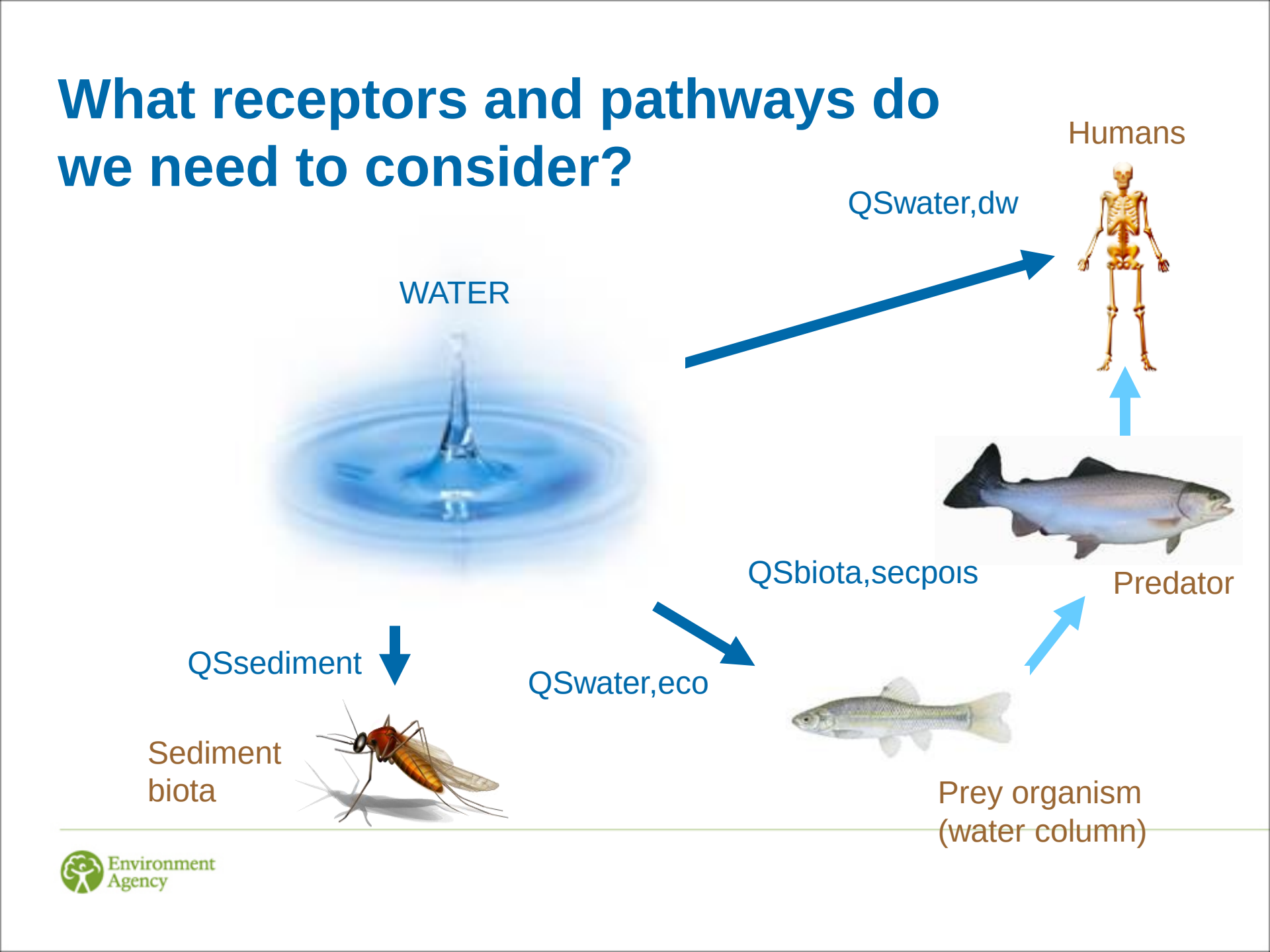


WFD Pollutants



How do we derive EQSs?

What receptors and pathways do we need to consider?



