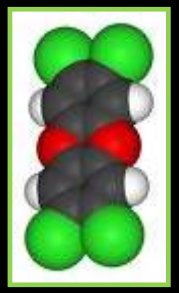
Atmospheric Deposition as a Source of Polychlorinated Biphenyls (PCBs) to the Willamette Basin

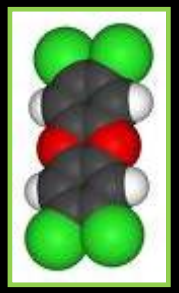
Bruce K. Hope, Ph.D.
Oregon Department of Environmental Quality
Portland, Oregon

U.S. EPA Workshop
PCBs in the Lower Columbia and Willamette Rivers
Portland, Oregon
July 30, 2009

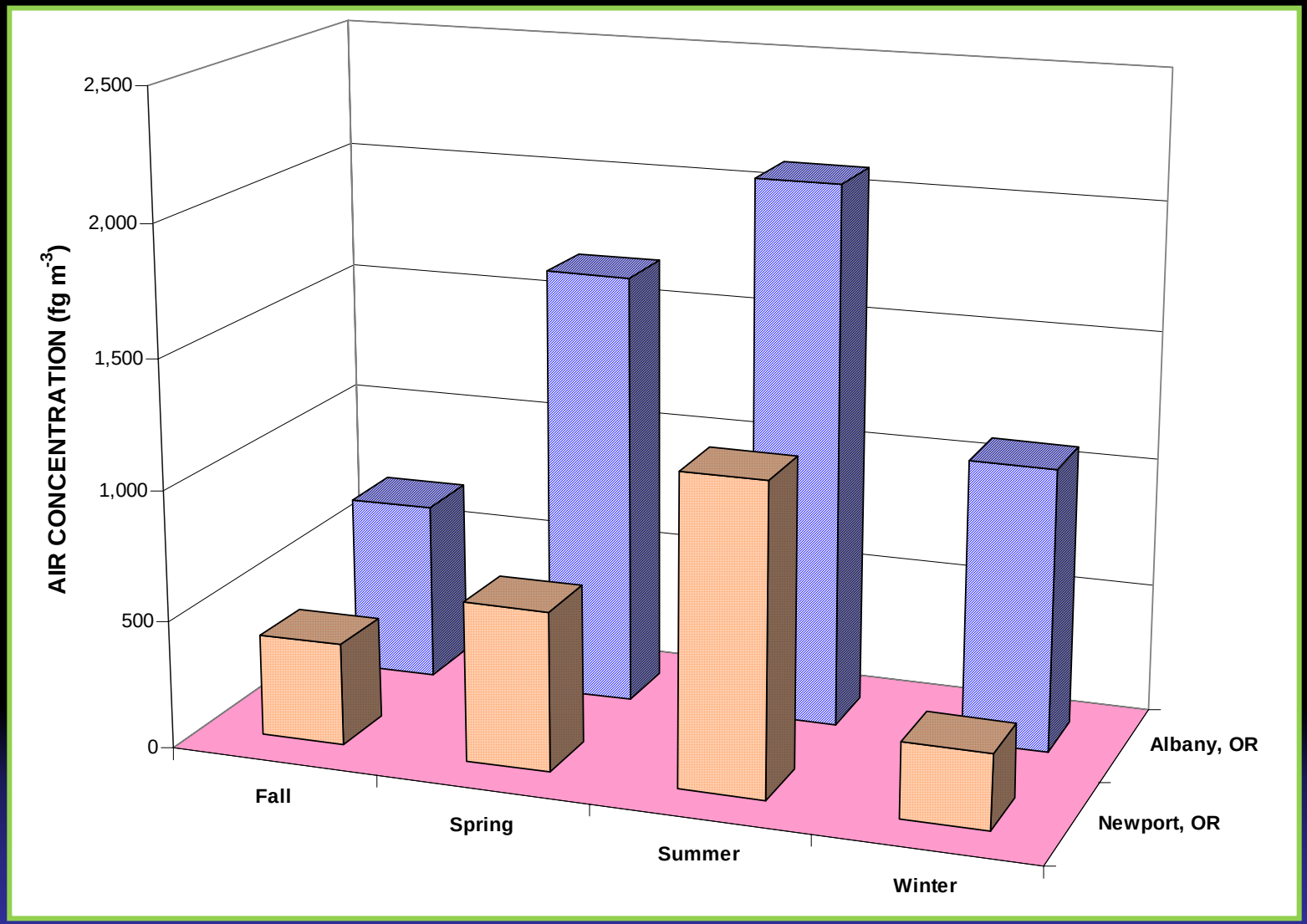


PCBs in the Willamette Basin

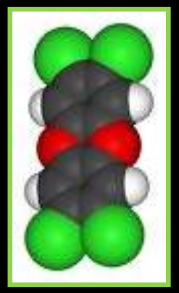
- In fish throughout the main stem Willamette River
- In air samples taken in the Basin and on the adjacent coast
- In soil samples taken within the Basin
  - 91 of 209 congeners detected
  - Relationship between soil & airborne congeners
- Also reported in sediment, invertebrates, birds
  - Limited congener-specific data



