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Module 1: Risk Assessment

Eva Holt (holt@recetox.muni.cz)

Module 1: Risk Assessment Outline

- Objectives of Module 1
- What is risk?
- Human health and ecological risk assessment definitions
- Risk assessment basics
- Where can we use risk assessment?
- Case studies
  - Human exposure to particle-bound PAHs from traditional cooking practices and potential carcinogenic risk
  - Biota exposure to toxic levels of uranium downstream of a mine

Objectives of Module 1

- Introduce you to the concept of risk as it relates to environmental chemistry/science/management
- Describe the risk assessment process for human health and ecological risk assessment
- Show examples of human health and ecological risk assessment

What is risk?

- "*(Exposure to) the possibility of loss, injury, or other adverse or unwelcome circumstance; a chance or situation involving such a possibility.*" [Oxford English Dictionary]
- In an environmental science context risk can be defined as the "*chance of harmful effects to human health or to ecological systems resulting from exposure to an environmental* ***stressor****" . [US EPA]

*__Stressor__ = can be physical, chemical, or biological; may induce an adverse response. Term 'agent' is also sometimes used.

http://blog.statefoodsafety.com
(accessed 19/11/2015)

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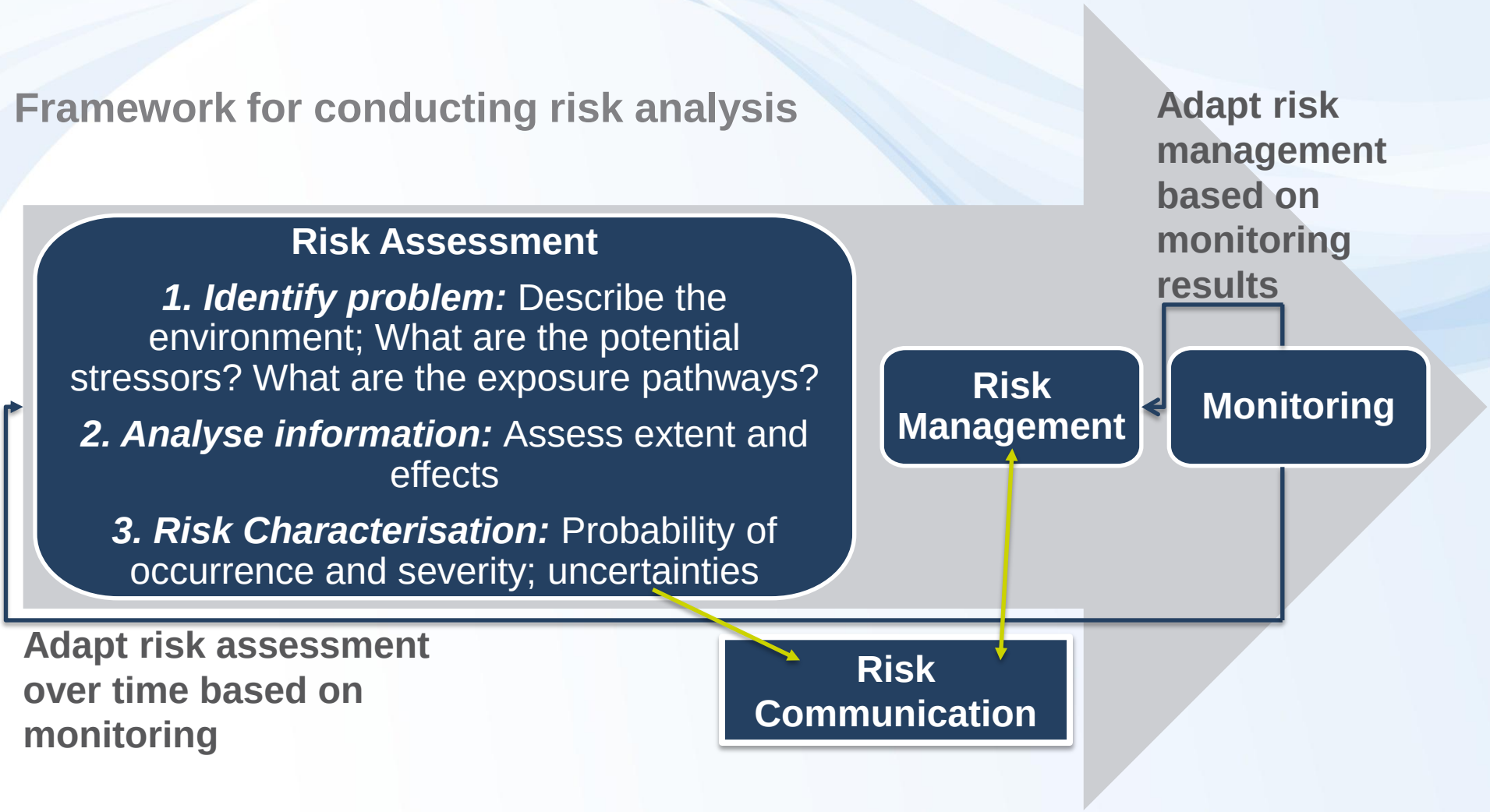
Human health and ecological Risk assessment definitions

- Human health risk assessment: estimating the nature and probability of adverse health effects in humans potentially exposed to environmental stressors, in the past, now and in the future
- Ecological risk assessment: determining risk (magnitude and likelihood) posed by a stressor to ecosystem health
- Sometimes we see the term environmental risk assessment used instead of ecological risk assessment

Risk Assessment Basics



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Risk Assessment Basics

Risk assessment paradigm (US EPA model)

Human health

Planning

Establish the scope and objectives

Hazard identification

Identify the type and nature of the adverse effect

Hazard characterisation

Qualitative and quantitative description of inherent properties of stressor

Exposure assessment

Evaluate how much of the stressor reaches the human

Risk characterisation

Estimate the risk posed to human health

Ecological

Planning

Establish the scope and objectives

Problem formulation

Determine which organisms are at risk

Analysis

Determine what is exposed, to what degree and whether exposure is harmful

Risk characterisation

Estimate the risk posed to ecological entities

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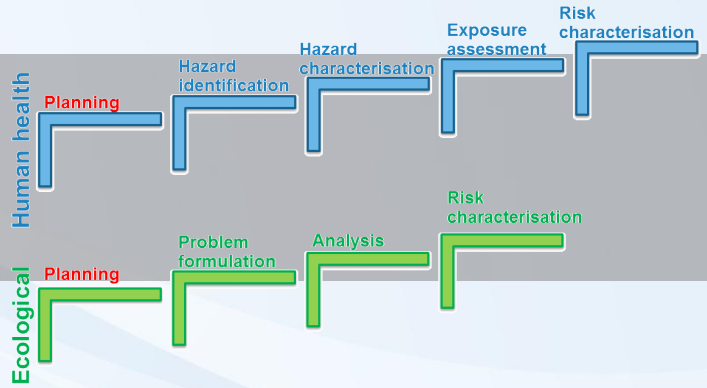
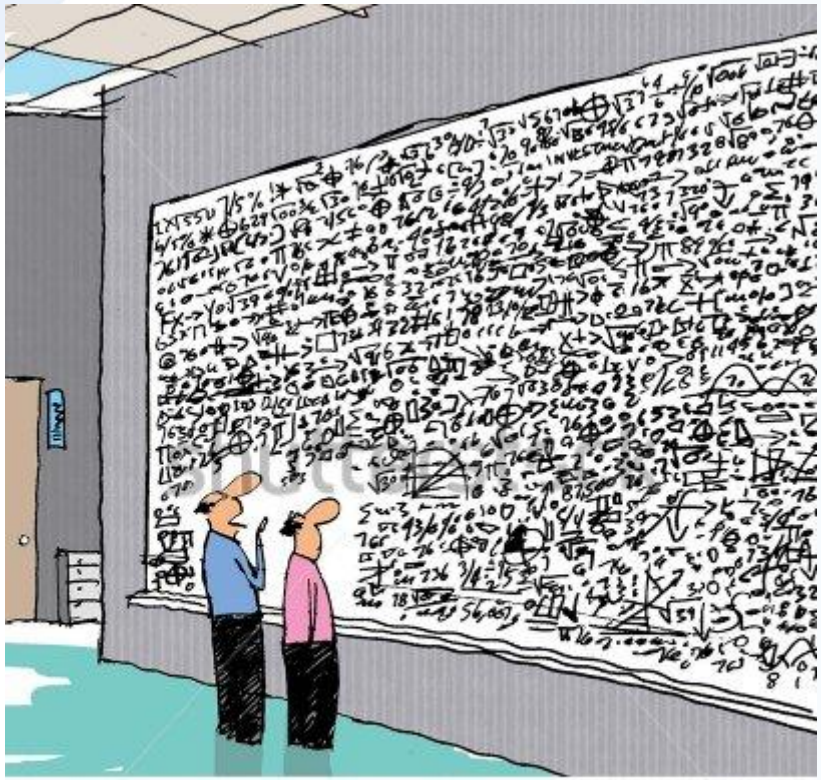
Risk Assessment Basics



- Planning



"…..and that in a nutshell is the plan, any questions?