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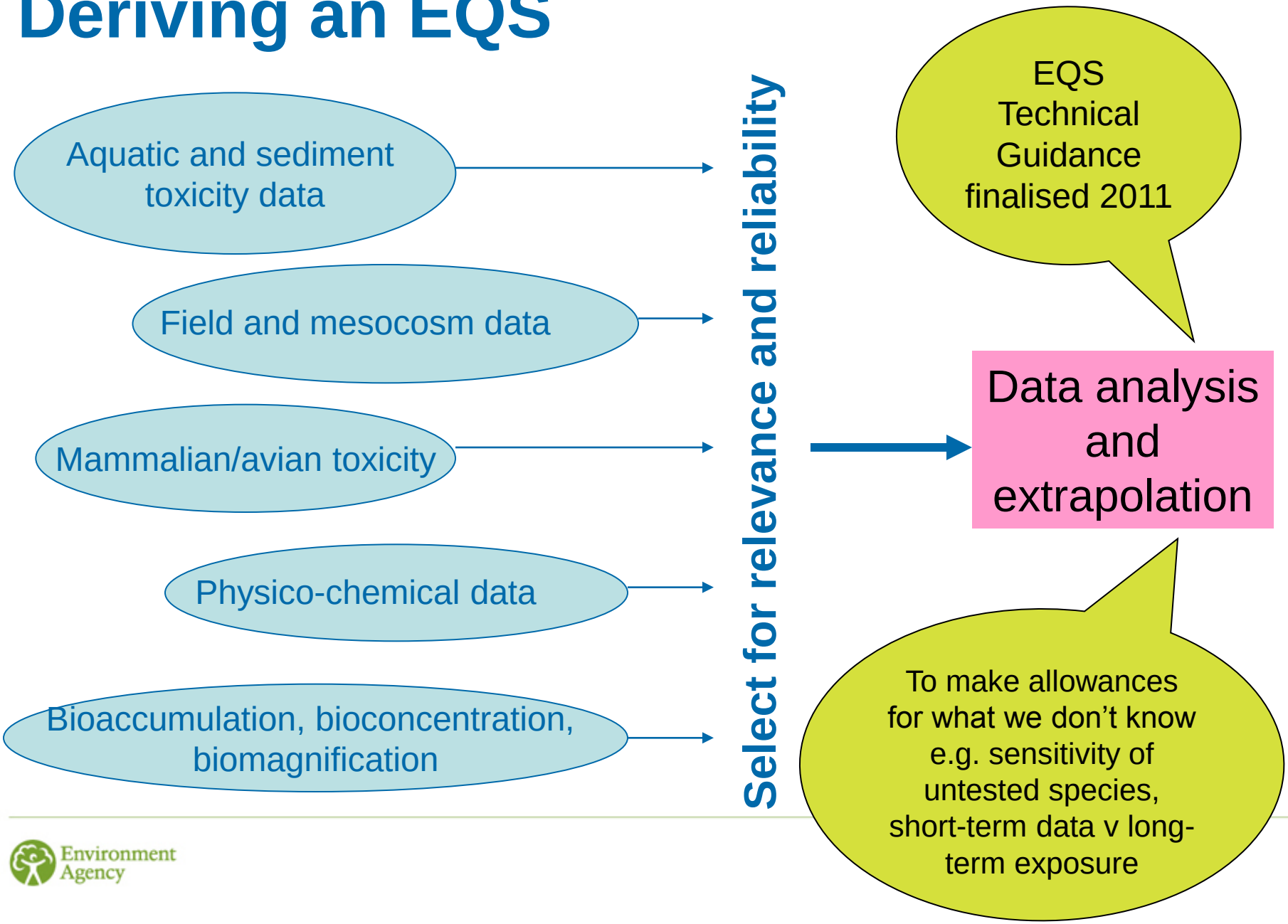
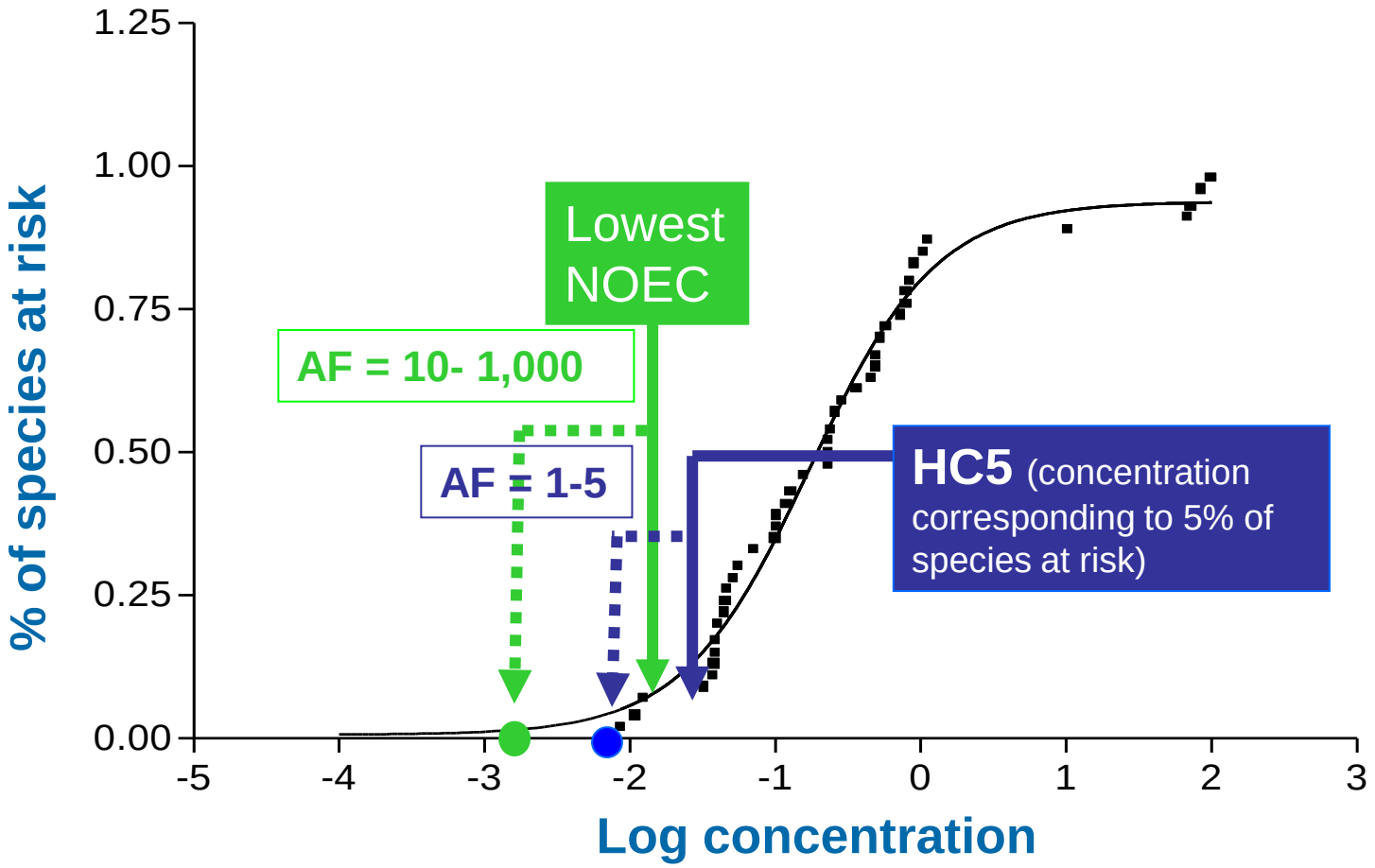
Deriving an EQS



