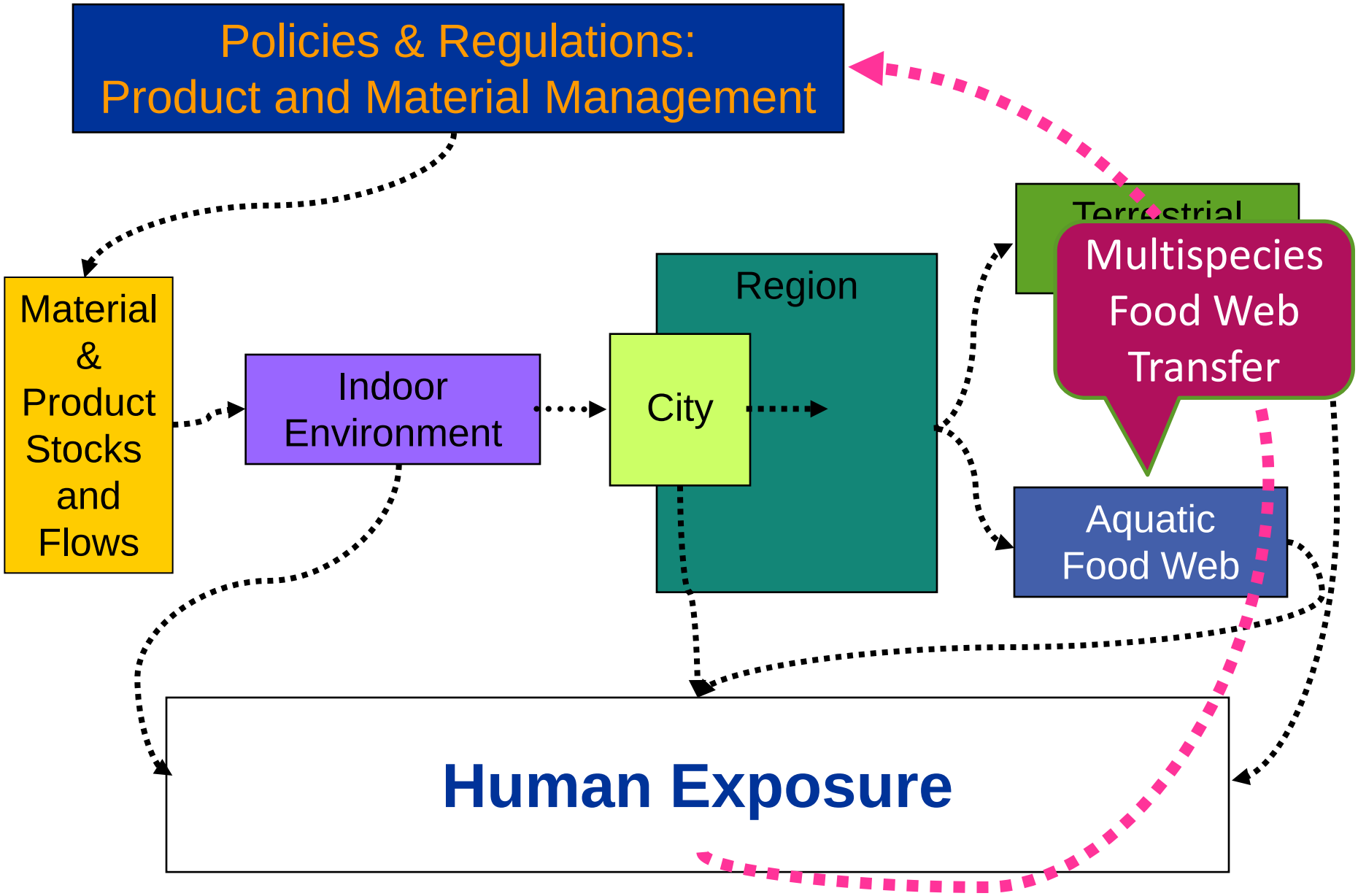
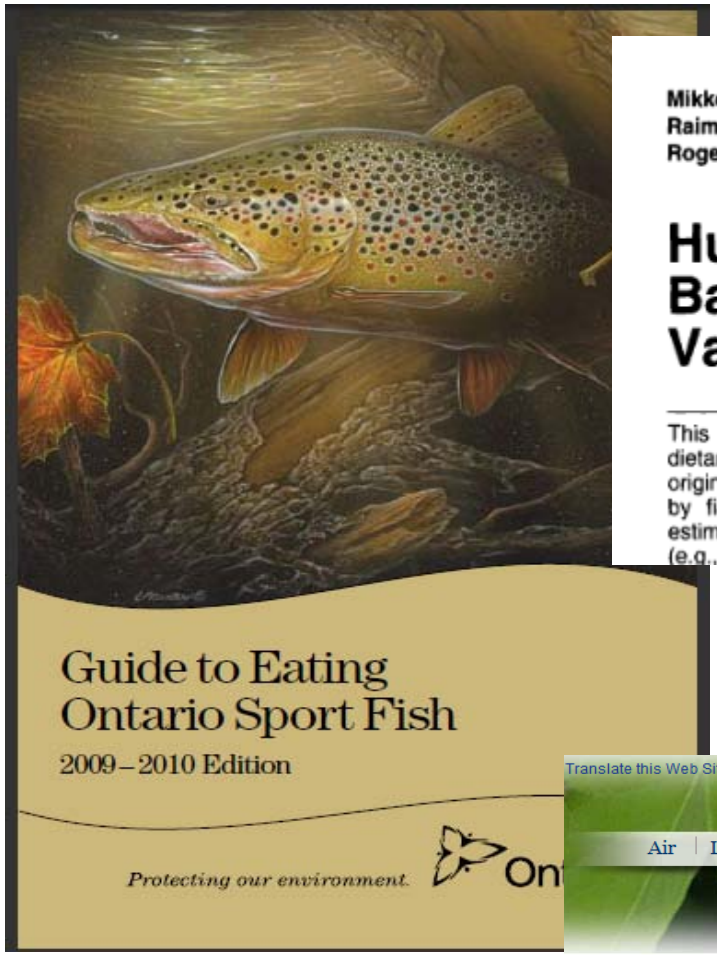
DAY 3: Source ⇨ Emission ⇨ Fate ⇨ Exposure ⇨ Toxicity⇨ Policy

1. Phthalates
   - Exposure
   - Toxicity
2. Polybrominated diphenyl ethers (PBDEs) & Polychlorinated biphenyls
   - Material Flow Analysis (MFA)
   - Indoor Environment
   - Urban Environment
3. PBDEs & Bisphenol A
   - Food web transfer
   - More controversy


Policies & Regulations:
Product and Material Management
Material & Product Stocks and Flows
Indoor Environment
City
Region
Terrestrial
Multispecies Food Web Transfer
Aquatic Food Web
Human Exposure



Mikko Kiljunen, Mari Vanhatalo, Samu Mäntyniemi, Heikki Peltonen, Sakari Kuikka, Hannu Kiviranta, Raimo Parmanne, Jouni T. Tuomisto, Pekka J. Vuorinen, Anja Hallikainen, Matti Verta, Jukka Pönni, Roger I. Jones and Juha Karjalainen

Human Dietary Intake of Organochlorines from Baltic Herring: Implications of Individual Fish Variability and Fisheries Management

This study examines the extent to which Finnish human dietary intake of organochlorines (PCDD/Fs and PCBs) originating from Northern Baltic herring can be influenced by fisheries management. This was investigated by estimation of human intake using versatile modeling tools (e.g., a herring population model and a bioenergetics

of 0.001 to 0.01 pg WHO-TEq kg^{-1}, which is some 2000–200 times stricter than EU guidelines.

The EU has also adopted maximum permissible levels for PCDD/Fs in feed and food, which have recently been reevaluated to include dioxinlike PCBs (6). A new maximum level for the sum of dioxins, furans, and PCBs in fish and

Translate this Web Site

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Division of Surface Water Sport Fish Consumption Advisory

Program Links

Overall Advice
Statewide Advisory
Limit Your Meals
From These Waters
Do Not Eat
Do Not Wade or Swim
Trimming and Cooking Fish
Common Ohio Sport Fish
Questions and Answers
Links to Related Sites
Fish Advisory Program Home

Ohio Sport Fish Health Advisory Web Site

The Ohio Department of Health, in cooperation with Ohio EPA and the Ohio Department of Natural Resources, issues sport fish consumption advisories under Ohio law (Ohio Revised Code Chapter 3701).

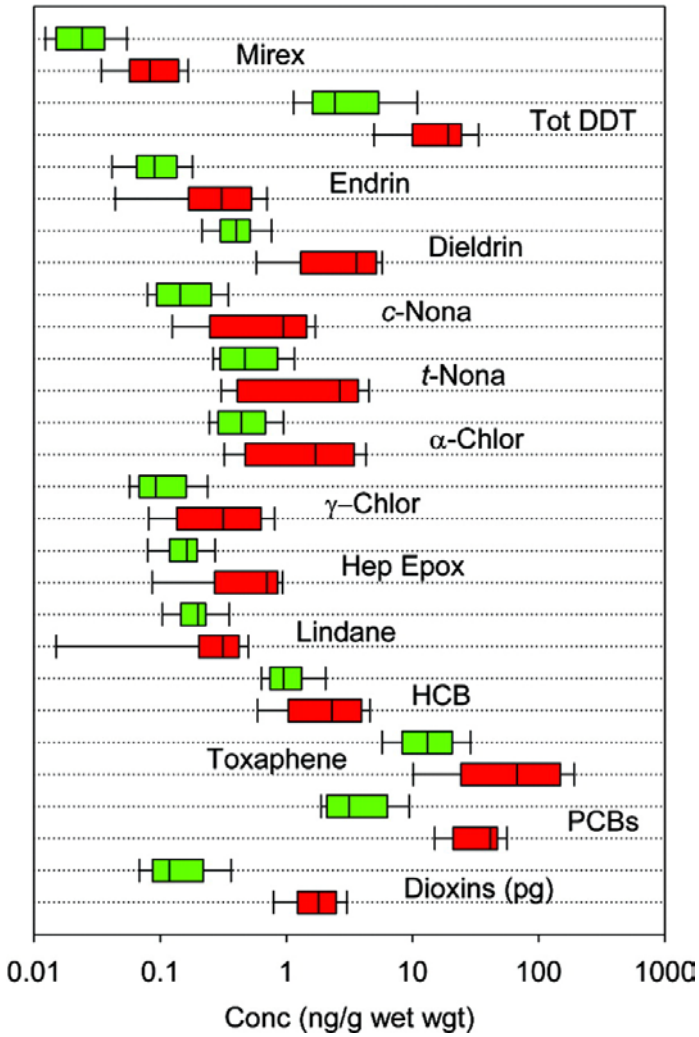
This website contains current information about consumption advisories.

- 2011 Updates
- News Release [PDF 54K]

Grand Lake St. Marys Note: The "do not eat" fish consumption advisory for Grand Lake St. Marys has been removed after an analysis showed no microcystin in fish filets from samples collected in the lake last fall.

Fig. 1. Concentrations (in ng/g wet weight, except dioxins) of 14 contaminants found in farm-raised (red bars) and wild (green bars) salmon.

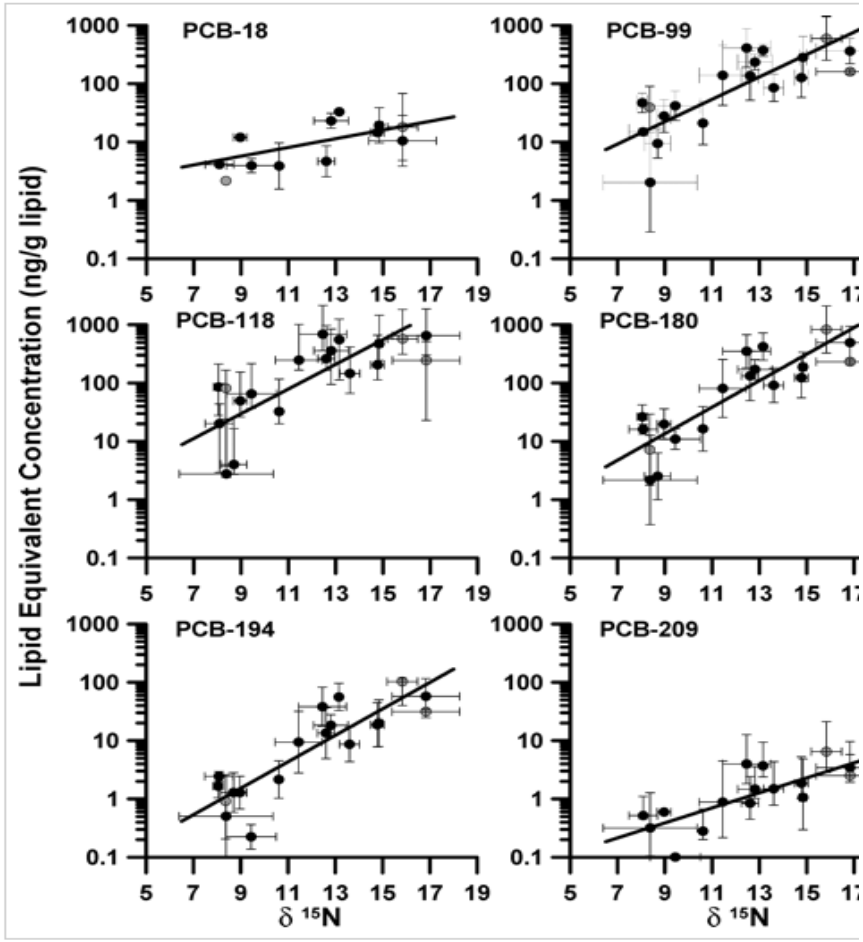
Hites et al. 2004. Global assessment of organic contaminants in farmed salmon. Science 303: 226-229.



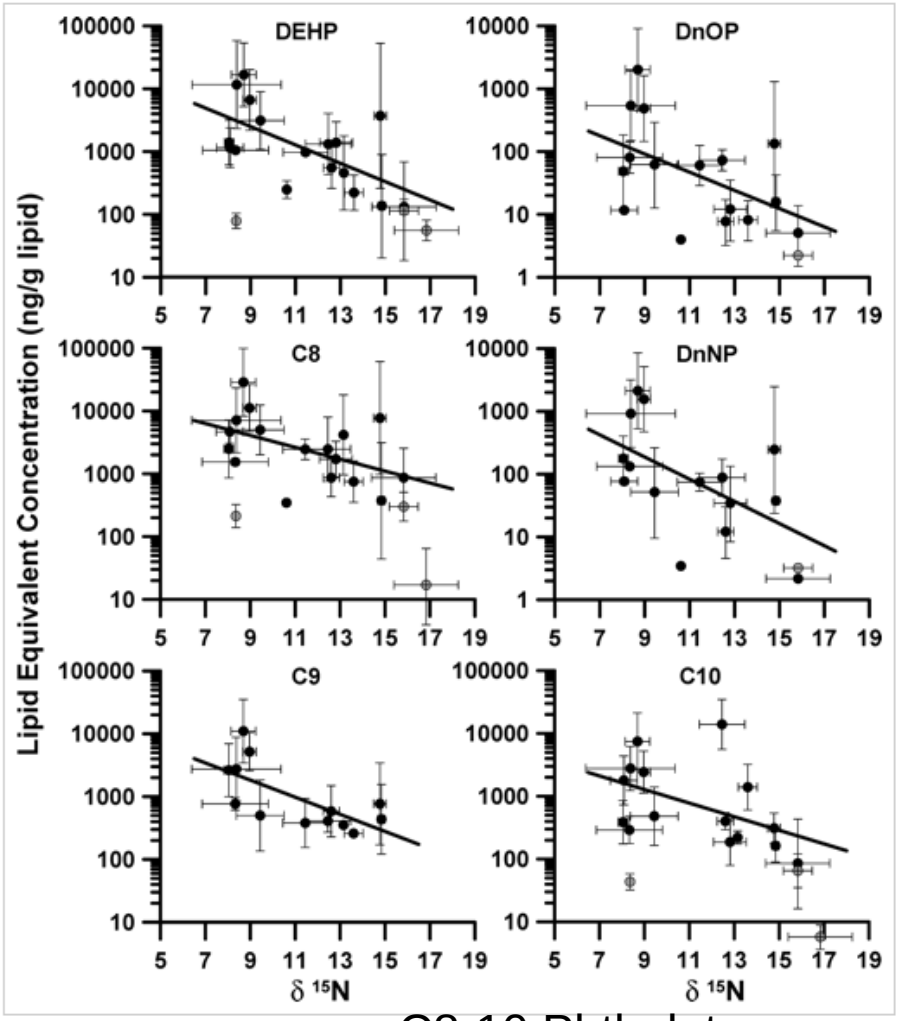
R A Hites et al. Science 2004;303:226-229

Published by AAAS

PCBs Bioaccumulate but Phthalates don't



PCBs

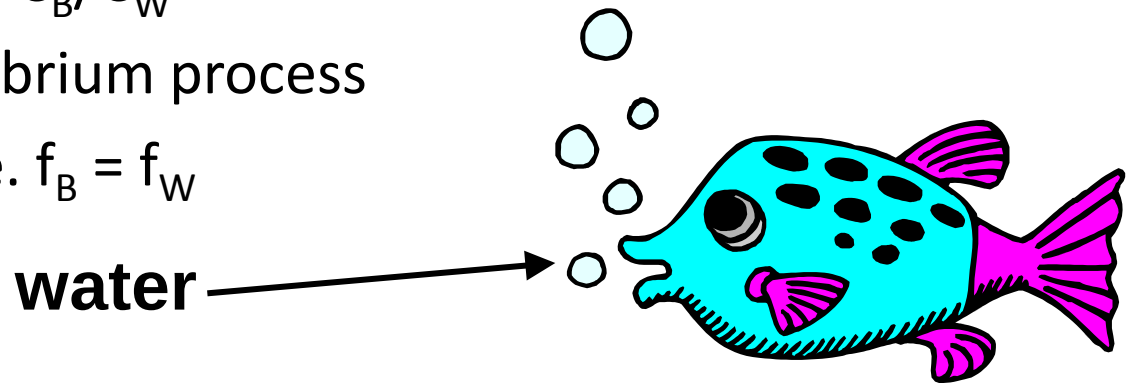


C8-10 Phthalates

MacIntosh et al. 2004 Environ Sci Technol 38:2011-2020

Some definitions
Bioconcentration

- Originally for trout muscle:water
- The process leading to [organism] > [medium inhaled water or air]
- Water or air borne exposure only
- Therefore can only be determined in lab study where uptake from diet is minimal
- BCF = C_B/C_W
- Equilibrium process
  - i.e. $f_B = f_W$



