Levels Of Polybrominated Diphenyl Ethers (PBDEs) In Fish, Beef, And Poultry Purchased In Food Markets In Northern California USA

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Background

- Recent studies of human milk, blood, and adipose tissues demonstrate exposure to PBDEs in the U.S. population.
- Exposure modeling performed using the limited available environmental data suggests that one of the main routes of human exposure to PBDEs is likely through the consumption of food products such as eggs, meats, fish, and dairy products.
- In the U.S., recent studies have shown the edible portions of farm-raised fish containing higher levels of PCDD/Fs, PCBs, and PBDEs than in wild fish.

Purpose of Study

- To evaluate the occurrence and potential for human exposure to PBDEs through the consumption of store-bought consumer food products in northern California USA.
  - fillets from several species of freshwater and ocean fish (both farm-raised and wild),
  - ground beef and ground deer meat, and
  - several species of poultry (chicken, turkey, duck, goose, and pheasant).

Foods Tested for PBDEs

- 5 species of wild, ocean fish (swordfish, pacific salmon, coho salmon, tuna and halibut),
- 2 species of farm-raised fish (atlantic salmon and catfish),
- Ground beef from conventionally-raised cattle,
- Ground beef from vegetarian, hormone-free, antibiotic-free cattle,
- Deer and elk meat,
- Meat from wild duck, goose, and pheasant,
- Poultry meat from conventionally-raised chicken and turkey, and
- Organic chicken and turkey.