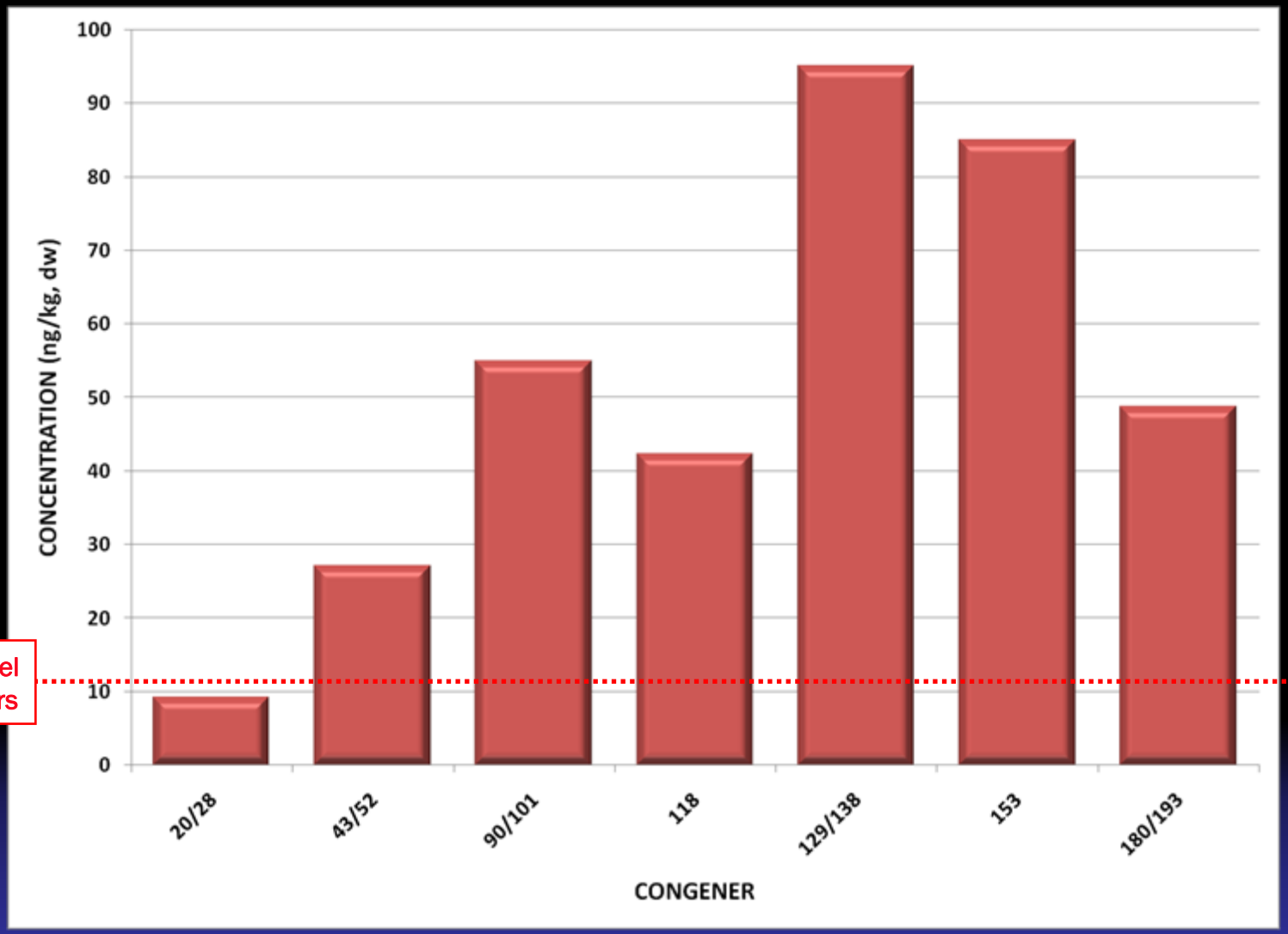
PCB-118 in Coastal & Basin Air



USEPA NDAMN 2000-02



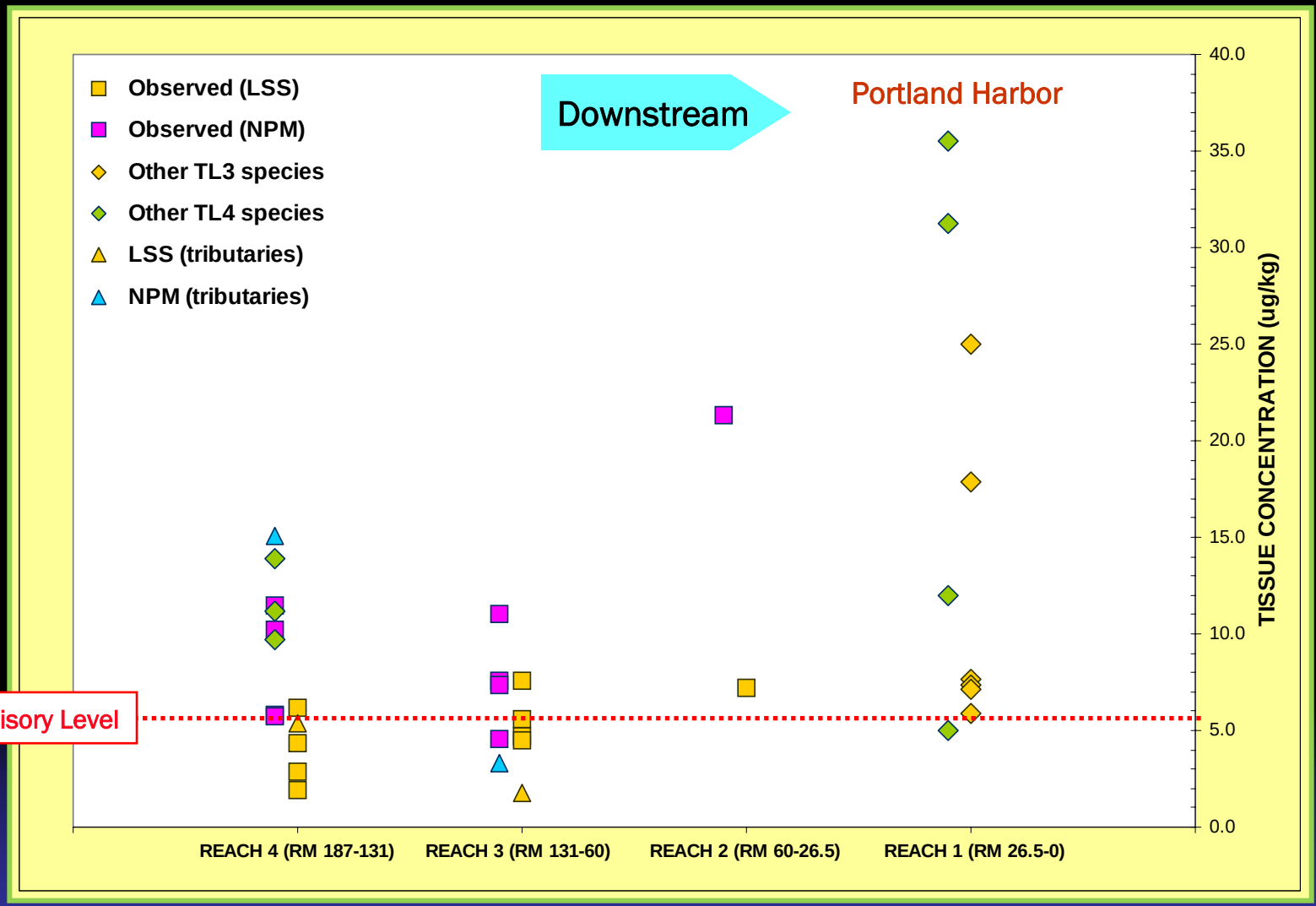
PCBs in Basin Soil

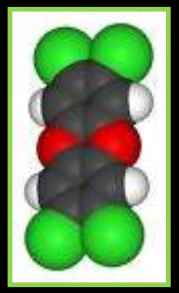


Average Level
All Congeners

USEPA 2007 (EPA/600/R-05/043F)