Extrapolation



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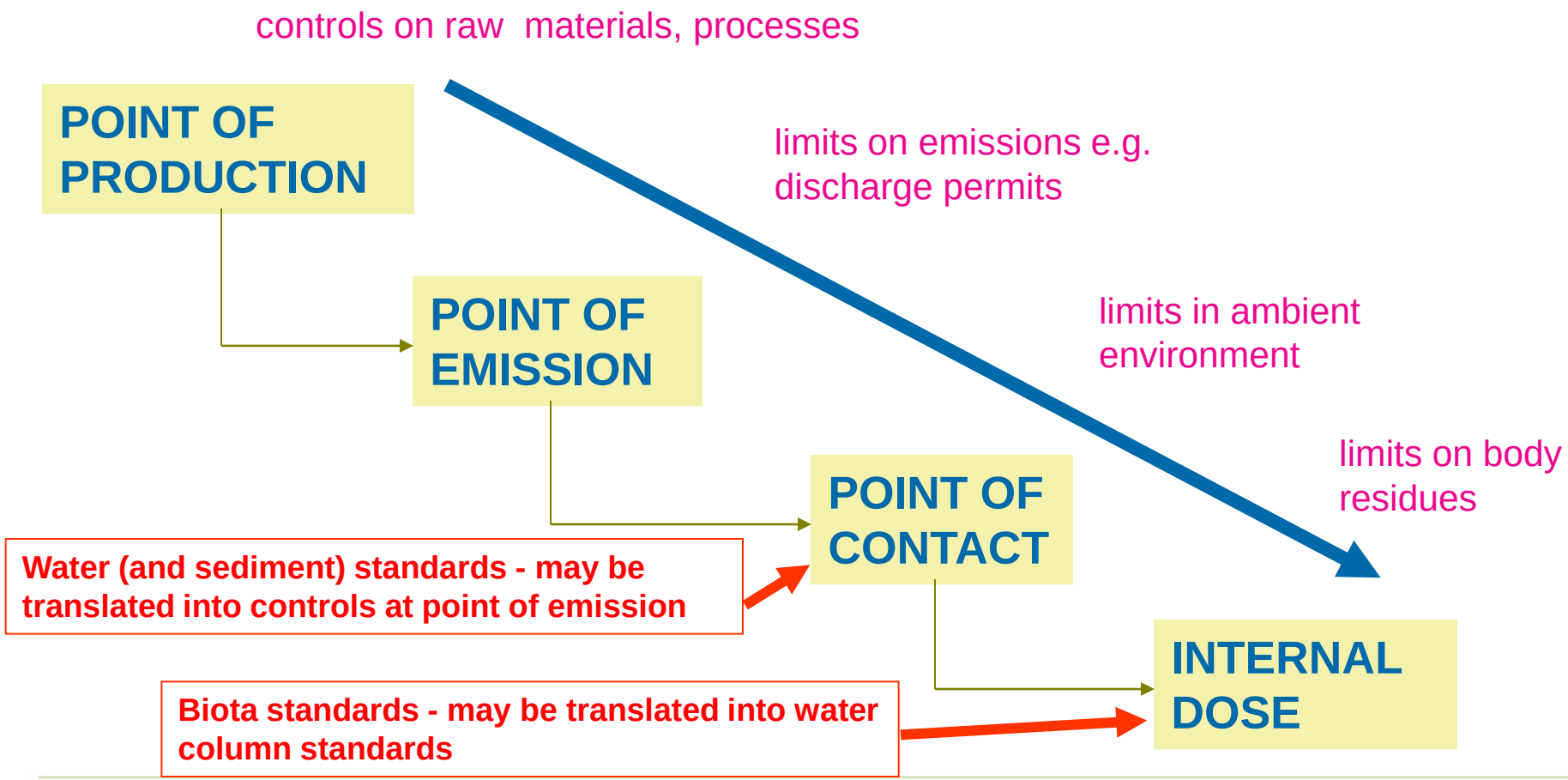
Implementing EQSs