Bioconcentration from water proportional to K_{ow}

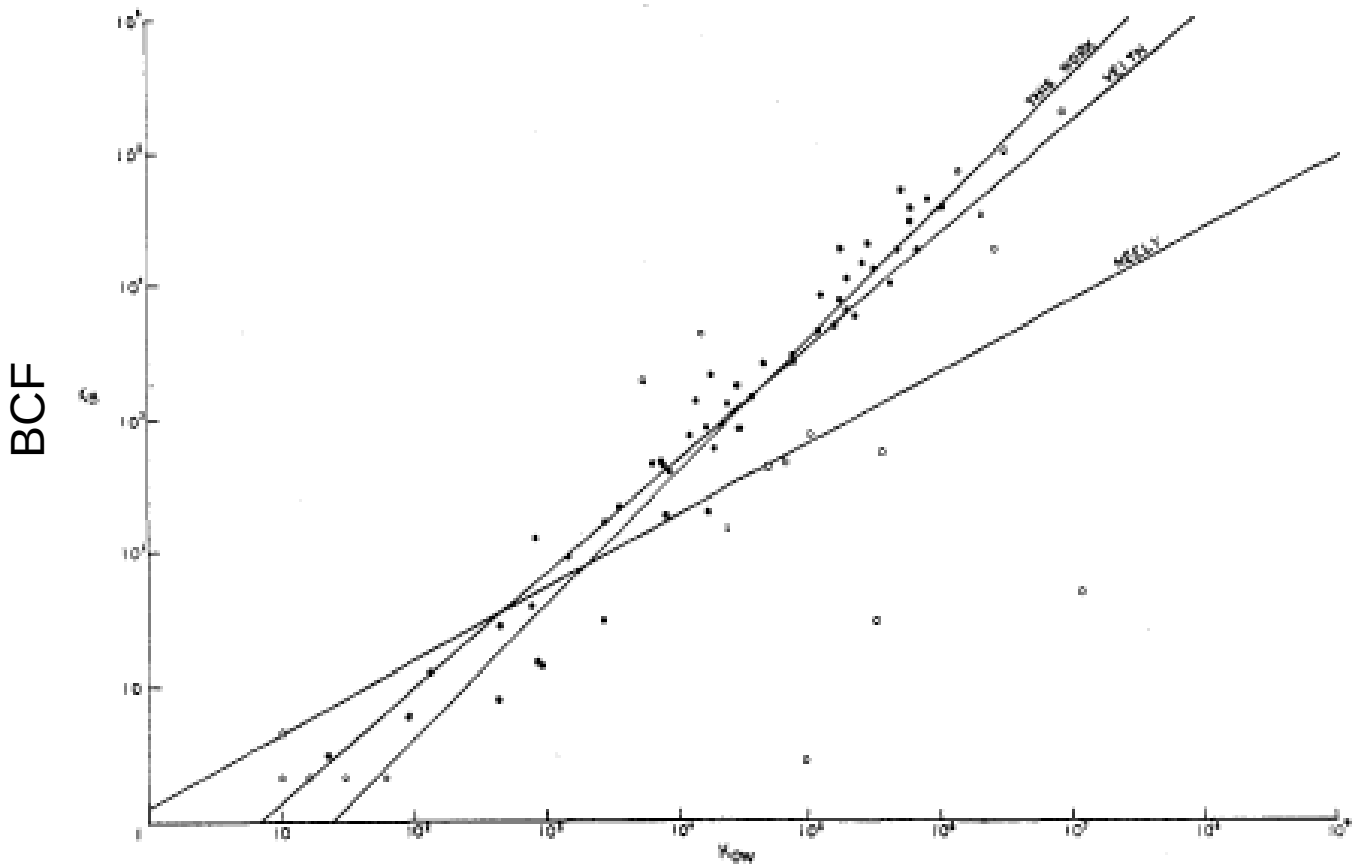


Figure 1. Plot of K_B vs. K_{ow} showing the correlations of Veith et al., Neely, and this work. Only solid points are included in the correlation.

K_{ow}

Mackay 1982 Environ. Sci. Technol.

BCF = 0.048 * K_{ow}

Where 0.048 approximates lipid content of fish

Loss of linear correlation for high Kow compounds

- Low chemical bioavailability in water, partitions onto particulate mater in water
- Insufficient exposure time to achieve equilibrium
- Large size of molecules – too big to partition across gills
- Growth of fish

Log BCF

Gobas et al. 1989 – lab study for guppy

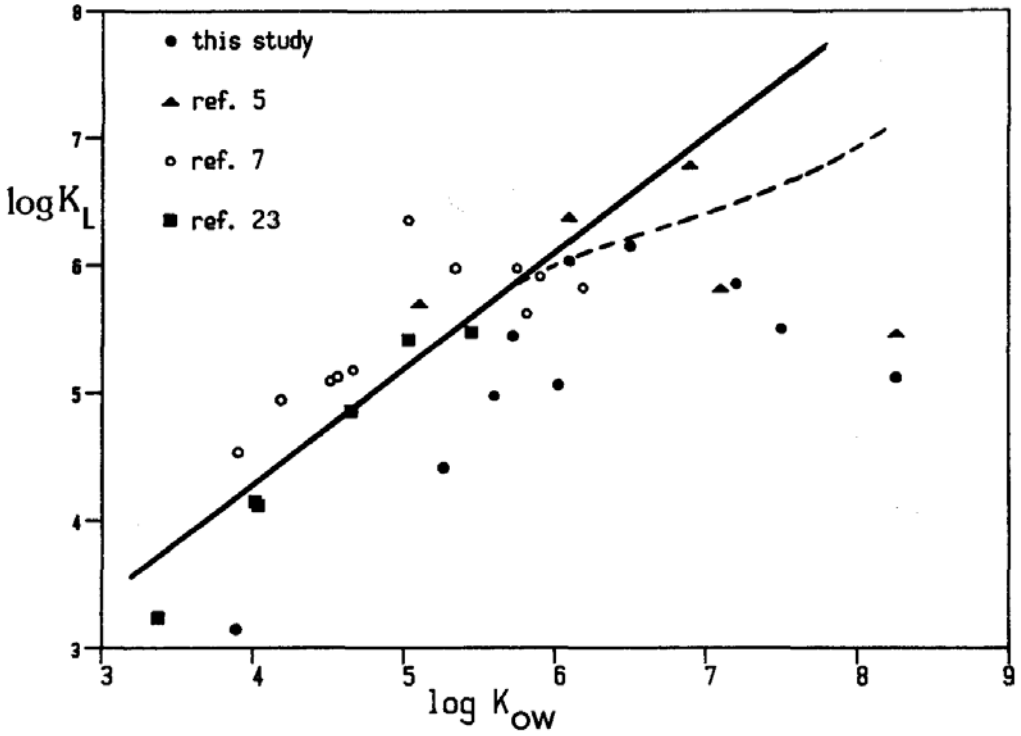
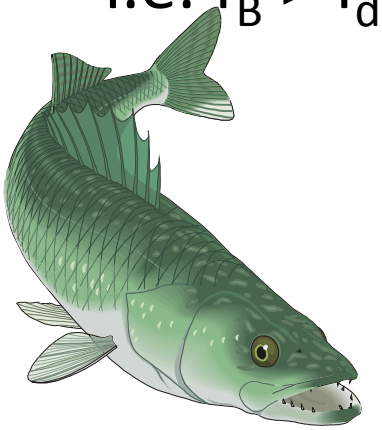
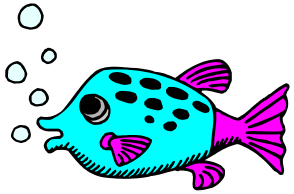


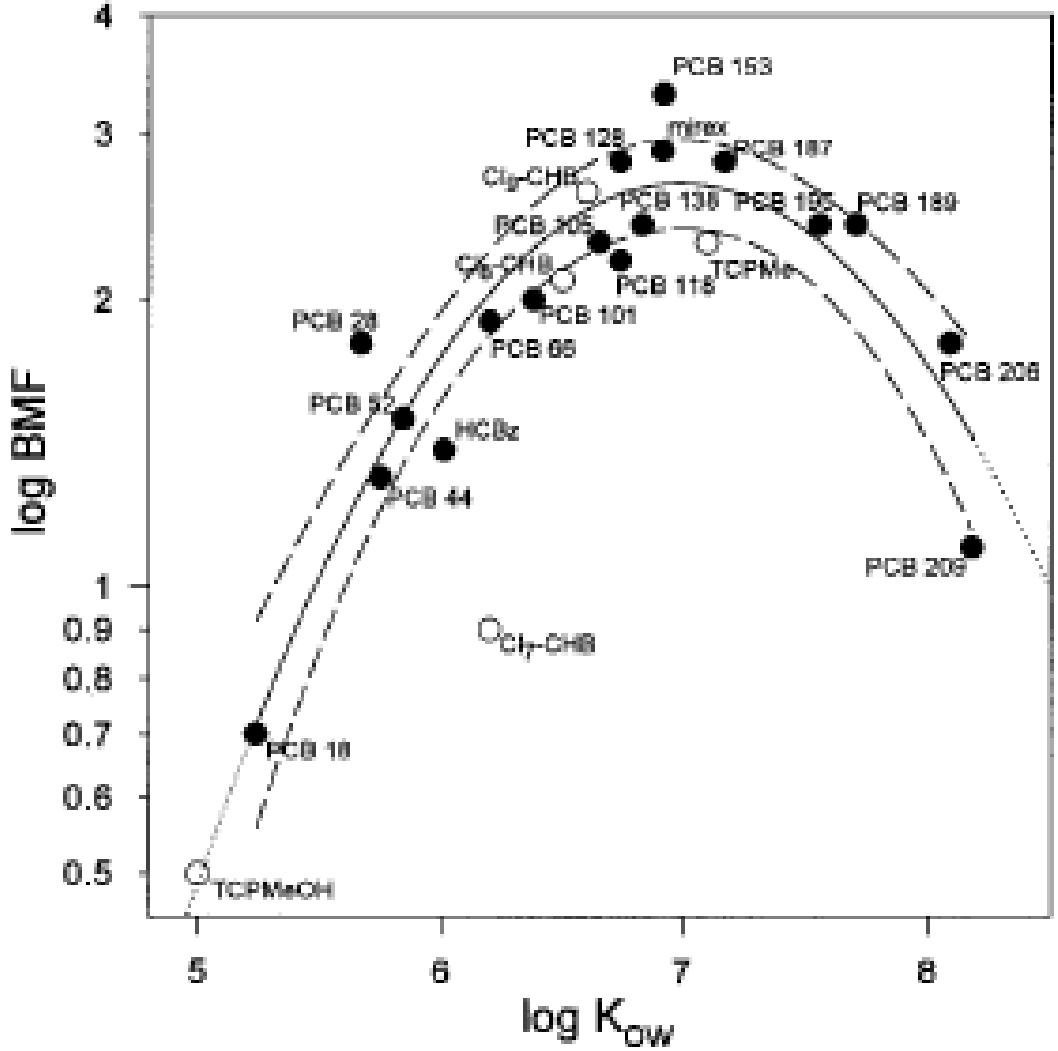
Fig. 2. Observed lipid weight-based bioconcentration factors (log K_L) in the guppy for selected halogenated aromatic hydrocarbons versus the 1-octanol/water partition coefficient (log K_{ow}). The solid line is Equation 19 (see the text); the dotted line is the nonlinear correlation, including chemical elimination into the feces.

Biomagnification

- Process leading to [organism] > [organism diet]
- Due to dietary absorption
- Best determined in lab
- BMF = C_B/C_D
- Non-equilibrium process
  - i.e. $f_B > f_{diet}$







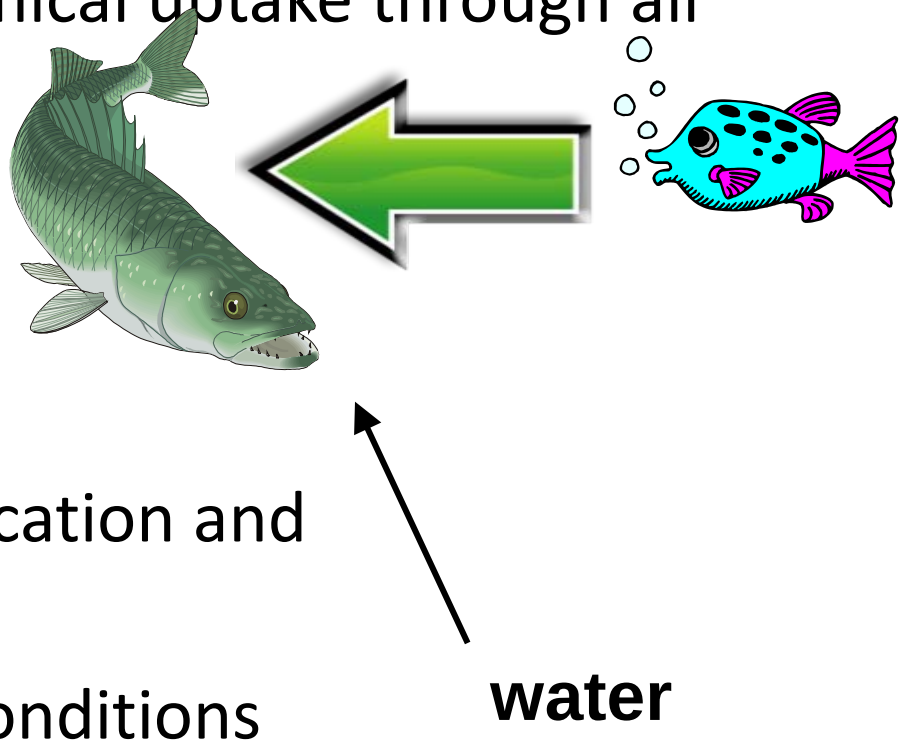
Fisk et al. 1998
Lab study of juvenile
Rainbow trout

Loss of linear correlation for high Kow

- Insufficient time to obtain equilibrium
- Size of molecule – too big to partition into the fish from gut

Bioaccumulation

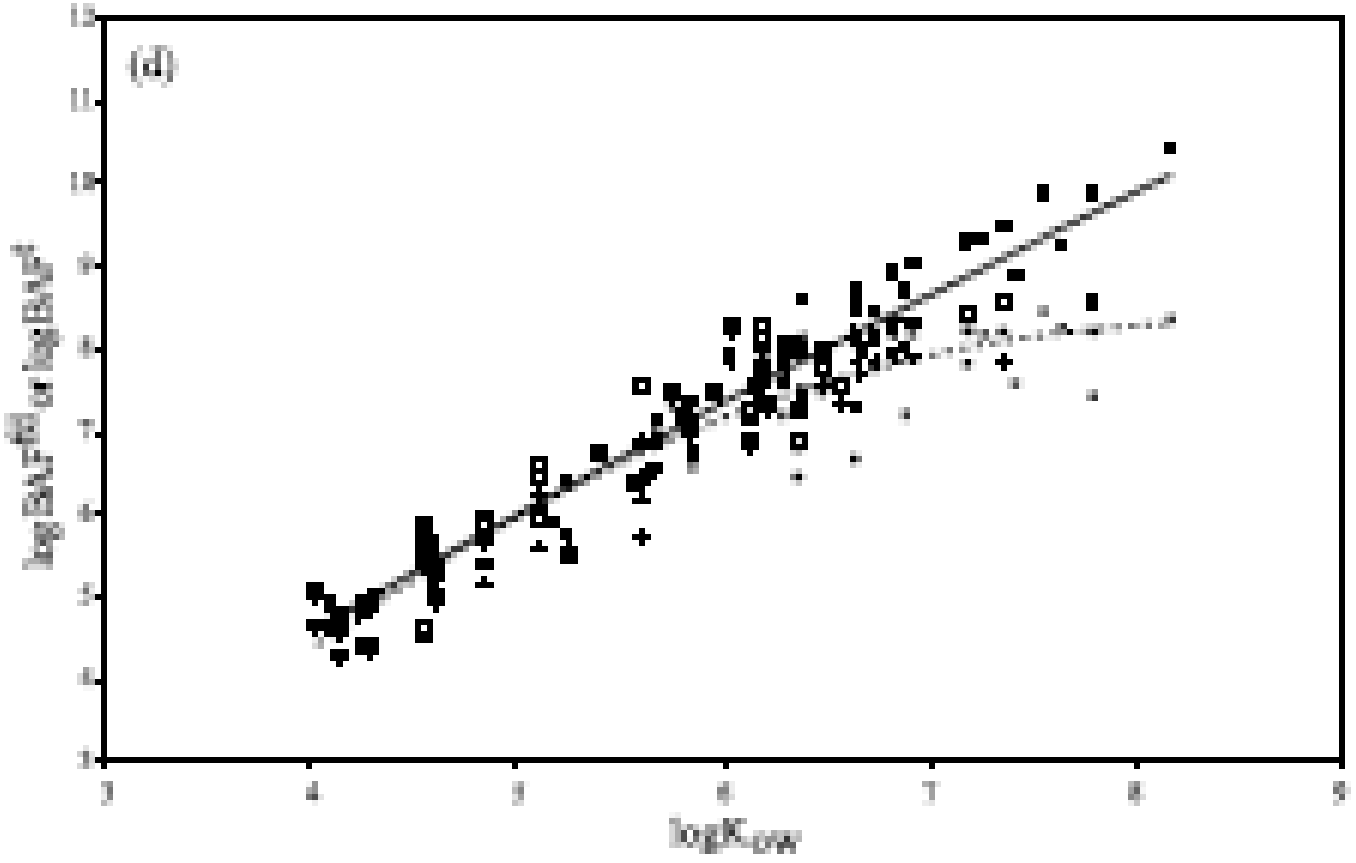
- Process leading to [organism] > [surrounding medium] as a result of chemical uptake through all possible routes of exposure
  - For fish
    - Diet
    - Water
    - i.e. sum of biomagnification and bioconcentration
- Can be assess under field conditions
- BAF = C_B/C_W
- Tends to increase with K_{ow}



BAFs measured in the field

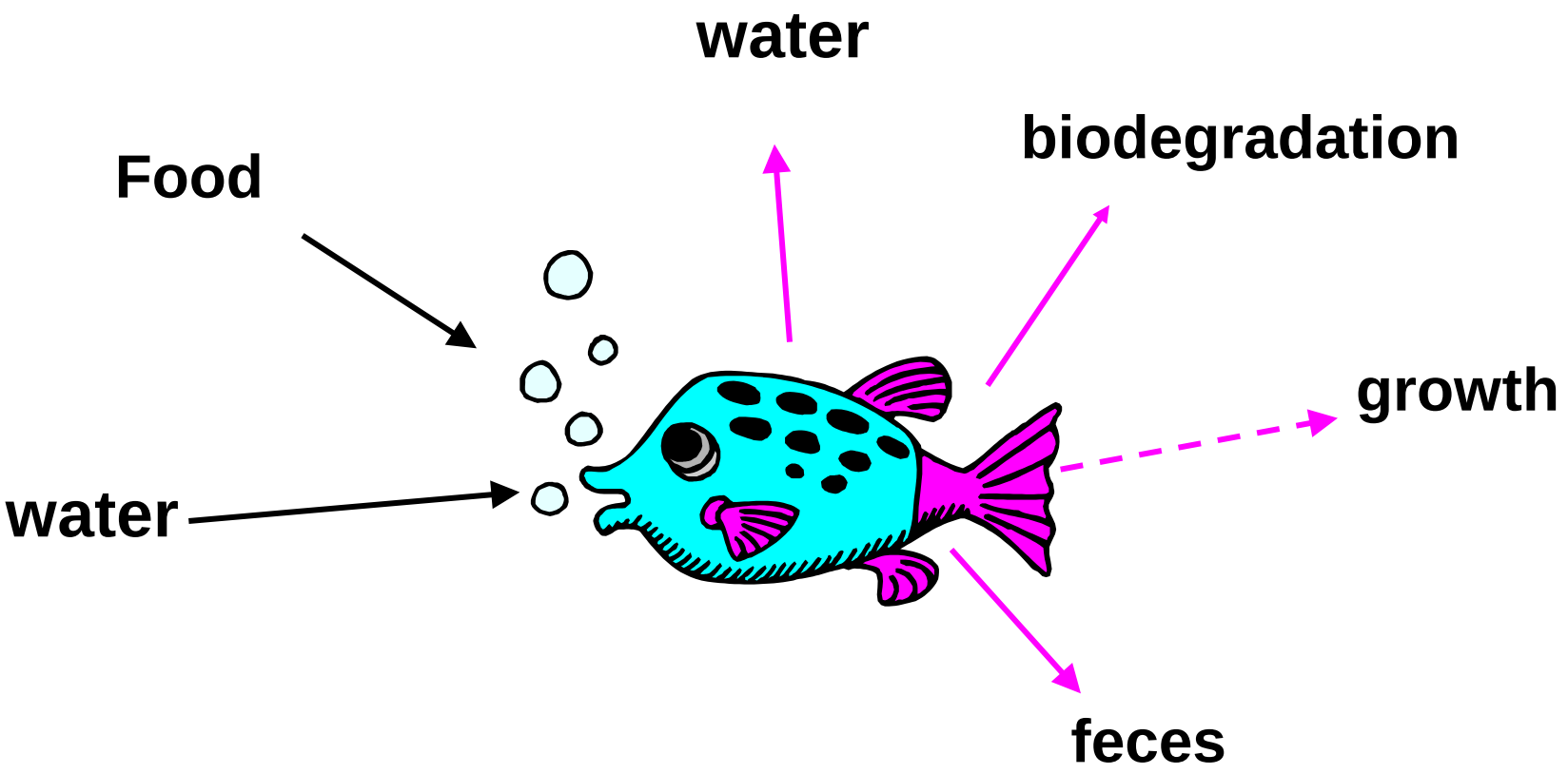
Voutsas et al. 2002

BAF



Log K_{ow}

Quantifying Chemical Uptake



Calculate concentration or fugacity = ?