Questions we need to ask at the beginning

- Who/what/where is at risk?
- What is the environmental hazard of concern?
- Where do these environmental hazards come from?
- How does exposure occur?
- What is the fate of the hazard in the body and impact of, e.g., age, sex, etc.
- What are the health/ecological effects?
- How long does it take for hazard to cause a toxic effect? Does it matter when the exposure occurs in the lifetime of a human/organism?

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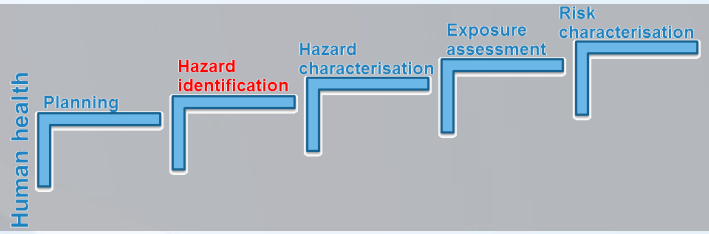
Risk Assessment Basics



- Human health risk assessment

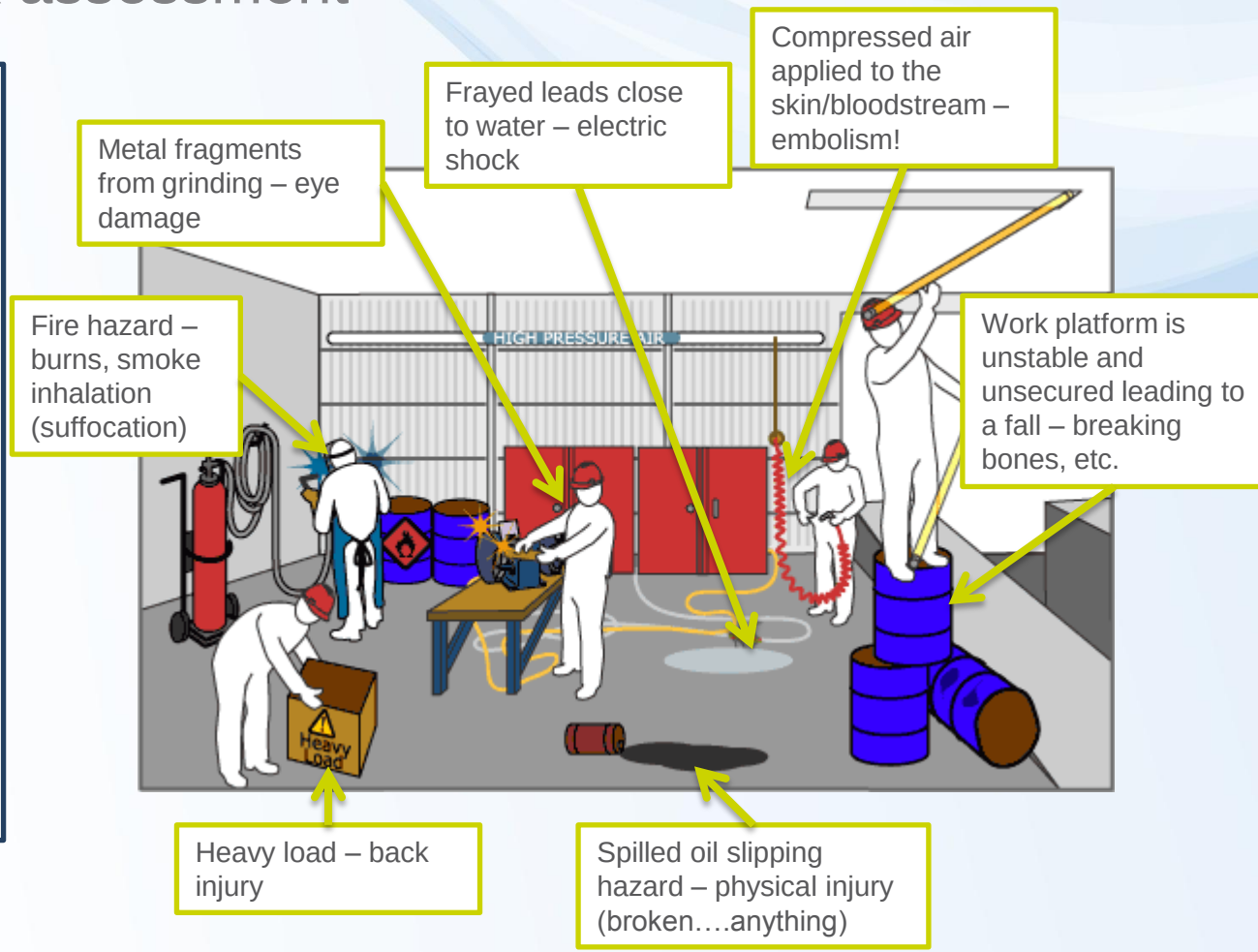
Hazard identification

- Determine whether exposure to a stressor can cause an adverse effect
- Carcinogenic or non-carcinogenic

Available data

- Clinical or epidemiological studies (human)
- Other animal studies
- QSAR

TOXNET – toxicology data network; focused mainly on chemical hazards



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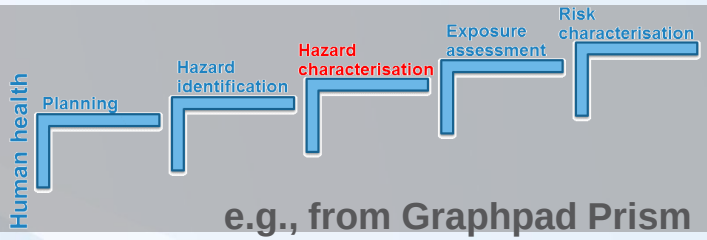
Risk Assessment Basics



e.g., from Graphpad Prism
(accessed 20/11/2015)

- Human health risk assessment

Hazard identification

- Determine whether exposure to a stressor can cause an adverse effect
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Available data

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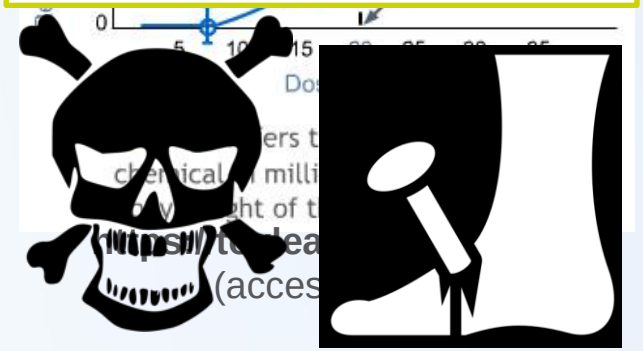
TOXNET – toxicology data network; focused mainly on chemical hazards

Hazard characterisation

- Describe the likelihood and severity of adverse effect with amount and condition(s) of exposure to, e.g., chemical agent
- Use existing, or develop guidelines

Adverse effects



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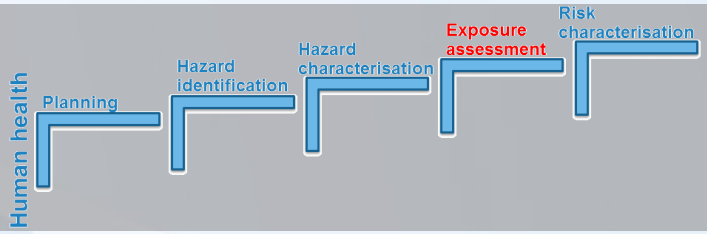
Risk Assessment Basics



- Human health risk assessment

Hazard identification → **Hazard characterisation** → **Exposure assessment**

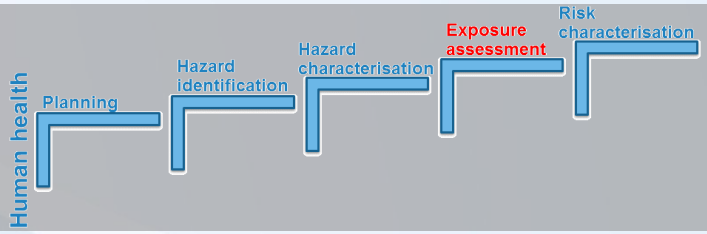
- Measure or estimate the magnitude, frequency and duration of exposure to, e.g., biological agent
- Considers exposure pathway and route, as well as size, nature and type of populations exposed

Available data

- Measured directly/estimated using environmental concentrations + fate/ transport + estimated intake)

http://epa-sdcc.ornl.gov/sdcc_owok_dust_tot.html
(accessed 20/11/2015)

