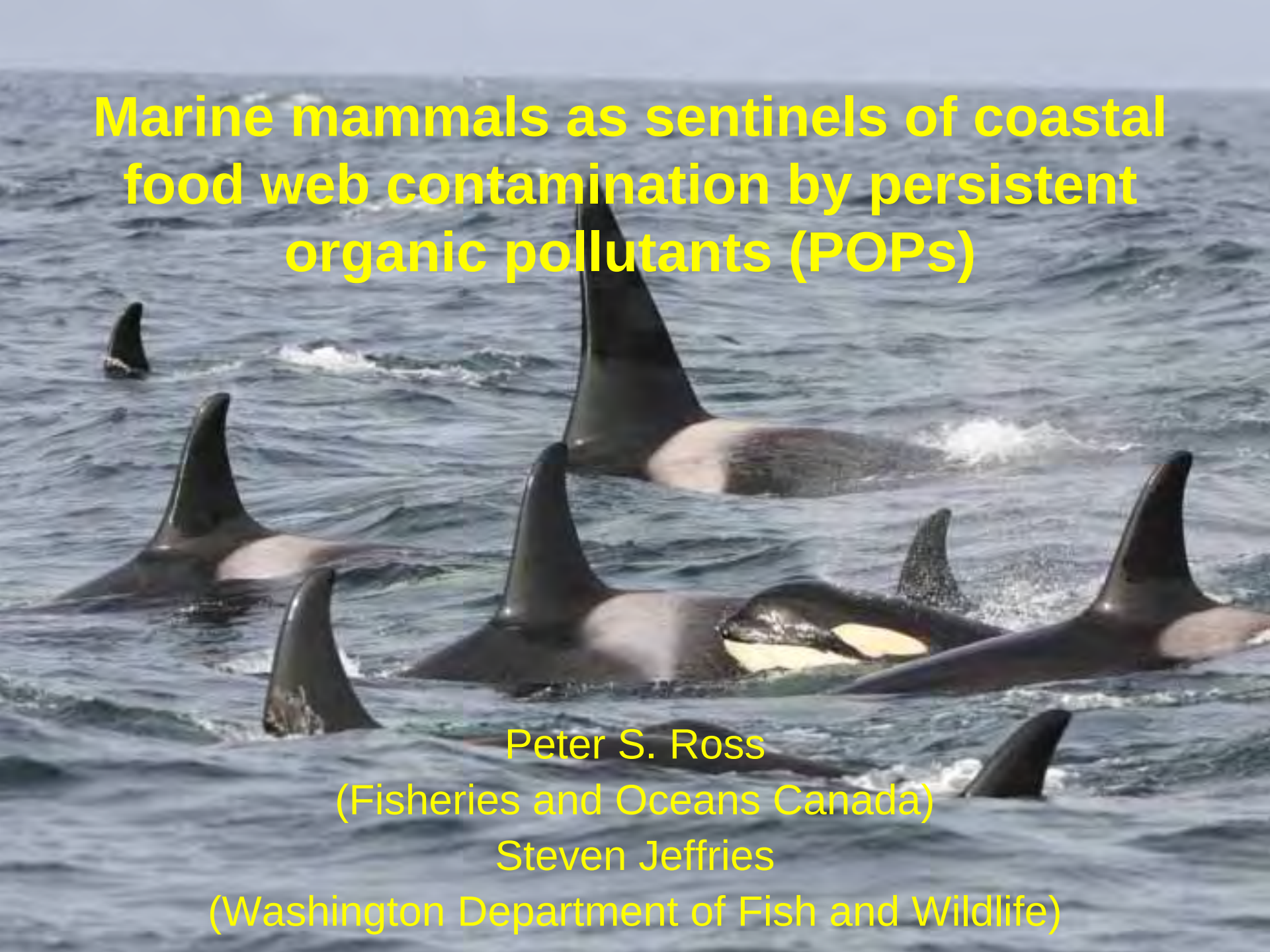
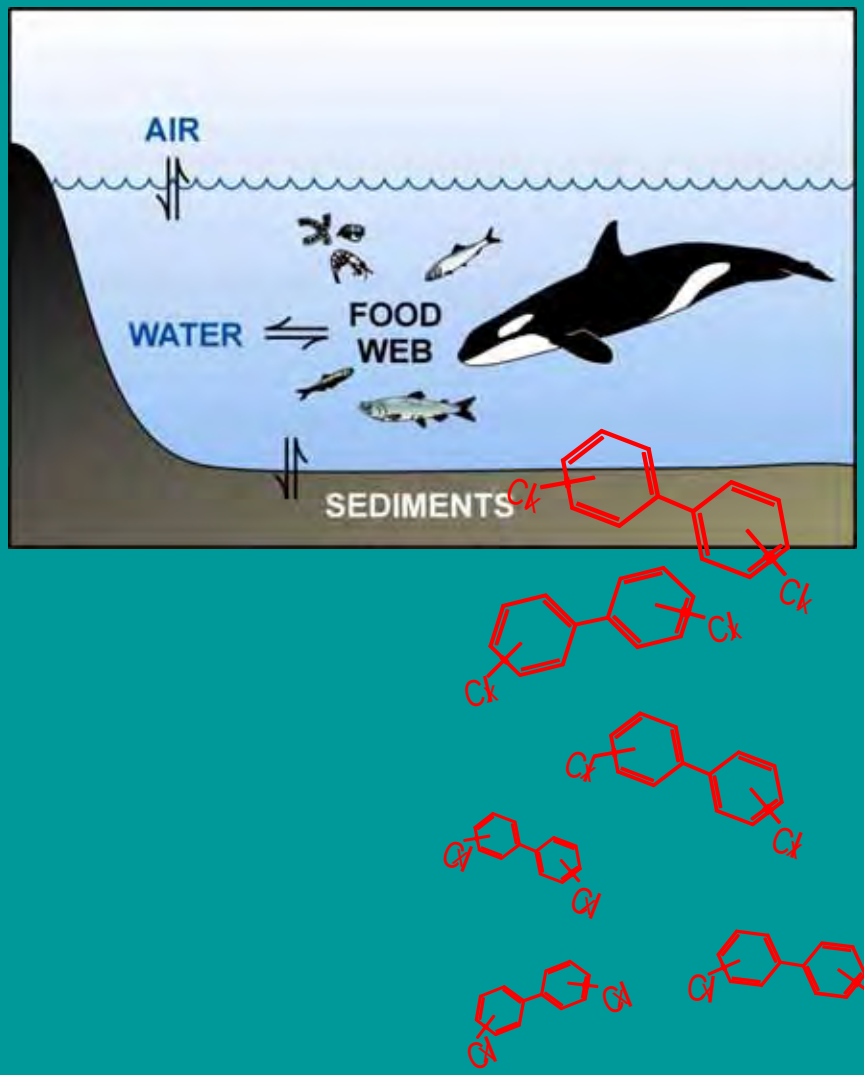
Marine mammals as sentinels of coastal food web contamination by persistent organic pollutants (POPs)



