Current Understanding of PBDEs In San Francisco Bay

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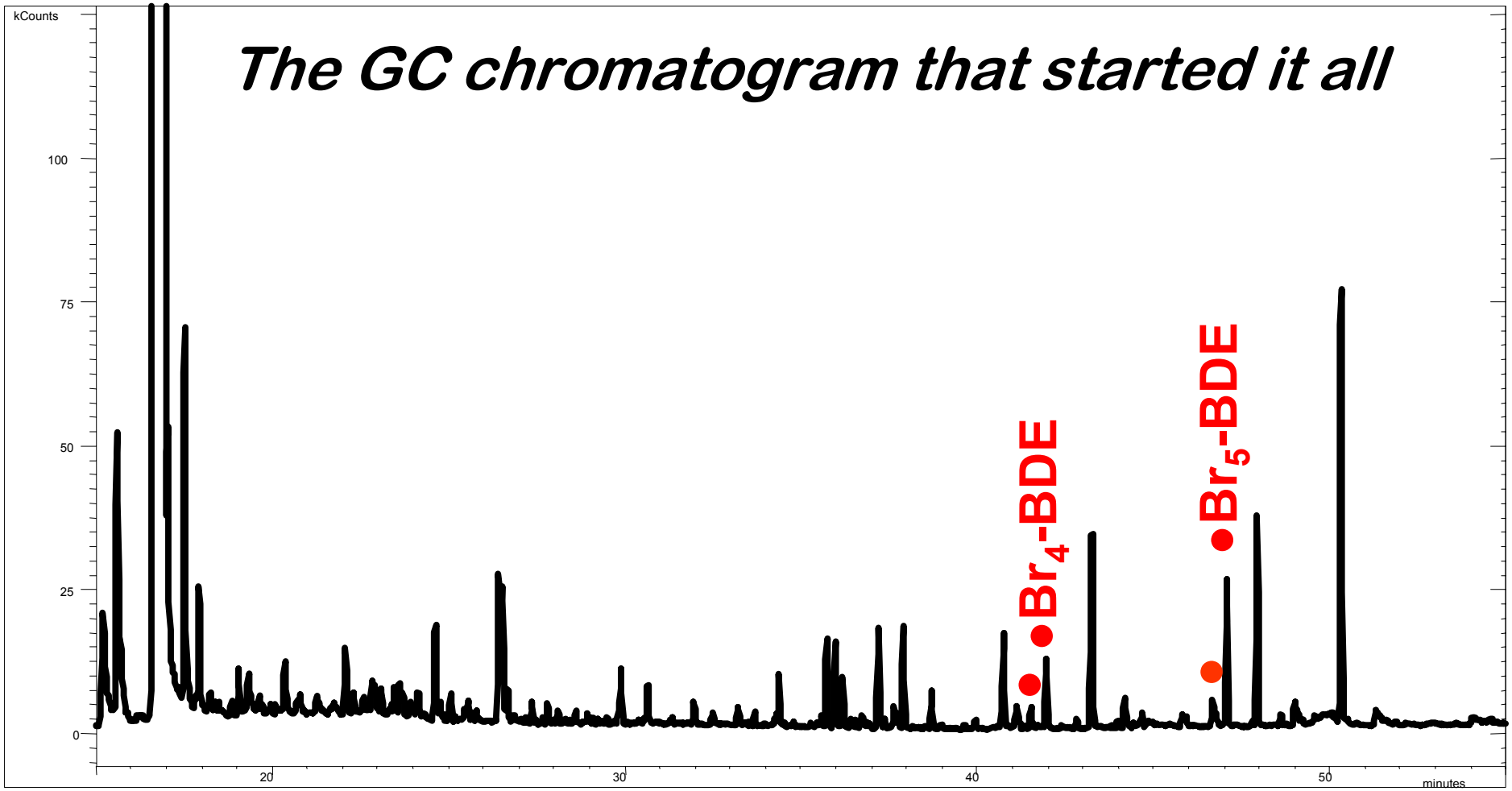
Based on a cooperative effort between

RMP and CEP

Special Thanks to

Chris Werme, John Oram, Lester McKee, Don Yee,

Myrto Petreas, and Allison Luengen



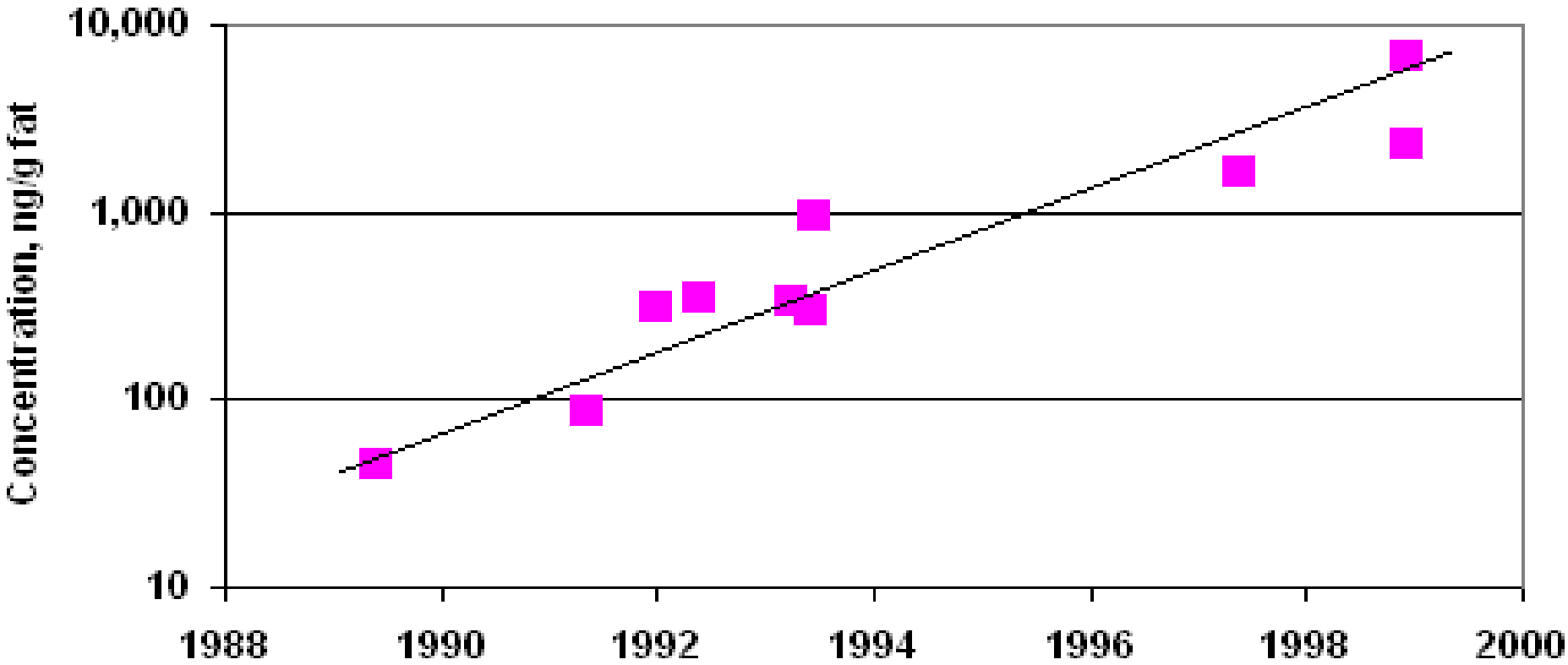
GCMS chromatogram of a 1994 water sample from Sacramento River.