Points of protection



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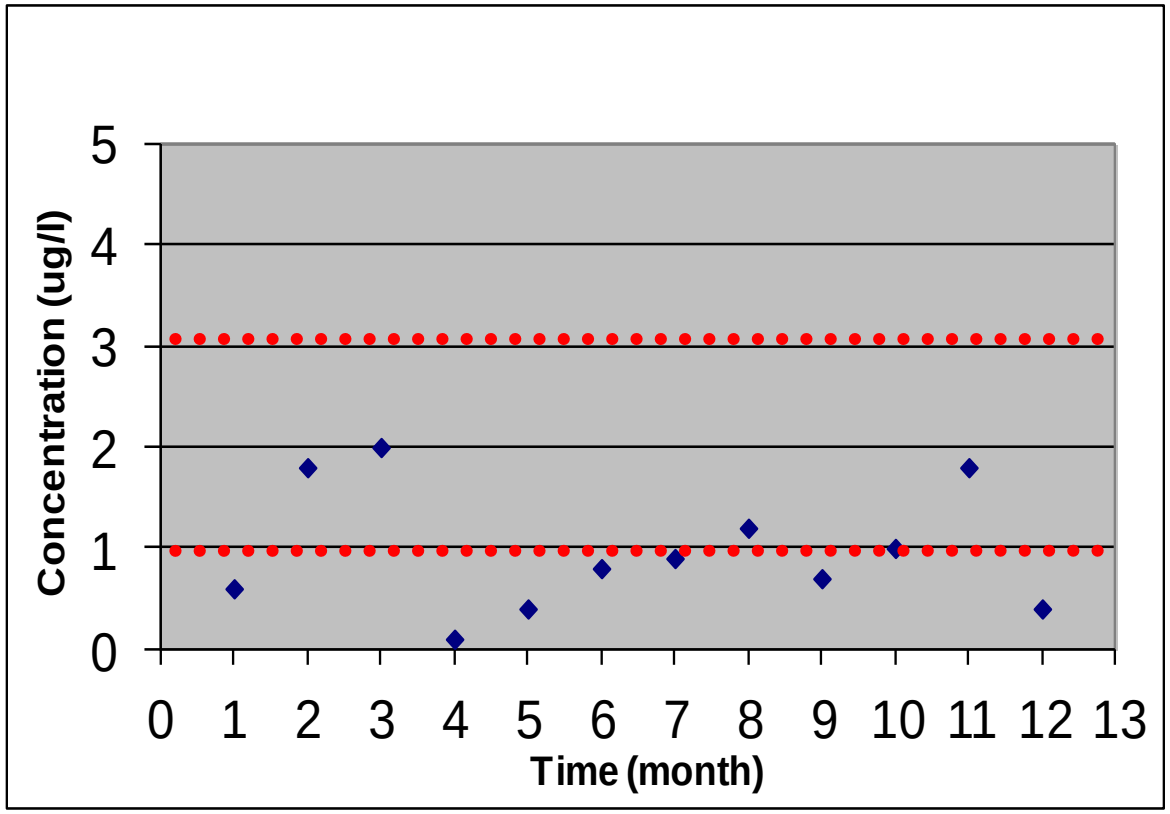
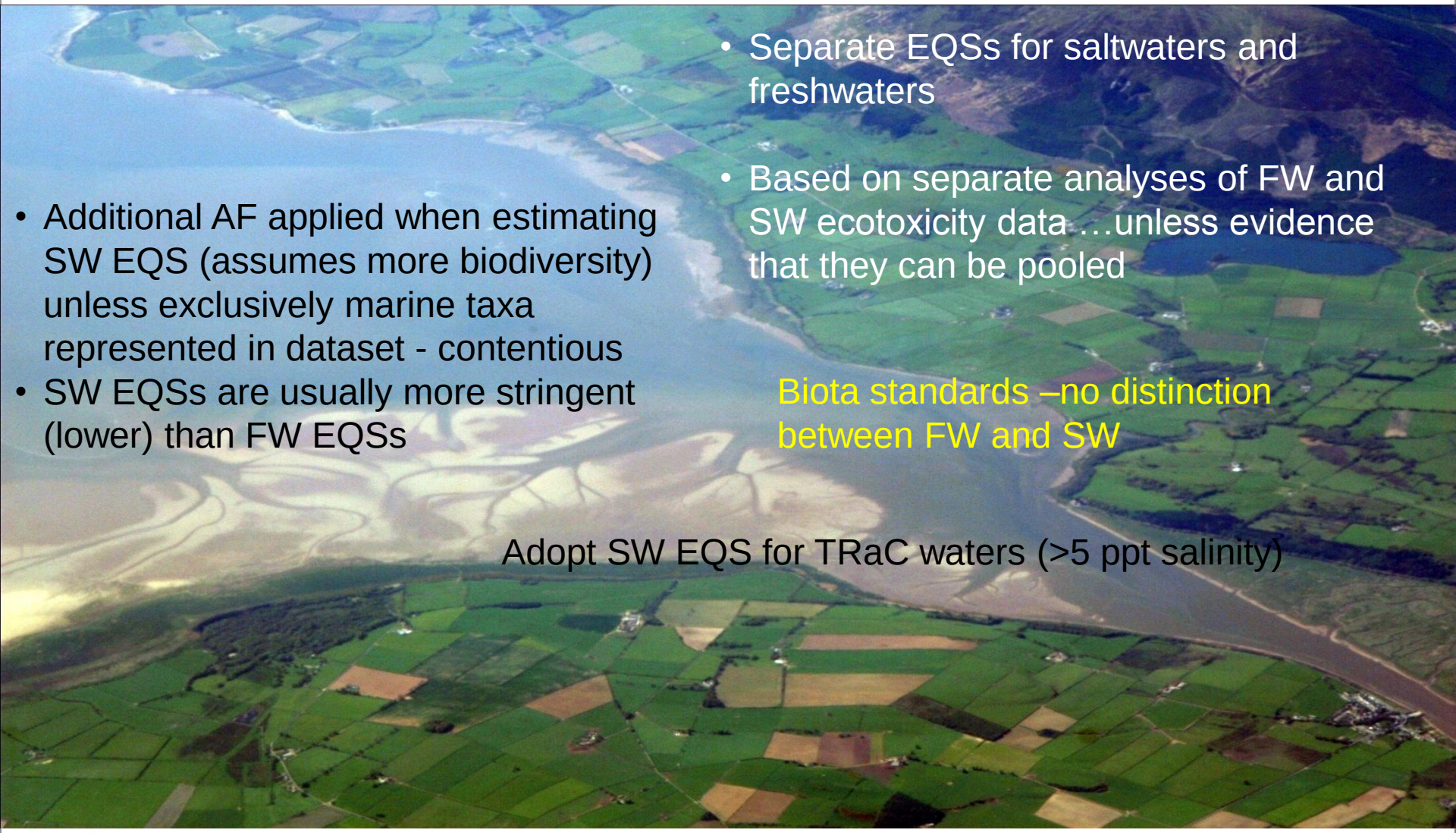
May be more than one EQS for a substance



Maximum Allowable Concentration (based on acute toxicity data)

Annual Average Concentration (based on chronic toxicity data)