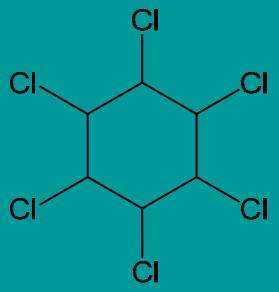
Peter S. Ross
(Fisheries and Oceans Canada)
Steven Jeffries
(Washington Department of Fish and Wildlife)

High trophic level marine mammals can accumulate high levels of Persistent Organic Pollutants (POPs) and related compounds

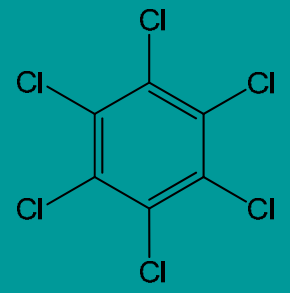
- POPs comprise a family of chemicals deemed *persistent*, *bioaccumulative* and *toxic*.
- Long-lived, high trophic level marine mammals are often highly contaminated with POPs, even in remote regions.
- A growing list of POPs are the subject of the Stockholm Convention.
- Marine mammals and seabirds have been widely used as sentinels of food web contamination by POPs.



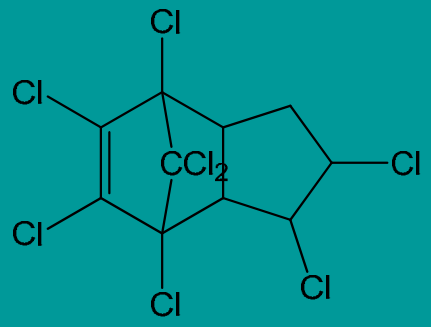
POPs



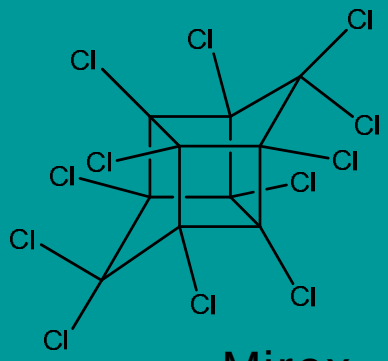
HCH



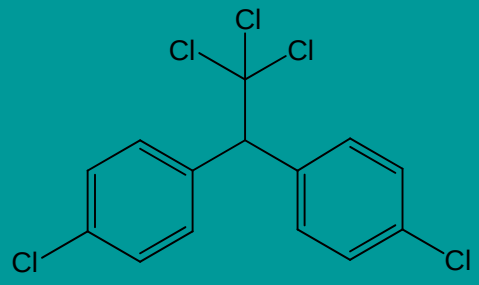
HCB



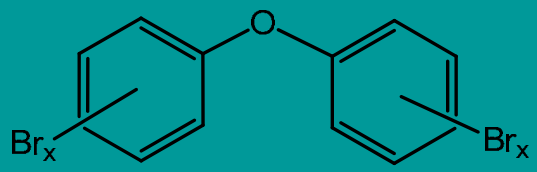
Chlordane



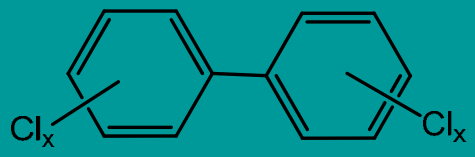
Mirex



DDT



PBDE



PCB

POPs (~PCBs) have been implicated in adverse effects in marine mammals

- *Seals fed contaminated fish:*
  - decreased reproductive success;
  - immunotoxicity;
  - disruption of vitamin A and thyroid hormone levels.