PBDEs containing 4 and 5 Br atoms are highlighted (Oros, 2002)

The plot that sounded the alarm!

PBDEs in SF Bay Harbor Seal Blubber

Levels doubled every 1.8 years during the '90s.



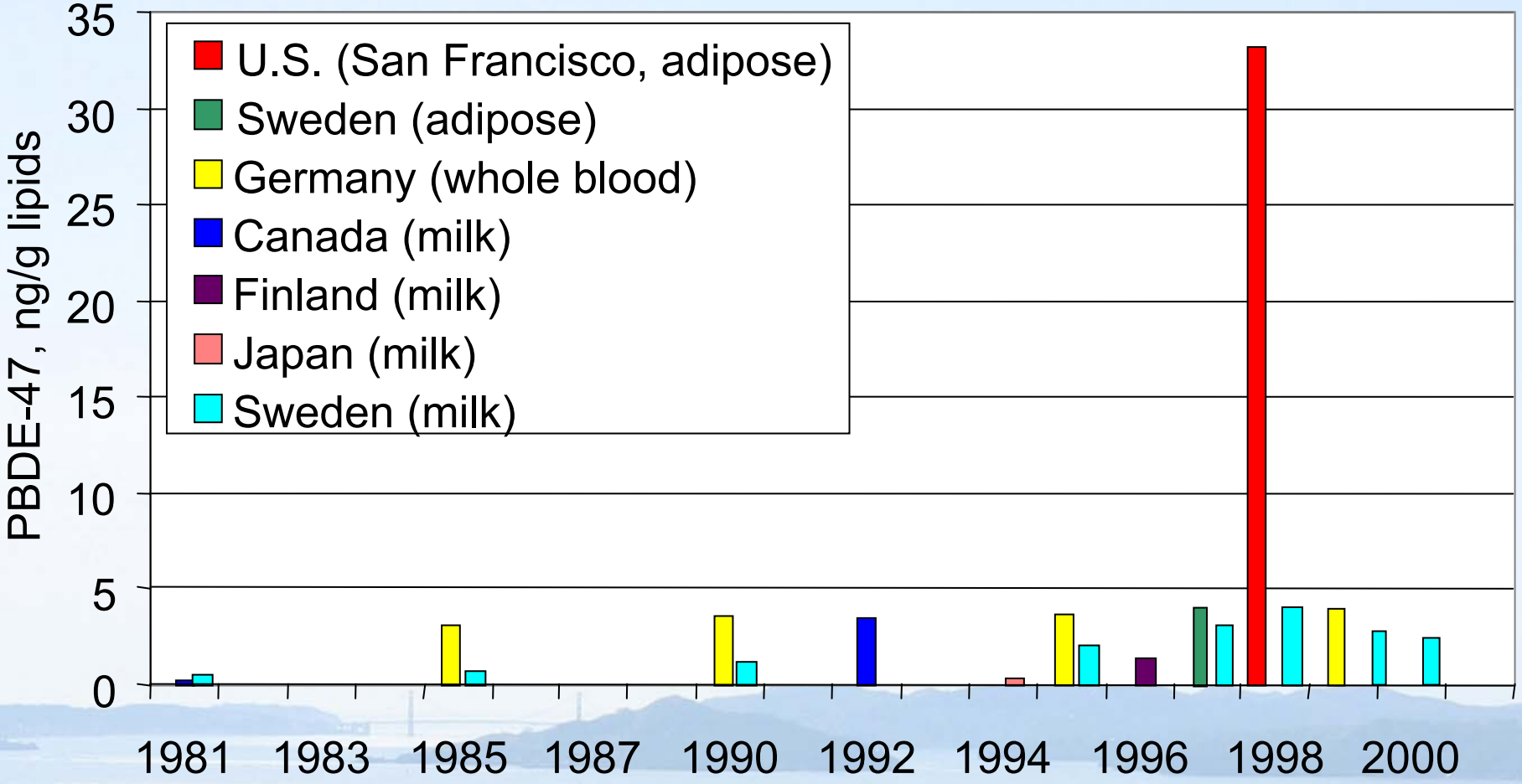
Source: She et al. (2002)

Potential Health Risks of PBDEs

- Disrupt endocrine systems, cause developmental effects, and are potential carcinogens
- Rodent body burdens associated with developmental effects are only ~10x higher than the total body burdens in the high end of general population in North America
- Top 5% of current human exposure in US is ≥ ~400 ng/g lipid (~0.1 mg/kg body weight)
- Significant dose causing developmental effects:
  - Mice: ≤0.8 mg BDE99/kg
  - Rats: ≤0.7 mg BDE47/kg

Source: Lisa Birnbaum, NHEERL/ORD, US EPA Office of Water

PBDE-47 in Human Tissues (lipid normalized)

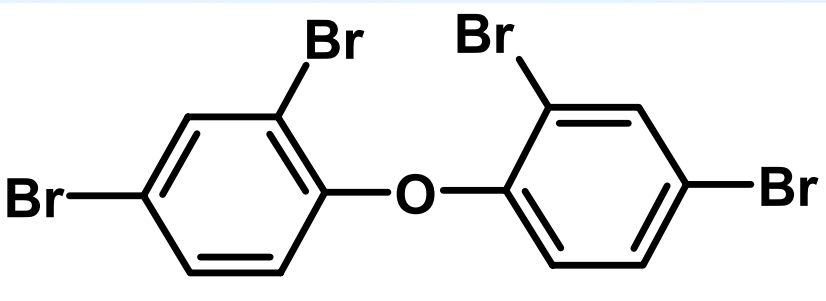


Source: Kim Hooper et al. Cal EPA

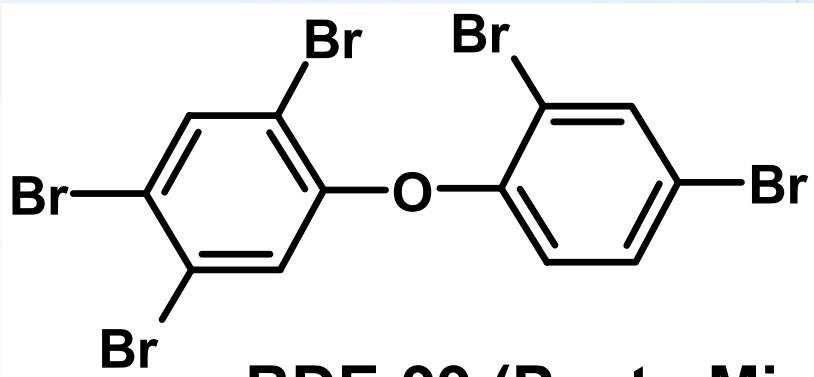
Key facts about PBDEs

- Chemically similar to PCBs and dioxins
- Added to many consumer products, and ubiquitous in the environment