Risk Assessment Basics

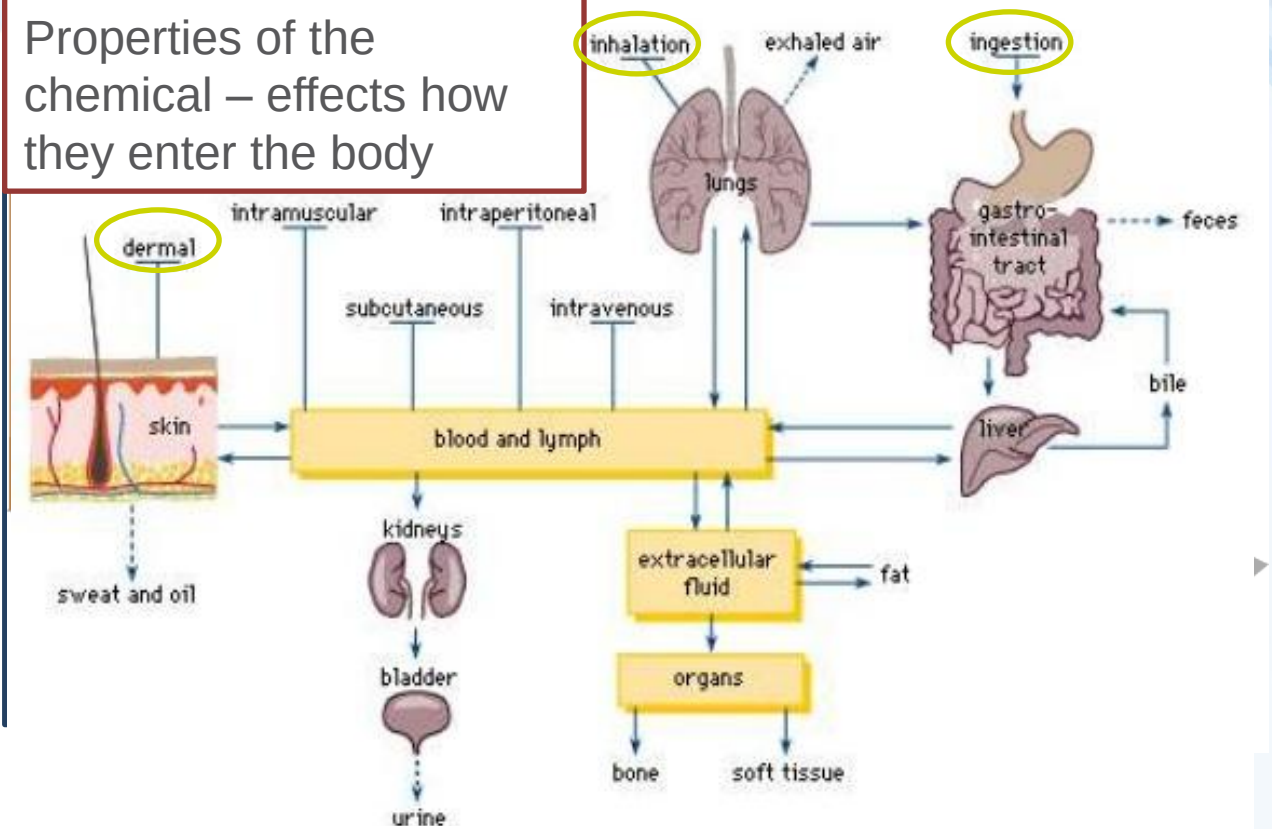


- Human health risk assessment

Hazard identification

Properties of the chemical – effects how they enter the body

Hazard characterisation



Exposure assessment

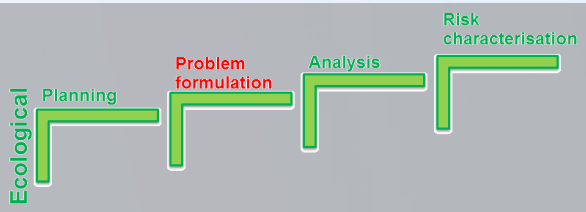
- Measure or estimate the magnitude, frequency and duration of exposure to, e.g., biological agent
- Considers exposure pathway and route, as well as size, nature and type of populations exposed

Available data

- Measured directly/estimated using environmental concentrations + fate/ transport + estimated intake)

http://www.slideshare.net/AngelAlhamad/different-route-of-exposure-of-toxicant (accessed 20/11/2015)

Risk Assessment Basics



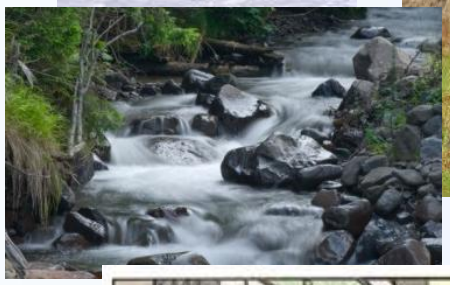
- Ecological risk assessment

Problem formulation:

- Define an assessment end-point to determine what ecological entity is important to protect
- Identify and determine what entity you are protecting and what attributes of entity are at risk
- Your ecological entities might include: Species (polar bear), ecosystem (stream), valued habitat (wetland), etc.

What to protect?

Think of ecological relevance, susceptibility to stressors and relevance to management goals



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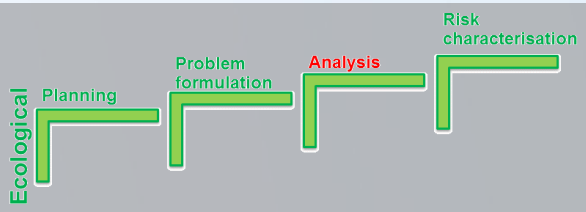
Risk Assessment Basics



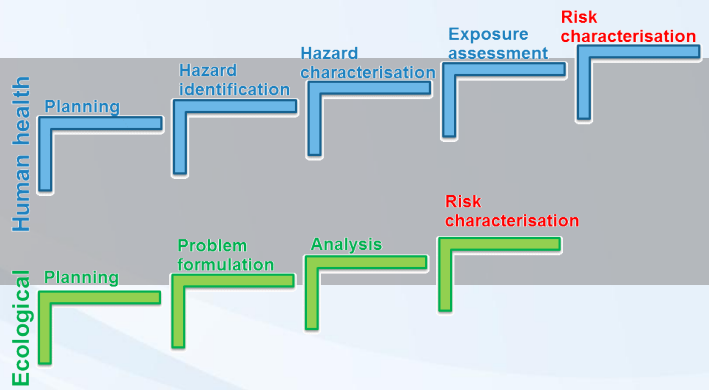
- Ecological assessment

Problem formulation:

Analysis:

- Characterisation of exposure and ecological effects
- Degree of exposure and ecological responses of plants and animals exposed to stressors
- Guidelines can be used or can also be developed
  - ECTOX database has ecotox data
- Determining exposure levels
  - Area use/home range; food ingestion; bioaccumulation rates; bioavailability; life stage

Risk Assessment Basics



- And finally……risk characterisation

risk characterisation = risk estimation + risk description

- Risk estimation: using the results of preceding steps in risk assessment estimate the risk
- Risk description: an interpretation of risk results. The level of harmful effects, as well as likelihood/probability of adverse effects, on humans or other organisms
- ***It is very important*** to include how the risk was assessed, the degree of confidence in the risk estimates, any assumptions made, as well as summarise limitations and uncertainties
- Citations must be used to support risk estimates and any interpretation of adverse effects
- Information is used for decision making

Risk Assessment Basics

- Further reading
  - For guidance on conducting risk assessment or risk analysis refer to government or non-government agencies (within your study region is best)
  - Some places to start on the web:
    - US EPA (**http://www2.epa.gov/risk**)
    - World Health Organization (WHO) (2010) WHO Human Health Risk Assessment Toolkit: Chemical Hazards (ISBN 978 92 4 154807 6)
    - UK Department for Environment, Food and Rural Affaris (DEFRA) (**https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69450/pb13670-green-leaves-iii-1111071.pdf**) – has some good case studies
  - Good journal source:
    - Environmental Health Perspectives

Where can we use risk assessment?

- Human health

Any suggestions?

  - Will an upgrade of a sewage treatment plant increase nuisance odours and pose a risk to health the local community through recreational activities?
  - What is the risk to children from lead dust exposure near to a smelter?

- Ecological

Ideas?

  - How would construction, operation and decommissioning of a gold mine impact downstream aquatic ecosystems?
  - Will invasive species increase during construction of a pipeline?

Case study 1:Carcenogenic risk from exposure to particle-associated PAHs

Case study modified from Kamal et al. 2015 (**Environ Sci Pollut Res (2015) 22:12644–12654, DOI 10.1007/s11356-015-4444-4**)

- Planning
  - The scope is people using primitive or traditional cooking practices in residences or commercial kitchens in Pakistan. PAH associated to dust is the stressor. Potential adverse effect of cancer was nominated.
  - An assessment endpoint was devised and used to evaluate impacts from potential particle-bound polycyclic aromatic hydrocarbon (PAH) exposure in the vicinity of primitive or traditional cooking
  - Assessment endpoint = reduction in incidence of disease. Disease measured as cancer incidence over a lifetime for residents or kitchen workers in vicinity of primitive or traditional cooking, Pakistan.