Gill Uptake/Elimination

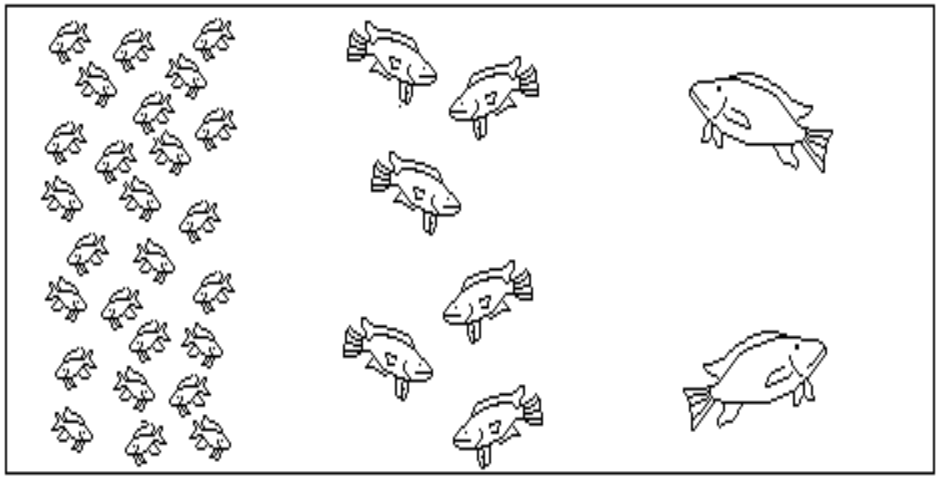
- Dissolved phase chemicals because must be small enough to diffuse across the gill surface
- Major pathway in smaller organisms
  - Juvenile fish
  - Algae
  - Zooplankton
- Smaller organisms have a greater respiratory surface-to-body weight ratio
  - Increases their ability to accumulate and eliminate from/to water

Metabolic Transformation

- Negligible
  - E.g., PCBs, PCDD/F
- Non-polar compounds metabolize to more polar excretion product
  - Phthalates, bisphenol A (glucoronidated)
  - Some metabolise to more toxic form
    - DDT to DDE
    - PAH to oxy-PAH (Cytochrome P450 oxidizing enzymes)
- PBDEs debrominated to form lower bromine congeners

Growth Dilution

- When growth rate > chemical uptake
- Important
  - young organisms who are growing at high rates
  - eutrophic conditions

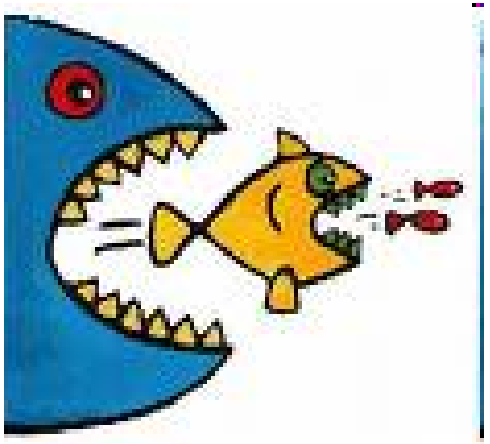


Dietary Uptake

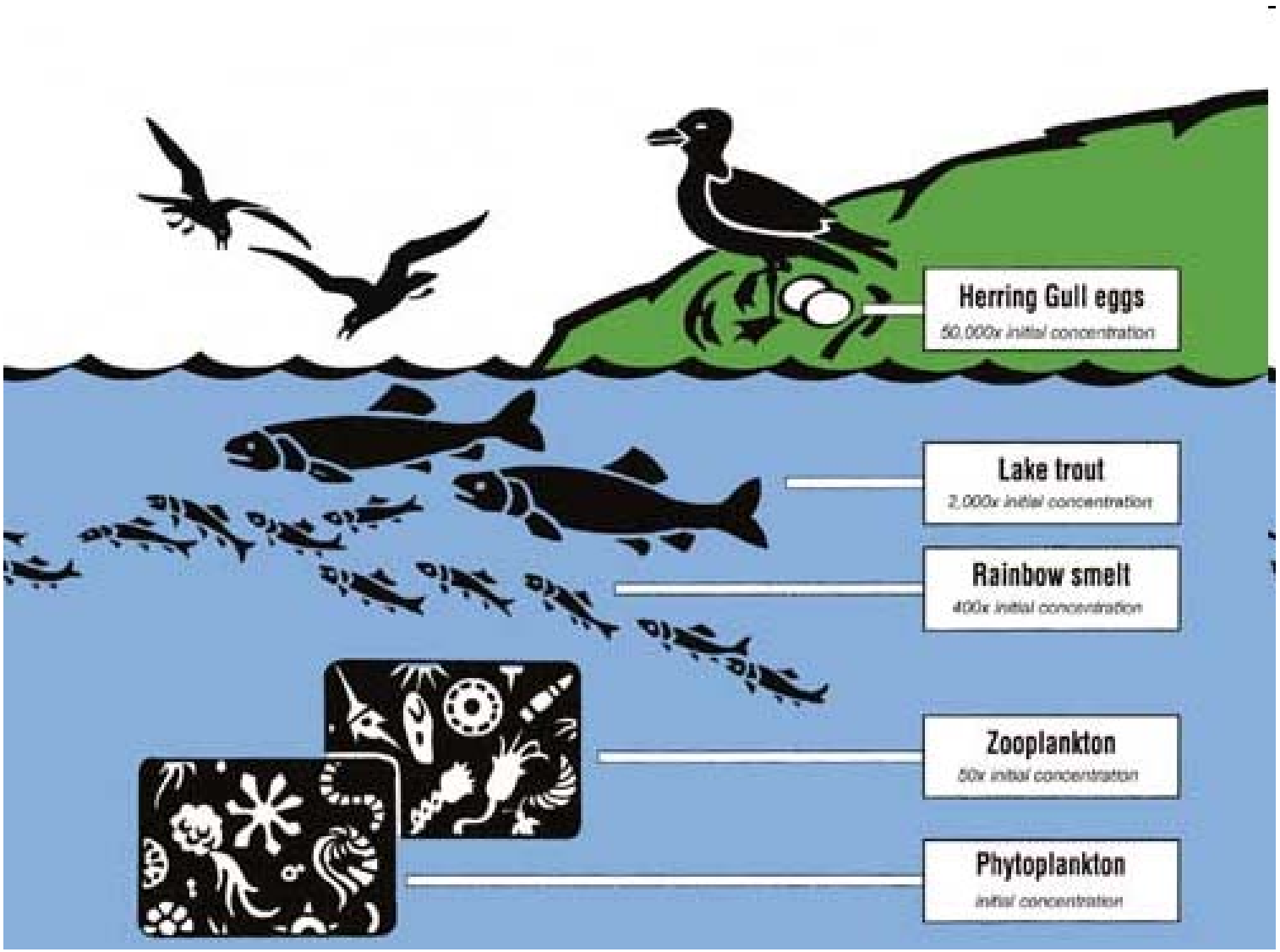
- Dominant pathway in adult, predatory fish
  - Log Kow 5 to ~7
- Contaminants are biomagnified through the food web

Fecal Egestion

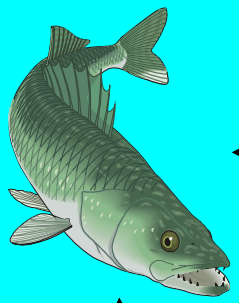
- Dominates for contaminants with very low (>5) or very high (<~7.5) log Kow



Bioaccumulation

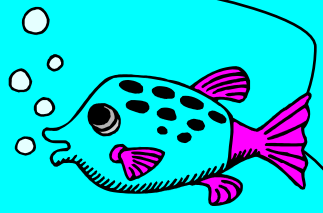


Piscivorous fish



Food web structure

- Longer the food web, more biomagnification
- More benthic driven, higher conc in fish

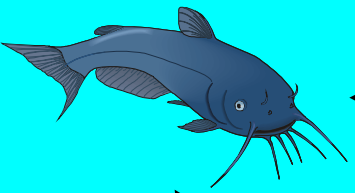


Planktivorous fish

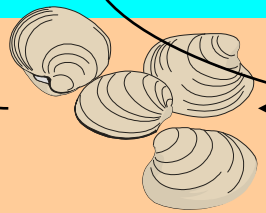
Zooplankton

Phytoplankton

Benthivorous fish

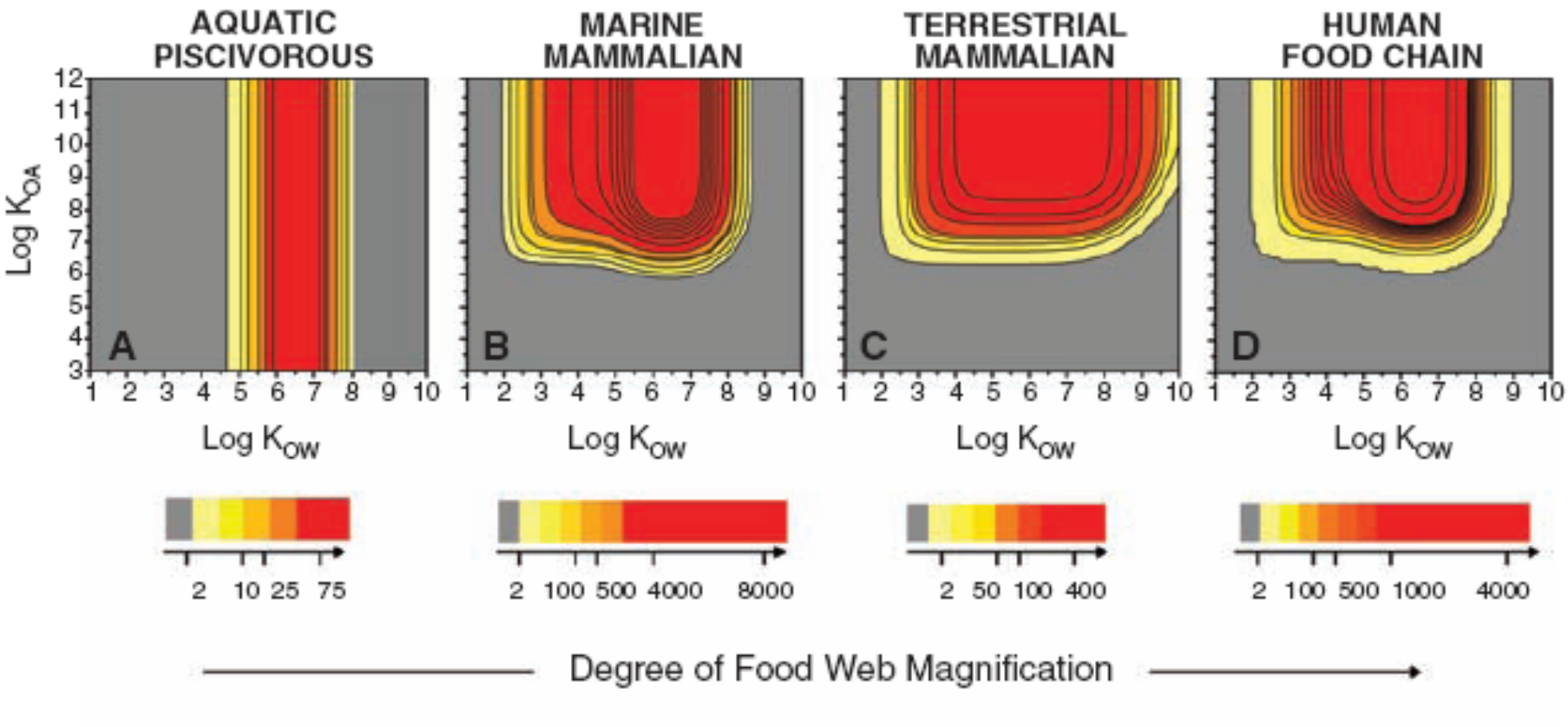


Benthic Invertebrates



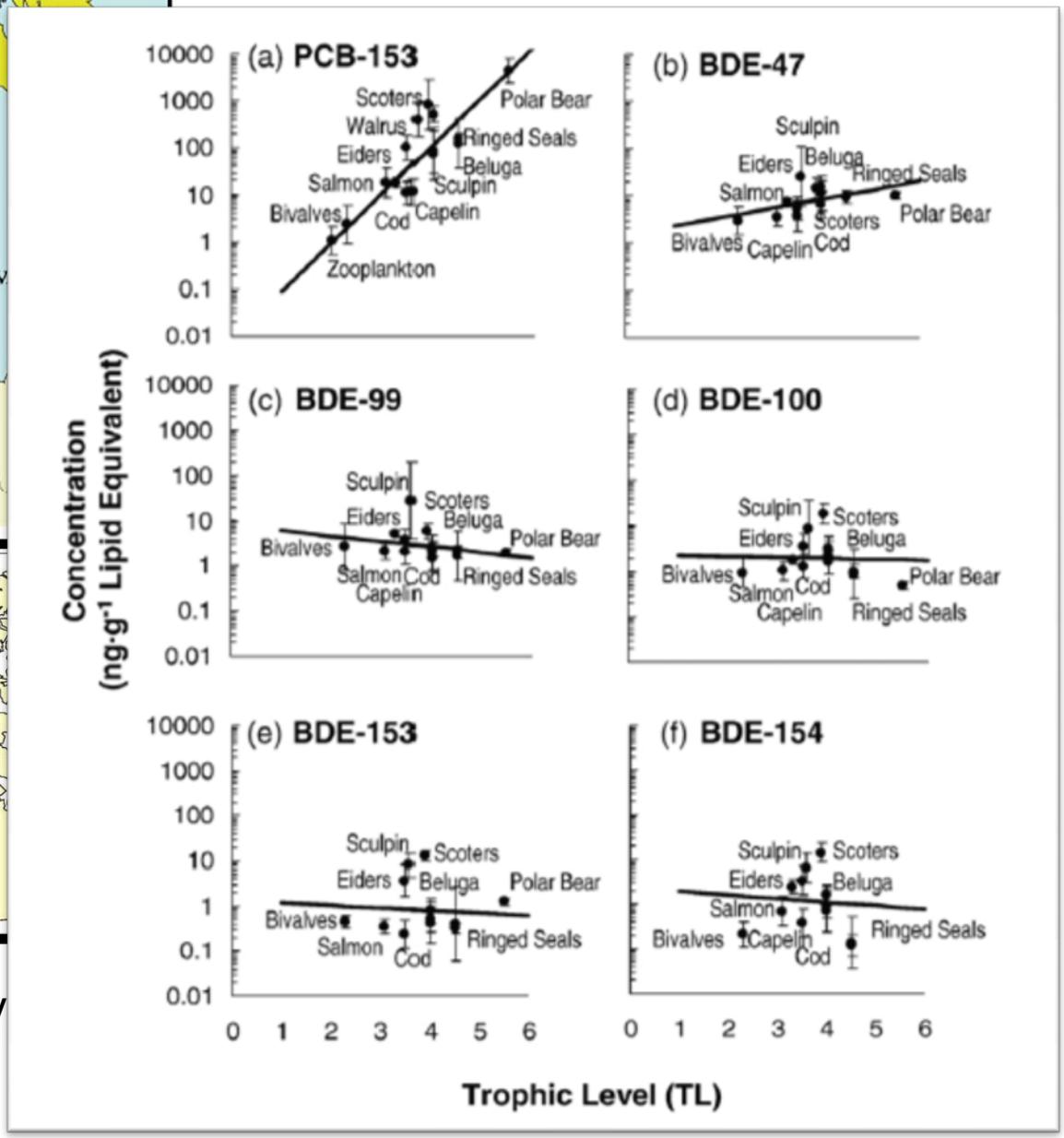
Sediment/Detritus

Food Web Biomangification & Physical-Chemical Properties



Kelley BC et al. 2007 *Science* 317: 236-239

What About PBDEs?



Kelley et al. 2008 Sci Total Env
401: 60-72.