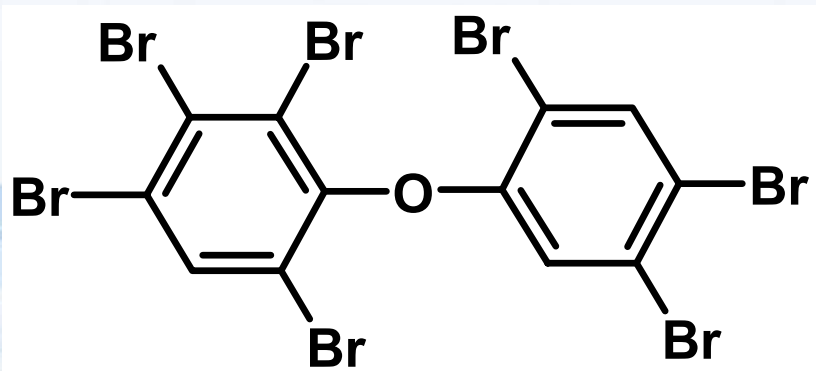
Three commercial formulations/ 209 possible congeners



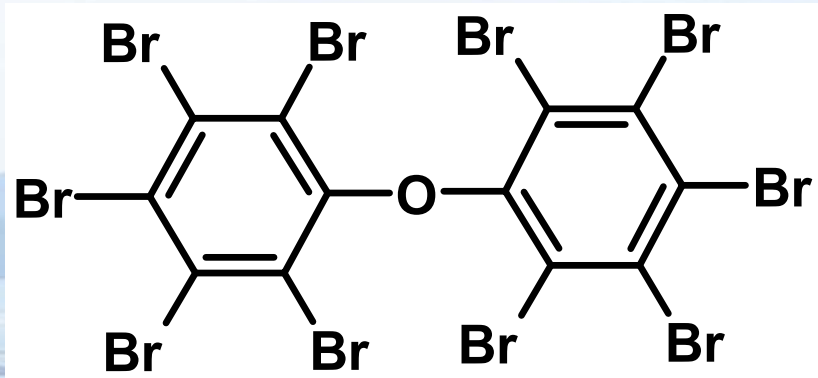
BDE-47 (Penta-Mix)



BDE-99 (Penta-Mix)



BDE-183 (Octa-Mix)



BDE-209 (Deca-Mix)

Total Market Demand in Americas

In use since the 1970s

PBDE Mixture	Million lbs/yr (2001)	% of World's Use	Major Uses
Penta-	16	95	Furniture; auto seats, carpet pads
Octa-	3	40	Automobiles, computers, appliances
Deca-	54	44	Electronics, upholstery
Source: Bromine Science and Environmental Forum, www.bsef.com			

Note: PCB production peaked in 1970 at 86 million lbs/yr

PBDE Watch

2002: RMP begins monitoring PBDEs

2003: AB 302 - Wilma Chan (Oakland-D) bans Penta- and Octa- PBDEs in CA

2006: CA begins phase-out of Penta- and Octa- (but not Deca-BDEs)

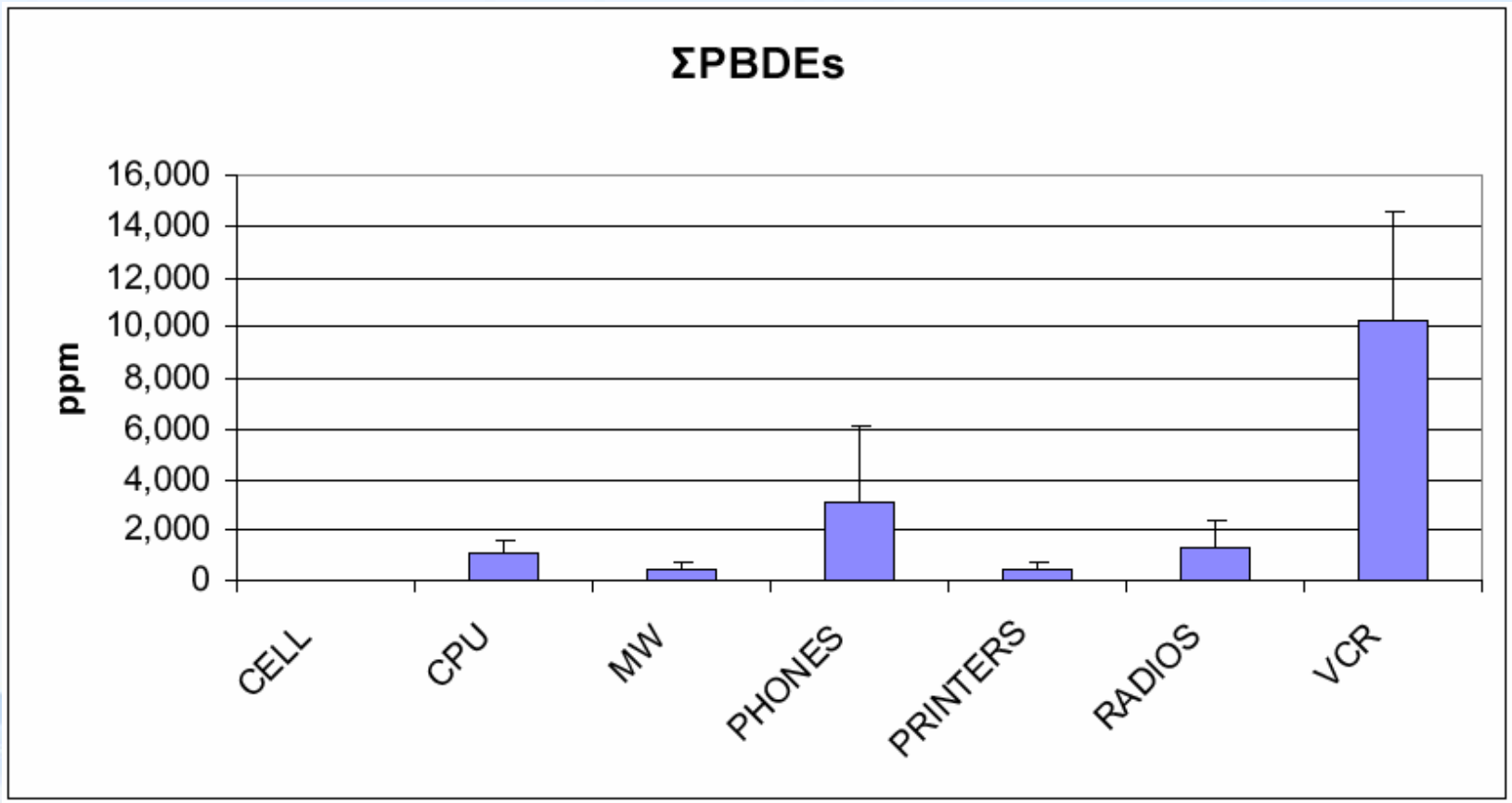
Our first conceptual model

- Concentrations of PBDEs are increasing rapidly.
- Levels are at or near levels of concern for human health.
- Are PBDEs the next PCB-like problem?

