



Stable isotopes as a tool for environmental contaminant studies

Workshop in Stable Isotopes and Predator-Prey Interactions.
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Hexachlorobenzene - fungicide formerly used as a seed treatment to control fungal diseases

Hexachlorocyclohexane - by-product of the production of the insecticide lindane, not been used for more than 20 y

Dichloro-Diphenyl-Trichloroethane - synthetic pesticide, disease control

p,p'-DDE
p,p'-DDT
p,p'-DDD

o,p'-DDE
o,p'-DDT
o,p'-DDD

Polychlorinated biphenyls - banned in 1970ies - used as dielectric fluids in transformers and capacitors, coolants, lubricants, stabilizing additives in flexible PVC coatings of electrical wiring and electronic components, pesticide extenders, cutting oils, flame retardants, hydraulic fluids, sealants, adhesives, wood floor finishes, paints, and in carbonless copy paper

Chlordanes - Manufactured chemicals used as a pesticide in USA from 1948 to 1988

trans-nonachlor
oxychlordane

Legend:
● Hydrogen (white)
● Carbon (grey)
● Oxygen (red)
● Chlorine (green)

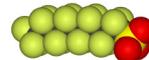
**Lipid soluble
Toxic
Persistent
Mobile**

New compounds

PFOS - a man-made fluorosurfactant and global pollutant.

PFOS was the key ingredient in Scotchgard, a fabric protector made by numerous stain repellents. PFOS has been used to make *aqueous film forming foam*, a component of fire-fighting foams, and alcohol-type concentrate foams. PFOS compounds can be also found in some impregnation agents for textiles, paper, and leather; in wax, polishes, paints, varnishes, and cleaning products for general use; in metal surfaces, and carpets. In the semiconductor industry, PFOS is used in multiple photolithographic chemicals including: photoacid generators (PAGs) and anti-reflective coatings (ARCs). Phased out in the European Union semiconductor industry due to health concerns.

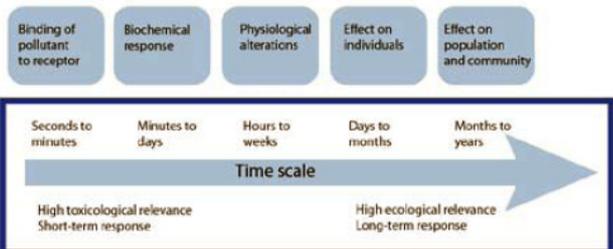
Perfluorooctanesulfonic acid



Other names PFOS

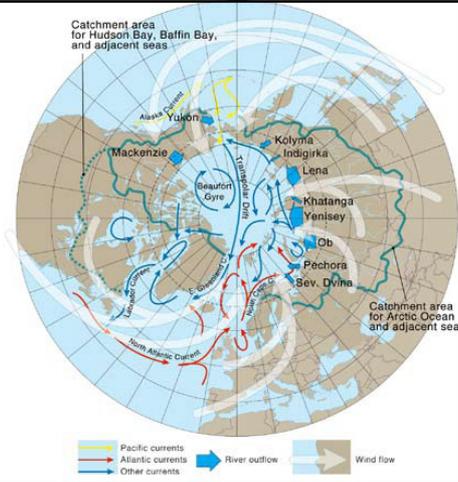
Repel both water and lipids,
Extremely resistant to degradation

BIOLOGICAL EFFECTS



The different physical pathways by which POPs are transported into the Arctic

Transports both into and within the Arctic occurs via air, ocean currents, rivers, and sea ice



AMAP 2004

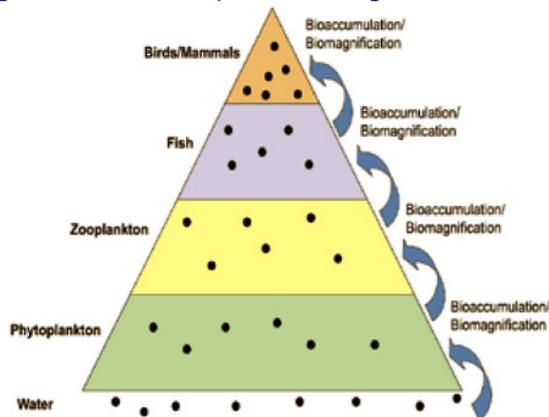
In addition to being toxic, organochlorines:

- high lipid solubility
- mobility
- low degradability

➡ They are transported to areas distant from the sources of use

➡ Potential to bioaccumulate in Arctic organisms

Organochlorine transported through the food chain



Example from arctic marine food web

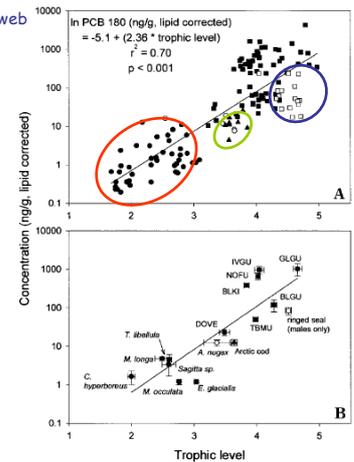
Exponential relation between PCB 180 concentration and trophic level for the Northwater Polynya marine food web.

(A) All data points
(B) Species means

Trophic level based on $\delta^{15}N$.

- (●) Pelagic zooplankton,
- (○) Benthic amphipods,
- (▲) Arctic cod,
- (□) Ringed seals,
- (■) Seabirds.