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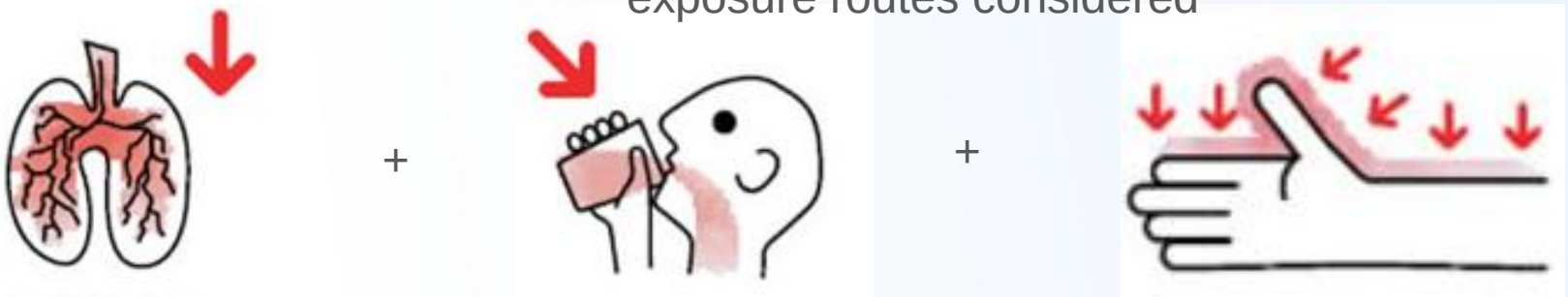
Case study 1:Carcenogenic risk from exposure to particle-associated PAHs

- Hazard identification and characterisation
  - Solid fuel combustion a major source of household energy in Pakistan. When burnt solid fuel produces particulate matter, particularly when stoves are poorly functioning and ventilation is bad.
  - Wood and coal identified as a major source of PAHs. PAHs are toxic to humans (assigned a toxic equivalency factor (TEF) relative to benzo(a)pyrene).
  - Samples of dust were collected from workplace and domestic kitchens in Pakistan with primitive or traditional cooking practices. Levels of PAHs in dust were determined, i.e., the potential PAHs dose. An equivalent toxicity was calculated for each dust sample.
- Exposure assessment

exposure routes considered



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WHO information used for exposure estimation

Case study 1:Carcenogenic risk from exposure to particle-associated PAHs

- Risk characterisation
  - Probabilistic incremental lifetime cancer risk (ILCR)
  - The ILCR model can be used in estimating the incremental probability an individual develops a tumour over an average lifetime (70 years)
  - ILCR compared to US EPA acceptable risk range ($1x10^{-6}$ – $1x10^{-4}$ or 1 per 1,000,000 or 1 per 10,000)

International Agency for Research on Cancer

World Health Organization

http://www.iarc.fr/

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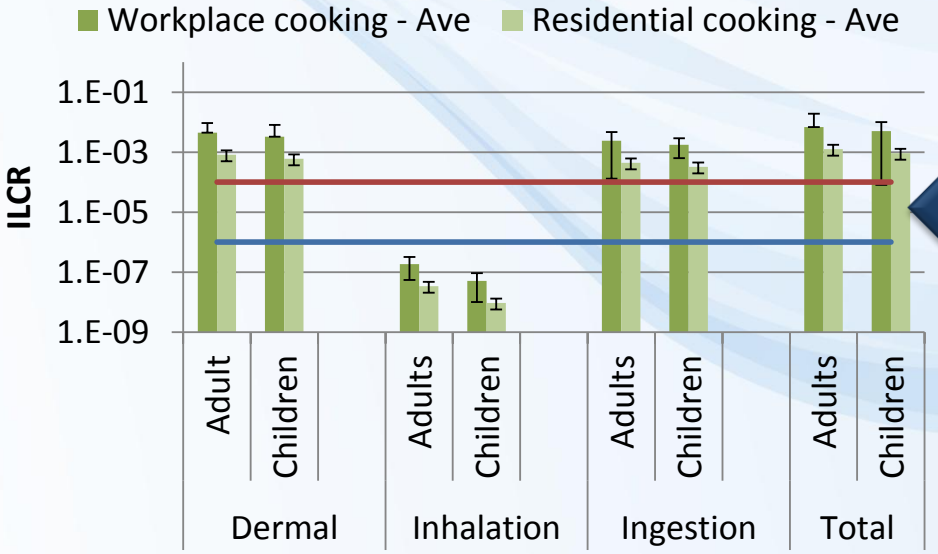
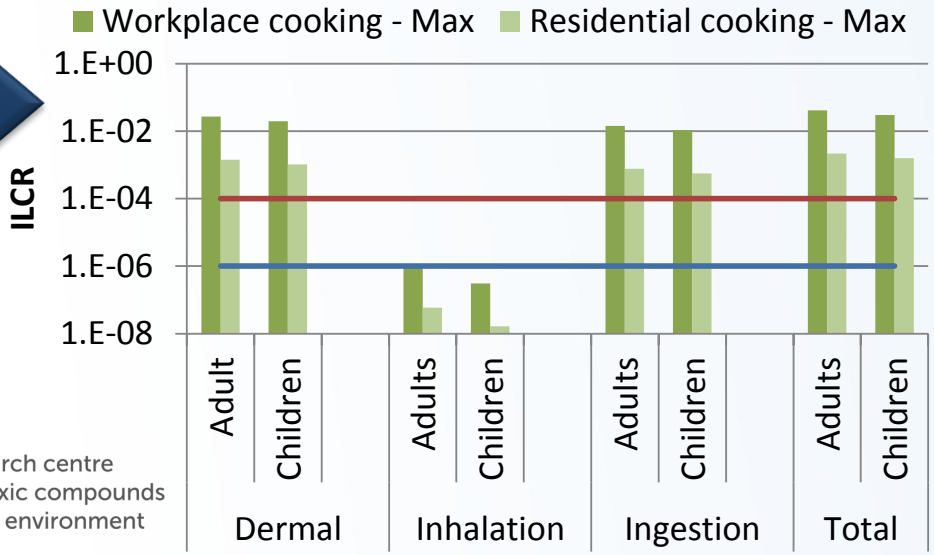
Case study 1:Carcenogenic risk from exposure to particle-associated PAHs

- Risk characterisation
  - Unacceptable risk of cancer in adults and children exposed to particle associated PAHs derived from primitive cooking stoves



Average scenario total ILCR exceeds acceptable risk

Work case scenario



Cancer risk over a lifetime

Adults 4/100

Child 3/100

HIGH risk of cancer!

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Biota exposure to toxic levels of uranium (U) downstream of a mine

abc.net.au (accessed 19/11/2015)

Magela Creek

(**https://www.environment.gov.au/science/supervising-scientist/research/ecological-risk**)

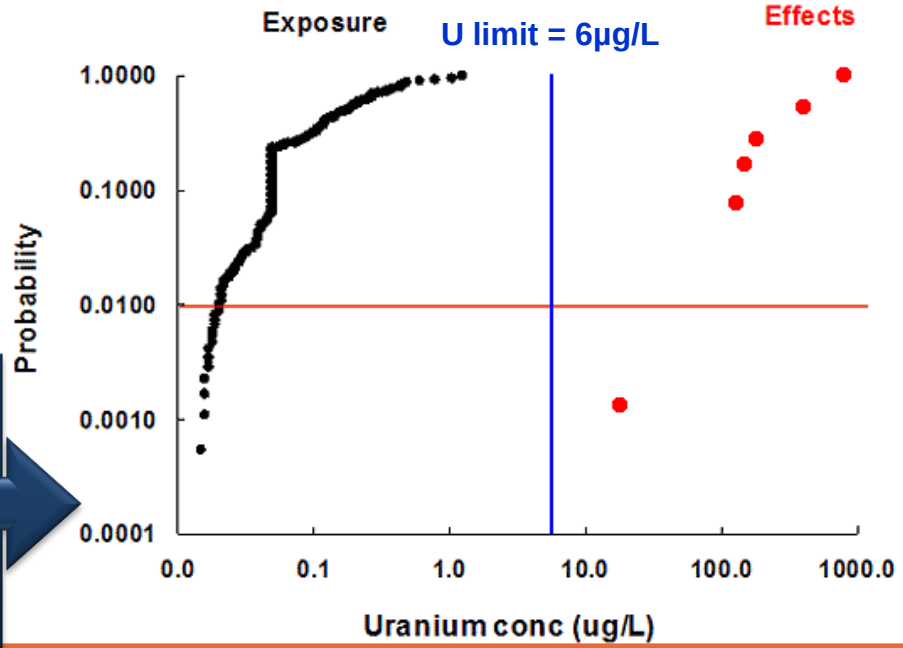
Case study modified from Australian Government Department of the Environment