Our main questions

- Where are PBDEs coming from?
- How will levels change after the bans?
- How do PBDEs compare with PCBs?

Sources: discarded electronics

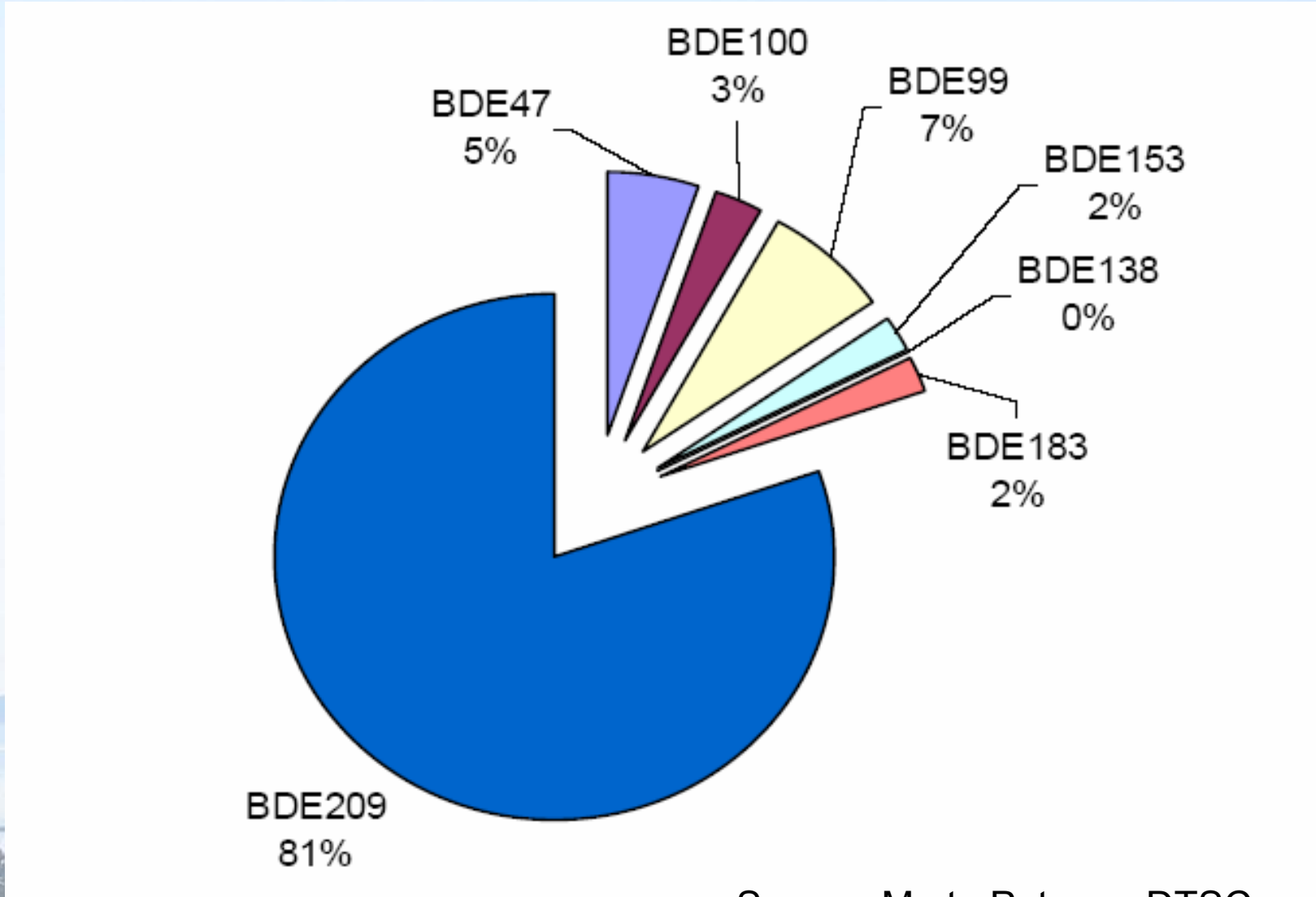


Source: Petreas and Oros (2006)