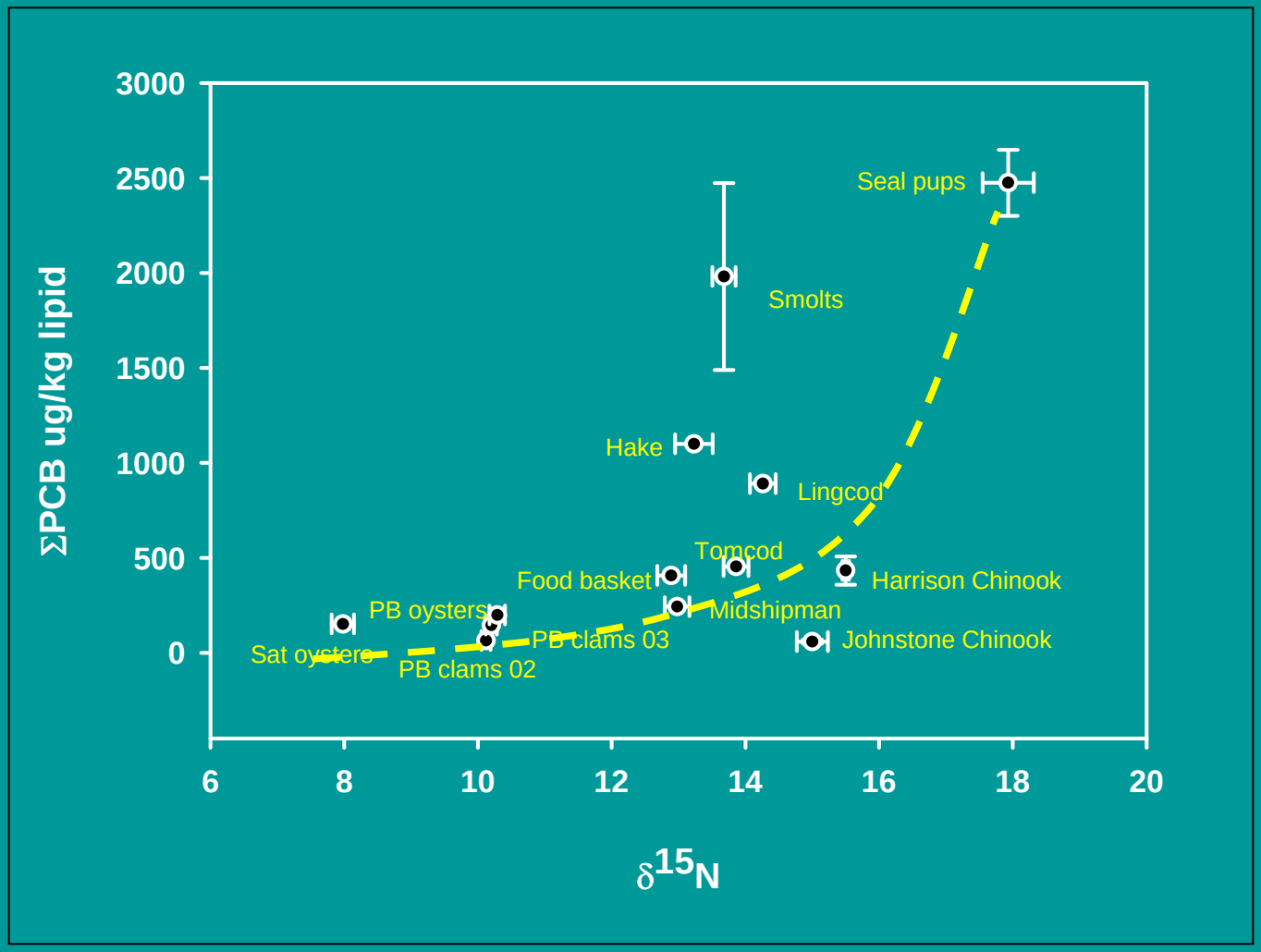
PDV mass mortalities in Europe

- *Epidemiological studies:*
  - reduced reproduction associated with PCBs;
  - endocrine disruption;
  - genomic upregulation.

- *Marine mammals inhabiting contaminated regions:*
  - decreased reproductive success;
  - increased incidence of disease.

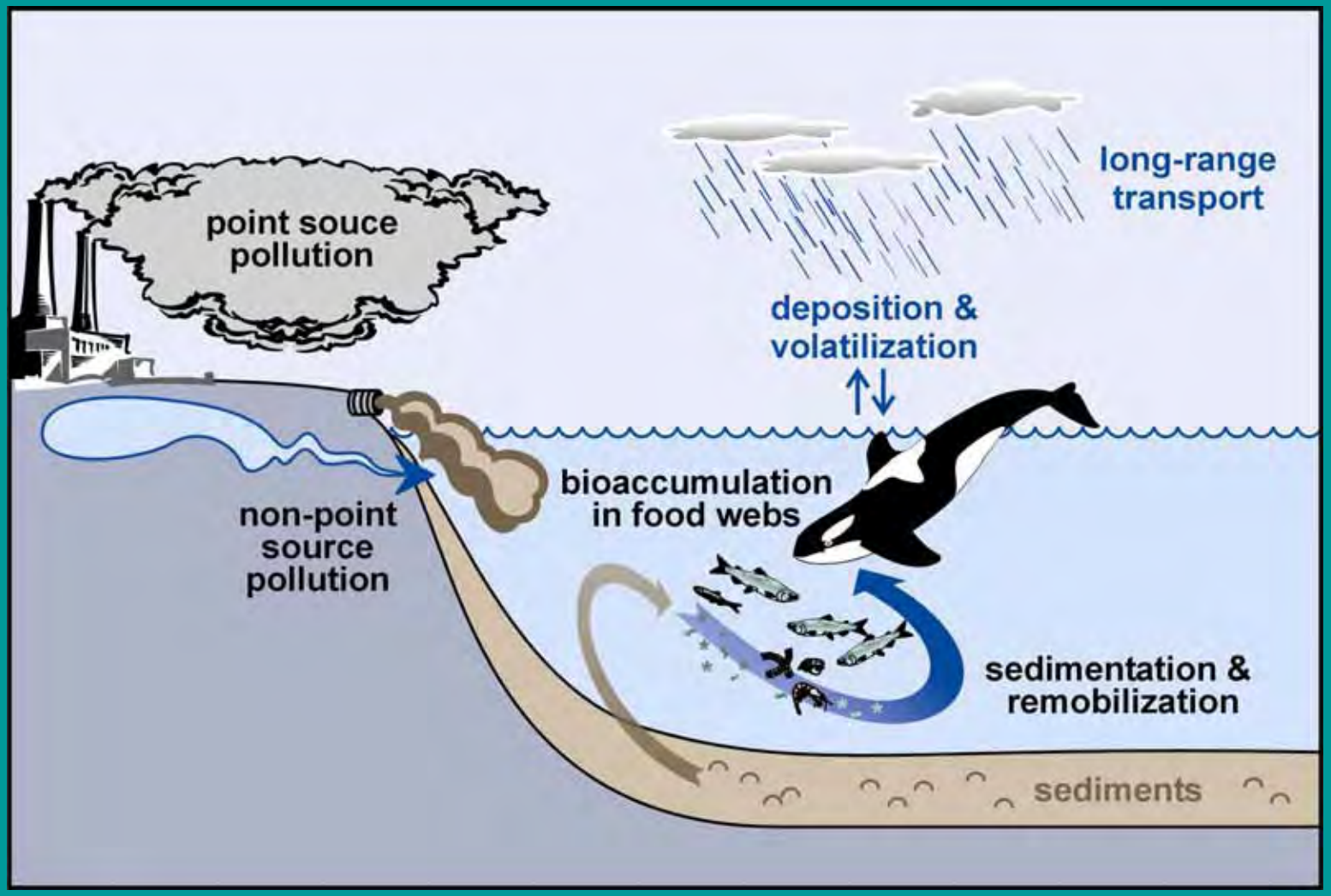
Contaminant exposure varies as a function of the *biology and ecology* of the species in question

PCB concentrations increase in the harbour seal food chain as revealed by stable isotopes of ^{15}N: ^{14}N