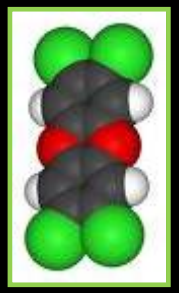
PCB-118 in Fish





PCBs in the Basin

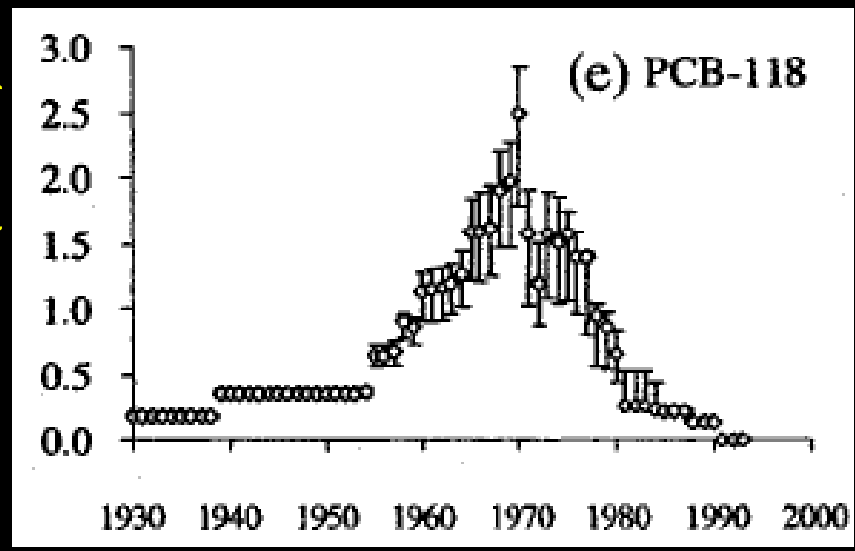
- Sources?
  - Wide spatial distribution of PCBs
    - Localized “hot spots” not explanatory
      - Portland Harbor
      - Residential combustion (burn barrels)
  - Suspect role for global legacy sources
    - Large and wide-spread source
      - 1.5 million mt PCBs produced, about 50% “emitted”
    - Global transport a concern for EU, Russia, Canada
- Mechanism?
  - Must explain levels in various media & receptors
    - Direct discharge to only one media inadequate
    - Multiple transport & fate processes in multiple media