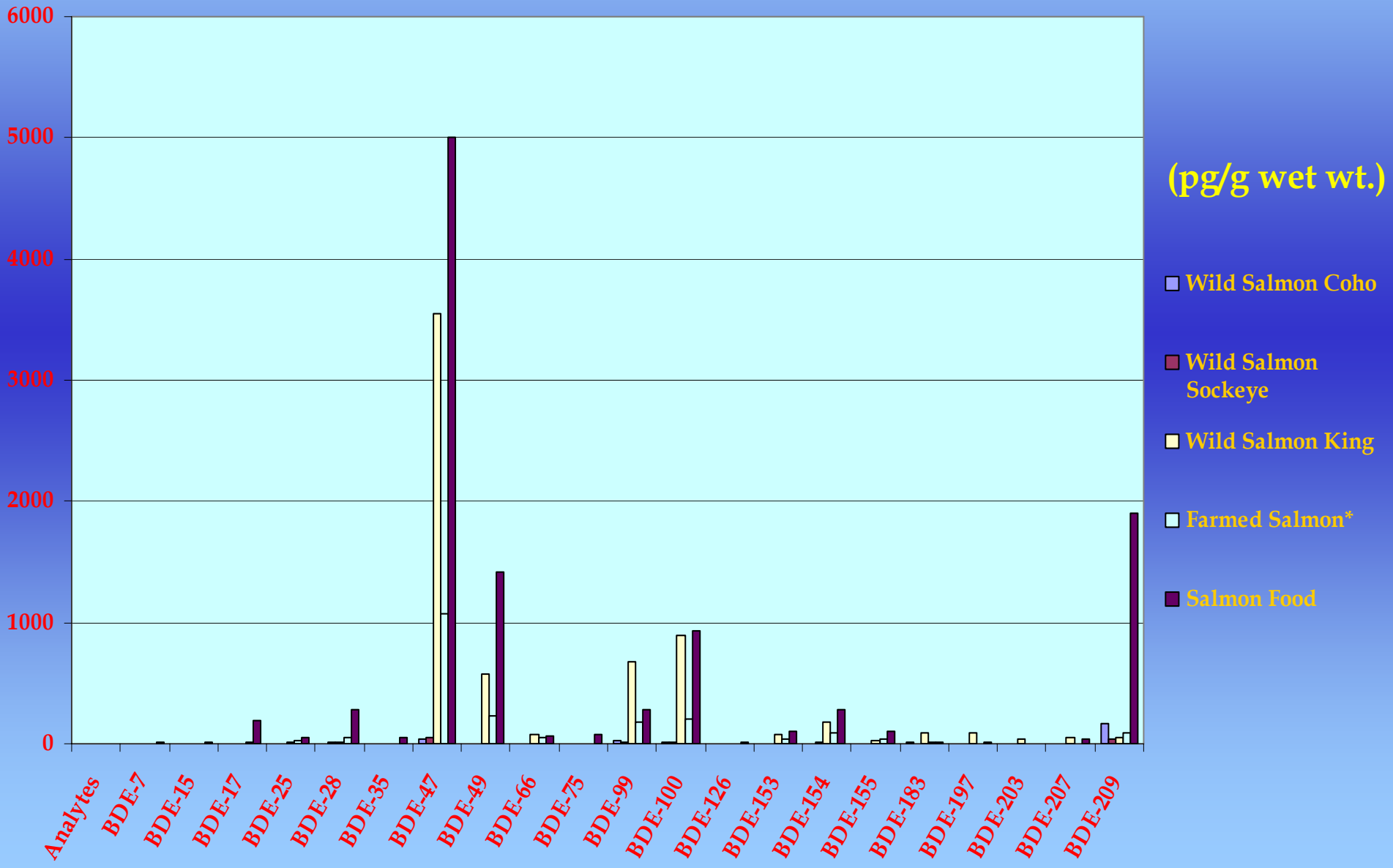
Analytical Method

- Food products collected in February, March and April 2004 from food markets in Sacramento and El Dorado Hills in northern California USA.
- Edible portions of meat products homogenized and soxhlet extracted with 1:1 methylene chloride/hexane.
- Cleanup procedures included silica gel and activated carbon columns.
- AutoSpec Ultima high resolution gas chromatograph/high resolution mass spectrometer (HRGC/HRMS).
- Tested for 31 individual PBDE congeners and total mono-through-deca-PBDE homologue groups using USEPA draft Method 1614.
- With exception of 3 internal standards (C^{13}BDE-3, -207, and –209), recoveries of internal standards greater than approximately 85%.
- LOQs varied from 10.0 to 250 pg/g (parts per trillion; ppt) wet weight (ww).

Analytes	Wild Salmon			Farmed Salmon*	Salmon Food