EQSs for saltwaters and freshwaters



- Separate EQSs for saltwaters and freshwaters
- Based on separate analyses of FW and SW ecotoxicity data …unless evidence that they can be pooled

- Additional AF applied when estimating SW EQS (assumes more biodiversity) unless exclusively marine taxa represented in dataset - contentious
- SW EQSs are usually more stringent (lower) than FW EQSs

Biota standards –no distinction between FW and SW

Adopt SW EQS for TRaC waters (>5 ppt salinity)

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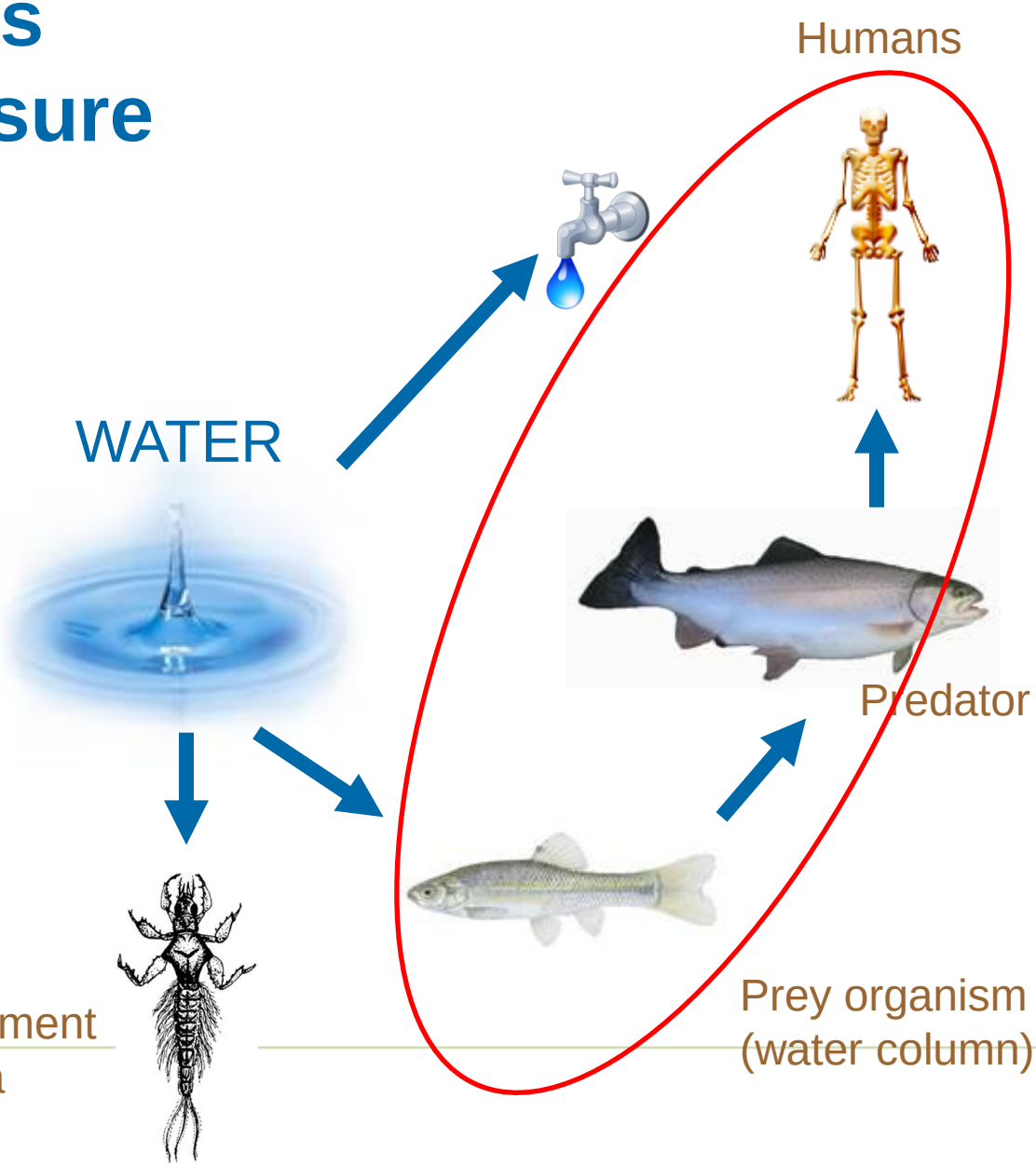
Biota standards

Setting standards – routes of exposure

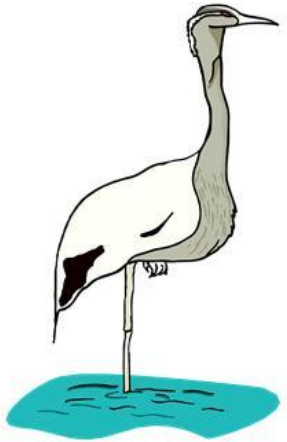
- For many substances, the main risk to plants and animals is through direct toxicity in water → water column EQS
- But for lipophilic substances that bioaccumulate, the main risk is to predators (and possibly humans) exposed to the chemical via the food chain → biota EQS



Deriving biota standards (secondary poisoning of wildlife)

BCF/BAF

BMF



no-effect dose from feeding study (usually mammals or birds)

QS_{biota}

Extrapolation to account for
- converting dose to diet conc
- duration of tox study
- interspecies variation
- lab food - natural food