Scenario

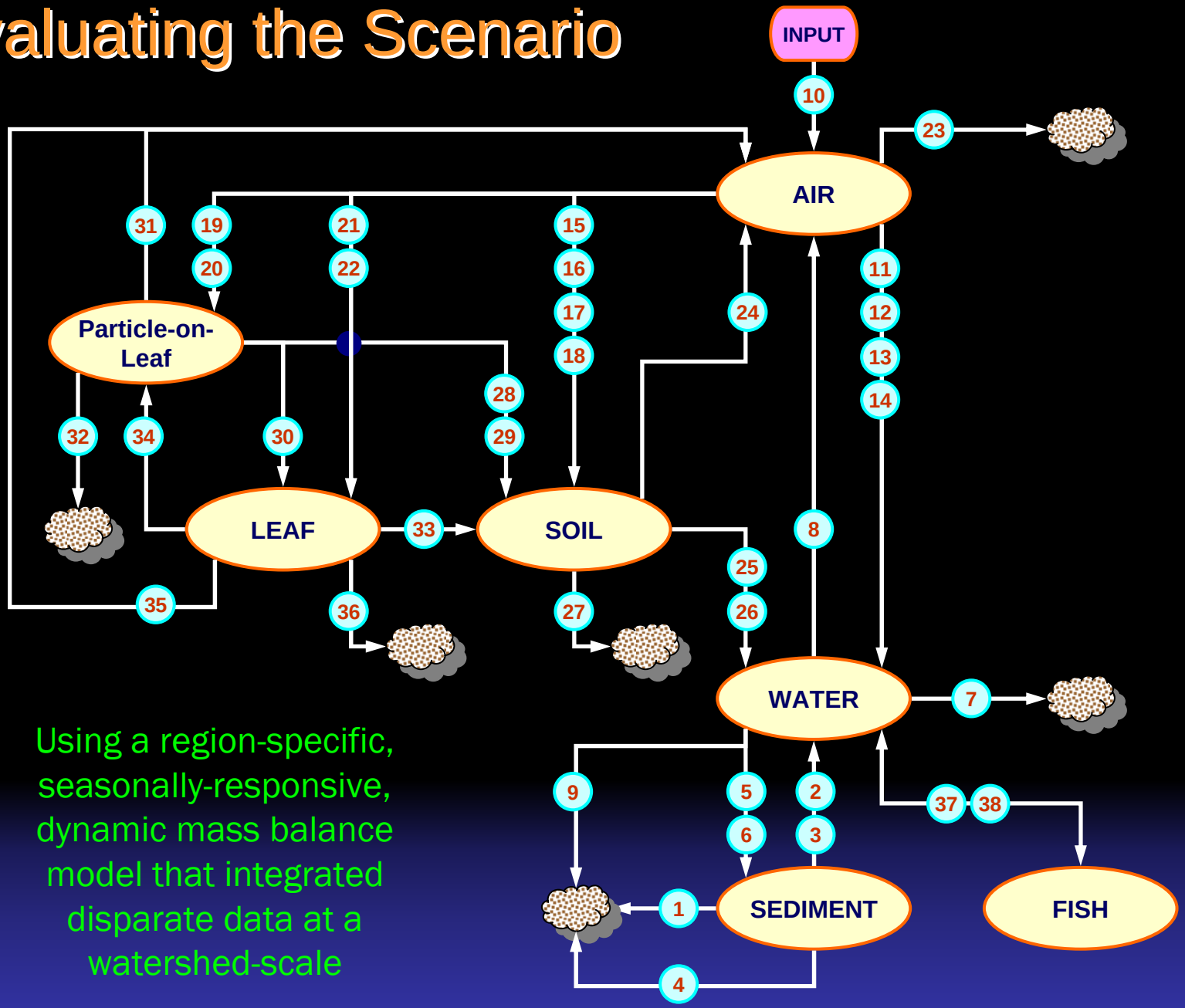
- PCB-118 as example
  - Toxicologically relevant
  - Modeled by others
  - Present in Basin
- Global production
  - Sharp rise, peak, decline characteristic of many PCB congeners
  - 95 million pounds produced
- Assume 1° emissions mirrored production