Sources: Auto Shredder Waste

Photo credit: Allison Luengen, UCSC

Auto Shredder Waste PBDE Profile



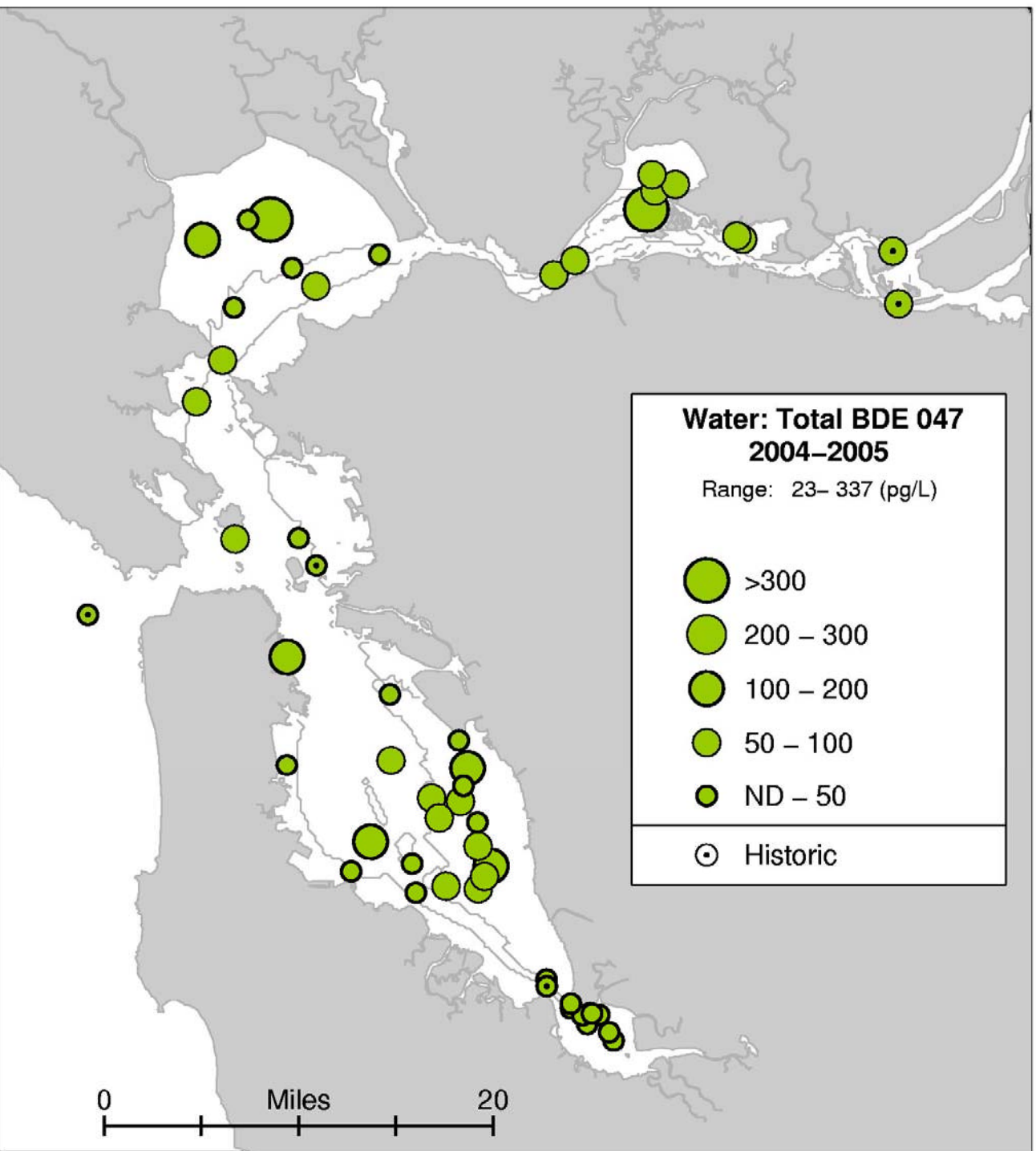
Source: Myrto Petreas, DTSC

Annual Loading Estimates

PBDE loads are 3-11x PCB loads.

Source	PBDE (kg/yr)	PCB (kg/yr)
Wastewater	37	2.5
Small tributaries	~64	9-15
Delta	~11	6-23
Atmosphere	1-2	-7
Total	**~114**	**10-34**

Sources: RMP special study on wastewater discharges; L. McKee; CARB (2005); D. Yee