- Planning and problem formulation
  - Scope is an aquatic ecosystem downstream of a U mine. Stressor is available U. Potential adverse effects include death, illness or change in behavior.
  - Surveys conducted to establish aquatic species present (ID: sensitive species)
  - An assessment endpoint was devised and used to evaluate impacts from potential uranium contamination downstream of the mine
  - Assessment endpoint = conservation of biological diversity of the region. Species abundance in Alligator Creek catchment surveyed during the mine operation and decommissioning

Biota exposure to toxic levels of uranium downstream of a mine

- Analysis
  - Exposure estimated using environmental U concentrations measured in Magela Creek
  - Effects observations measured using ecotoxicity tests (6 native species; NOEL)
  - A U limit was derived to using the ecotox data (99% species protection)

- Risk characterisation
  - Null hypothesis testing and likelihood estimation based on frequency information for effects and exposure



Cumulative probability for exposure to U in Magela Creek, and for potential effects of U on 6 species of native species (NOEL)

  - Risk of adverse effects from exposure to U as a result of mine discharge was assessed to be low

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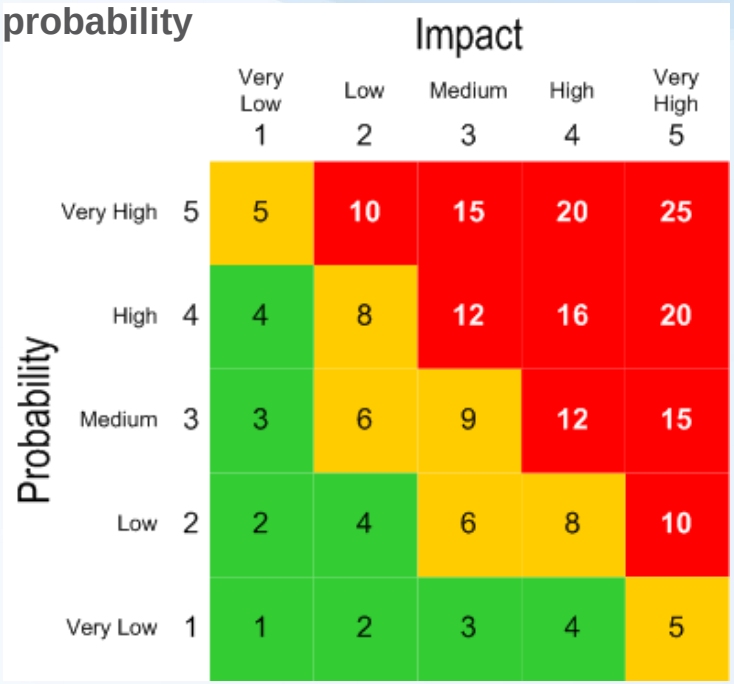
Biota exposure to toxic levels of uranium downstream of a mine

- Risk characterisation can also use semi-quantitative assessment (e.g., ranking risk)
  - Helps set priorities when assessing multiple stressor risks and considers uncertainties.
  - Needs to be scrutinised and reviewed by experts

e.g., 1 Risk matrix of consequences versus likelihood

Likelihood	Consequences				
	Insignificant 1	Minor 2	Moderate 3	Major 3	Unknown 4
A (Almost certain)	High (H)	H	VH	VH	U (H)
B (Likely)	Medium (M)	H	H	VH	U (M)
C (Possible)	Low (L)	M	H	VH	U (L)
D (Unlikely)	L	L	M	H	U (L)
E (Unknown (U))	U (L)	U (L)	U (M)	U (H)	U

e.g.,2 Risk matrix of impact versus probability



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Questions/discussion/tea break?

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Module 2: International conventions for persistent, toxic, mobile and bioaccumulative chemicals

Eva Holt (holt@recetox.muni.cz)

Module 2: International conventions for PTMB chemicals

- Objectives of Module 2
- Basic concepts of PTMB chemicals
- Key conventions dealing with PTMB chemicals
- Global monitoring of PTMB chemicals

Objectives of Module 2

- Re-introduce PTMB chemicals, including the concept of transboundary movement of chemicals
- Describe some of the main international conventions dealing with PTMB chemicals
- Highlight global monitoring programs for PTMB chemicals and what the monitoring data is used for

Basic concepts of PTMB chemicals

- You will remember these from a previous (Lisa's) lecture
  - What is persistent?

Lasting for years or even decades before degrading into less dangerous forms. High resistance to degradation (abiotic and biotic)

  - Which toxic compounds?

Everything is, right? Even water? High toxicity at very low concentrations

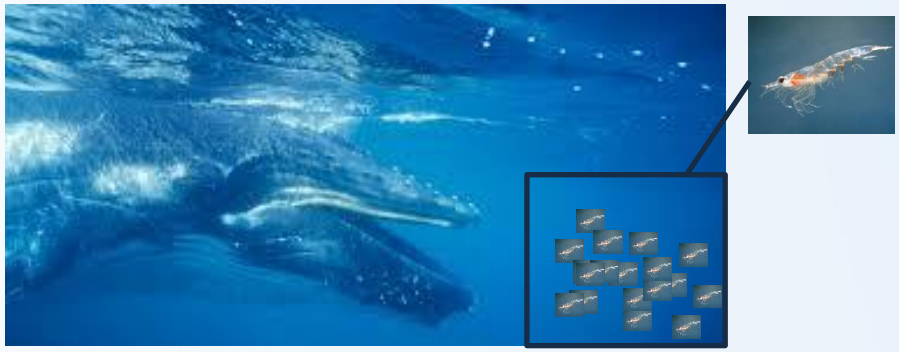
  - How mobile?

Moves to remote areas far from sources

  - What is bioaccumualtive?

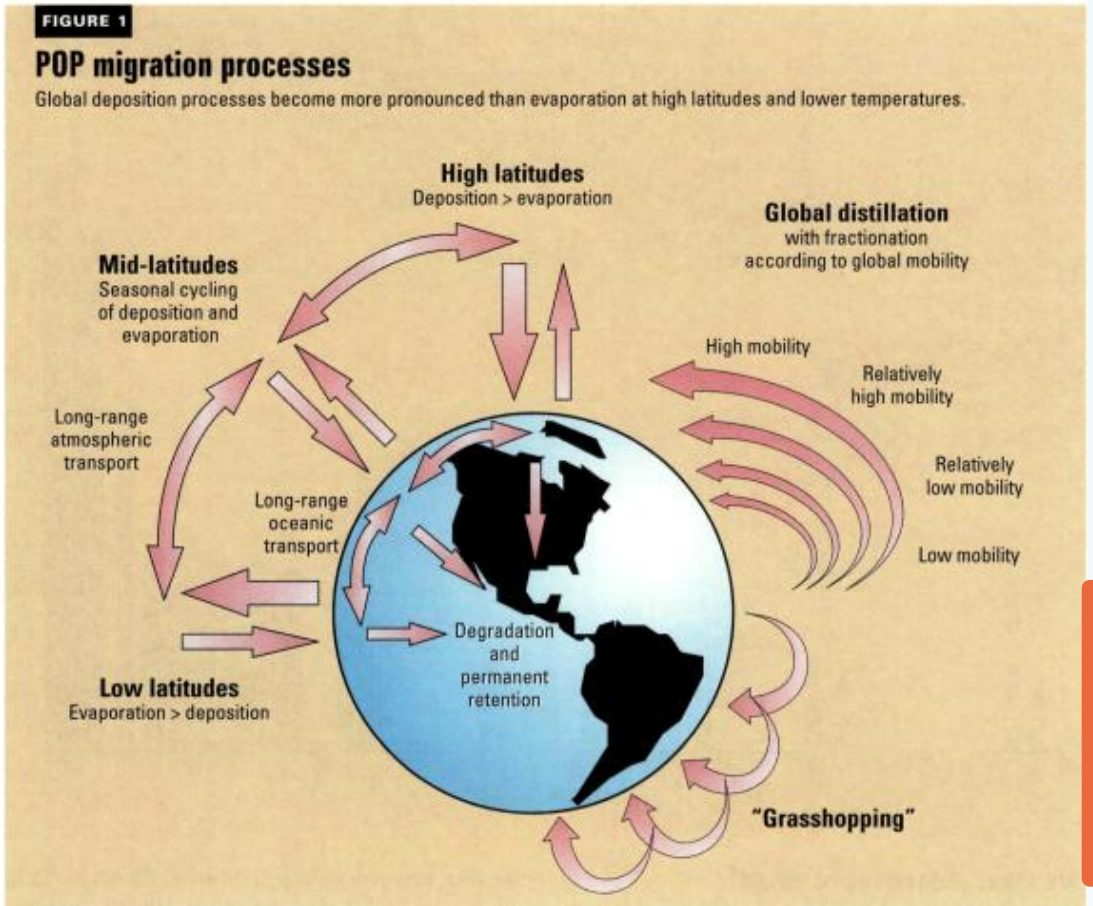
Toxic substance taken up at a higher rate than being removed from an organism. Lipophilic compounds (they like lipids).