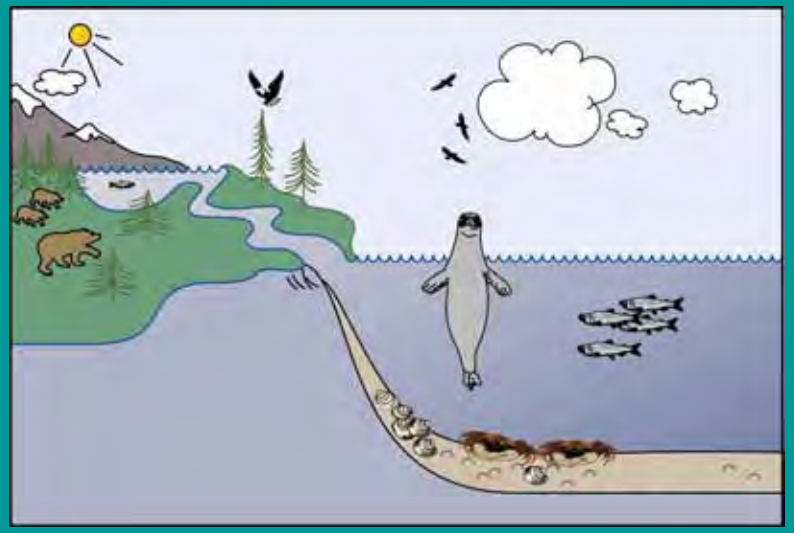


(Cullon et al, in prep)

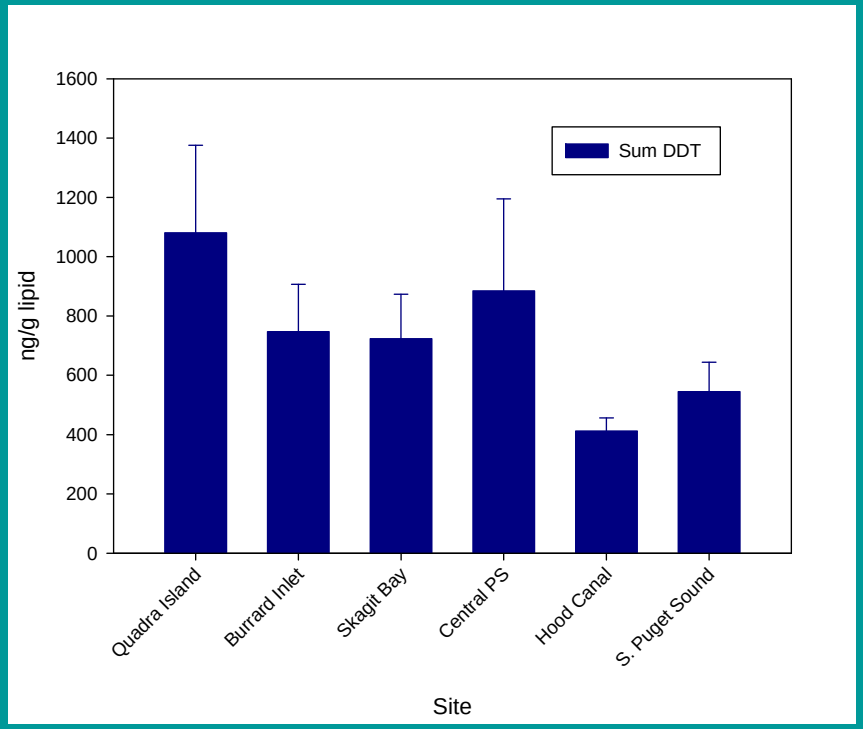
In addition to *feeding ecology*, proximity to *sources* contributes to contaminant exposure in marine mammals

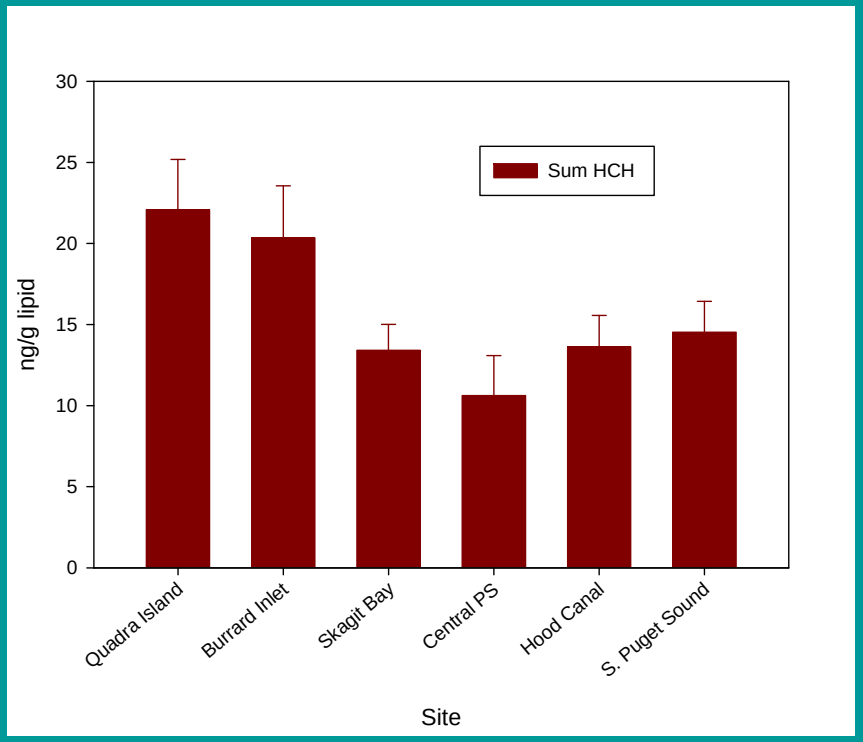


Southern British Columbia (Canada) and northern Washington (USA) are home to 7 million people and 50,000 harbour seals