BDE-99 debromination in Common Carp

Food

Body (Carp)

After 5 days

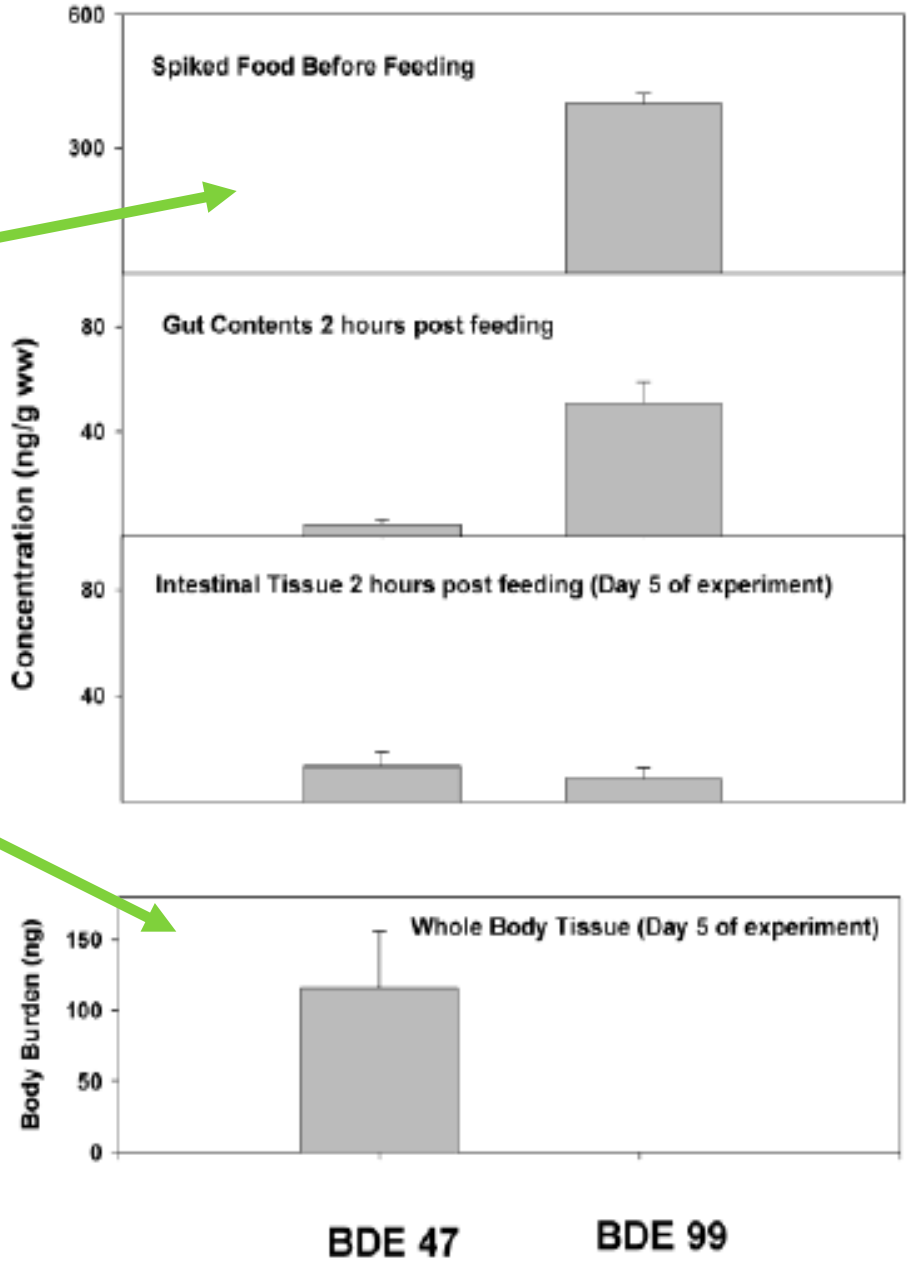


FIGURE 1. Relative concentrations of the exposure compound, BDE 99, among tissues demonstrating the change in concentration of BDE 99 and the appearance of the debrominated product, BDE 47, in the undigested food material and intestinal tissues approximately 2 h post-feeding. Levels of BDE 47 in whole body tissues reflect the entire body burden accumulated through the first 5 d of exposure. (Error bars represent standard deviation of three replicates.)

Stapleton et al.

Environ. Sci. Technol., 40 (15): 4714 -4721, 2006

Development of a Multichemical Food Web Model: Application to PBDEs in Lake Ellasjøen, Bear Island, Norway

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Division of Environmental Engineering, Department of Chemical Engineering and Applied Chemistry, University of Toronto, Toronto, ON, Canada, M5S 3E5

SARAH B. GEWURTZ AND MIRIAM L. DIAMOND*
Department of Geography, University of Toronto, Toronto, ON, Canada, M5S 3G3

ANITA EVENSET AND GUTTORM N. CHRISTENSEN
Akvaplan-niva, Polar Environmental Centre, Tromsø, N-9296, Norway

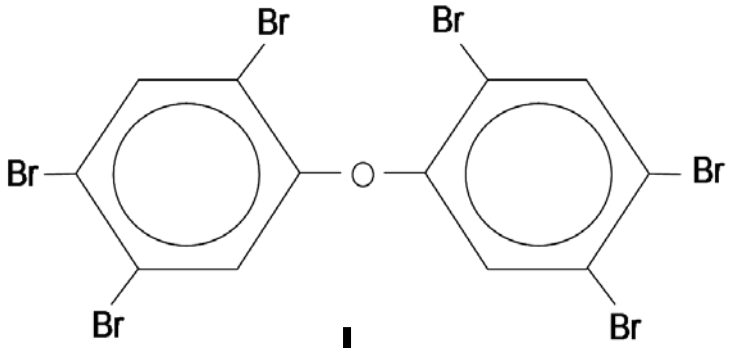
DENNIS GREGOR
Gartner Lee Limited. 512 Woolwich St., Suite 2, Guelph, ON.

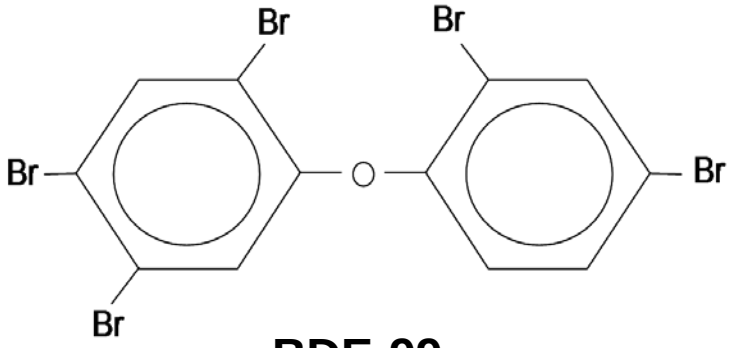
(*1*−*3*). For compounds that are l
ment, it may be important to si
parent chemical and its transfo
fully assess risk (*4*). Tradition
equations for the parent chen
products have been used to es
where compartment-specific cl
are poorly known, these singl
brated until the predicted conc
measured data. However, this si
be inappropriate because the c
parent compound and its trans
it is more appropriate to constru
for each parent and transform
mental media, including cons
conversion, and then to solve th

This approach was used b
developed the multispecies aqu
for interconversion of chemical
For metals, the interconversio
compared to their residence tim
interconversion rates for the s
such, Diamond et al. (*6*) combi