Fisk et al. 2001

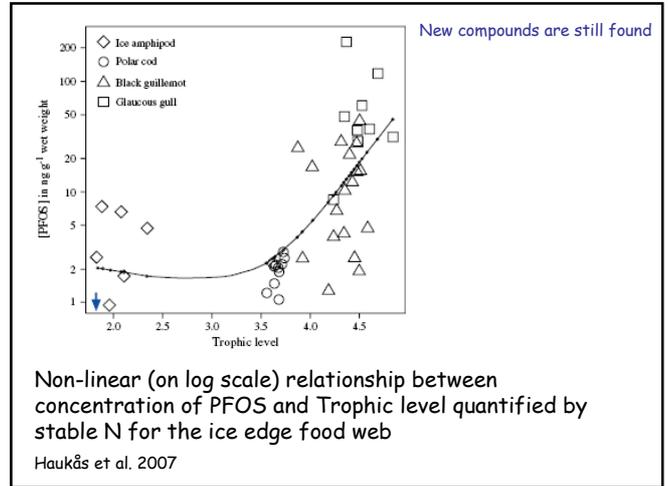
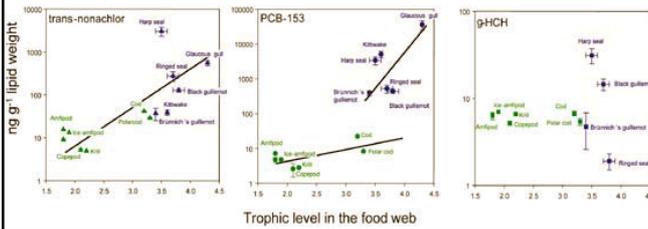


Biomagnification in a Barents Sea food web

In general: concentration of organochlorine compounds increases often exponentially through the food web. But...

Some compounds, such as PCB 153 accumulate faster in **endotherms** (purple) than in **ectotherms** (green). And...

Some compounds do not biomagnify at all: as, γ -HCH



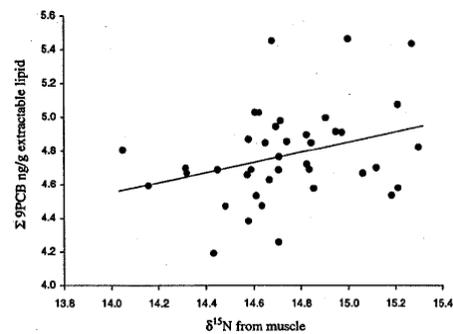
Non-linear (on log scale) relationship between concentration of PFOS and Trophic level quantified by stable N for the ice edge food web

Haukås et al. 2007

Variation in contaminants within each species

- Different individuals or segments within populations can have different trophic positions as revealed by stable isotope signatures
- There are several examples of good correlations between individual contaminant levels and isotope signature levels

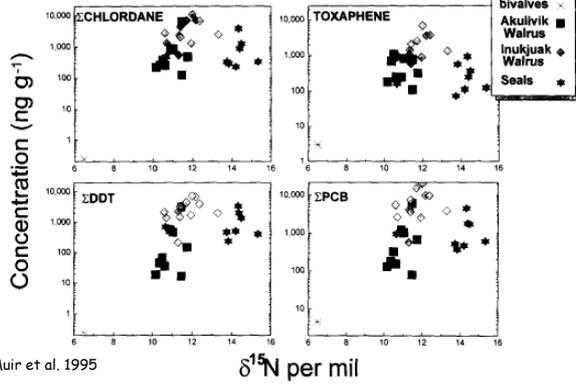
Correlation between PCB in liver and stable nitrogen isotopes from muscle of **glaucous gulls** from Bjørnøya (Bear island), the Barents Sea



Explain up to 18% of the variation in OCs

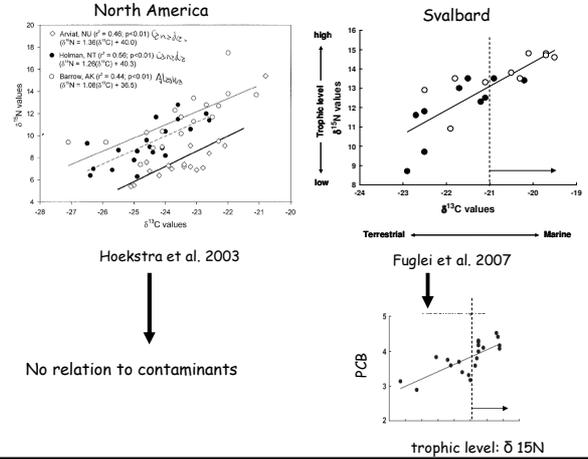
Sagerup et al. 2002

Walrus fed on ringed seals (Inukjuak) had higher OC concentrations than those fed only on benthic crustaceans (Akulivik)



Muir et al. 1995

Arctic fox



Hoekstra et al. 2003

No relation to contaminants

Fuglei et al. 2007

trophic level: $\delta^{15}\text{N}$



Conclusion: Stable isotopes in ecotox studies

- Stable isotopes is useful tool both for explaining variation in contaminant levels:
 - Between individuals within habitats (glaucous gulls) and between habitats (arctic fox) as a function of feeding behaviour
 - Between species as a function of trophic level and food web affiliation (marine and terrestrial)