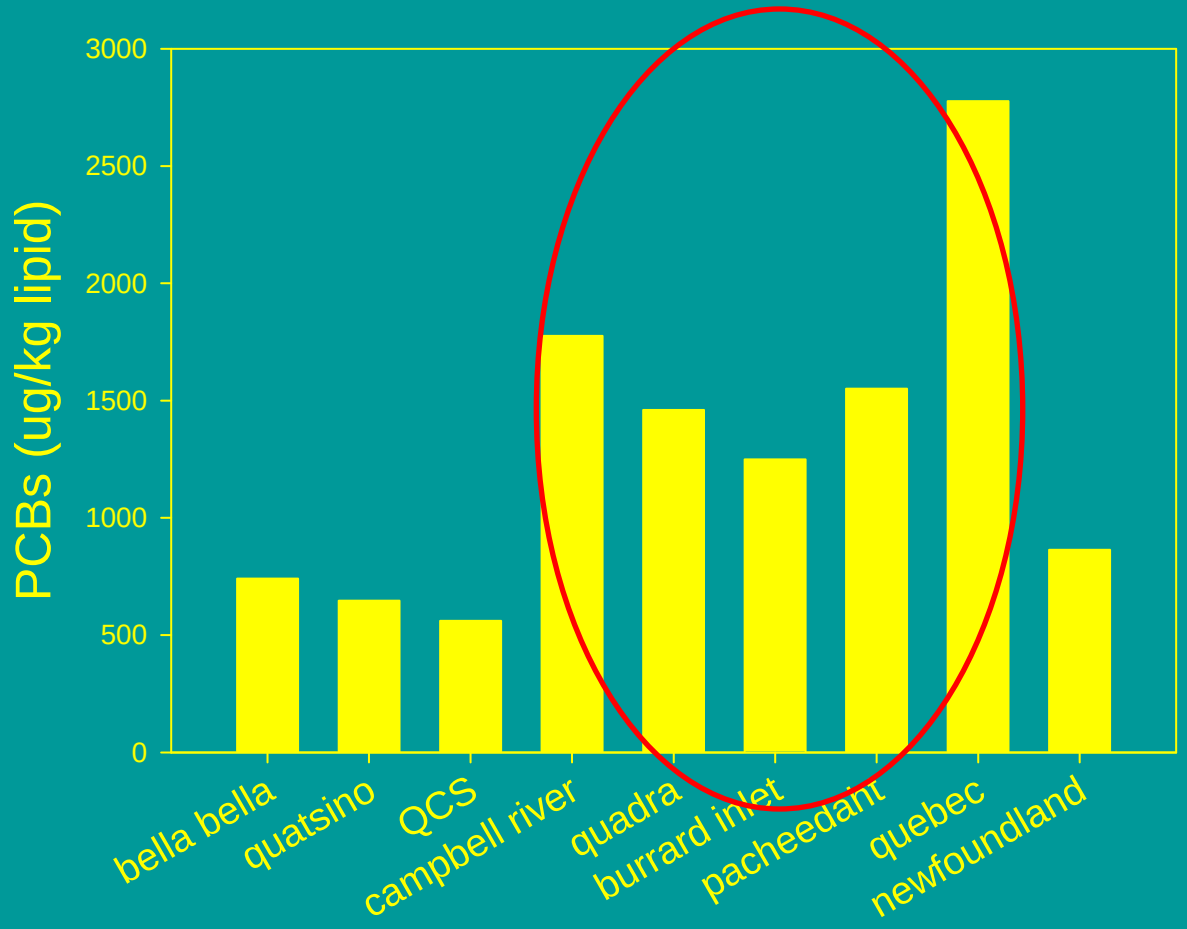


Some legacy POPs are higher in seals at remote sites, underscoring role of long range transport processes: DDT and HCH



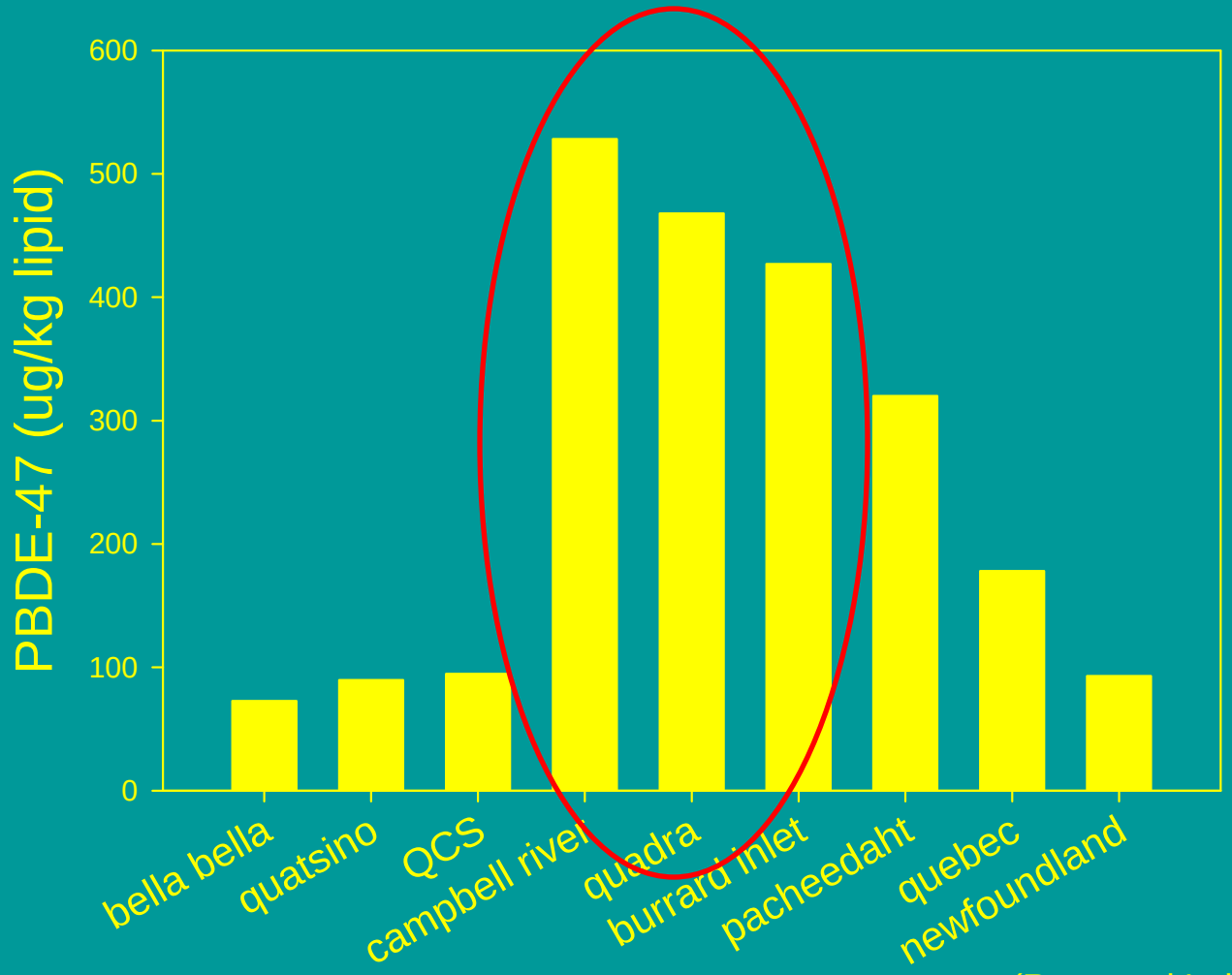


Despite longstanding regulations, industrial PCBs are still higher in seals near urban areas