	Coho Salmon	Sockeye Salmon	King Salmon		
BDE-7	ND	ND	ND	0.63	17.2
BDE-13	ND	ND	ND	ND	ND
BDE-15	ND	0.405	2.59	1.22	10.5
BDE-17	ND	ND	4.32	11.6	186
BDE-25	ND	ND	15.5	26.4	55.2
BDE-28	3.57	8	14.2	54.5	278
BDE-35	ND	ND	ND	1.32	47.7
BDE-47	34.6	45.5	3550	1070	5000
BDE-49	1.45	ND	578	234	1420
BDE-66	2.04	5.36	80.6	49.4	66.9
BDE-75	0.492	ND	5.01	5.69	79.7
BDE-85	ND	ND	ND	ND	ND
BDE-99	20.3	18.7	672	176	280
BDE-100	7.65	7.83	900	199	932
BDE-126	ND	ND	ND	2.23	6.89
BDE-138	ND	ND	ND	ND	ND
BDE-153	2.6	3.72	82.2	32.2	106
BDE-154	3.08	8.52	175	91.4	283
BDE-155	0.556	3.54	29.1	41.3	97.5
BDE-181	ND	ND	ND	ND	ND
BDE-183	8.61	ND	92.1	7.38	8.84
BDE-197	3.25	4.97	88.8	4.75	7.05
BDE-203	ND	ND	32.9	ND	ND
BDE-207	ND	5.52	48.3	6.36	42.4
BDE-209	167	41.3	47.5	93.9	1900
Total Mono-Nona BDEs	88	112	6522	2106	9642
Total BDEs	255	153	6570	2200	11542