Biota standards

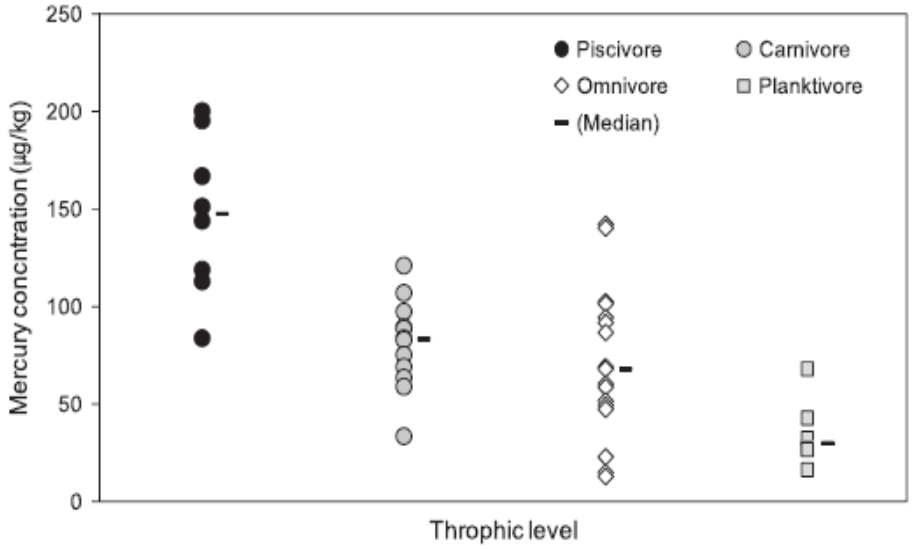
- For some substances, EQS Directive 2008/105/EC offers biota (and/or sediment) EQSs instead of water standards for classifying chemical status
- QS_{biota} is expressed as a concentration in body tissue of prey organism. Using bioaccumulation data, can be converted to corresponding concentration in water
- WFD biota standards for lipophilic priority compounds (Hg, HCB, HCBD) – more proposed (January 2012)

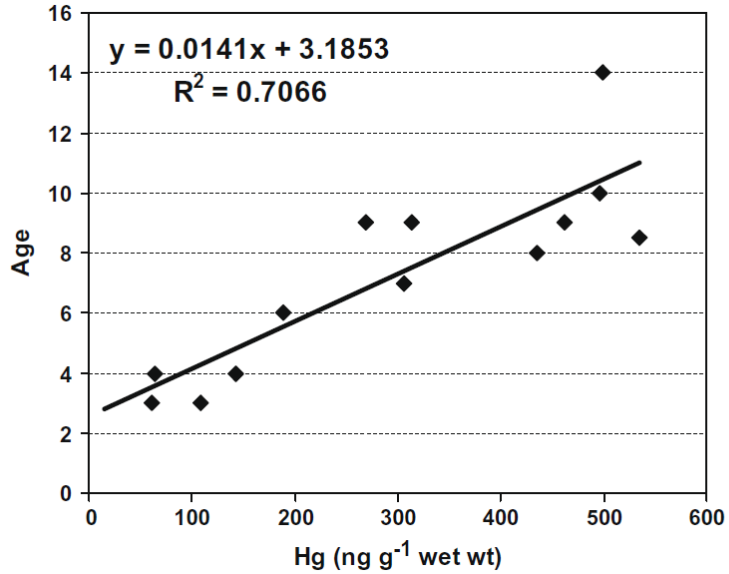
Sampling and analysing wild-caught biota (1)

- Cannot guarantee ‘catch’ (species, age class, tissue)
- Where have they been?
- Depletes native biota
- Survey in UK - unable to determine EQS compliance or to identify trends with confidence – very large sample sizes required
- Some MSs have established biota monitoring programmes (+’biobanks’), but different species

Sampling and analysing wild-caught biota (2)

- Variability resulting from different species
  - lipid content[1]
  - feeding strategy[2,3]
  - tissues used for analysis[2]
  - fish age[1]





1 Boscher et al (2010), Chemosphere 78, 785-792
2 Christoforidis et al (2008), Chemosphere 70, 694-702
3 Kim et al (2012), 89, 1360-1368

Assessing compliance with a biota standard - what are the options?

Biota EQS

Corresponding water concentration back-calculated from biota EQS using BMF/BAF

Biota

- Wild-caught biota

- Caged biota

- Passive sampler (as 'surrogate' biota)

Water

- Water sampling

- Passive sampler (to estimate water conc)

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Assessing compliance with biota standards – a role for passive samplers?

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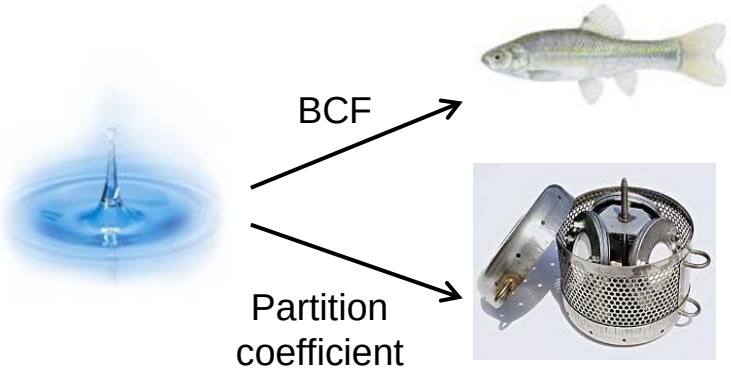
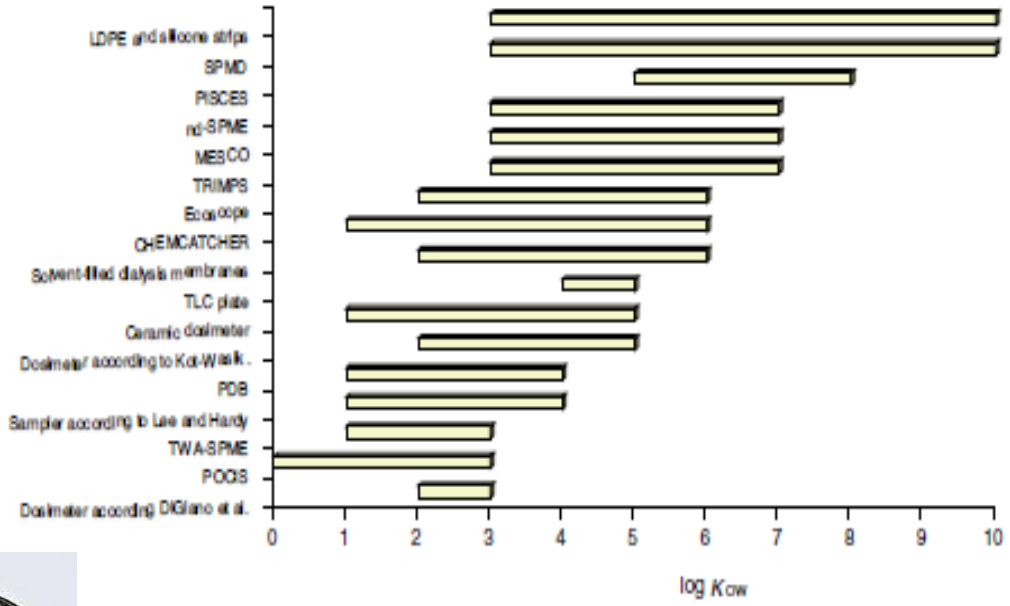
Passive samplers as ‘surrogate biota’ (1)