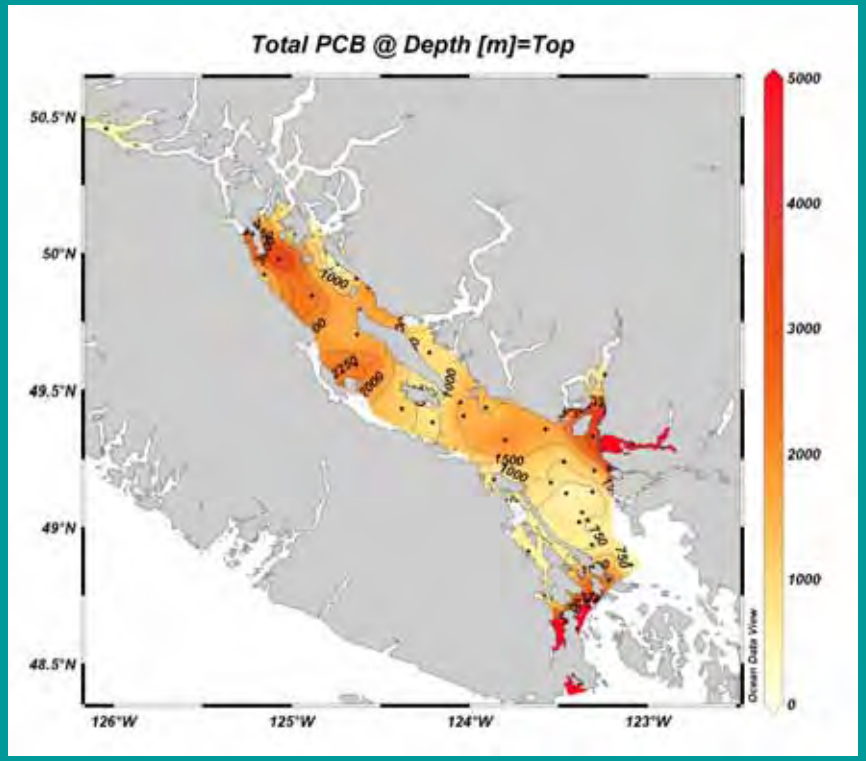
(Ross and Lebeuf in prep 2011)

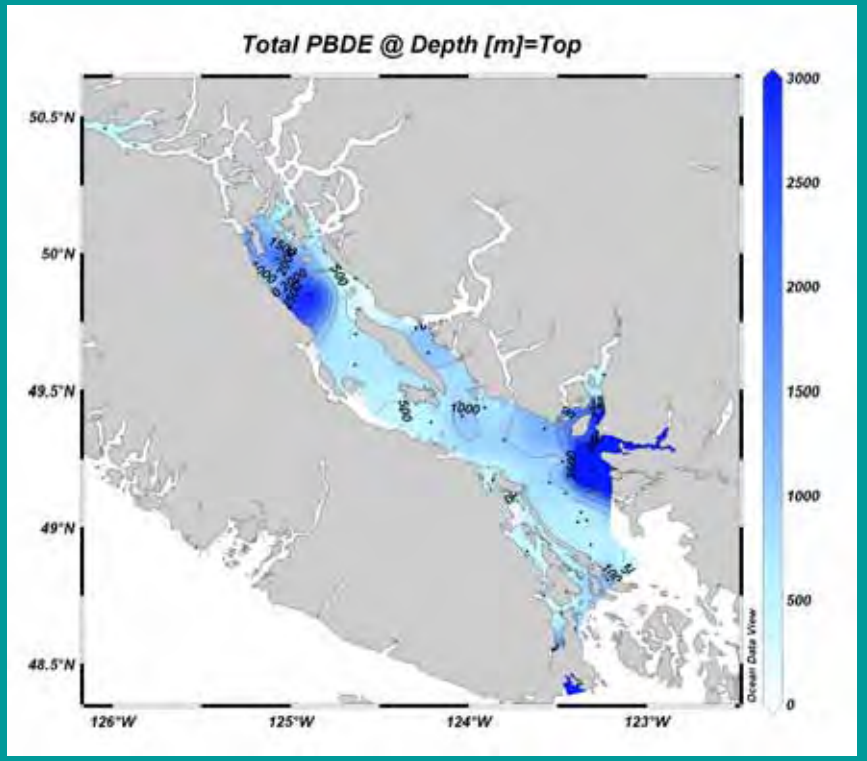
Accentuated uptake of “currently used” PBDEs in Canadian harbour seals near municipal sewage outfalls



(Ross and Lebeuf in prep 2010)

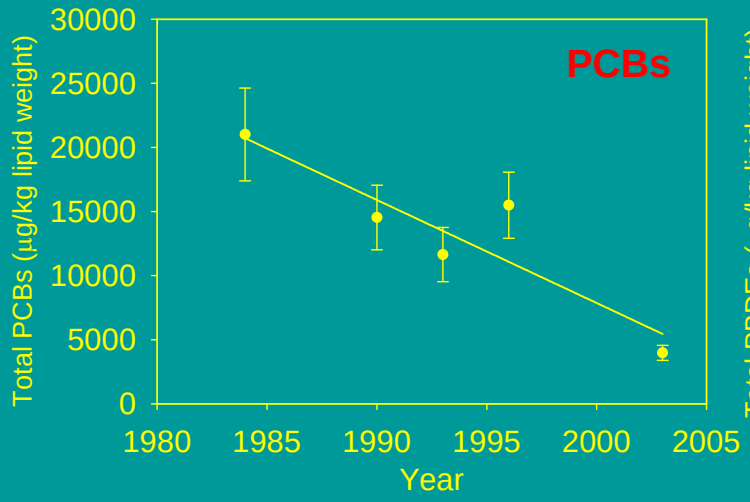
Sediment concentrations point to historic (PCB) and current (PBDE) sources in the Strait of Georgia, and reveal the vulnerability of coastal environments to land-based pollution