The concentration of PBDEs (pg/g wet weight) in fish. * Average

Salmon Products

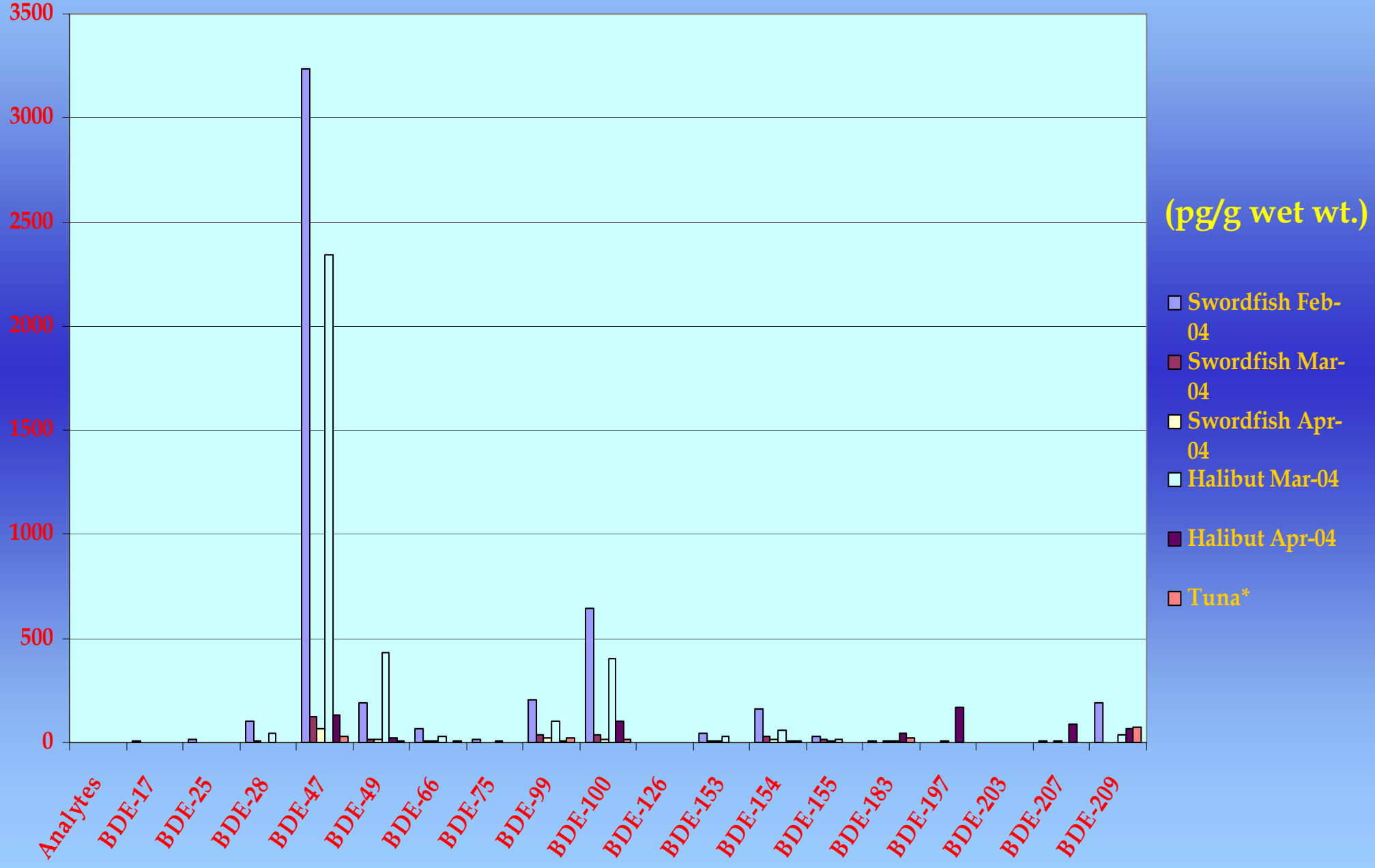


Wild Fish Products

Analytes	Swordfish			Halibut		
	Feb-04	Mar-04	Apr-04	Mar-04	Apr-04	Tuna*
BDE-7	ND	ND	ND	ND	ND	ND
BDE-13	ND	ND	ND	ND	ND	ND
BDE-15	0.53	ND	ND	ND	ND	ND
BDE-17	5.90	0.90	ND	ND	ND	ND
BDE-25	12.0	ND	ND	ND	ND	ND
BDE-28	99.0	5.72	ND	44.2	ND	3.15
BDE-35	ND	ND	ND	ND	ND	ND
BDE-47	3240	126	62.5	2340	132	30.0
BDE-49	193	15.9	11.1	434	21	6.93
BDE-66	68.0	10.6	4.11	31.5	ND	4.07
BDE-75	12.0	ND	ND	9.81	ND	1.23
BDE-85	ND	ND	ND	ND	ND	ND
BDE-99	206	37.3	24.0	103	10	23.0
BDE-100	641	33.1	14.0	400	100	11.1
BDE-126	2.30	ND	ND	ND	ND	ND
BDE-138	ND	ND	ND	ND	ND	ND
BDE-153	47.0	8.31	3.98	31.8	3.14	3.63
BDE-154	164	28.0	12.0	55.7	4.10	9.17
BDE-155	31.0	11.7	4.96	11.2	2.16	2.59
BDE-181	ND	ND	ND	ND	ND	ND
BDE-183	4.30	1.53	8.01	4.15	42.5	20.5
BDE-197	2.90	ND	5.04	ND	165	ND
BDE-203	ND	ND	ND	ND	ND	ND
BDE-207	6.60	ND	5.13	ND	86.9	2.26
BDE-209	189	ND	ND	36.7	68.7	75.7
Total Mono-Nona BDEs	4580	282	148	3490	503	49.0
Total PBDEs	4766	282	148	3530	572	125