Biomagnification through the food web results in higher trophic organisms accumulating more PBTs through consumption of lower trophic organisms



Basic concepts of PTMB chemicals

- Transboundary movement - from us to the polar bears



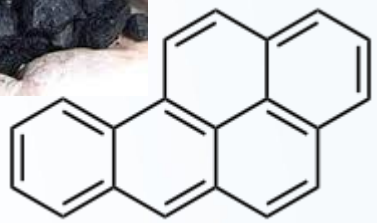
Tracking the Distribution of Persistent Organic Pollutants
Wania & Mackay, VOL. 30, NO. 9, 1996 Environmental Science & Technology (News)

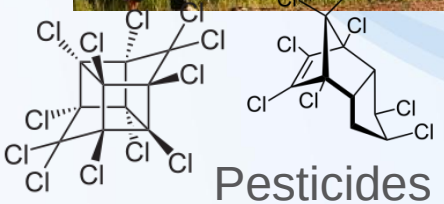
Basic concepts of PTMB chemicals and transboundary movement

Some PTB contenders

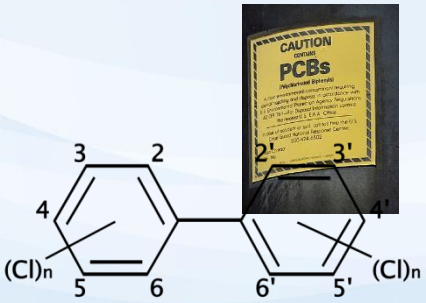
Hg

PAHs



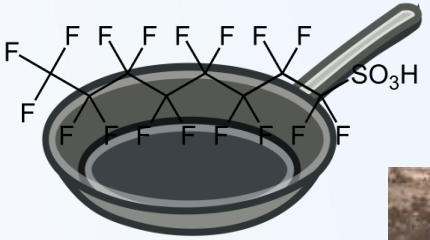


Pesticides



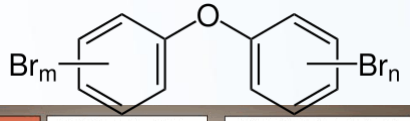
Those that are also mobile

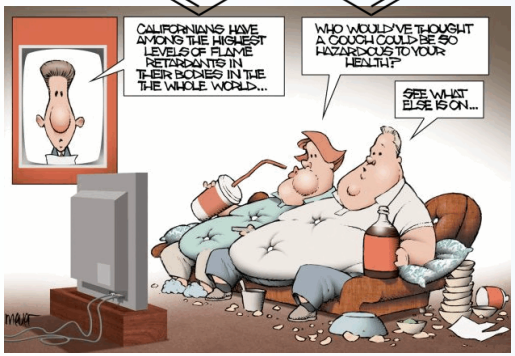
C—Pb



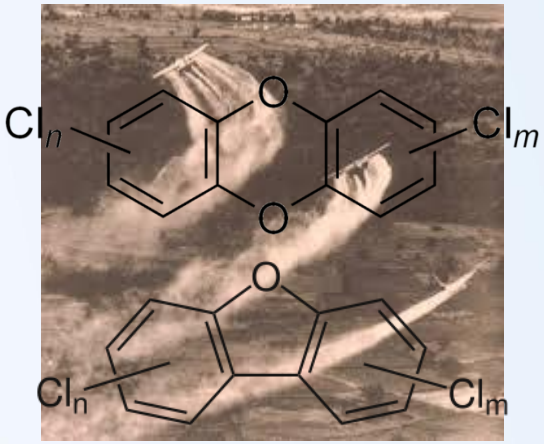
PFCs

PBDEs

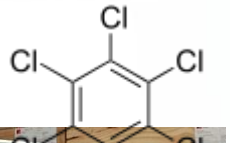




PCDD/Fs



HCB



Key conventions dealing with PTMB chemicals

- Question for the group – what international environmental conventions do you know about?

A clue

Rio earth summit (1992): **United Nations Framework Convention on Climate Change** perhaps? Also have **Convention on Biological Diversity** and **United Nations Convention to Combat Desertification**

Key conventions dealing with PTMB chemicals

- Why mention Rio?

Principle 15 of the Rio Declaration on Environment and Development

"*In order to protect the environment, the **precautionary approach** shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.*"

Key conventions dealing with PTMB chemicals

Global treaties to protect human health and the environment from chemicals

- Stockholm Convention (SC) on Persistent Organic Pollutants (POPs)
  - Reduce exposure by eliminating or reduce use and emissions

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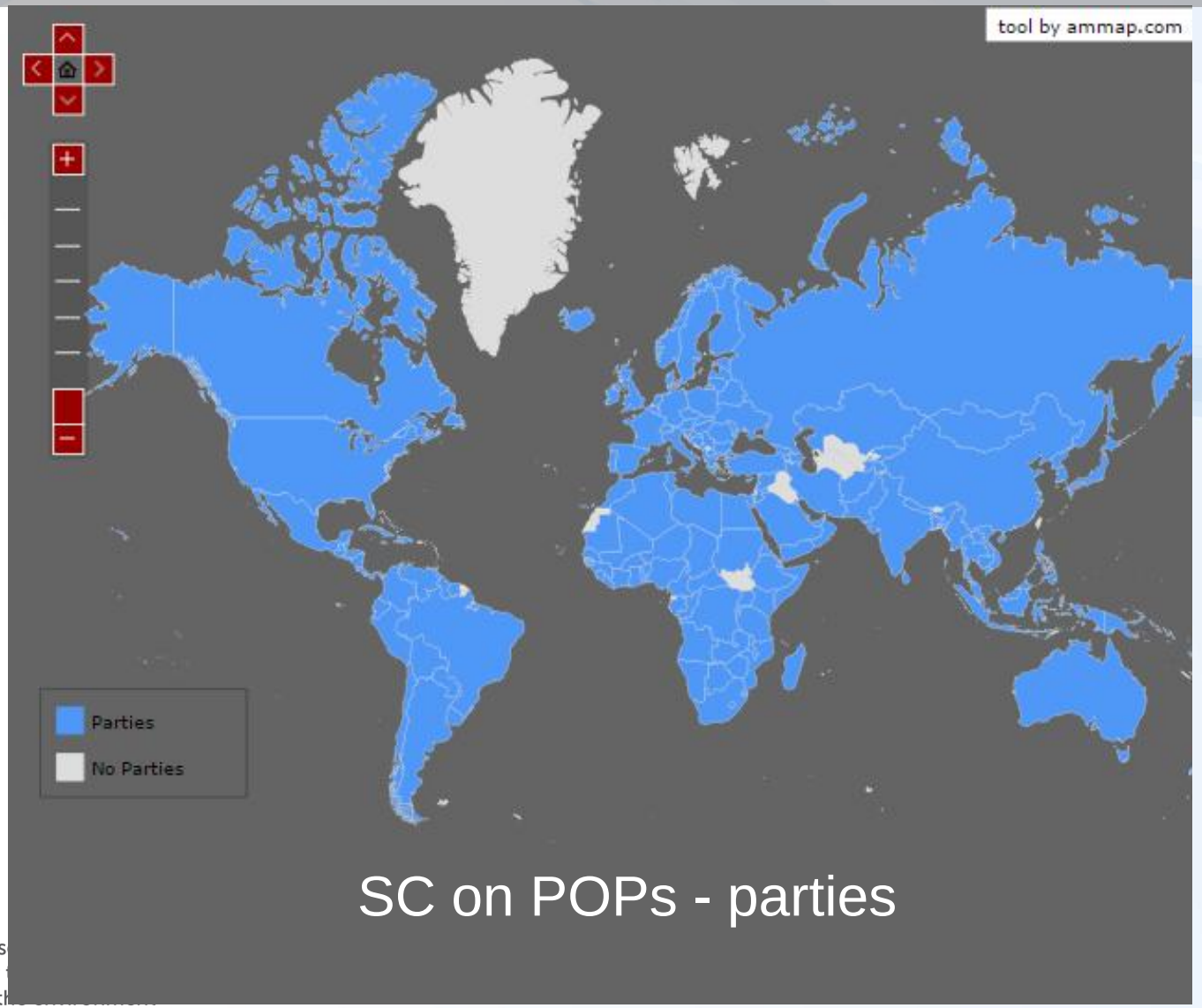
  - Requires parties to:
    - Restrict, prohibit and/or eliminate the production and use, import and export intentionally or unintentionally produced POPs
    - Promotes the use of best available techniques and best environmental practices for preventing releases of POPs into the environment.
    - Ensure POPs stockpiles and wastes managed safely and in an environmentally sound manner
    - To target additional POPs /list new ones

Key conventions dealing with PTMB chemicals



SC on POPs - parties

Key conventions dealing with PTMB chemicals

- Stockholm Convention (SC) on Persistent Organic Pollutants (POPs)
  - A POP by definition share these properties:
    - highly toxic
    - persistent
    - travel long distances
    - accumulate in fatty tissue

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Listing of POPs in the Stockholm Convention

The chemicals targeted by the Stockholm Convention are listed in the annexes of the convention text:

Annex A (Elimination)

Parties must take measures to **eliminate** the production and use of the chemicals listed under Annex A. Specific exemptions for use or production are listed in the Annex and apply only to Parties that register for them.