Debromination Paths

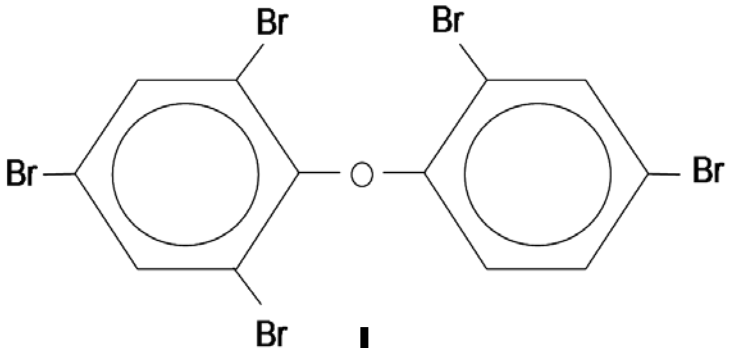
BDE-153

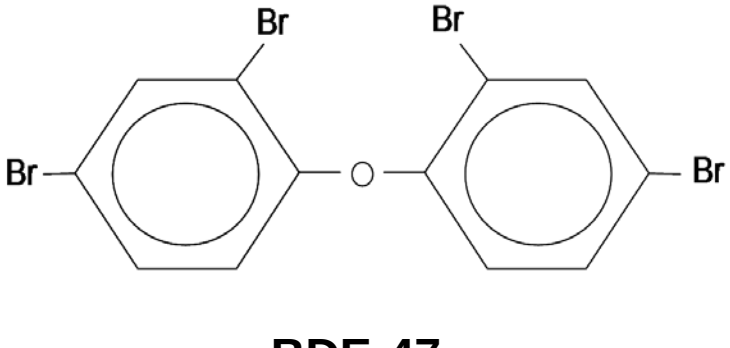




BDE-99

BDE-100





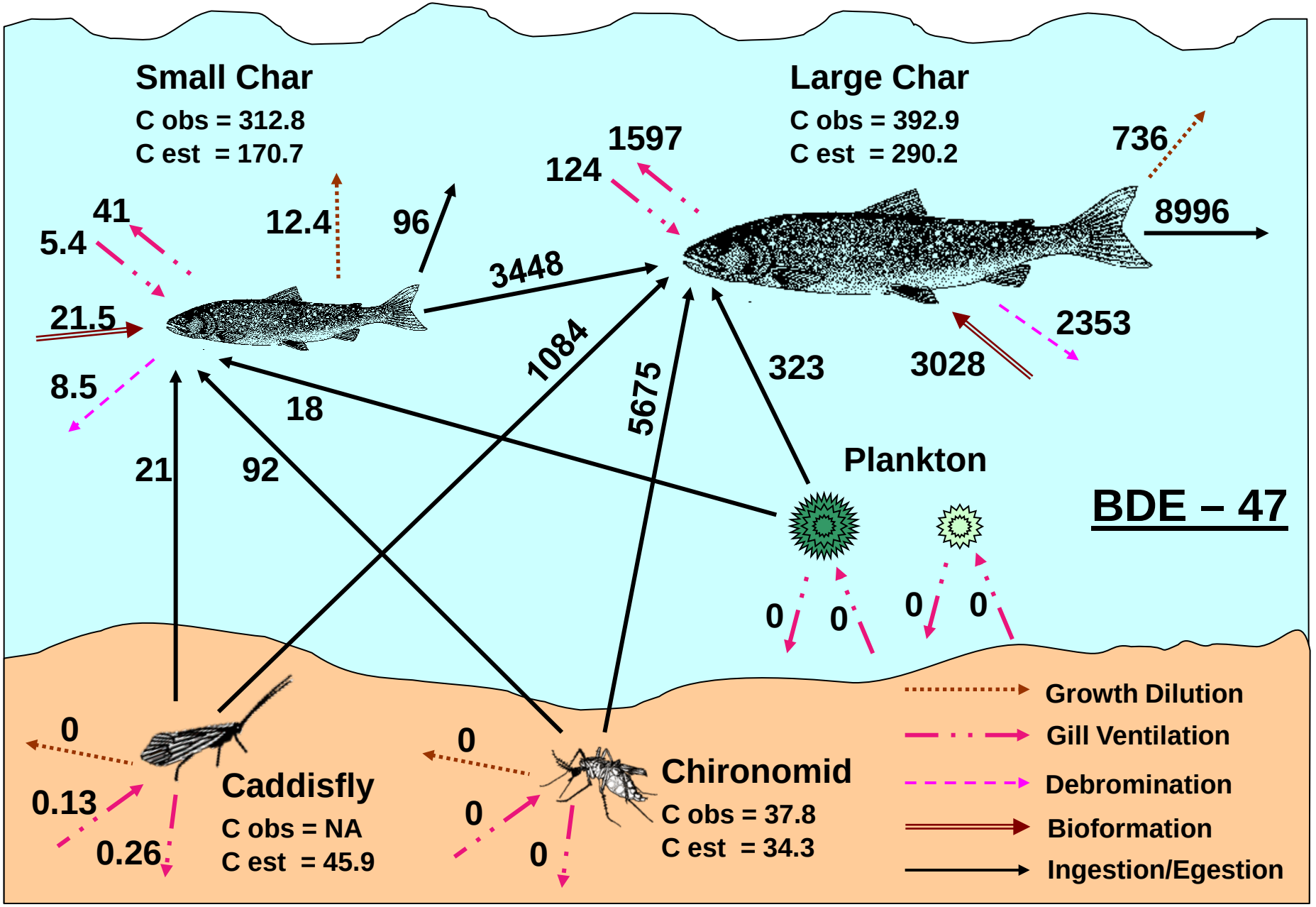
BDE-47


Svalbard
74° N
19° E
Bear Island
Norway

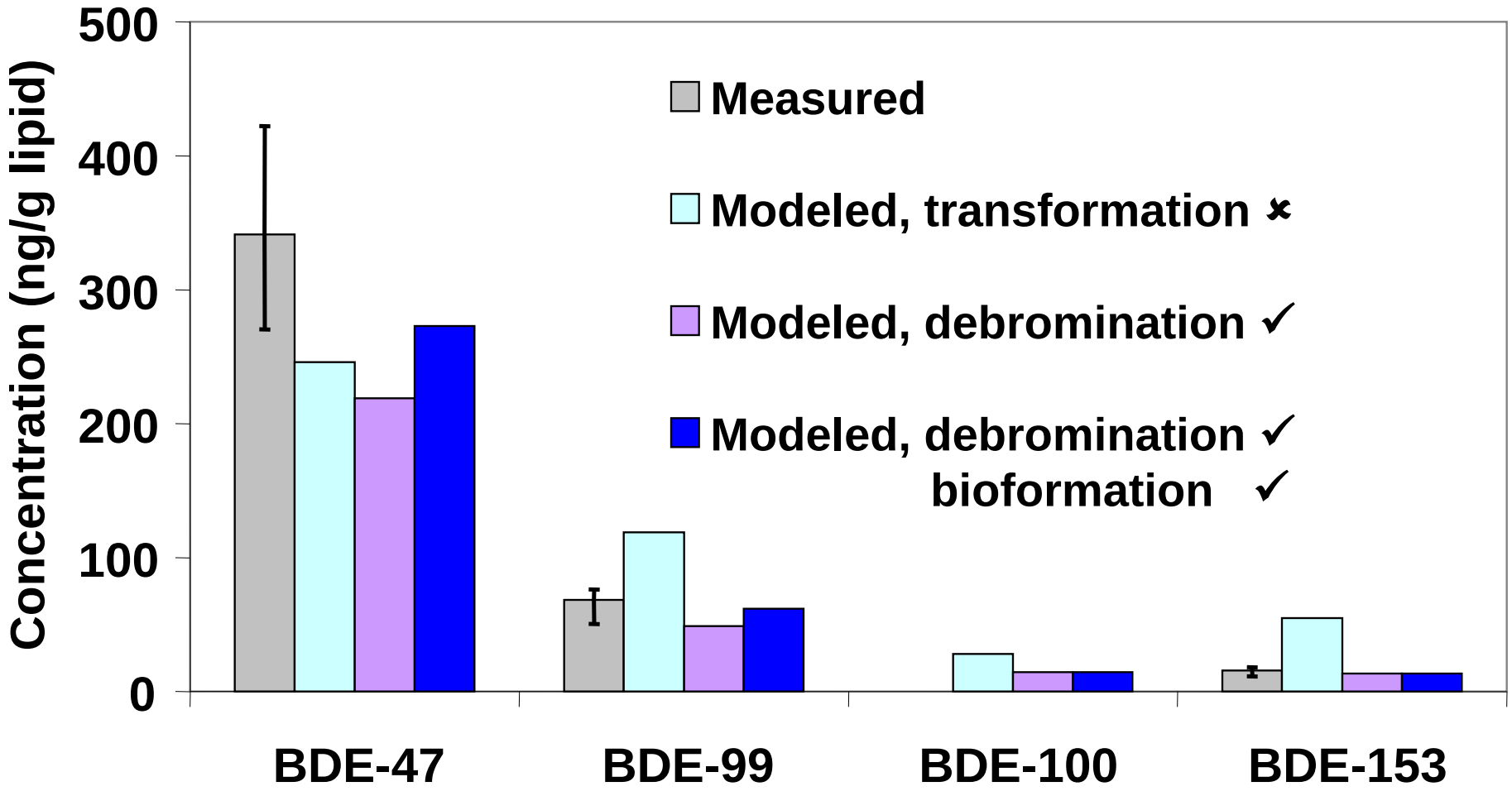

Bjørnøya met.-station
N
0 1 2km
Contour interval 100 m

Bear Island

Bear Island: Transport Rates: BDE-47



Measured vs. Modelled – Arctic Char

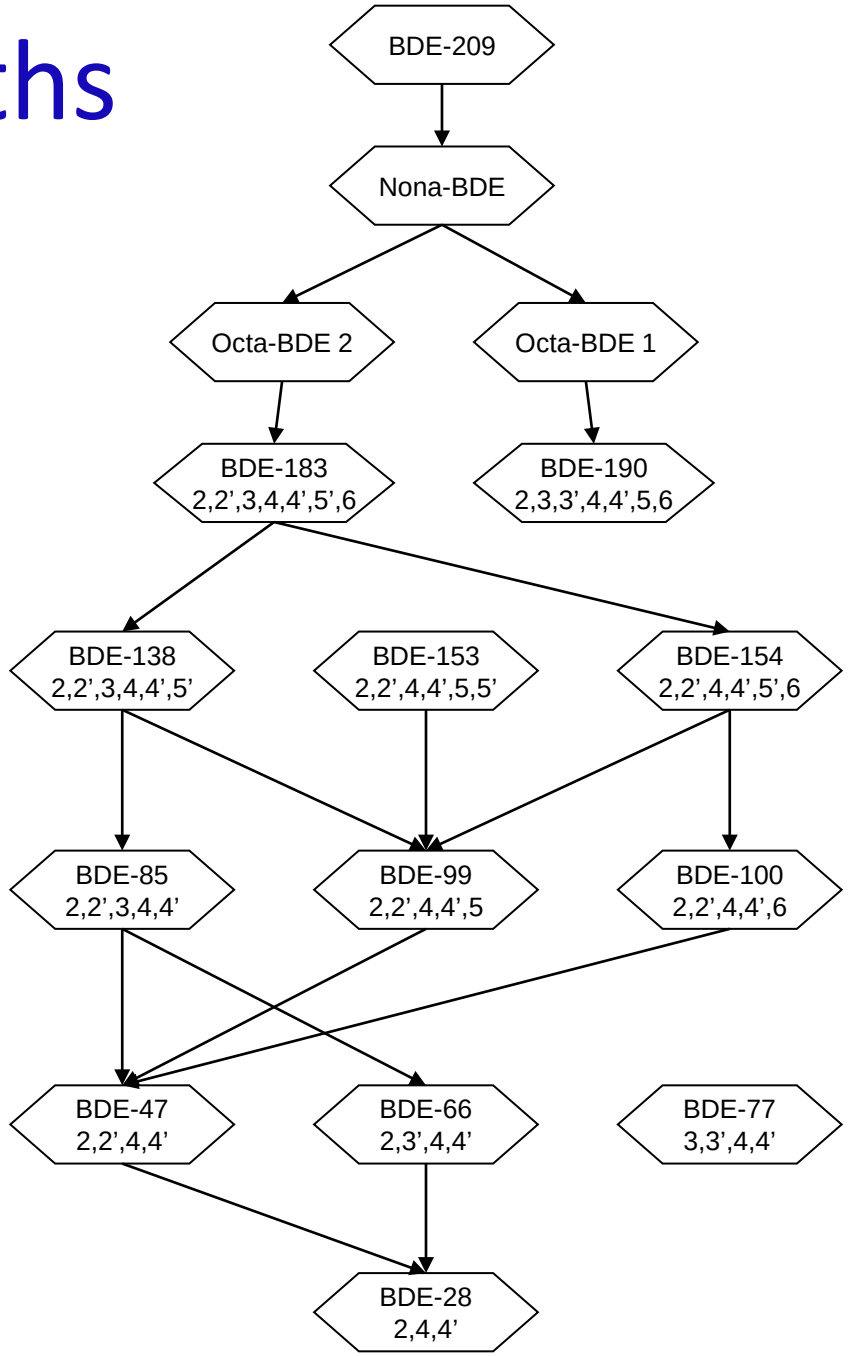


Next step

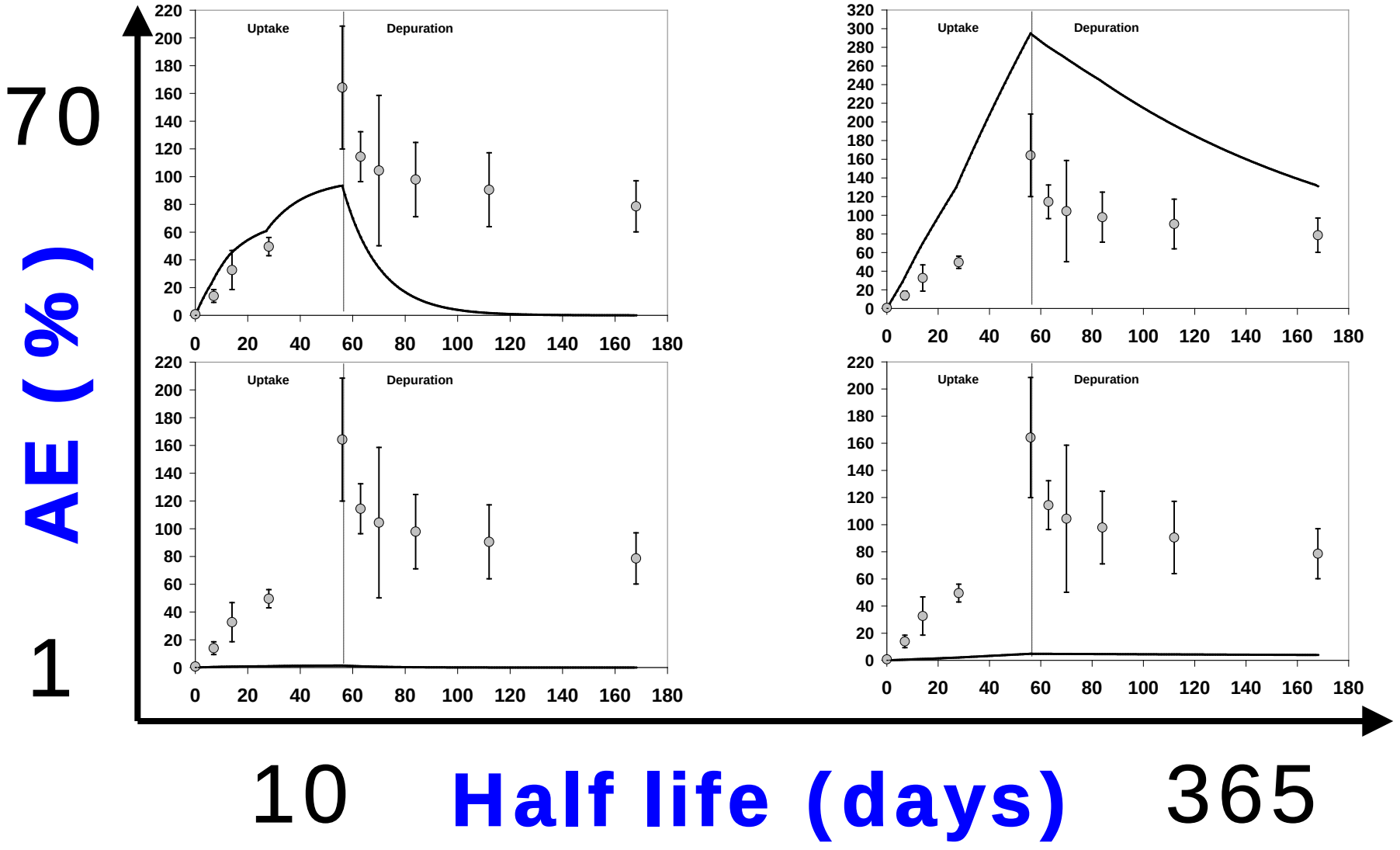
- ↑congeners BUT apply to ONE FISH
- Use experimental data rather than natural environment data
  - Better model parameterization
- Run model for multiple scenarios with same basic fish energetic parameters
  - for multiple doses
  - for more than one time-point

Debromination paths considered

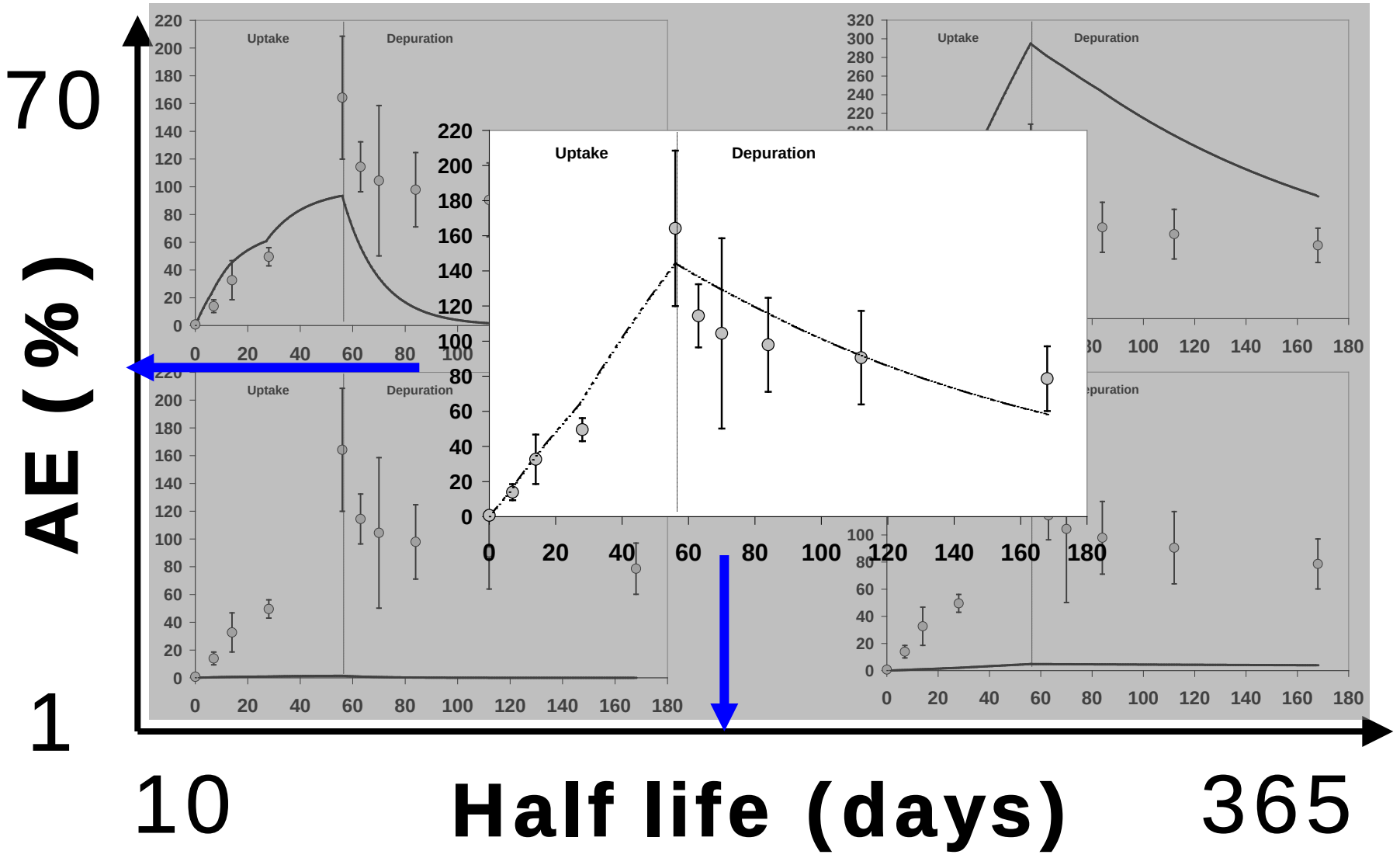
Gandhi et al. 2011. Can biotransformation of BDE-209in lake trout cause bioaccumulation of more toxic lower-brominated PBDEs (BDE-47, 99) over the long term? Environ Internat 37: 170-177.



Model Calibration: BDE-153

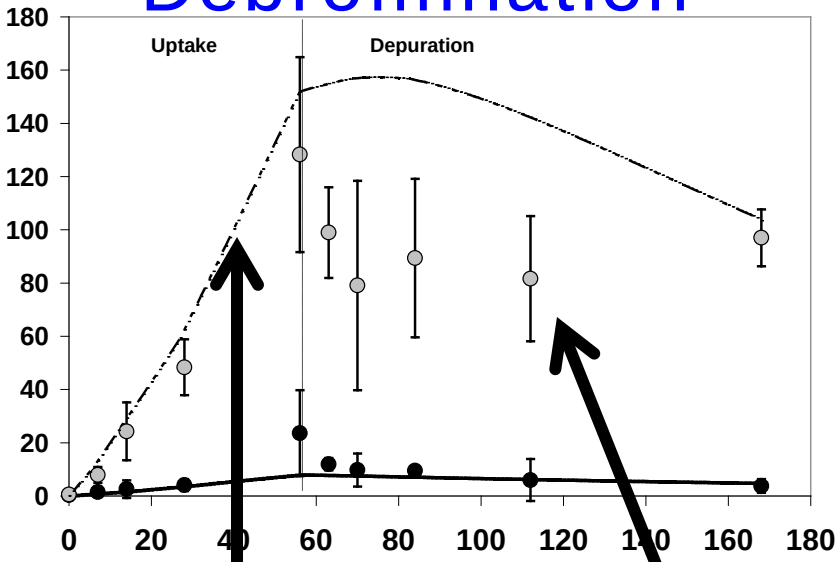


Model Calibration: BDE-153

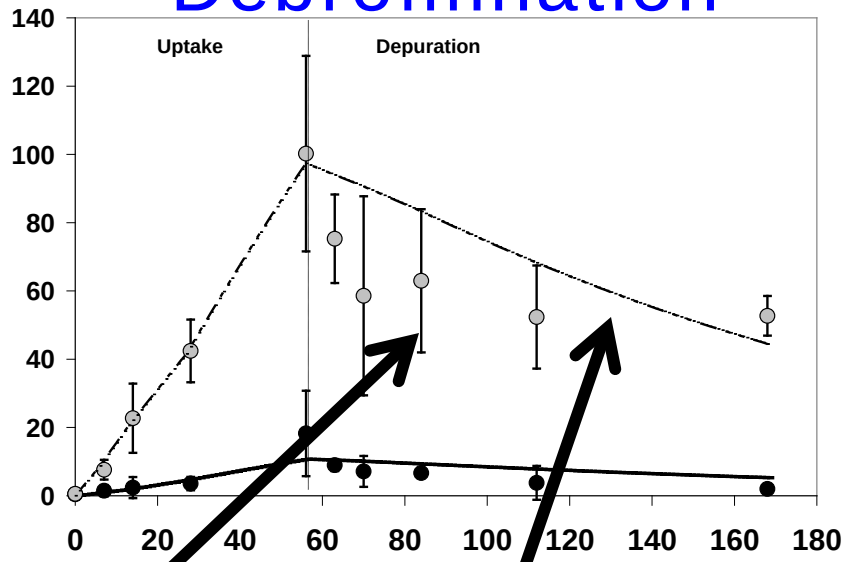


Model vs Obs (multichem, BDE-99)

Without Debromination



With Debromination

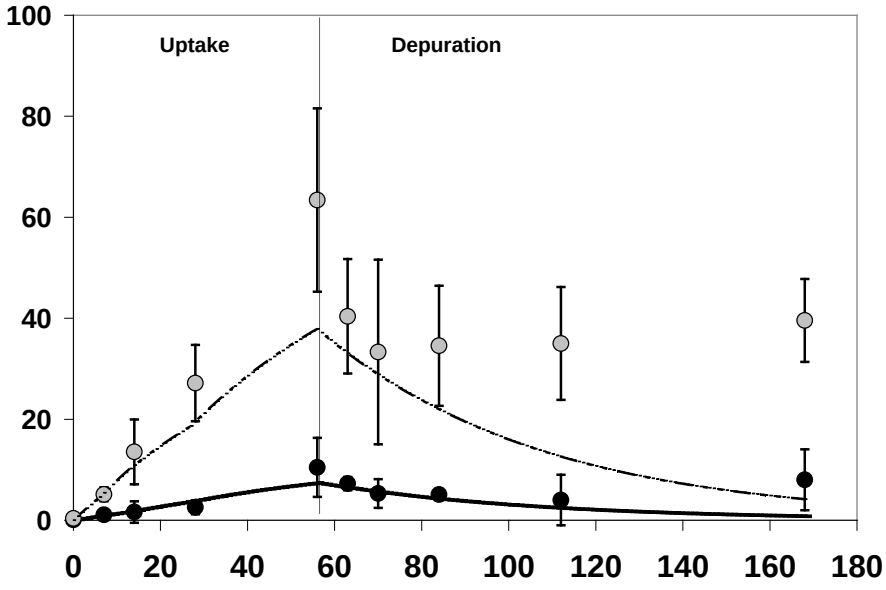


Experimental Data

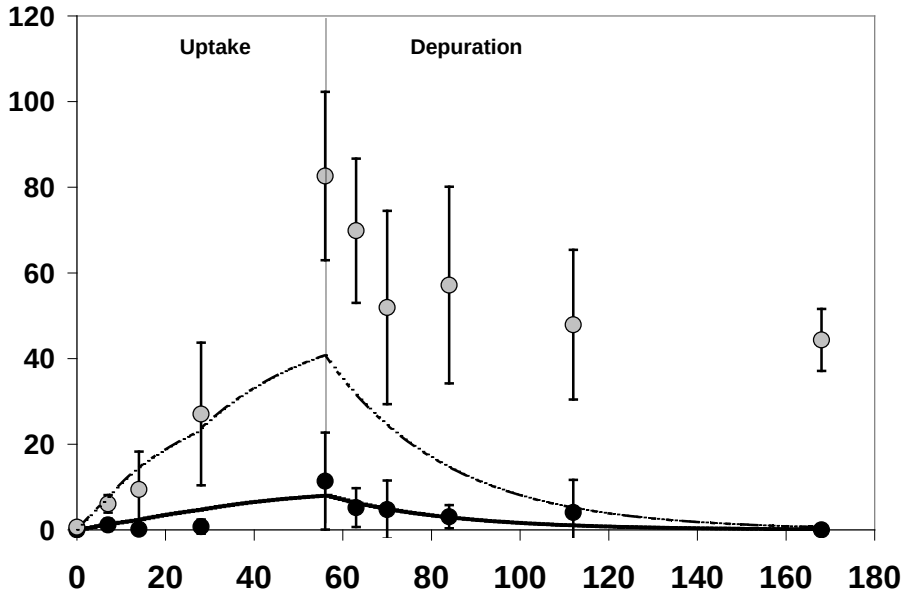
Model Estimation

…if the model did not account for the bioformation (i.e., single-chem model)..

BDE-100



BDE-47



Take Home Messages

- Chemicals vary in their tendency to bioaccumulate
  - Bioavailability
  - Tendency to biomagnify vs loss via metabolism
  - Uptake efficiency across the gut wall
  - Greatest bioaccumulation of higher chlorinated PCBs, polyunsaturated fatty acids (omega-3 fatty acids)

- Multi-chemical, dynamic fish model using the fugacity approach
- Applied to 13 PBDEs
  - 168-day Experimental data with juvenile lake trout → Tomy et al. 2004
- Model results suggest
  - Bioformation of lower brominated compounds
  - Debromination/metabolic half-lives: 20-150 days
  - ⇑ Br → ⇑ Half-lives
  - Assimilation efficiency → 20-40%

Bisphenol A

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On the Trail of Water Bottle Toxins

What does the governmen's decision on BPA mean for reusable water bottles?

globeandmai

HOME NATIONAL WORLD REPORT ON BUSINESS SP

POSTED AT 4:54 AM EDT ON 29/05/08

The hidden chemical in cans

MARTIN MITTELSTAEDT

From Thursday's Globe and Mail

Canned foods sold in Canada contain the estrogen-min
prompted many consumers to shun plastic baby bottles
conducted for The Globe and Mail and CTV. The highest
parts per billion.

Toxic Baby Bottles in Canada

Environ Defense

Bisphenol A Leaching from Popular Brands of Polycarbonate Baby Bottles

Road Map

- Why are we concerned?
- Where is BPA?
- What is BPA & why do we use so much?
- Our exposure
  - Outdoor environment?
  - Exposure assessment
    - **have we missed something?**
- Alternatives?

http://www.bikertony.org/PicsChile/PicsChileTorres1-2/02road%20side%20pop%20bottle%20prayer%20thingy(not%20sure).jpg

CBCnews.ca

Ottawa to ban baby bottles made with bisphenol A

Last Updated: Friday, April 18, 2008 | 4:55 PM ET

Canada moves to ban bisphenol A in baby bottles

Last Updated: Saturday, October 18, 2008 | 12:16 PM ET Comments 69 Recommend 58

CBC News

The federal government has decided to add bisphenol A to the country's list of toxic substances and draft regulations that ban the sale in Canada of plastic baby bottles containing the chemical.

What's the Controversy?

Population Dose

Age group?
Highly exposed?
Main exposure route?

<

>

=

Tolerable Dose

Exposure scenario?
Endpoint?

Policy Decisions

- EU
  - Food Safety Authority 2007, exposure << NOAEL of 5 mg/kg body wt/d
  - Voluntary industry phase out of BPA use in PVC polymerization or stabilizer of vinyl chloride
- US
  - State- level initiatives
  - California (2007) AB 1108 restricts BPA & certain phthalates from kids (<3 yrs) toys
- Japan 2005
  - Exposure << effects level
- Canada 2008
  - Declared toxic, with removal of baby bottles

Canadian Environmental Protection Act or CEPA

April 14, 2008 – Notice to designate BPA "CEPA Toxic"

(list on Schedule 1)

Toxics Reduction Scientific Expert Panel

Co-chairs M Diamond & L Collins

April 14, 2008 – First meeting to hear evidence to adjudicate on BPA

DRAFT
NTP BRIEF ON BISPHENOL A

[CAS NO. 80-05-7]

April 14, 2008

Peer Review Date: June 11, 2008

NOTICE

This DRAFT NTP Brief is distributed solely for the purpose of public comment and pre-dissemination peer review. It should not be construed to represent final NTP determination or policy.

National Toxicology Program

1. What are the Health Concerns?

- Harvard Center for Risk Analysis

- Evidence for low dose effects of BPA is weak
- Funded by American Plastics Council

2. What are the Health Concerns?

Chapel Hill Expert Panel

"…. Human exposure to BPA is within the range that is predicted to be biologically active in over 95% of people sampled."

"Recent trends in human diseases relate to adverse effects observed in experimental animals exposed to low doses of BPA. Specific examples include: the increase in prostate and breast cancer, uro-genital abnormalities in male babies, a decline in semen quality in men, early onset of puberty in girls…"

Vom Saal et al. 2007 Reproductive Toxicology 24: 131-138.

3. What are the health concerns?

NTP Nov 26, 2007

Some concern: neural & behavioural effects in pregnant women, fetuses, infants & children

Minimal concern: prostate cancer, birth defects & abnormalities, accelerated puberty

Negligible concern: adverse reproductive effects

4. What are the health concerns?

NTP April 14, 2008

Some concern: neural & behavioural effects in fetuses, infants & children at current exposures; effects on prostate & mammary gland, earlier age for puberty in girls

Negligible concern: birth defects, reduced birth weight & growth, reproductive effects (non-occupationally exposed)

5. What are the health concerns?

NTP June 11, 2008

Some concern: neural & behavioural effects in pregnant women,fetuses, infants & children; effects on prostate gland

Minimal concern: effects on mammary gland, accelerated puberty

Negligible concern: birth defects & abnormalities, adverse reproductive effects

US FDA "Some Concern"

Jan 1, 2010

Effects in Mice & Rats	Human Health Trends
Abnormal urethra	Abnormal penis & urethra
Prostate hyperplasia & cancer	⇧ Prostate cancer
Mammary gland hyperplasia	⇧Breast cancer
⇩ Sperm count	⇩ Sperm count
Early puberty in females	Early sexual maturation
Hyperactivity/Impaired learning	ADHD
Abnormal oocytes	Miscarriage
⇧ Body weight	⇧ Obesity

What's the controversy?