The concentration of PBDEs (pg/g wet weight) in fish. * Average

Wild Fish Products

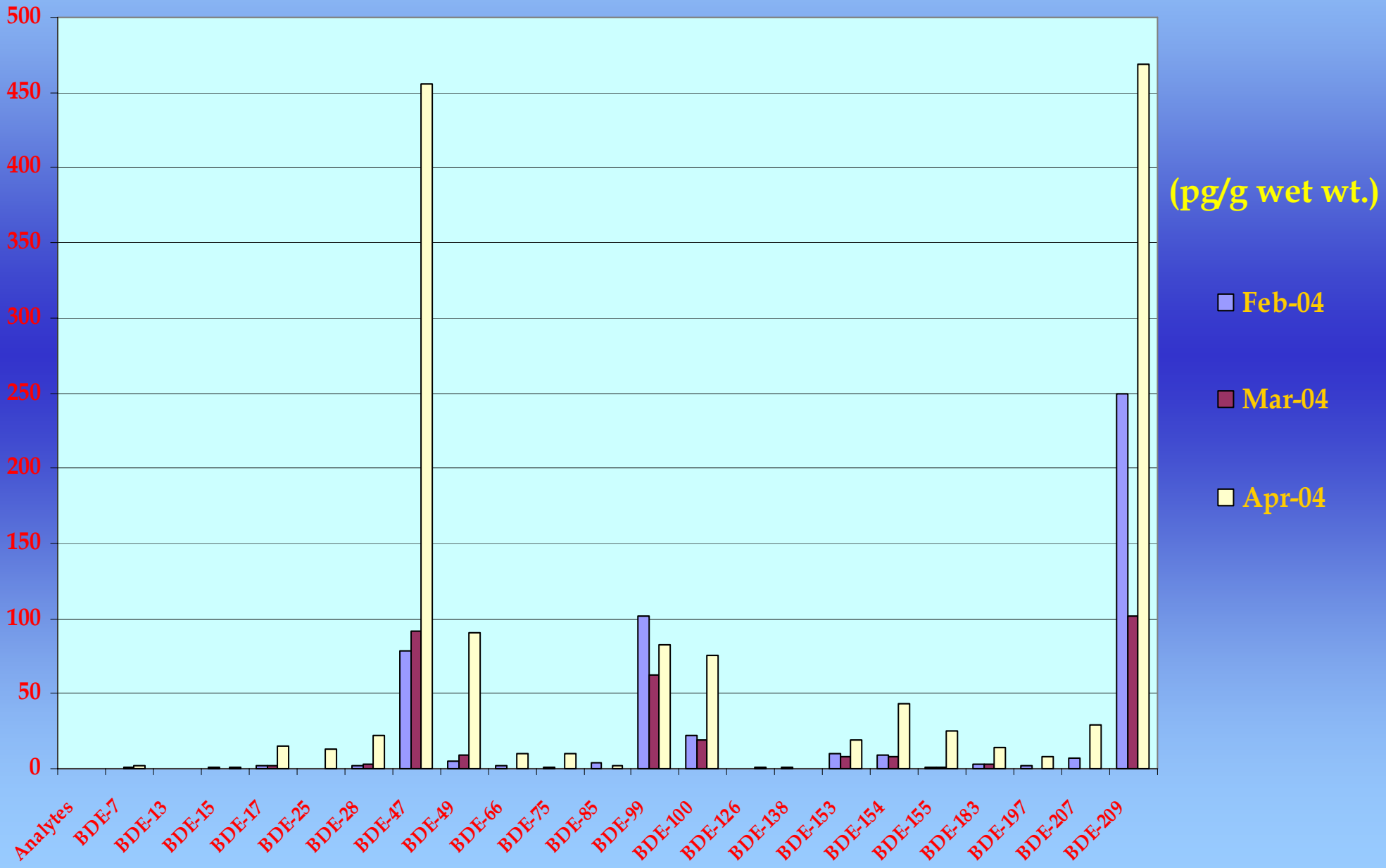


The Farm-Raised Catfish Fillets

Analytes	Feb-04 Catfish Fillet	Mar-04 Catfish Fillet	Apr-04 Catfish Fillet
BDE-7	0.50	1.04	1.90
BDE-13	0.19	ND	ND
BDE-15	1.40	0.48	0.97
BDE-17	1.80	2.21	15.4
BDE-25	ND	ND	12.9
BDE-28	2.50	3.21	22.6
BDE-35	ND	ND	ND
BDE-47	78.0	91.2	456
BDE-49	4.90	9.12	91.0
BDE-66	2.30	ND	10.1
BDE-75	0.82	ND	9.70
BDE-85	4.10	ND	2.00
BDE-99	102	62.0	82.0
BDE-100	22.0	19.3	75.6
BDE-126	ND	ND	1.20
BDE-138	1.20	ND	ND
BDE-153	10.0	8.19	18.8
BDE-154	9.00	8.42	43.7
BDE-155	1.20	1.41	25.6
BDE-181	ND	ND	ND
BDE-183	3.30	2.77	14.40
BDE-197	2.10	ND	7.82
BDE-203	ND	ND	ND
BDE-207	7.30	ND	29.4
BDE-209	249	102	469
Total Mono-Nona BDEs	257	209	1030
Total PBDEs	506	311	1500

The concentration of PBDEs (pg/g wet weight) in fish.