Aldrin	Chlordane	Chlordecone
Dieldrin	Endrin	Heptachlor
Hexabromobiphenyl	Hexabromocyclododecane (HBCD)	Hexabromodiphenyl ether and heptabromodiphenyl ether
Hexachlorobenzene (HCB)	Alpha hexachlorocyclohexane	Beta hexachlorocyclohexane
Lindane	Mirex	Pentachlorobenzene
Polychlorinated biphenyls (PCB)	Technical endosulfan and its related isomers	Tetrabromodiphenyl ether and pentabromodiphenyl ether
Toxaphene		

Annex B (Restriction)

Parties must take measures to **restrict** the production and use of the chemicals listed under Annex B in light of any applicable acceptable purposes and/or specific exemptions listed in the Annex.

DDT	Perfluorooctane sulfonic acid, its salts and perfluorooctane sulfonyl fluoride

Annex C (Unintentional production)

Parties must take measures to reduce the **unintentional releases** of chemicals listed under Annex C with the goal of continuing minimization and, where feasible, ultimate elimination.

Hexachlorobenzene (HCB)	Pentachlorobenzene	Polychlorinated biphenyls (PCB)
Polychlorinated dibenzo-p-dioxins (PCDD)	Polychlorinated dibenzofurans (PCDF)	

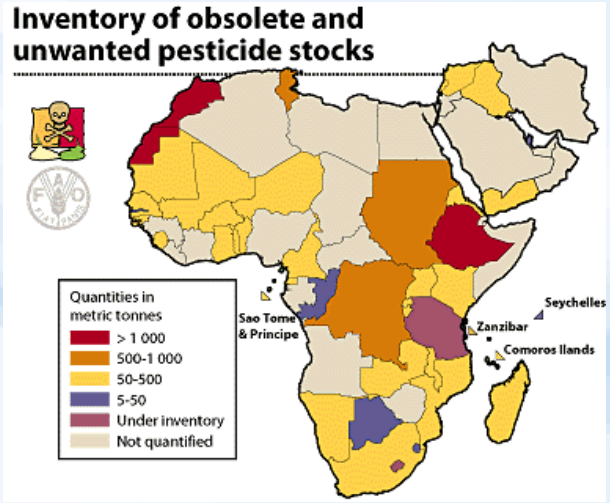
Pesticide · Industrial chemical · Unintentional production

Key conventions dealing with PTMB chemicals

- Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal
  - Under which framework was set up for controlling movement of hazardous wastes across international borders
  - Criteria developed for “environmentally sound management” of hazardous wastes

Key conventions dealing with PTMB chemicals

- Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal
  - *The provisions of the Convention center around the following principal aims:*
    - *the reduction of hazardous waste generation and the promotion of environmentally sound management of hazardous wastes, wherever the place of disposal;*
    - *the restriction of transboundary movements of hazardous wastes except where it is perceived to be in accordance with the principles of environmentally sound management; and*
    - *a regulatory system applying to cases where transboundary movements are permissible.*" [**http://www.pic.int/**]



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Key conventions dealing with PTMB chemicals

- Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade
  - "*Objectives of the convention are:*
    - *to promote shared responsibility and cooperative efforts among Parties in the international trade of certain hazardous chemicals in order to protect human health and the environment from potential harm;*
    - *to contribute to the environmentally sound use of those hazardous chemicals, by facilitating information exchange about their characteristics, by providing for a national decision-making process on their import and export and by disseminating these decisions to Parties.*" [**http://www.pic.int/**]

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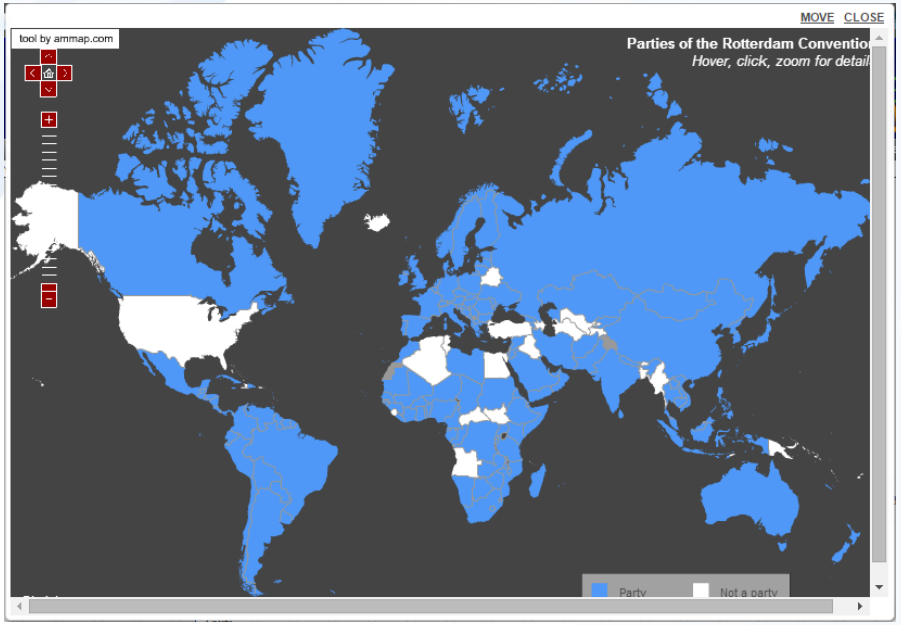
Key conventions dealing with PTMB chemicals



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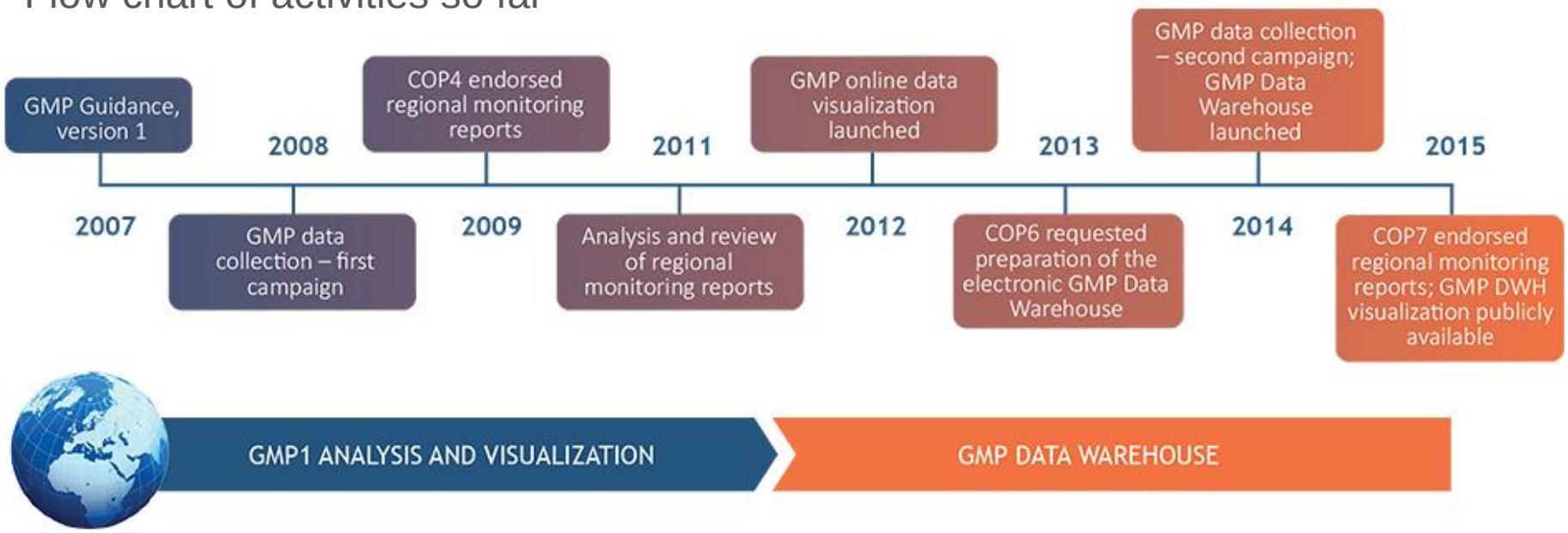
- Rotterdam Convention
  - "*The **Prior Informed Consent (PIC)** procedure – The PIC procedure is a mechanism for formally obtaining and disseminating the decisions of importing Parties as to whether they wish to receive future shipments of those chemicals"* listed in the Convention or *"for ensuring compliance with these decisions by exporting Parties."*
  - "***Information Exchange** - The Convention facilitates information exchange." Notification required "when taking a domestic regulatory action to ban or severely restrict a chemical."*

Global monitoring of PTMB chemicals

- Example - The Global Monitoring Plan on Persistent Organic Pollutants (GMP)
  - Article 16 of SC on POPs: requires effectiveness of measures adopted by the Convention regularly evaluated

GMP: aims at collecting comparable, harmonized and reliable information on POP levels in core environmental matrices (air, breast milk/blood and water).