- Analytical methods
  - GC-MS or LC-MS **LOWER**
  - ELISA (enzyme linked immunosorbent assay) **HIGHER**
- Vom Saal & Hughes (2005 EHP 113: 926-933)
  - Harvard meta-analysis, **ANIMAL STRAIN** & **FUNDING** significant predictors of positive (BPA is an EDC) vs negative (BPA is not an EDC) outcomes
- Funding
  - Sample size, # generations

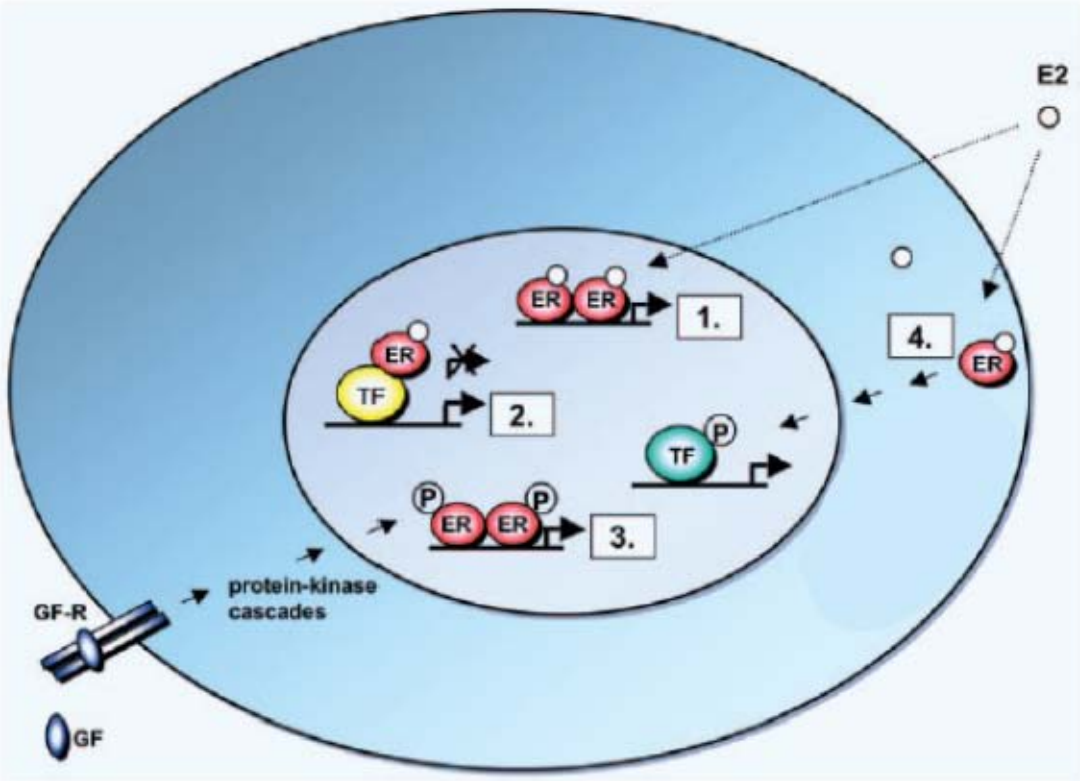
What's the controversy?

Metabolism

- ~2/3 BPA glucuronidated in adult
- Minimal metabolism in fetus
- Humans
  - Glucuronidated in gut wall & liver, then excretion in urine
- Rodents
  - Glucuronidated in liver, excreted to bile where it is cleaved into BPA & glucuronidase, reabsorbed in blood, finally excreted in feces

BPA's Estrogenic Activity

Other hormone receptor-mediated pathways



P. Harper, Sick Kids Hospital

Björnström & Sjöberg, Mol Endocrinol 2004 19:833

Road Map

- Why are we concerned?
- Where is BPA?
- What is BPA & why do we use so much?
- Our exposure
  - Outdoor environment?
  - Indoor environment?
  - Exposure assessment
    - **have we missed something?**
- Alternatives?

http://www.bikertony.org/PicsChile/PicsChileTorres1-2/02road%20side%20pop%20bottle%20prayer%20thingy(not%20sure).jpg

Usage Rates

- > 27 companies use/import BPA in Canada 2006
- Global production capacity < 3 billion kg/y in 2003
- World demand ⬆ **6-10%/y**
- US demand
  - 7.3 million kg in 1991
  - >1 billion kg in 2004 (~4.5 g/person each day)

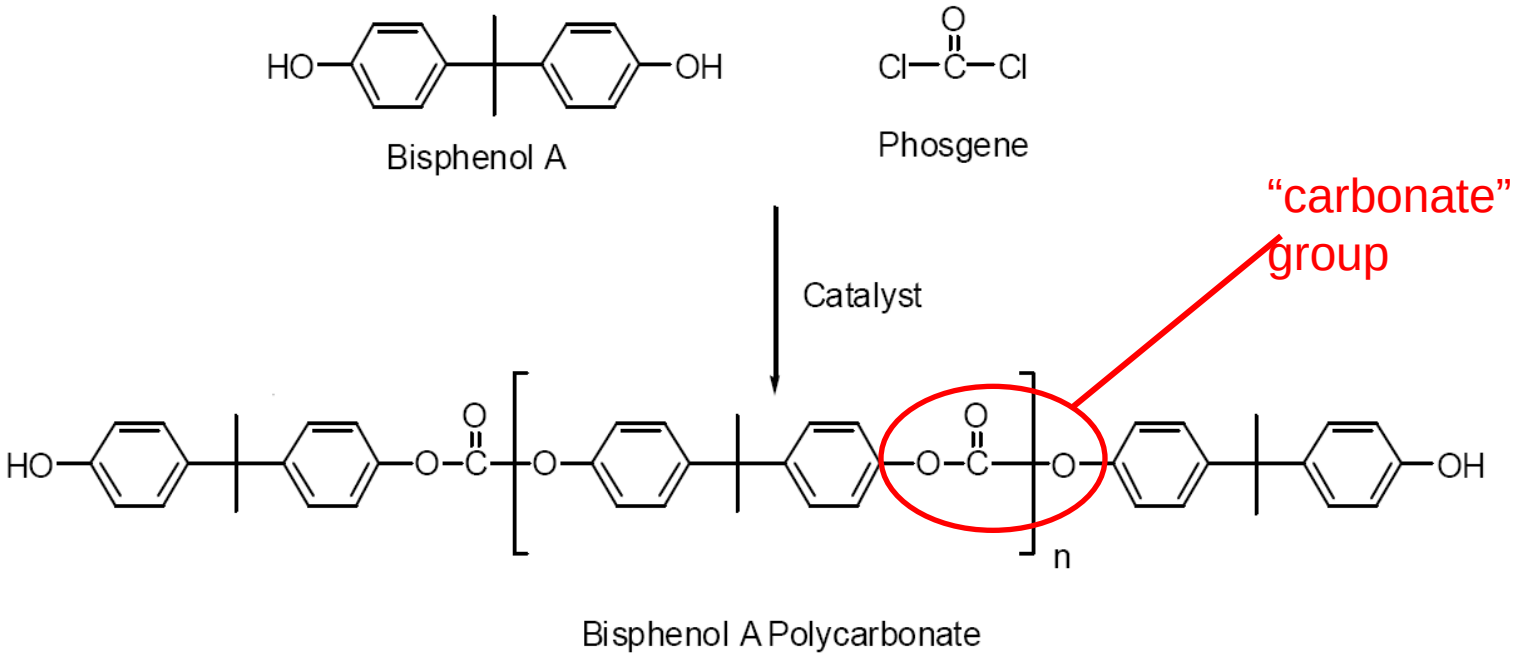
Where is my bisphenol A coming from?

Where is BPA?

- Food
  - Polycarbonate bottles
  - Can epoxy linings
  - Kettles
  - Food containers
  - Pipe surface coatings
- Consumer Products
  - Adhesives
  - Eye glass coatings
  - Thermal paper
  - Crash helmets
- Electronics
  - Cell phone & lap top casings
  - CDs & DVDs
  - Power plugs
- Automotive
  - Bumpers
  - Safety glazing
  - Inside lights
  - Grills

BPA Chemistry - background

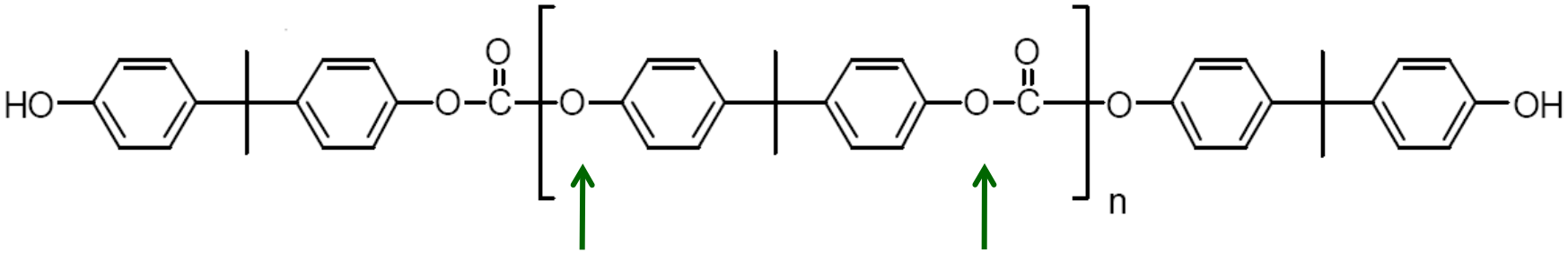
- **Polycarbonate polymer – bottles and other food containers**



- **Single step combines BPA, second monomer and catalyst**
  - **"thermoplastic" polymer**
  - **"n" determines melting temperature**
  - **first heat, then mold, cool to fix form of final product**
  - **forms hard, clear, dent resistant polymer**

BPA Chemistry - background

- **Polycarbonate polymer – bottles and other food containers**

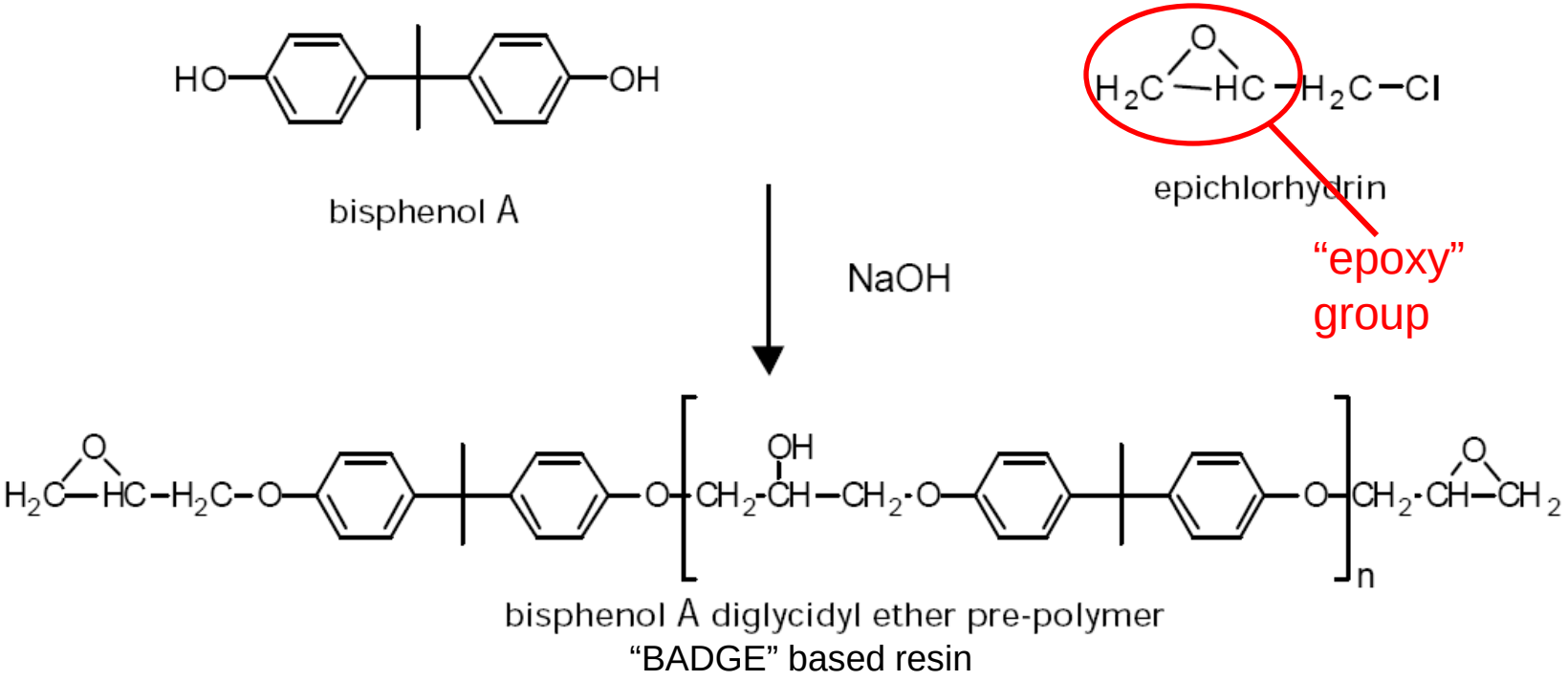


Hydrolysis of these sites releases BPA

- **Polycarbonate also potential source of BPA release**
  - **hydrolysis of carbonate group produces BPA**
  - **promoted by heat, alkaline conditions (also acid)**
  - **depends on time, nature of food or liquid contents**
  - **also affected by history – cleaning, heating, etc.**

BPA Chemistry - background

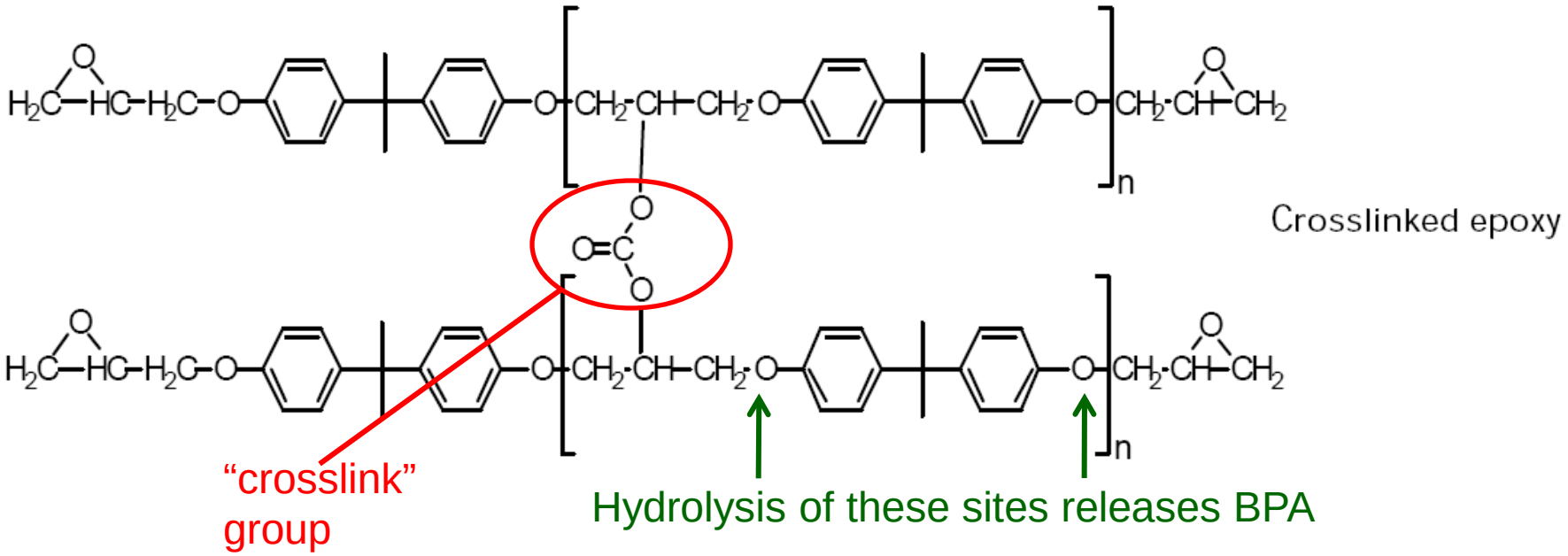
- **Epoxy liners and coatings – "thermoset" polymer**



- **Step one produces epoxy "pre-polymer" (or resin)**
  - **liquid easily blended with curing agents, other ingredients (e.g. titanium oxide for white liners)**
  - **liquid easily sprayed for coating surfaces**

BPA Chemistry - background

- **Epoxy liners and coatings – "thermoset" polymer**



- **Step two adds curing agent and heat to make "thermoset"**
  - **thermoset polymer cured in place, does not re-melt**
  - **high thermal and chemical stability, good surface adhesion**
  - **"hydrolysis" of ether oxygen can result in release of BPA (may be promoted by heat, acid or alkaline conditions)**
  - **long-term stability depends partly on contents**

S. Brown, Queen's University

Road Map

- Why are we concerned?
- Where is BPA?
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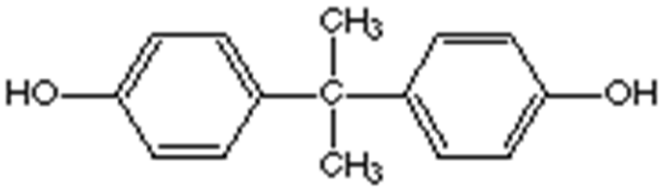
  - Indoor environment?
  - Exposure assessment
    - **have we missed something?**
- Alternatives?