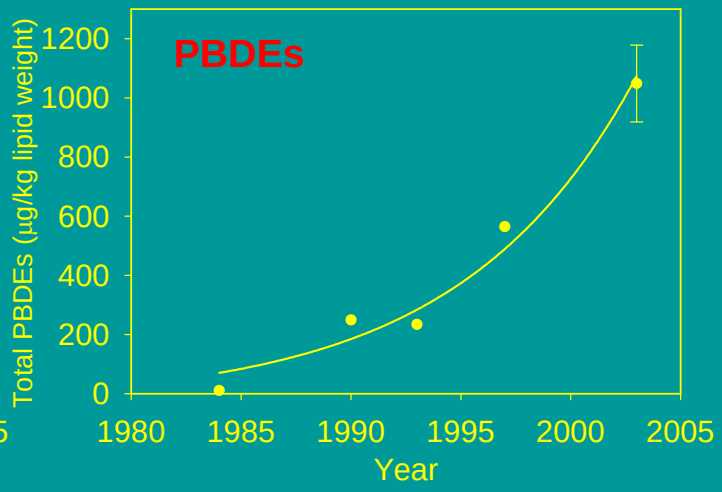


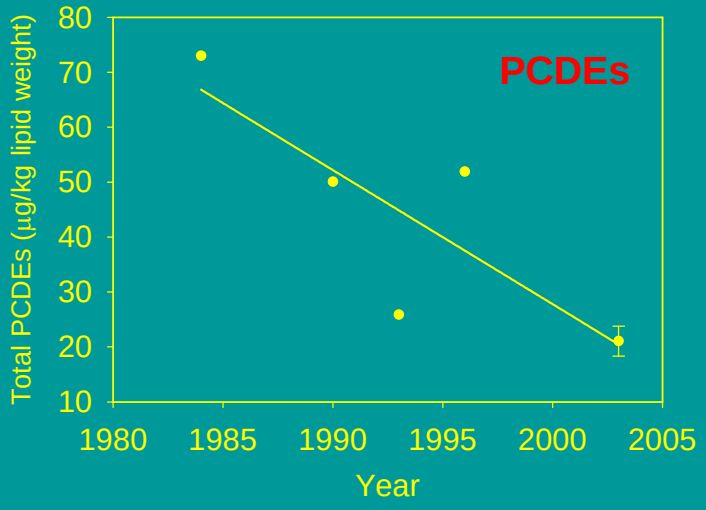


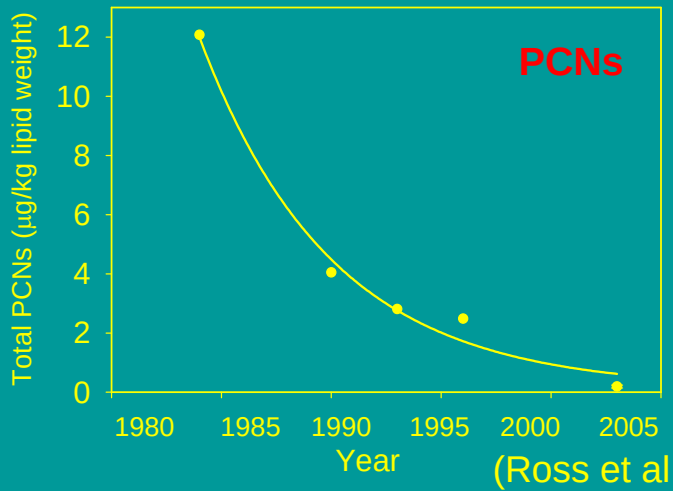
(Grant et al, 2010)

Monitoring of harbour seals over time reveals positive environmental response to regulations and also identifies emerging concerns









(Ross et al, in prep)

‘Cleaner’ crabs: Regulations reduce inputs of highly toxic dioxins and furans by 95% into coastal waters in British Columbia

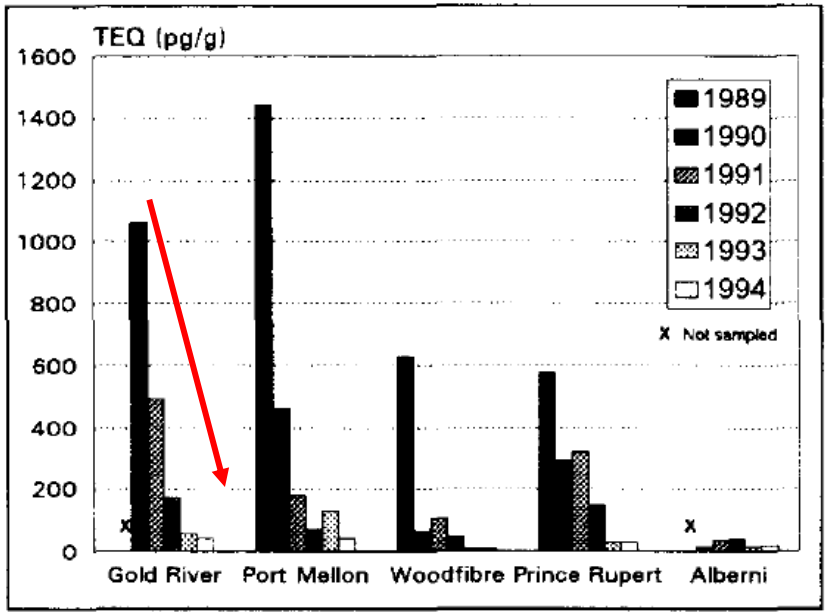


Figure 4: Dioxin and furan TEQs in Dungeness crab hepatopancreas at pulp mill outfall sites on fjords and the channel at Prince Rupert.

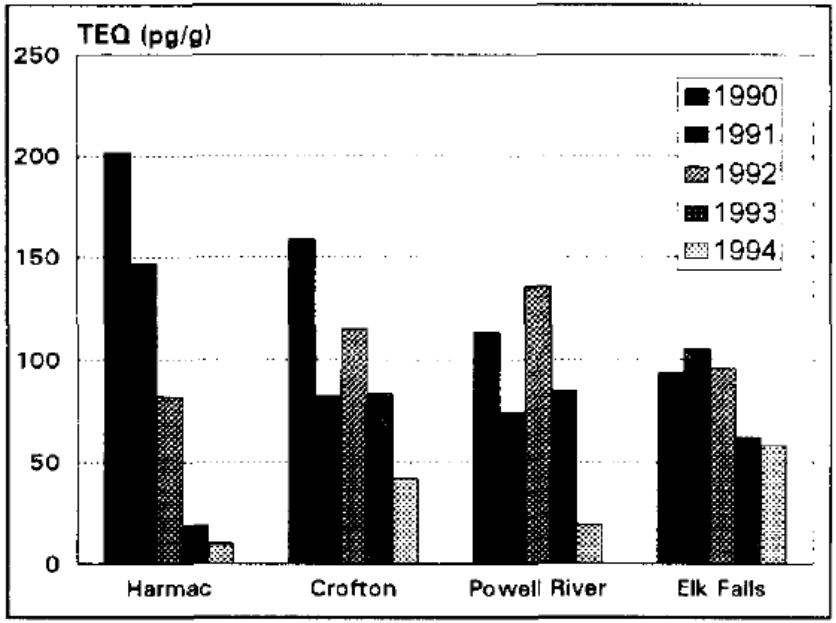


Figure 5: Dioxin and furan TEQs in Dungeness crab hepato-pancreas at pulp mill outfall sites on relatively exposed coasts.