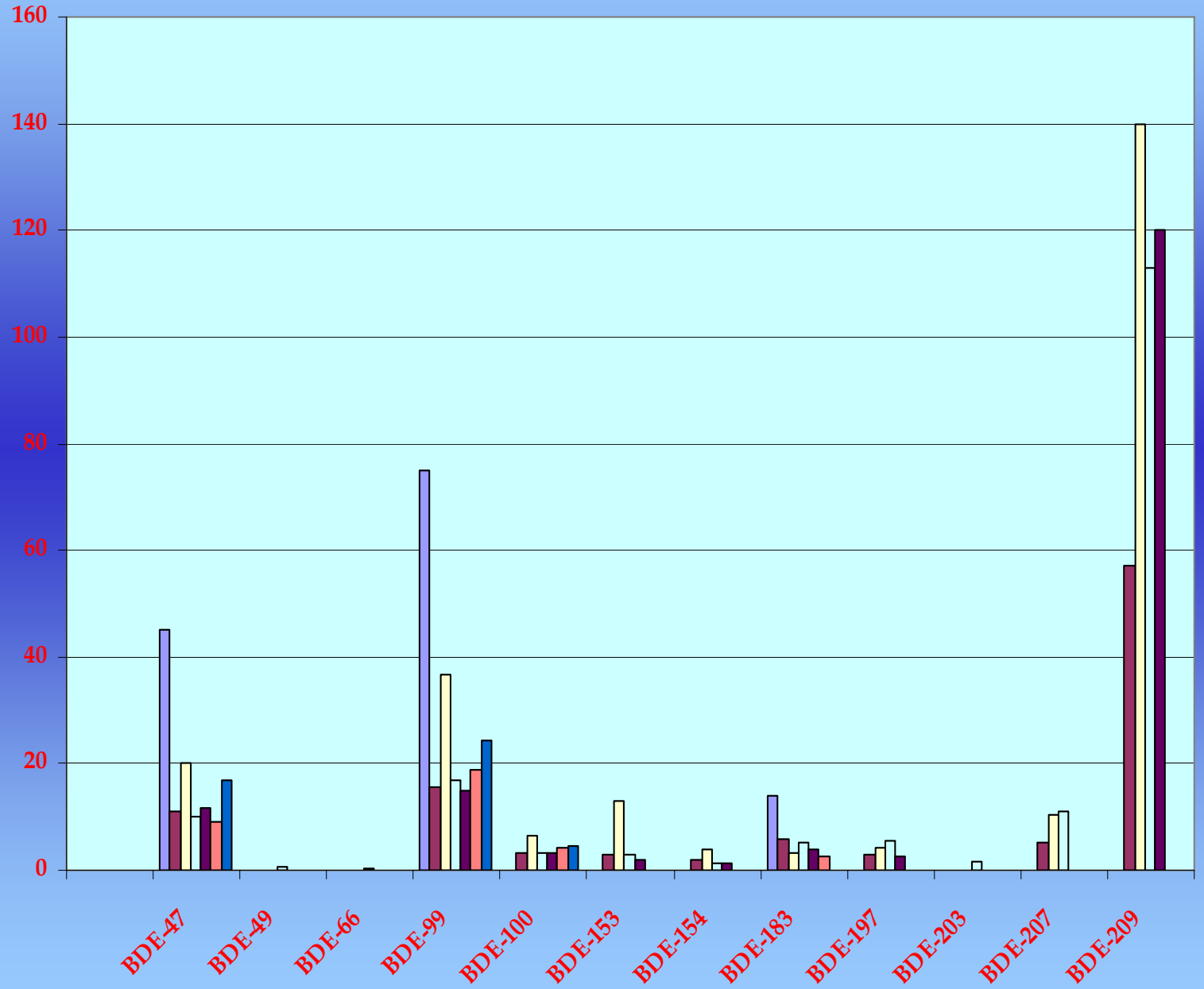
Farm Raised Catfish Fillets



Analytes	Conventional Products(Ground Beef)			Vegeterian, Hormone-Free(Ground Beef)			Organic
	Feb-04	Mar-04	Apr-04	Feb-04	Mar-04	Apr-04	Pork Tenderloin
BDE-7	ND	ND	ND	ND	ND	ND	ND
BDE-13	ND	ND	ND	ND	ND	ND	ND
BDE-15	ND	ND	ND	ND	ND	ND	ND
BDE-17	ND	ND	ND	ND	ND	ND	ND
BDE-25	ND	ND	ND	ND	ND	ND	ND
BDE-28	ND	ND	ND	0.36	ND	ND	ND
BDE-35	ND	ND	ND	ND	ND	ND	ND
BDE-47	45.0	11.0	20.0	10.0	11.7	9.24	16.9
BDE-49	ND	ND	ND	0.61	ND	ND	ND
BDE-66	ND	ND	ND	0.45	ND	ND	ND
BDE-75	ND	ND	ND	ND	ND	ND	ND
BDE-85	ND	ND	ND	ND	ND	ND	ND
BDE-99	75.0	15.7	36.8	17.0	14.9	18.9	24.5
BDE-100	ND	3.31	6.41	3.40	3.24	4.19	4.46
BDE-126	ND	ND	ND	ND	ND	ND	ND
BDE-138	ND	ND	ND	ND	ND	ND	ND
BDE-153	ND	2.84	13.1	2.80	1.84	ND	ND
BDE-154	ND	1.79	4.04	1.20	1.22	ND	ND
BDE-155	ND	ND	ND	ND	ND	ND	ND
BDE-181	ND	ND	ND	ND	ND	ND	ND
BDE-183	14.0	5.81	3.37	5.10	3.76	2.59	ND
BDE-197	ND	2.90	4.19	5.50	2.49	ND	ND
BDE-203	ND	ND	ND	1.50	ND	ND	ND
BDE-207	ND	5.22	10.5	11.0	ND	ND	ND
BDE-209	ND	57.0	140	113	120	ND	ND
Total Mono-Nona BDEs	164	164	98.6	63.9	39.1	34.9	45.9
Total BDEs	164	164	239	177	159	34.9	45.9

The concentration of PBDEs (pg/g wet weight) in beef.