Bisphenol A

http://www.bikertony.org/PicsChile/PicsChileTorres1-2/02road%20side%20pop%20bottle%20prayer%20thingy(not%20sure).jpg

Fate of BPA in the Environment

Emissions:
- sewage treatment plants (us)
- industrial discharges (NPRI)

Fate:
- Soil, sediment
- Water

Matrix	Half Life	Notes
Air	0.2 days	Unlikely to be transported
Water	2.4-4 days	Biodegradation most significant process Little volatilization, photo-degredation, or hydrolysis
Soil	30 days (3 days)	Low mobility Not expected to be stable, mobile or bioavailable
Tissue		Fish - Bioconcentration Factor =3.5-68 Clams - Bioconcentration Factor =134-144

Source: Kleywegt & Fletcher 2008

Chemical	Indoor Emission (ug/m^2 d)	Chemical Mass (mg)	Residence Time (y)	Annual Release (%)
BPA	1.2-2.5	240	76	1.3
BBP	0.4-13.3	22	27	4
DEHP	4.3-7.7	17000	1175	0.1
PCB	0.8	600	800	0.1
PBDE	0.03-0.2	4.6		0.001

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http://www.bikertony.org/PicsChile/PicsChileTorres1-2/02road%20side%20pop%20bottle%20prayer%20thingy(not%20sure).jpg

Biomarker Exposure Assessment

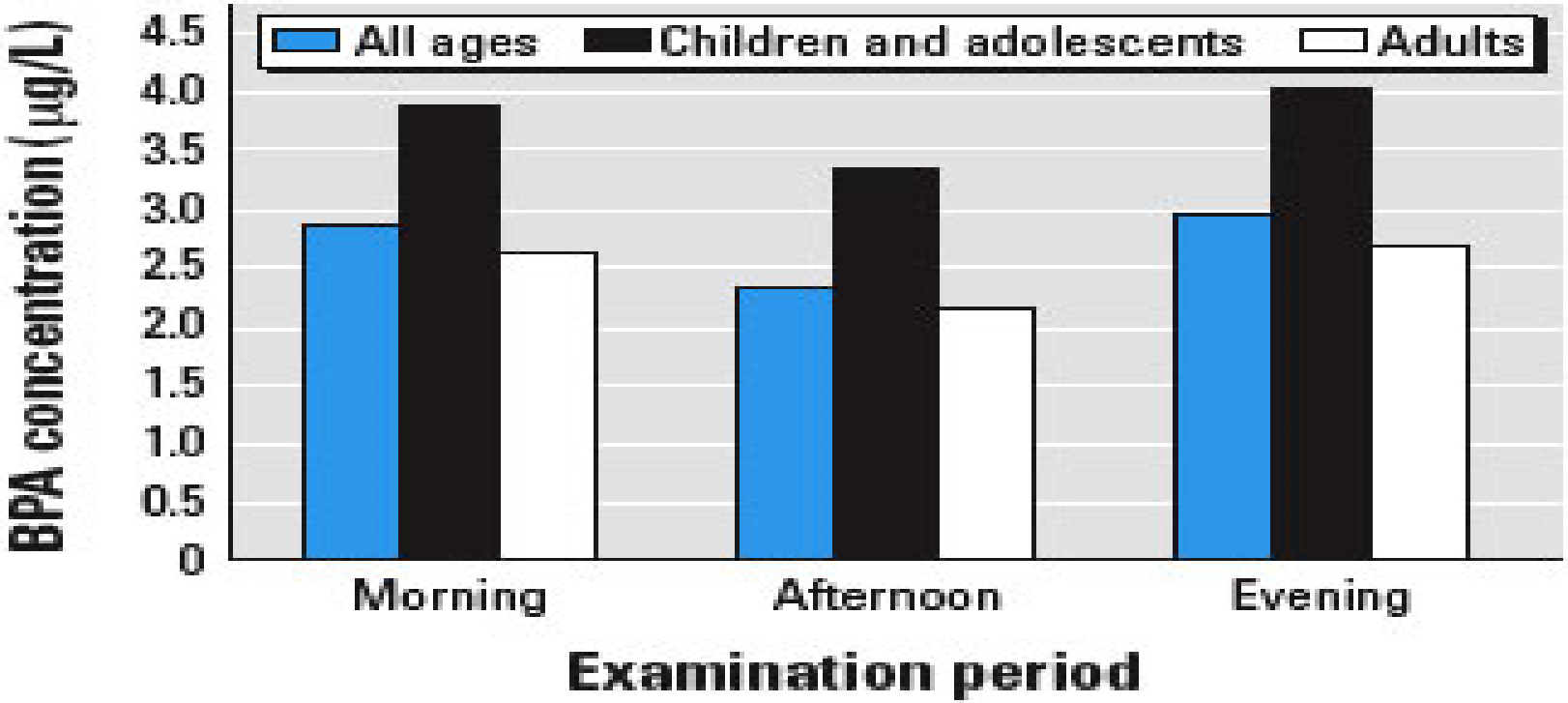
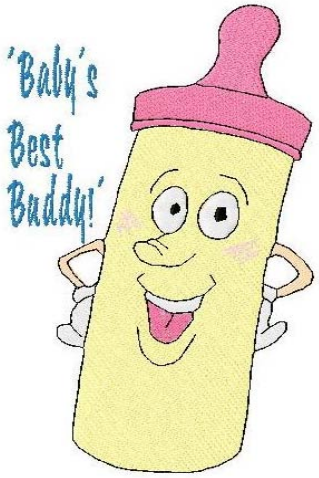
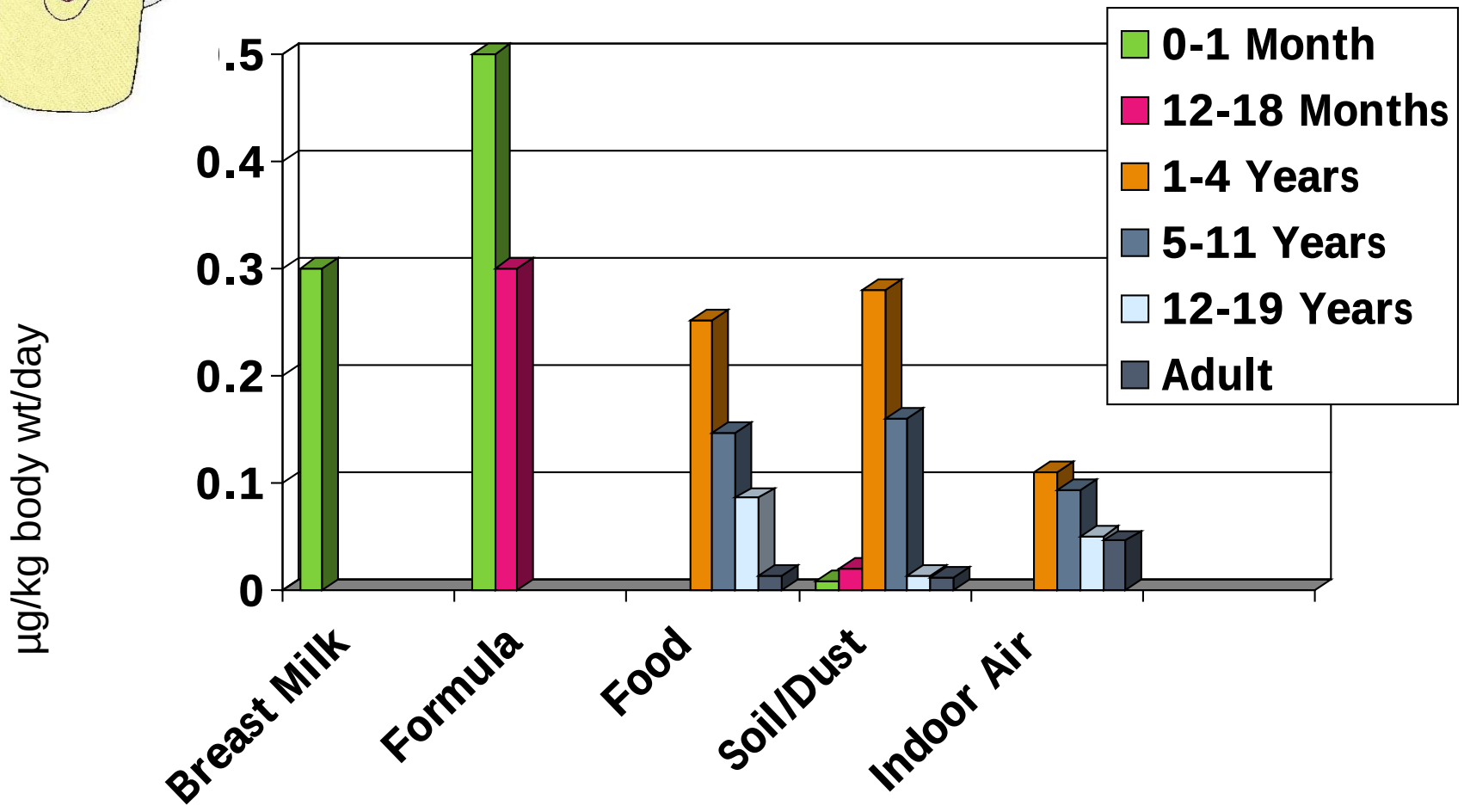


Figure 1. Geometric mean urinary concentrations of BPA (µg/L) for each daily examination period.

Calafat et al. 2008 Exposure of the U.S. Population to Bisphenol A and 4-*tertiary*-Octylphenol: 2003–2004. Environ Health Perspec 116(1):39-44



Average Exposure



Average Exposure, *Draft Screening Assessment for Phenol, 4,4'-(1-methylethylidene) bis- (80-05-7) April 2008* CEPA.

Where does mom get BPA from?

Table 11. Potential daily intake of bisphenol A (µg/kg-bw per day) from use of epoxy resins as interior protective lining for food and beverage cans

Canned food	1-4 year olds[3]		5-11 year olds[3]		12-19 year olds[3]		Adults[3]	
	Avg[1]	Max[2]	Avg	Max	Avg	Max	Avg	Max
Soft drinks	0.00189	0.00889	0.00216	0.0102	0.00253	0.0119	0.00181	0.00854
Evaporated milk	0.00248	0.00637	0.00106	0.00273	0.00056	0.00143	[illegible]	[illegible]
Soups	0.187	1.25	0.104	0.694	0.0596	0.398	0.0587	0.392
Tuna	2.7×10^{-5}	3.0×10^{-4}	4.2×10^{-4}	4.7×10^{-3}	2.7×10^{-4}	3.0×10^{-3}	2.0×10^{-4}	2.3×10^{-3}
Pastas	0.0494	0.330	0.0304	0.203	0.0189	0.126	0.00804	0.0537
Vegetables	0.00847	0.358	0.00814	0.345	0.00418	0.177	0.00309	0.131
Fruits	0.00260	0.0306	0.00132	0.0156	0.00034	0.00402	[illegible]	[illegible]
TOTAL	**0.252**	**1.98**	**0.147**	**1.28**	**0.0864**	**0.731**	**0.0730**	**0.596**

http://www.ec.gc.ca/substances/ese/eng/challenge/batch2/batch2_80-05-7.cfm

accessed 20 October, 2008

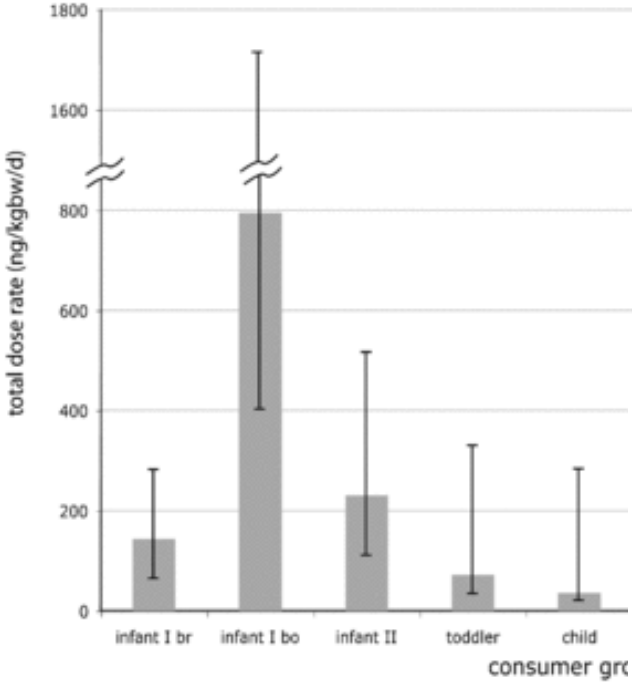
Mom's transfer of BPA to infant

Table 13. Potential daily intake of bisphenol A (µg/kg-bw per day) from consumption of human breastmilk containing either average or maximum bisphenol A concentrations.

Infant age group	Average Concentration of bisphenol A (1.8 ppb)[1]	Maximum concentration of bisphenol A (7.1 ppb)[1]
0 to 1 month[2]	0.26	1.09
2 to 3 months[3]	0.21	0.84
4 to 7 months[4,5]	0.19	0.73

http://www.ec.gc.ca/substances/ese/eng/challenge/batch2/batch2_80-05-7.cfm

accessed 20 October, 2008



Infant – 1. PC baby bottle
2. Breast milk
Adult – canned soup

Figure 1. Mean total exposure dose rates with source-related variability.

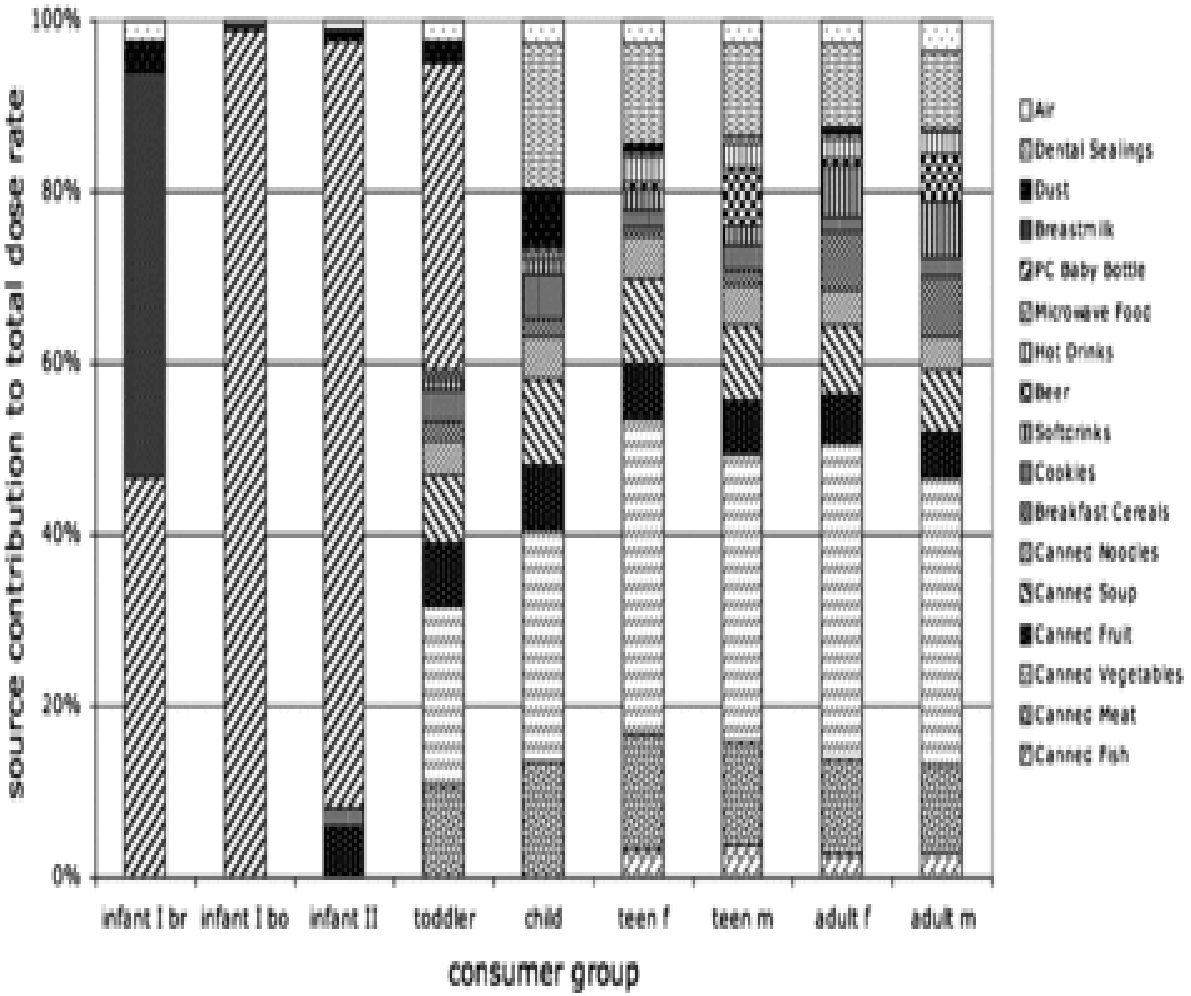
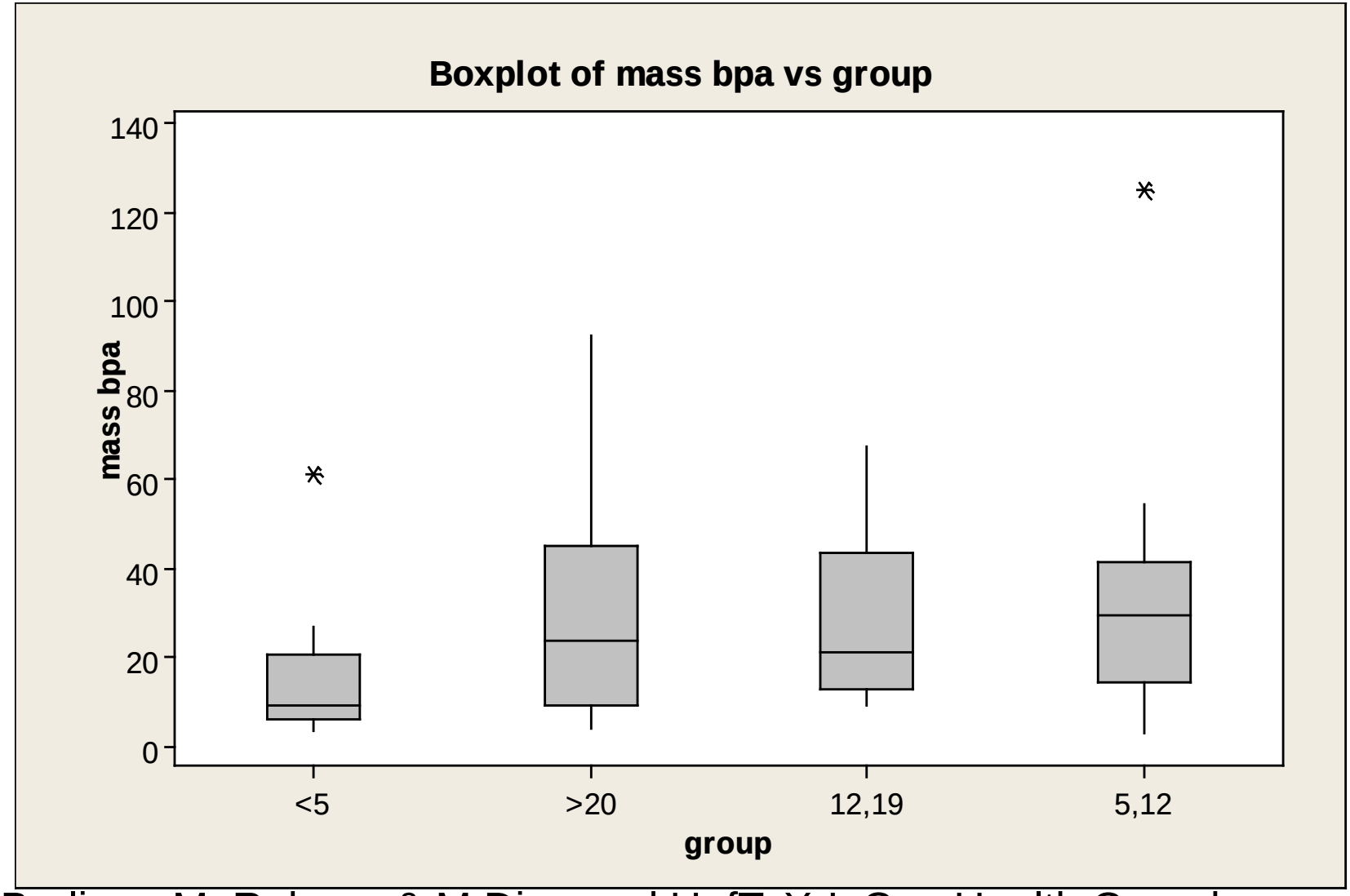
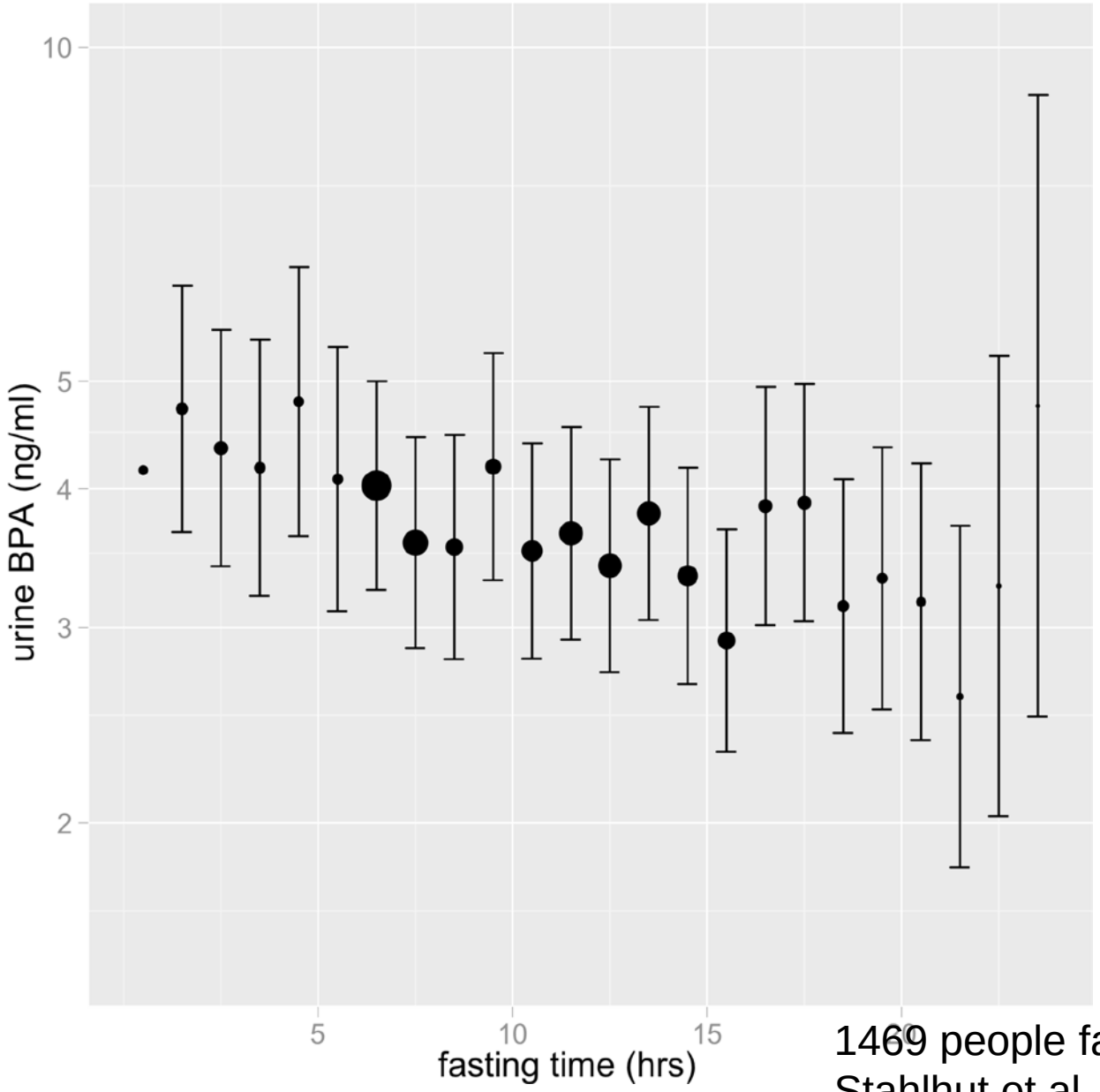