43,000 mt total production
18 - 3047 mt emitted
<1 - 7% of total emitted

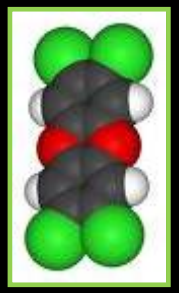


Breivik et al. 2002. *Science of the Total Environment* 290: 181-198

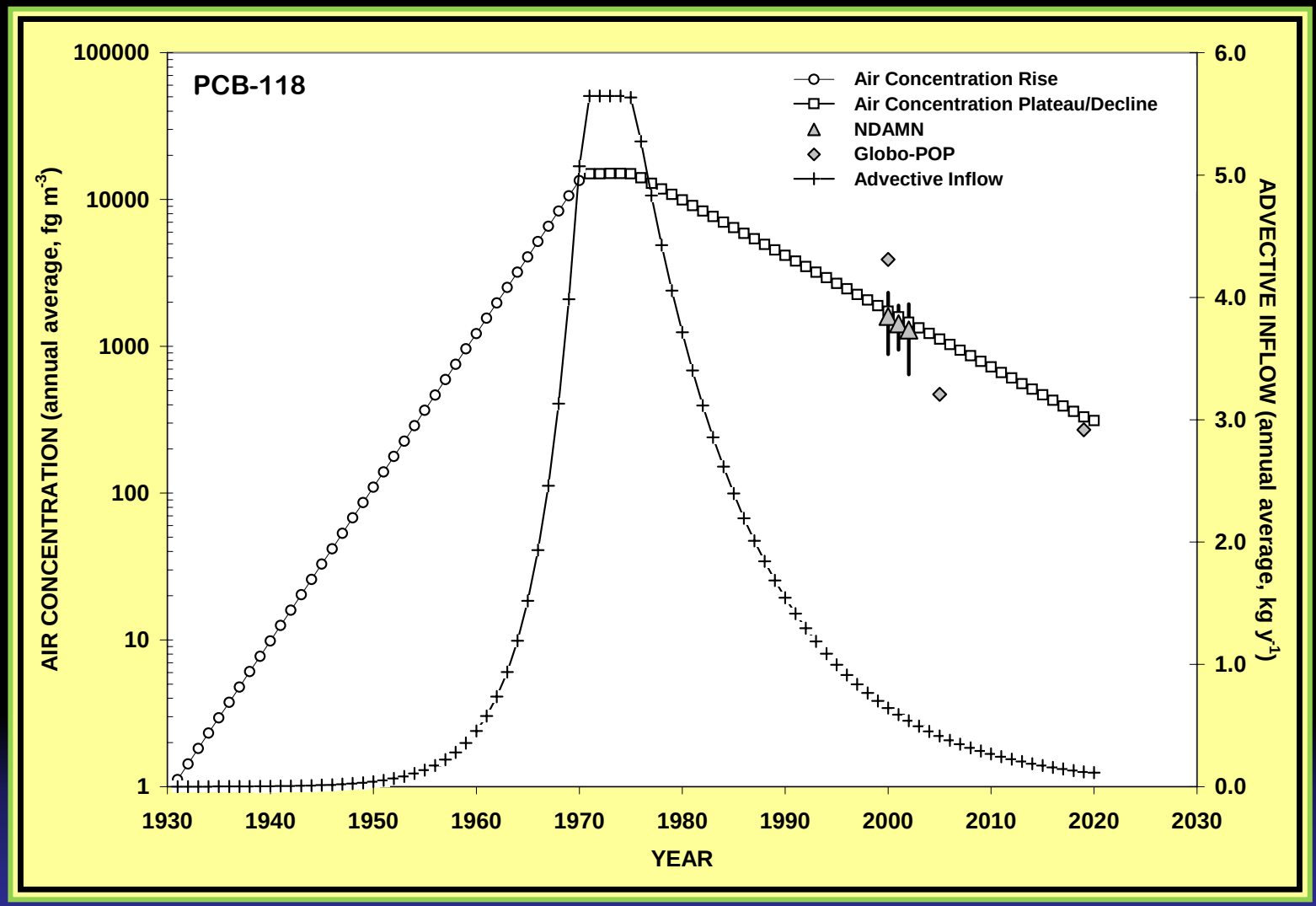
Evaluating the Scenario

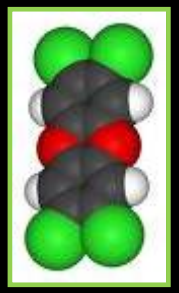


Using a region-specific, seasonally-responsive, dynamic mass balance model that integrated disparate data at a watershed-scale