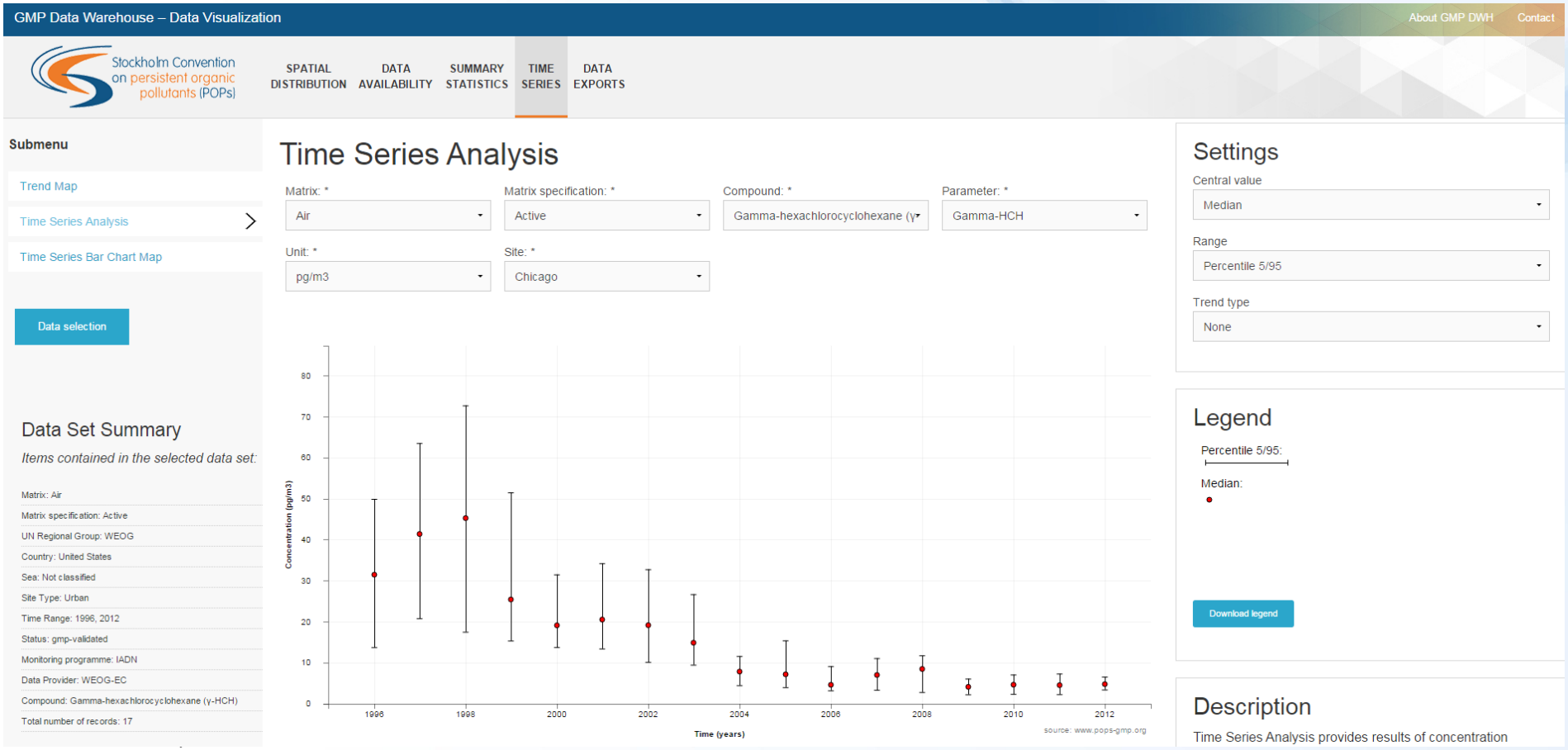
Flow chart of activities so far



Global monitoring of PTMB chemicals

- Available Global Monitoring Plan (GMP) data

What happens to POPs levels over time? Are measures to eliminate or reduce emissions working?



Global monitoring of PTMB chemicals

- Available Global Monitoring Plan (GMP) data

Which countries have the highest exposure to POPs? How are people exposed and what are the risks? Do levels decrease over time?

Summary Statistics

Matrix: * Human milk

Matrix specification: * Pooled

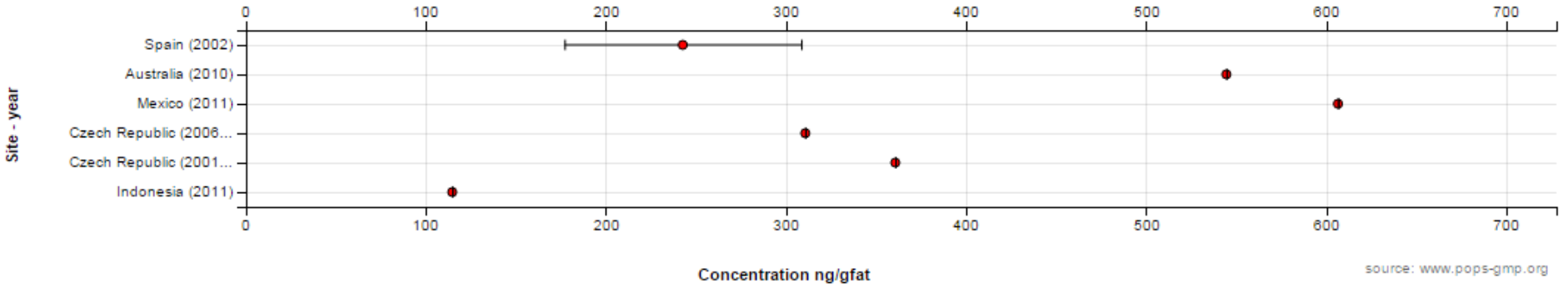
Compound: * Dichlorodiphenyltrichloroethane (DE

Parameter: * p,p-DDE

Unit: * ng/gfat

Site: -- Choose an option --

Year:



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Global monitoring of PTMB chemicals

- Available Global Monitoring Plan (GMP) data

Do we know anything about spatial trends? Where are the highest POPs contaminations? Can we figure out why? Are the POPs mobile

Summary Statistics

Matrix: * Water

Matrix specification: * Marine water - open ocean

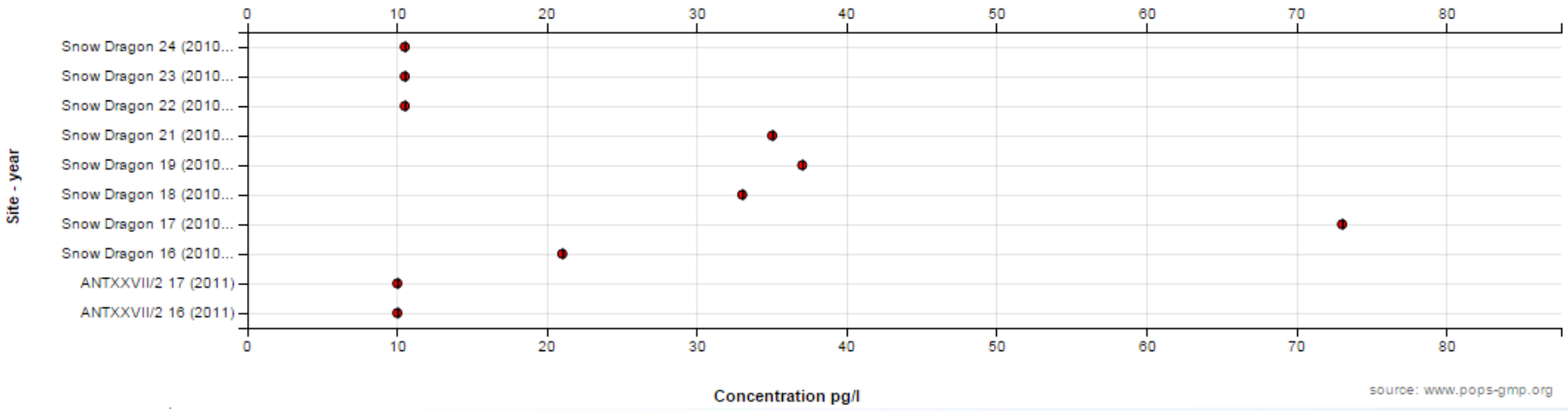
Compound: * Perfluorooctane sulfonic acid (PFO

Parameter: * PFOS

Unit: * pg/l

Site: -- Choose an option --

Year:



The end…..any questions?

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