Figure 2. Contribution of sources to the total dose rate for the mean exposure scenario.
Von Goetz et al. 2010 Risk Analysis

BPA on our hands



D. Berliner, M. Robson & M Diamond UofT, X-L Cao Health Canada



1469 people fasting*
Stahlhut et al. 2009 EHP

Exposure from Drinking Bottles

Table 3. Percent change in urinary concentrations of phenols associated with 1-week use of polycarbonate drinking containers.

Phenol	Percent change (95% CI)	*p*-Value	*p* for heterogeneity
BPA			
Overall	69 (40 to 102)	< 0.0001	
≥ 90% compliance	77 (45 to 117)	< 0.0001	
< 90% compliance	55 (6 to 127)	0.03	0.54
BP-3			
Overall	45 (16 to 81)	0.001	
≥ 90% compliance	36 (2 to 80)	0.04	
< 90% compliance	64 (11 to 142)	0.01	0.42
MePB			
Overall	–6 (–25 to 18)	0.60	
≥ 90% compliance	17 (–10 to 51)	0.24	
< 90% compliance	–34 (–56 to 0)	0.05	0.01
PrPB			
Overall	5 (–24 to 44)	0.77	
≥ 90% compliance	15 (–23 to 70)	0.49	
< 90% compliance	–10 (–49 to 59)	0.70	0.46
TCS			
Overall	12 (–17 to 50)	0.46	
≥ 90% compliance	11 (–18 to 50)	0.50	
< 90% compliance	17 (–39 to 126)	0.62	0.88

Concentrations (μg/L) < LOD were recorded as 1/2 LOD, which is 0.2 for BPA and BP-3; 1.15 for TCS; 0.5 for MePB; and 0.1 for PrPB. Twenty-eight participants reported < 90% compliance over intervention week, 48 participants reported ≥ 90% compliance, and compliance was missing for one participant.

Carwile et al. 2009 EHP

VOLUME 117 | NUMBER 9 | September 2009 • Environmental Health Perspectives

79 university students

Exposure from Cash Register Receipts

Table 3 Transfer of BPA to two fingers depending on skin properties (papers according to Table 1; individual measurements)

	BPA on two fingers (μg)	
	Recorder 2	Shop 4
Standard (slightly greasy skin)	1.2, 0.9, 1.5, 1.1	0.7, 1.3
Dry skin after washing and drying	0.7, 0.6	1.0, 0.6
Humid finger	7, 28	
Wet fingers	46, 36	
Oily finger	14, 9	11, 7

a cash register is unlikely to transfer substantial amounts of BPA to the food packs or other surfaces. These data suggest

Table 5 BPA transfer during repeated contacts

Number of contacts	BPA on finger (μg)
1 (standard)	1.2, 0.9, 1.5, 1.1
3	1.1, .9
10	1.3, 0.7
1, then 3 with clean paper	1.0, 0.7

Table 6 BPA transferred onto fingers by wet contact; amounts extractable with ethanol directly or after washing with soap and cold or warm water, either immediately after contacting recorder paper 2 or after waiting 20 or 60 min

Direct extraction (μg)	Washing	Extraction after washing (μg)	Recovered residue in skin (%)
Cold water			
46	Immediately	2.5	5.4
36	After 20 min	3	8.3
44	After 60 min	3.1	7.0
Warm water			
18, 33	Immediately	0.2, 0.4	1.1, 1.2
36, 25	After 20 min	0.1, 0.5	0.3, 2.0
22, 29	After 60 min	0.8, 0.3	3.6, 1.0

Wash your hands!

Biedermann et al. 2010
anal Biochem Chem

Road Map

- Why are we concerned?
- Where is BPA?
- What is BPA & why do we use so much?
- Our exposure
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  - Exposure assessment
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- Alternatives?

http://www.bikertony.org/PicsChile/PicsChileTorres1-2/02road%20side%20pop%20bottle%20prayer%20thingy(not%20sure).jpg

Alternatives?
BPA Epoxy Can Linings

- BPA-based epoxy phenolic coatings
- Polyester
  - Shorter shelf life
  - Less resistant to acidic foods
- Cycloaliphatic epoxy resins
- PVC vinyl-based

Phenolic Gold linings from CDI SAKATA

Source: S. Brown, Danish EPA 2004

C&EN
CHEMICAL & ENGINEERING NEWS
SERVING THE CHEMICAL, LIFE SCIENCES, AND LABORATORY WORLDS

OCTOBER 25, 2010 | VOLUME 88, NUMBER 43 | P. 10 | DOI:10.1021/CEN102110135533

Removing Bisphenol A

Canned Foods: Many companies plan to phase out use of chemical in produc

Melody Voith

Although several firms said they rely on their suppliers to make changes to food packaging, the report commends ConAgra and Campbell Soup for "extensive testing processes for BPA-free can linings." Yet the firms' efforts still lack transparency, says report author Emily Stone of Green Century. "The companies are tight-lipped about the substitutes they are testing," she says.

Text Size A A

CAN PLANS

Survey grades food companies in BPA phaseout activity

	SEEKING ALTERNATIVES	PLANNING PHASEOUT	PUBLIC DISCLOSURE
Hain Celestial	A	A	A
ConAgra	A	A	B+
H. J. Heinz	A	A	B+
General Mills	A	C	B+
Nestlé	C	A	B+

NOTE: Top five of 22 food company respondents.
SOURCE: Green Century Capital Management

View Enlarged Image

Food companies are making notable progress in replacing the bisphenol A (BPA) used to make epoxy can linings, according to a new report by **Green Century Capital Management**, an advisory firm focused on environmentally responsible investing, and As You Sow, a shareholder advocacy group.

R
- Canada Lists BPA As Toxic Compound
- BPA Craziness

Topics Covered

BPA, food packaging, cons

Alternatives? Polycarbonate

- Glass, stainless steel
- HDPE, PP
- Polyamide (nylon)
- Polyethersulphone

$9 each

$8 each

Source: S. Brown, Danish EPA 2004

Alternatives?

Printing inks, toners, dental materials, plumbing coatings

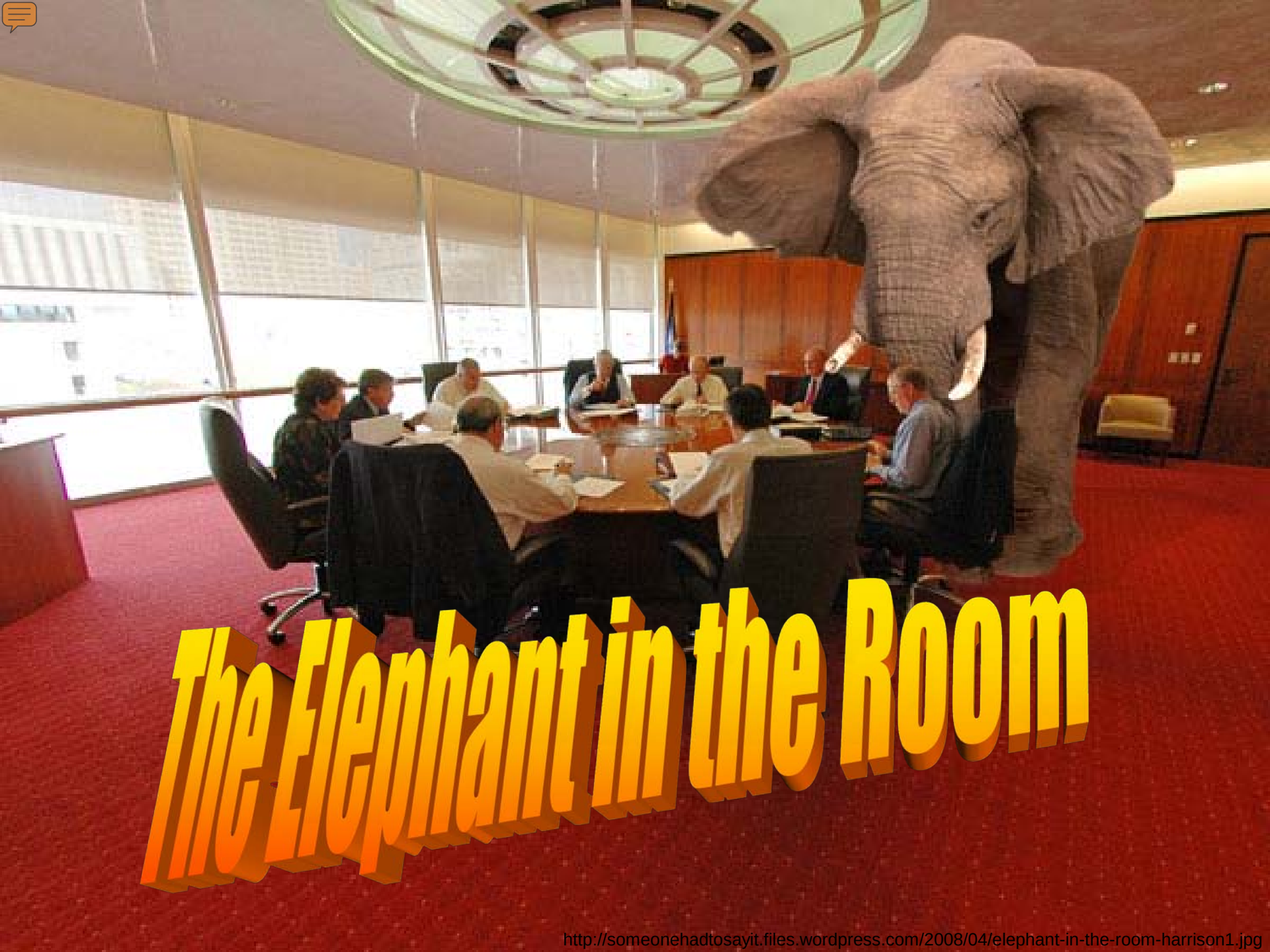
- Nitrocellulose, polyvinyl butyral, polyamide polyester
- For food packaging: polypropylene, nylon

Source: Danish EPA 2004

Conclusions

- Why are we concerned?
  - Toxicity is controversial, regulatory action
- Where is BPA? All over the place
- What is BPA & why do we use so much?
  - Durable, excellent material properties
- Our exposure
  - Outdoor environment? 70% Degrades
  - Indoor environment? Emissions 100's ng/h
  - Exposure assessment
    - **have we missed something?** **Where does mom get her BPA?**
- Alternatives? Not well tested!

Reduce Use ⇨ Sustainability



http://someonehadtosayit.files.wordpress.com/2008/04/elephant-in-the-room-harrison1.jpg

Need multi-pronged to minimize exposure & promote health

Safe Products

Increase longevity of products

Less time indoors

Less is better

Increase ventilation

Less Time Indoors!

- 22/24 hours spent indoors
- Kids 6-11 yr old spend 53 hours/week with electronic devices
- 6% of 9-13 yr olds in US play outside in a typical week (R. Louv)

http://www.gossipjackal.com/entertainment/2010/07/24/premature-death-linked-to-sedentary-lifestyle/

Sony plans lawsuit against government ad

Less Stuff

***Story Of Stuff*, Referenced and Annotated Script**
By Annie Leonard

THE STORY OF STUFF
WITH ANNIE LEONARD

"The average U.S. Person now consumes twice as much as they did 50 years ago."

mine, in fact I got a little obsessed with all my
uy comes from and where it goes when we
I looked it up. And what the text books said is
tion to production to distribution to consump-
economy.

years
and
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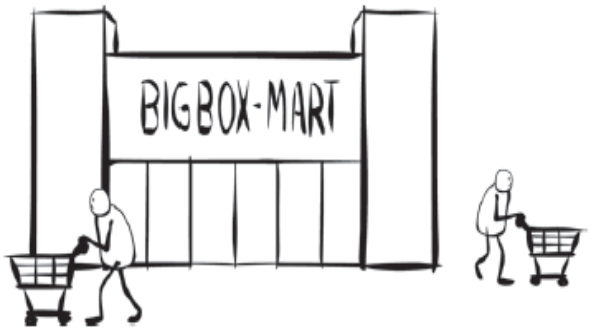

For one thing, this system looks like it's fine. No problem. But the truth is it's a system in crisis. And the reason it is in crisis is that it is a linear system and we live on a finite planet and you

Planned & Perceived Obsolescence

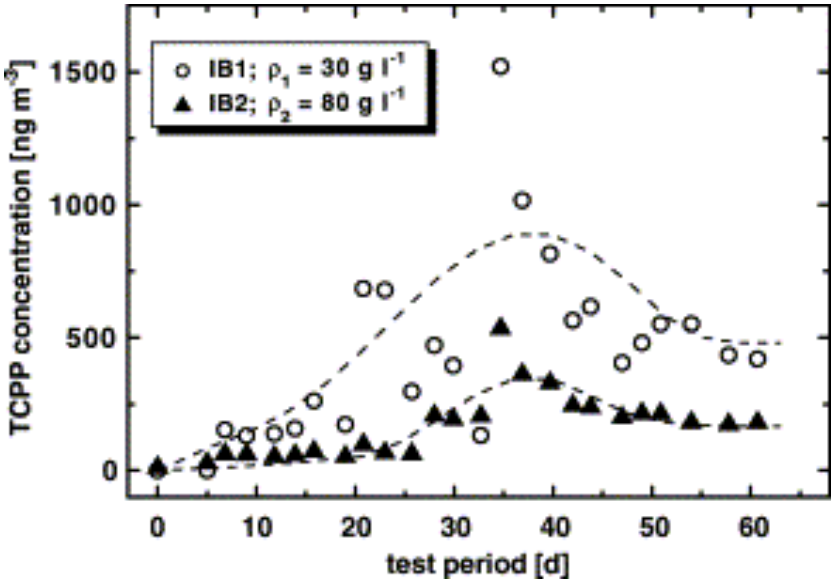

Fig. 2. Emission of TCPP from two PIR insulating boards with different specific (ρ_1=30 g l^{-1}, ρ_2=80 g l^{-1}).

Do we maximize SVOC releases as a consequence of continual replacement of "stuff"

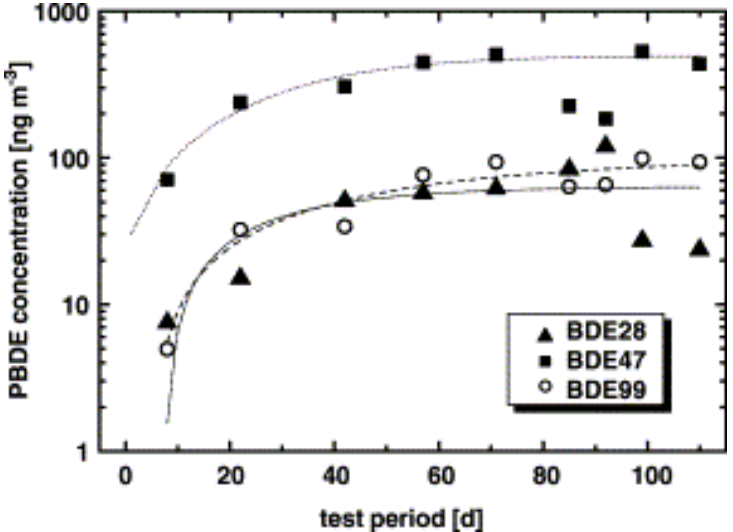

Fig. 4. Emission of selected PBDE from a printed circuit board at simulated operating conditions (60°C) as a function of time

Kemmlein et al. 2003 Atmos Environ 37: 5485-5493

Acknowledgements

Funding

- NSERC
- Great Lakes Commission
- Ontario Min of Environment
- Environment Canada

Stuart Harrad, Univ of Birmingham

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