- Can we infer biota concentrations from the accumulation of substances by passive sampling devices (PSD)?
- Range of PSDs available covering wide spectrum of physico-chemical properties
- Simple to deploy
- Promote consistency across MSs?





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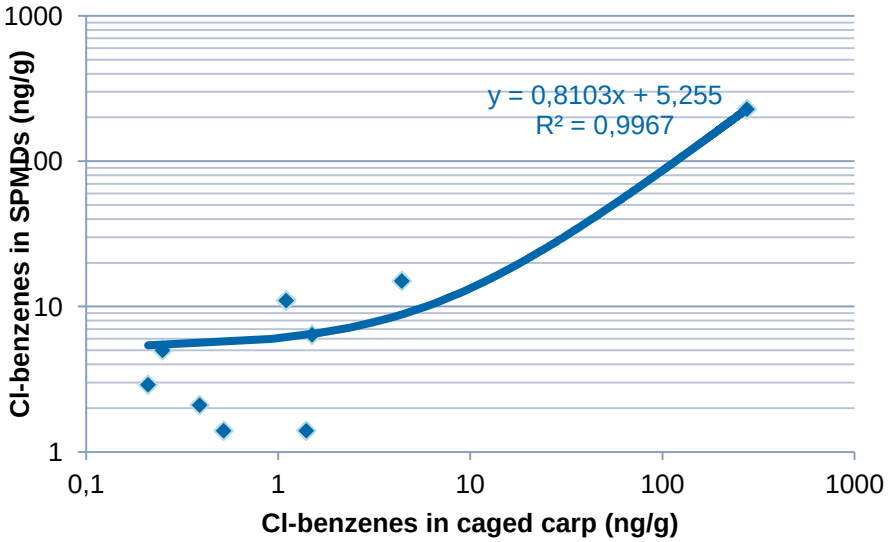
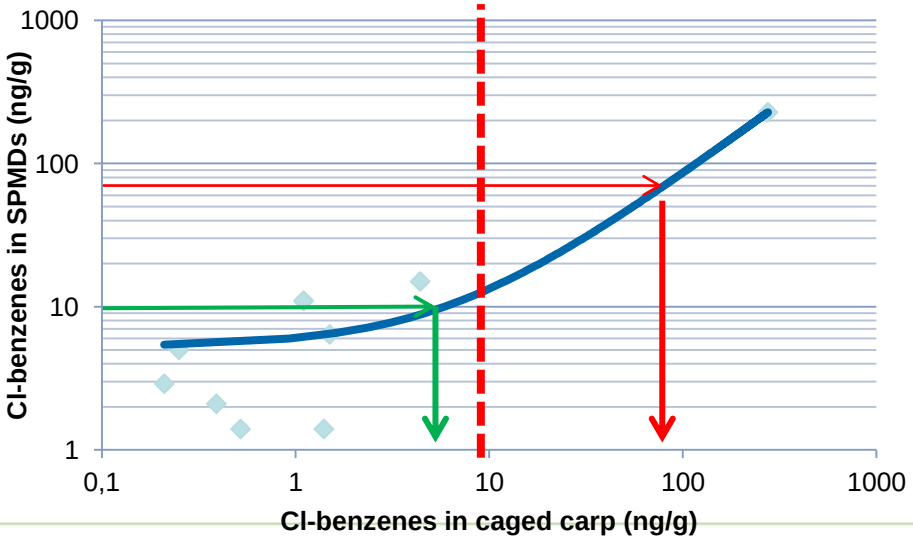
Passive samplers as ‘surrogate biota’ (2)