(Hagen et al 1997)

Source controls stopped the increase in PBDE concentrations in marine seabirds, but not (yet) in birds with a more nearshore ecology

(Elliott et al 2005)

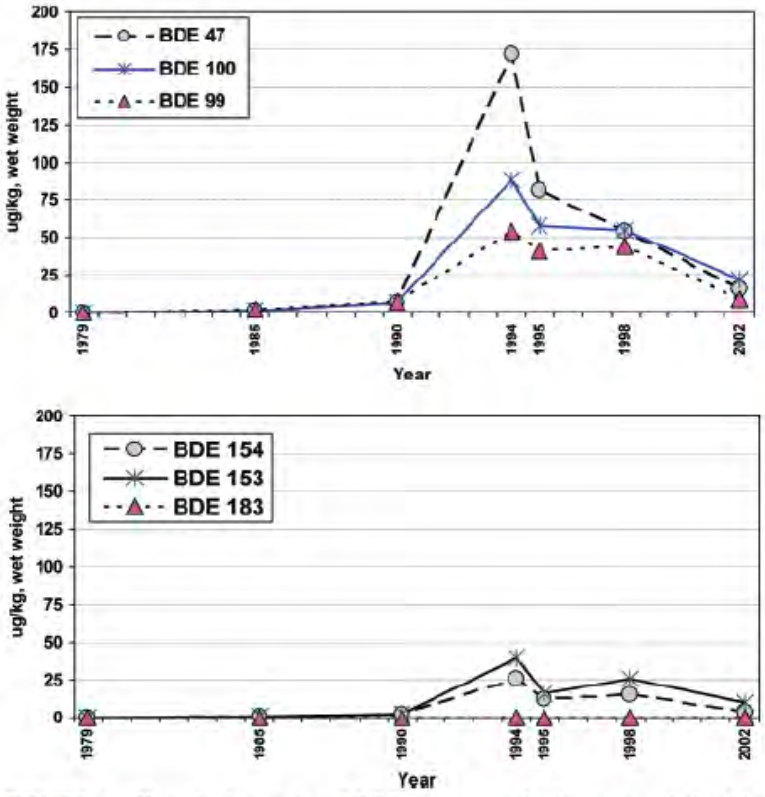


FIGURE 3. Trends in major PBDE compounds in eggs of double crested cormorant collected at Mandarte Island, British Columbia, Canada, 1979–2002. Laboratory analysis at NWRC, 1979, 1994, 1998; at AXYS, 1985, 1990, 1995, 2002.

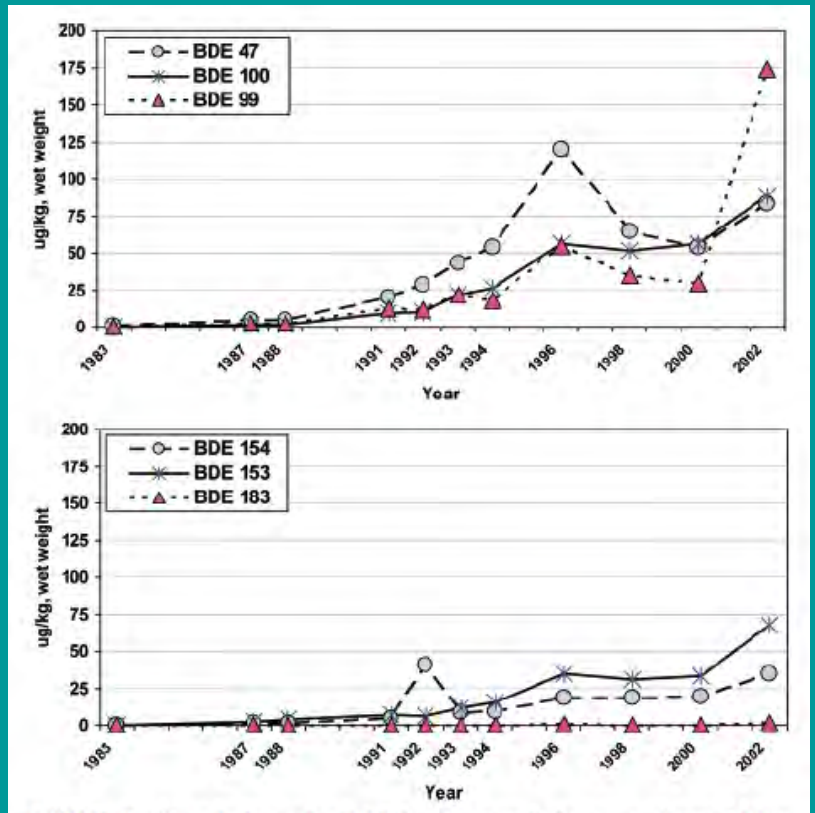


FIGURE 2. Trends in major PBDE compounds in eggs of great blue herons collected at a colony in the estuary of the Fraser River, British Columbia, Canada, 1983–2002 (no. 1, Figure 1). Chemical analysis at NWRC 1983–2000, at AXYS 2002 (see text for details).

Conclusions

- Marine mammals provide an integrated measure of food web contamination;
- Understanding biology and ecology of the species is key to interpreting trends;
- Contaminant fate in the coastal is driven by physico-chemical interactions;
- Monitoring of sentinel species can reveal effectiveness of regulations.

Coastal food webs: The special vulnerability of those marine mammals, seabirds and peoples that need an abundance of healthy foods from the ocean

Thank you

- Species at Risk Act Science Fund (Fisheries and Oceans Canada), Georgia Basin Action Plan (Environment Canada), Washington Department of Fish and Wildlife, SeaDoc Society
- Graeme Ellis, Neil Dangerfield, Lance Barrett-Lennard, Norman Crewe, Cory Dubetz, Robie Macdonald,
- Photo credits Graeme Ellis, Brian Gisborne, Peter S. Ross, John K.B. Ford, Ingrid Visser