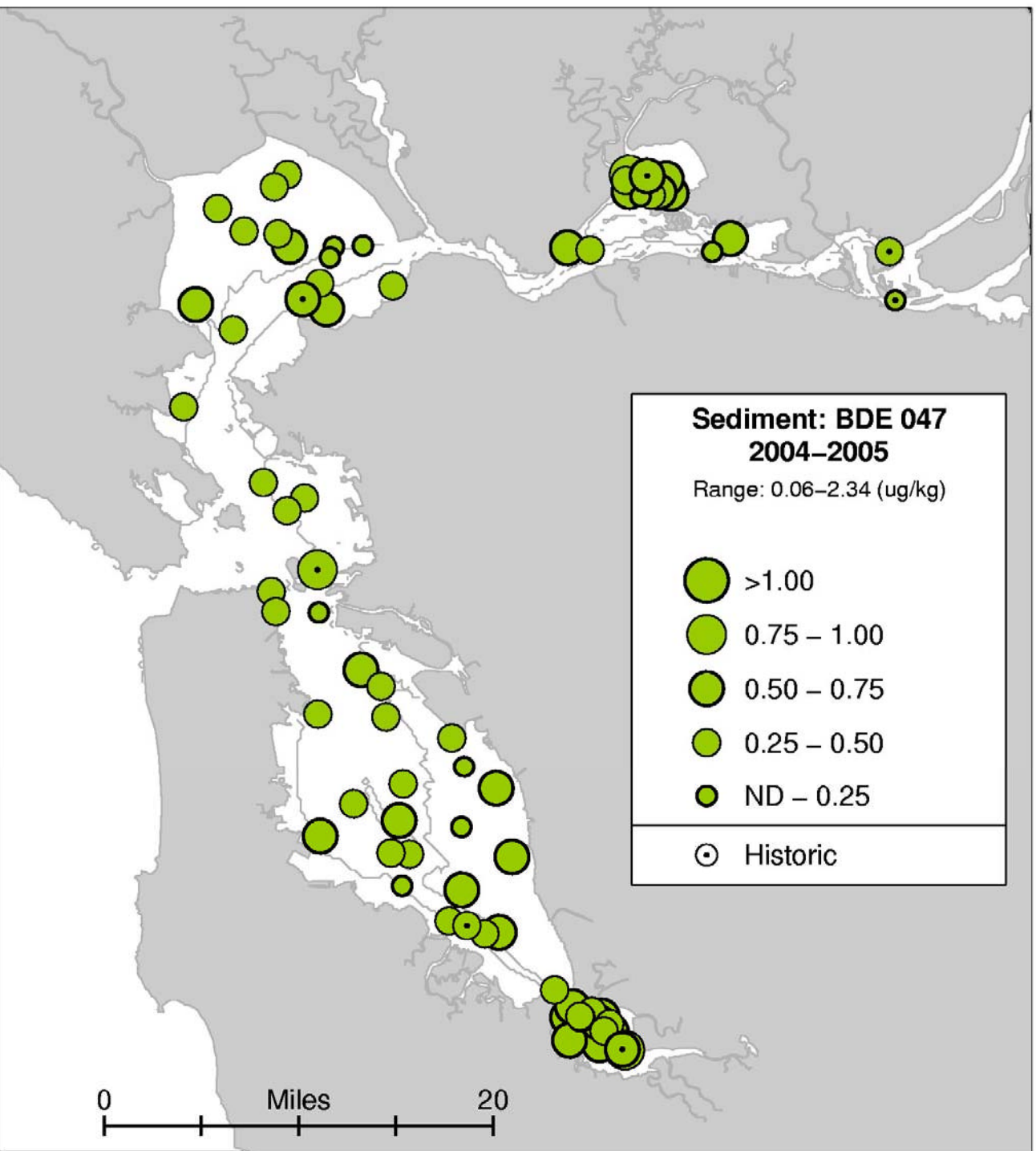
Water

2004-2005 RMP
BDE-47

Levels =
<340 ppq

Inventory =
0.33 kg BDE-47,
0.28 kg BDE-209

0.61 kg
BDE-47+209

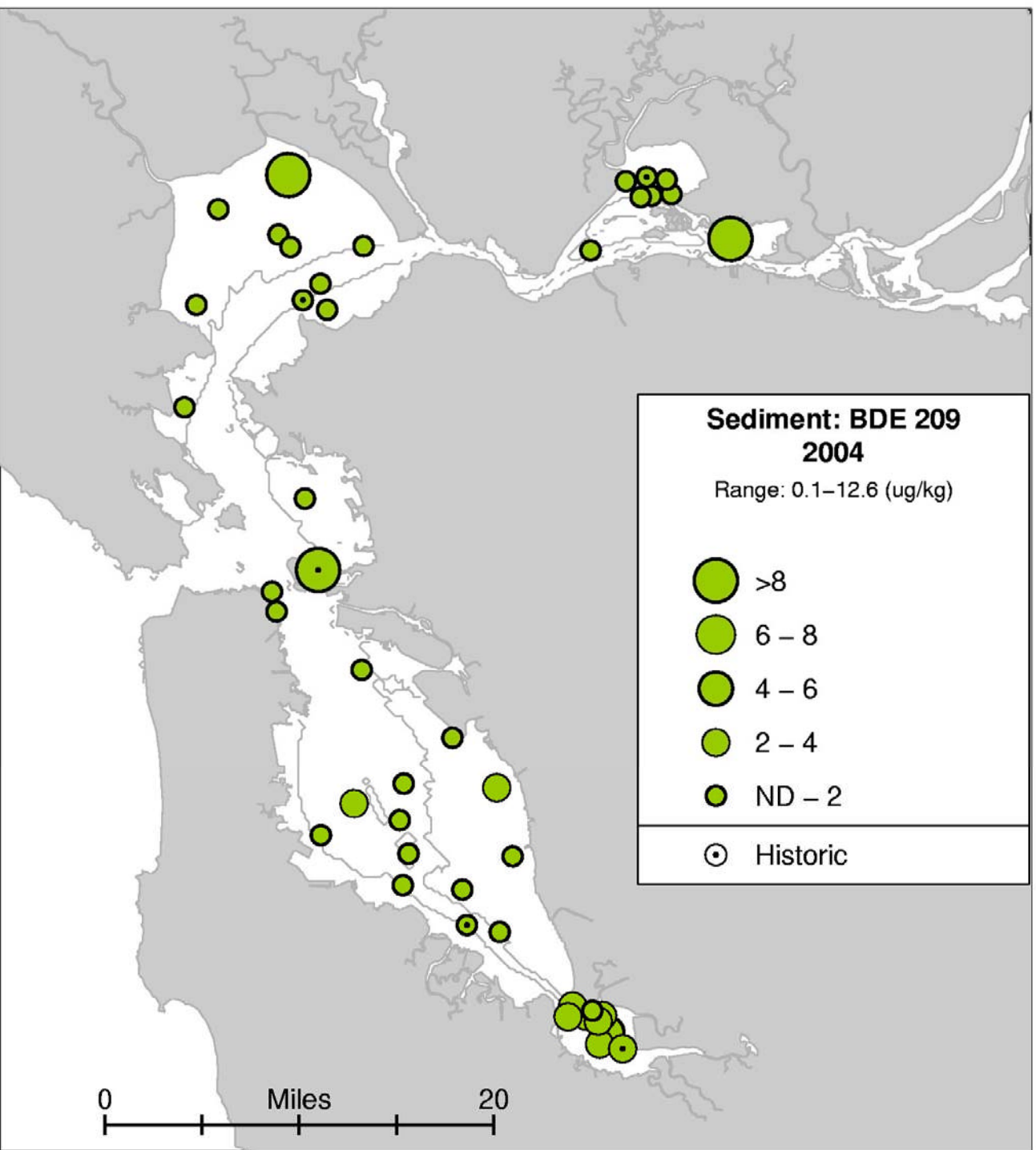


Sediment

2004-2005 RMP
BDE-47

Levels =
<2 ppb

Inventory =
38-152 kg
BDE-47



Sediment

2004 RMP

BDE-209

Levels =
<13 ppb

Inventory =
98 kg BDE-209

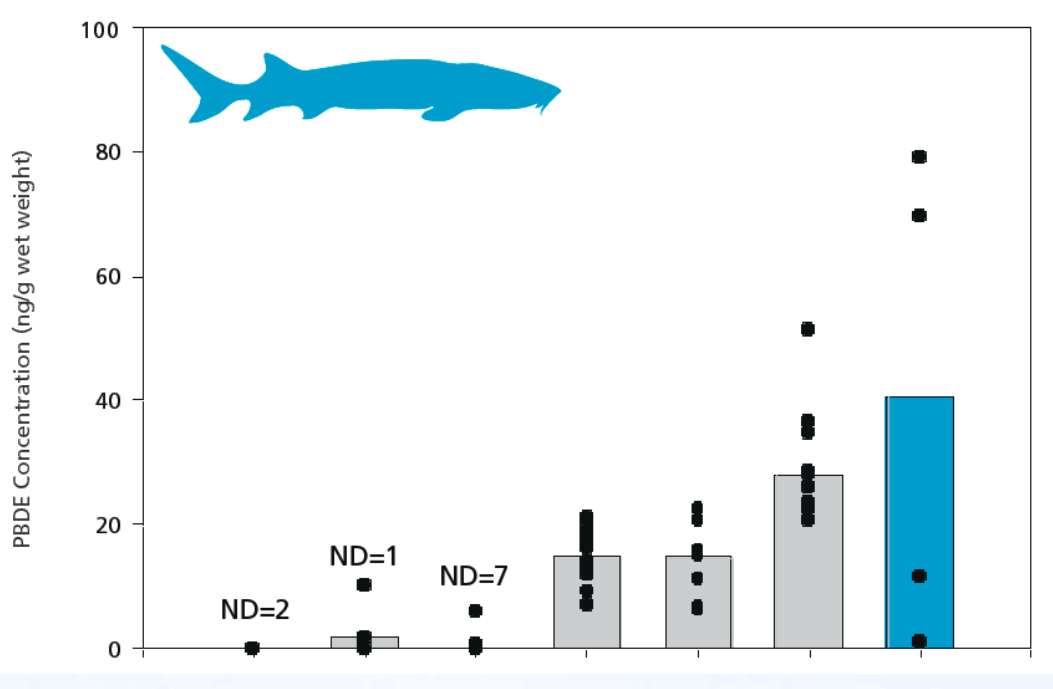
136-250 kg
BDE-47+209

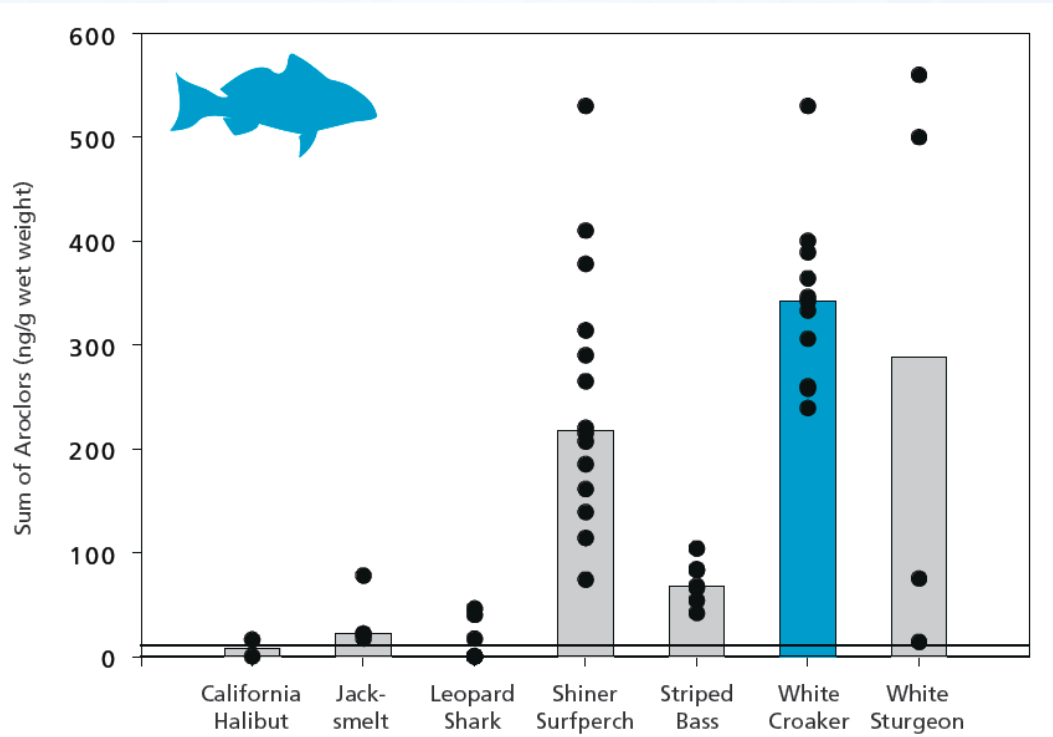