EQS_{biota} for HCB = 10 ug/kg



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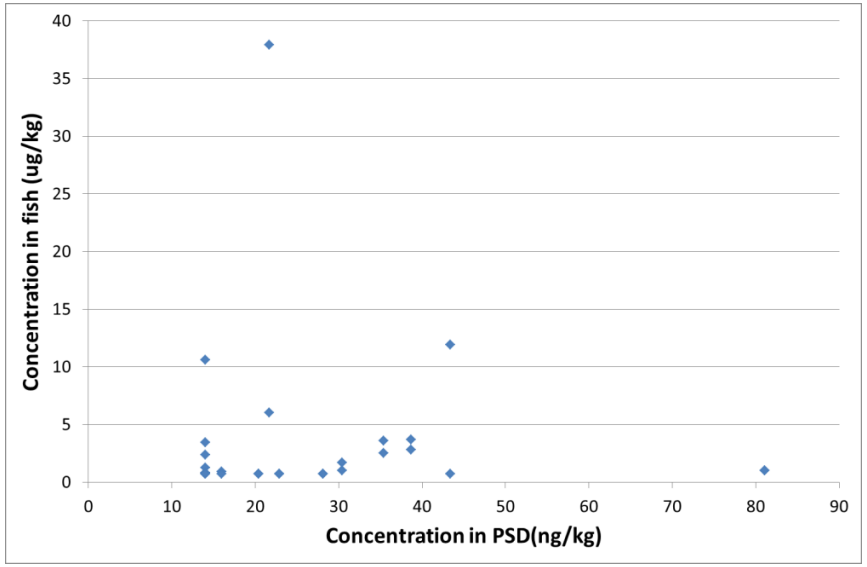
Data extracted from Verweij et al (2004) Chemosphere 54, 1675-1689

3. Passive samplers as ‘surrogate’ biota (3)

- UK study compared residues of range of lipophilic organics accumulated by PSDs and fish (3-4 week deployment of SPMDs vs caged chub, *Leusiscus idus*)
- Few meaningful relationships
- Possible reasons
  - between-fish variability in biota (variability between PSDs?)
  - metabolism by biota (PAHs)
  - fouling of PSDs
  - role of ingestion of contaminants by biota?
  - deployment period (equilibrium not attained)?



Benzo-b-fluoranthene: caged fish vs SPMD

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Passive sampling to estimate water concentration

- Can we assess compliance with EQS back-calculated from biota EQS?
- Effectively use PSD as "concentrating" device; need partition co-efficients to estimate twa in ambient water
- Some research experience[1] e.g. comparing SPMDs, sediments and caged fish to estimate bioavailable concs of PAH, PCB and organochlorines in water
- PSDs take up dissolved fraction - not directly comparable with conventional 'spot' sampling
- Back-calculated water concentration may be subject to high uncertainty (choice of BAF/BCF factor[2]) ... how reliable is it?

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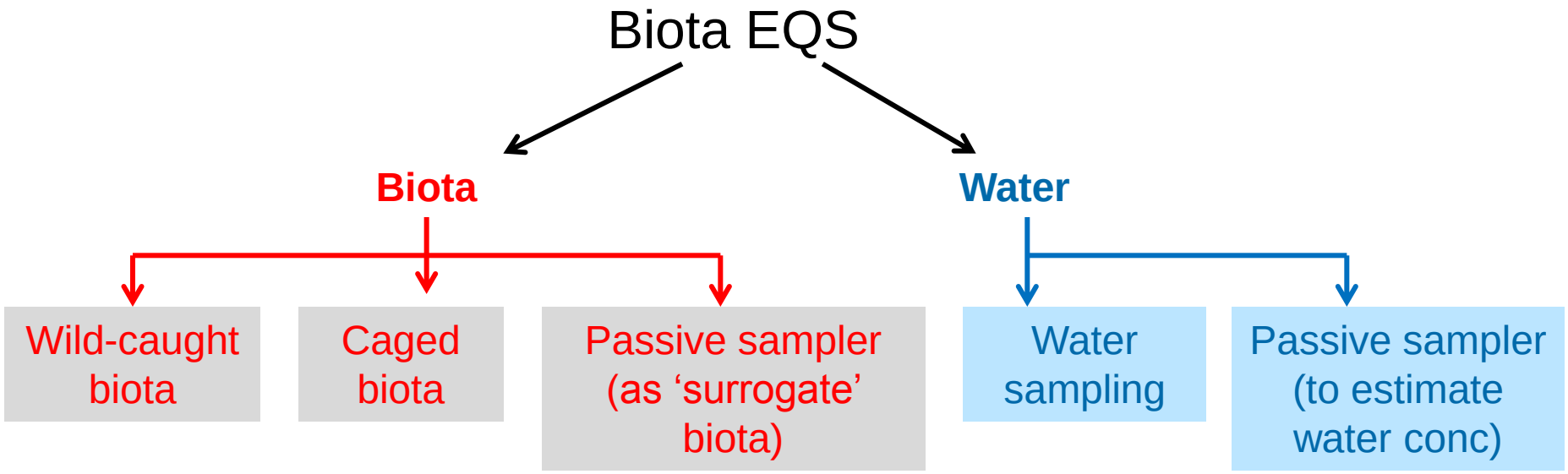
1 Verweij et al (2004) Chemosphere 54, 1675-1689
2 Moermond and Verbruggen (2012) IEAM 10, 1351

Where do we go from here?

- Biota standards potentially offer a more reliable measure of environmental exposure than water samples for substances that bio-accumulate.
- Biota can act as a composite sample
- However, biota standards require serious attention before we can use them to assess waterbody status with confidence
- High risk of inconsistency in approach (and bias) between MSs
- Biota monitoring is well-established in marine environment (e.g. OSPAR) but not in freshwaters. Align marine and freshwater methods?
- Do PSDs have a role to play?
- Opportunities to align R&D to these regulatory issues?

Biota standards and PSDs – possible research



Review current practice - use of different species, tissues etc

Analyse possible bias

Is food ingestion underestimated in caged biota and PSDs?

Explore use of other species e.g. filter feeding molluscs

Useful relationships PSD vs biota? Compare residues in PSDs and biota sampled at same location and time - existing data and *de novo* R&D

Analyse reasons for poor correlations

Which PSDs?

Review 'state of the art' wrt analytical LOQs

Review robustness of back-calculated water EQS

Trials to compare predicted biota concs with actual biota residues

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Thank you for your attention

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