Modeled Air Concentrations

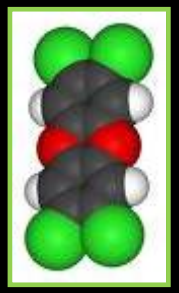




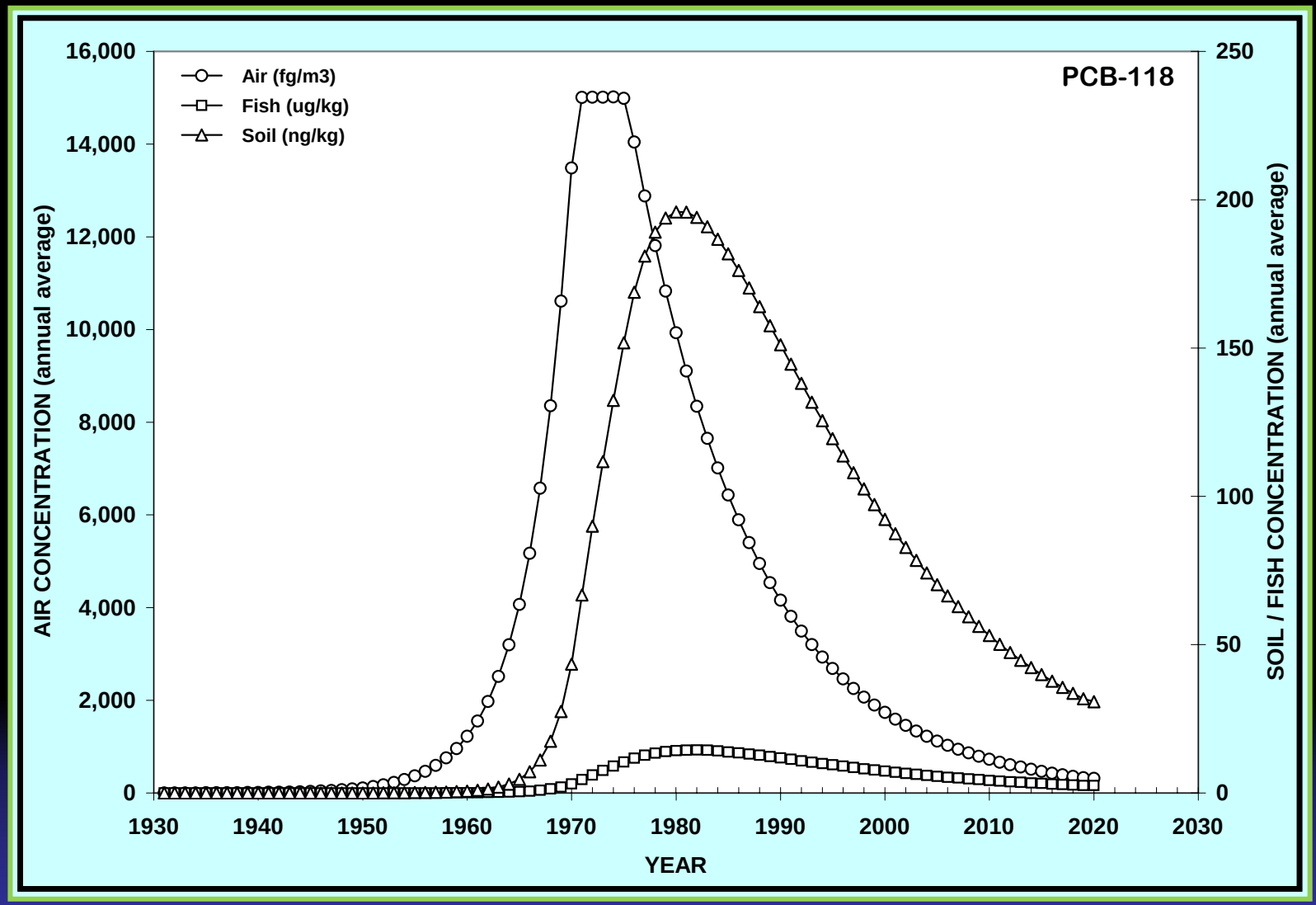
Modeled vs. Observed Levels

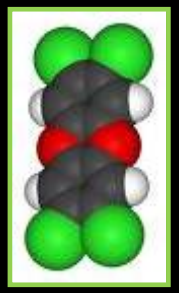
MEDIA (units)	MODEL ESTIMATE (mean ± 1 sd)	OBSERVED (mean ± 1 sd)
AIR ($fg\ m^{-3}$)	1557.2 ± 88.1 {2001}	1437.9 ± 590.6 {2000-02}
SOIL ($ng\ kg^{-1}$)	49.8 ± 0.8 {2003}	42.4 {2003}
WATER ($pg\ L^{-1}$)	10.0 ± 4.0 {2003}	7 -15 {2003}
SEDIMENT ($\mu g\ kg^{-1}$)	0.05 ± 0.01 {2003}	<0.001 {limited data}
FISH (trophic 4) ($\mu g\ kg^{-1}$)	5.9 ± 0.5 4.2 ± 0.4	9.9 ± 4.8 {1993} 4.6 ± 2.6 {2000}
VEGETATION ($ng\ kg^{-1}$)	1900 ± 100 {2003}	55 - 17500 * {1999-2000}

* Davidson, et al., ES&T 37(2): 209-215, 2003
Became available after modeling was completed



Trends in Media Concentrations





Discussion

- Reasonable agreement between observed and estimated levels for advective input only
  - Direct discharges to land or water unlikely sources
- Inputs from diffuse global sources sufficient
  - Possible role for transpacific anthropogenic sources
  - Precipitation depth is key factor
    - Columbia vs. Willamette Basin
  - Episodic biomass burning events (forest fires)
    - Local source of PCBs stored in SOM and vegetation
- Portland Harbor remains a separate issue
  - Lowest achievable cleanup influenced by on-going global inputs?