Summary of PBDE and PCB Inventories

PBDEs: 136-250 kg in surface sediments

PCBs: 2500 kg in surface sediments

**PBDE inventory is 10-20x lower than that of PCBs*





Fish

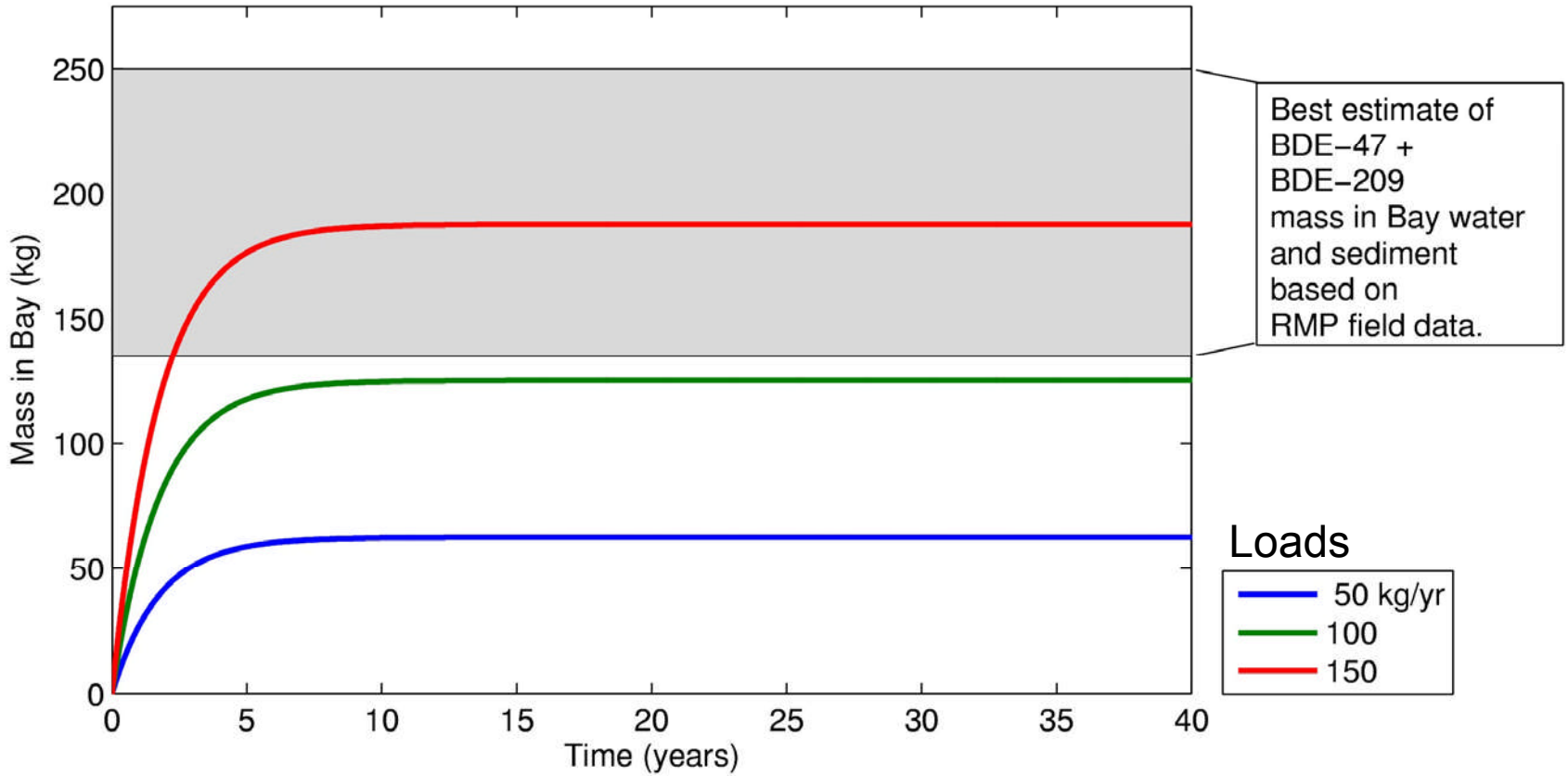
Consistent with sediment inventories, concentrations of PBDEs in sport fish are ~10x less than concentrations of PCBs.

Source: RMP 2003 data

Modeling PBDEs

**Predicted inventories are consistent with those estimated from monitoring.*

Model predictions are preliminary.

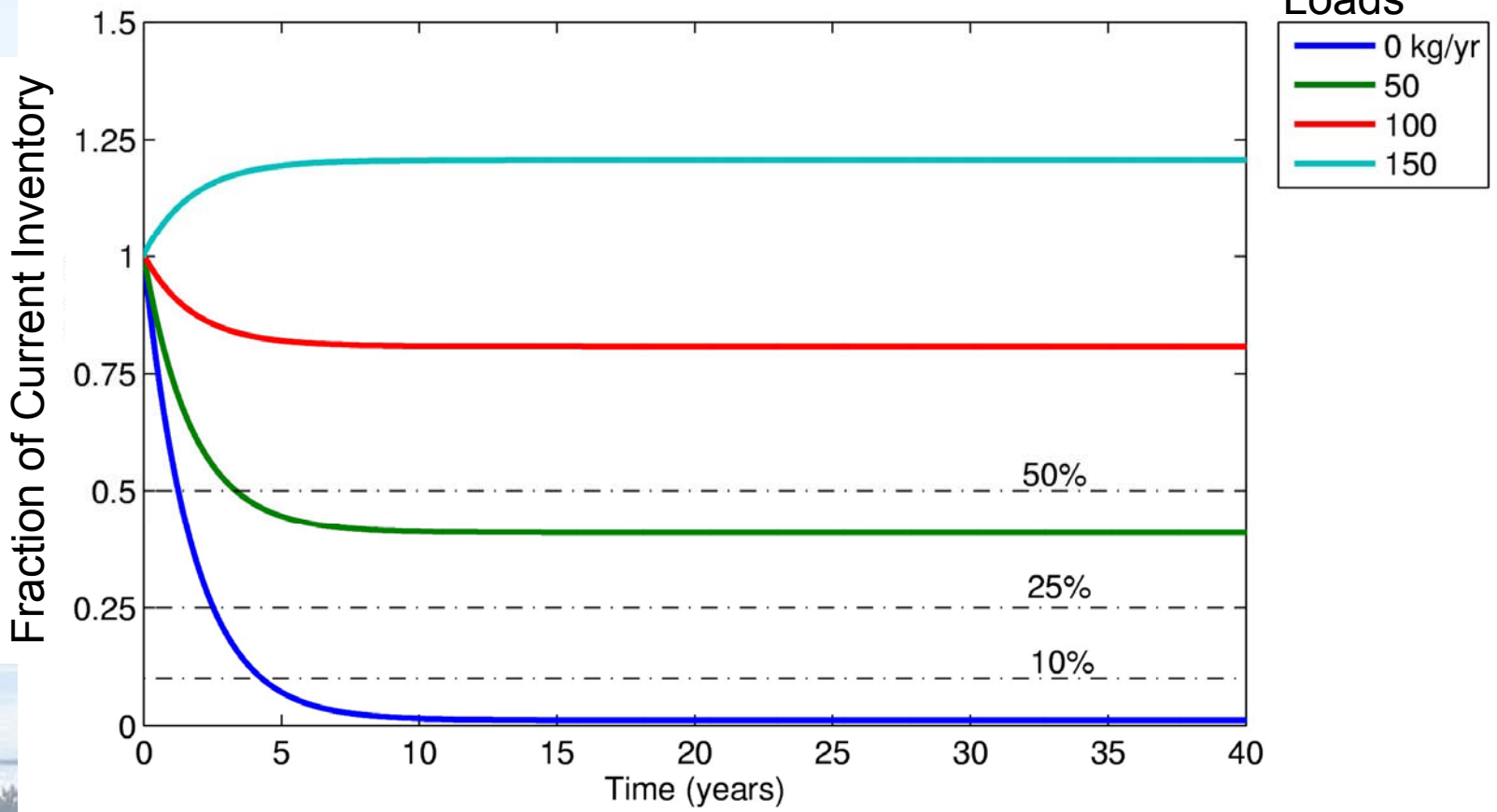


Source: J. Oram, SFEI

Predicting Recovery from PBDEs

**At 0 PBDE load, 10% of the current inventory will be reached in 5 yrs.*

Model predictions are preliminary.



Source: J. Oram, SFEI

Why are predicted recoveries so fast?

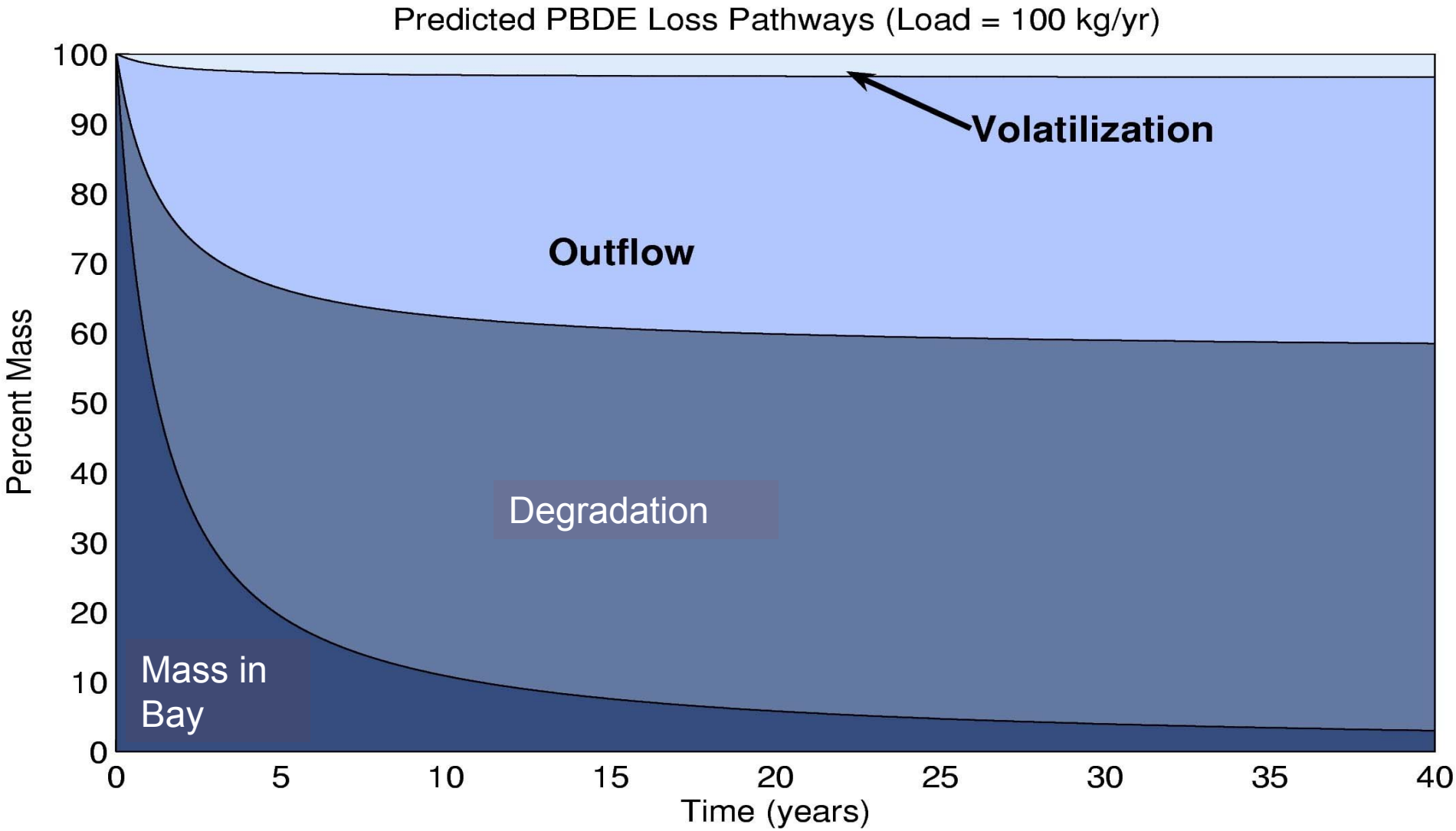
**PBDEs degrade much faster than PCBs*

Parameter	BDE-47[a]	PCB-118[b]
Degradation half-life in water (years)	0.5	56
Degradation half-life in sediment (years)	1.5	56

a. Wania and Gugani (2003); b. Davis (2004)

Predicted PBDE loss Pathways

**Degradation accounts for >50% of loss.*



Our emerging hypothesis

- PBDE inputs are ~5 times PCB inputs, but PBDE inventories are >10 times lower.
- PBDEs degrade more quickly than PCBs.
- With the bans on Penta- and Octa-formulations, we expect relatively rapid declines.
- Risks to the biota remain unknown.

Next Steps

- Verify declines in loads.
- Verify declines in inventories.
- Determine potential risks to biota.