Meat Products



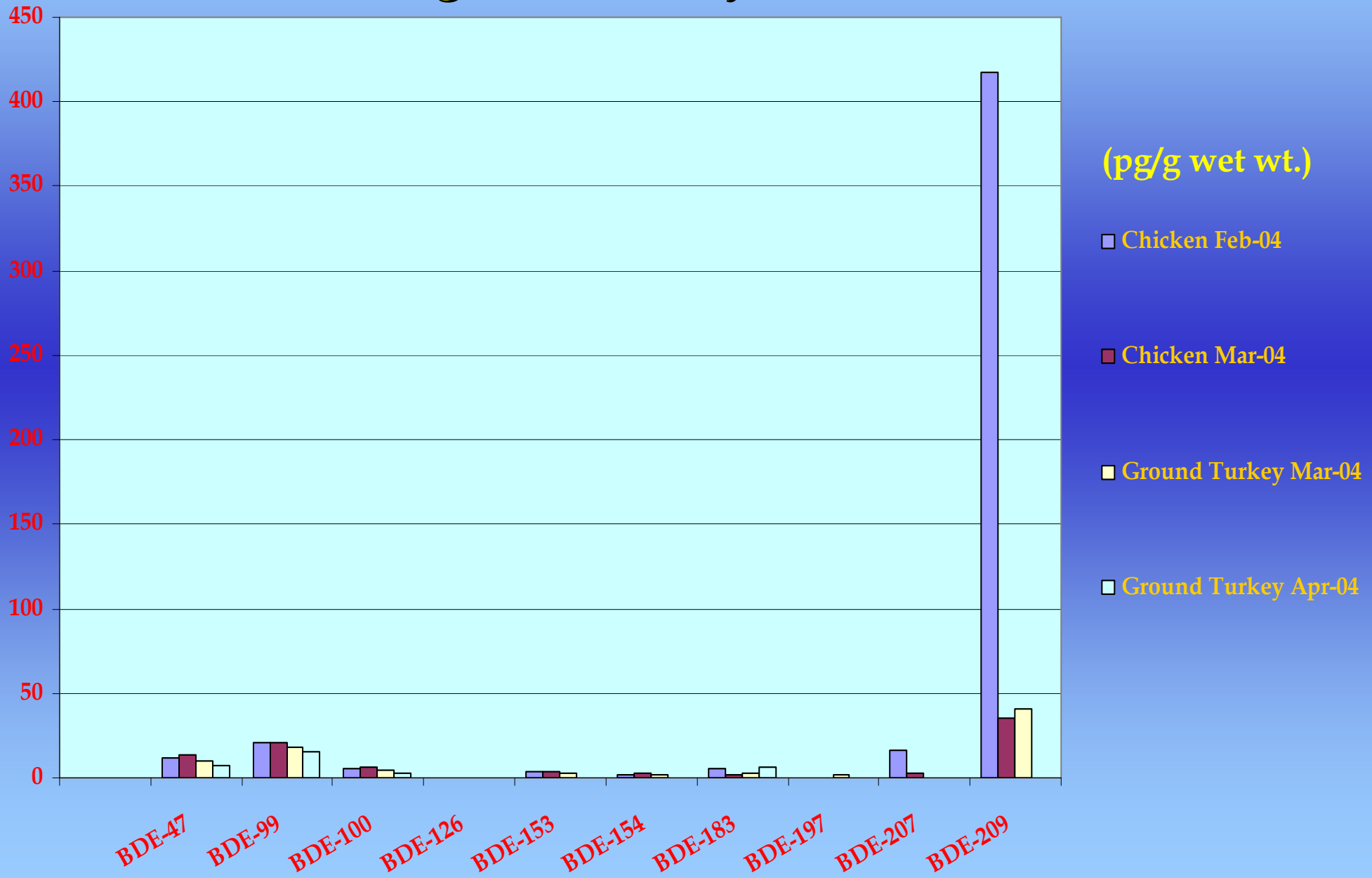
(pg/g wet wt.)

- Conventional Products(Ground Beef) Feb-04
- Conventional Products(Ground Beef) Mar-04
- Conventional Products(Ground Beef) Apr-04
- Vegeterian, Hormone-Free(Ground Beef) Feb-04
- Vegeterian, Hormone-Free(Ground Beef) Mar-04
- Vegeterian, Hormone-Free(Ground Beef) Apr-04
- Organic Pork Tenderloin

Analytes	Chicken		Ground Turkey	
	Feb-04	Mar-04	Mar-04	Apr-04
BDE-7	ND	ND	ND	ND
BDE-13	ND	ND	ND	ND
BDE-15	ND	ND	ND	ND
BDE-17	ND	ND	ND	ND
BDE-25	ND	ND	ND	ND
BDE-28	ND	ND	ND	ND
BDE-35	ND	ND	ND	ND
BDE-47	12.0	13.9	10.0	7.25
BDE-49	ND	ND	ND	ND
BDE-66	ND	ND	ND	ND
BDE-75	ND	ND	ND	ND
BDE-85	ND	ND	ND	ND
BDE-99	21.0	20.7	18.1	15.0
BDE-100	5.20	6.05	4.40	2.98
BDE-126	ND	ND	ND	ND
BDE-138	ND	ND	ND	ND
BDE-153	3.40	3.56	3.09	ND
BDE-154	1.90	2.27	1.82	ND
BDE-155	ND	ND	ND	ND
BDE-181	ND	ND	ND	ND
BDE-183	5.30	1.86	2.44	6.37
BDE-197	ND	ND	1.76	ND
BDE-203	ND	ND	ND	ND
BDE-207	16.0	2.95	ND	ND
BDE-209	417	35.1	41.1	ND
Total Mono-Nona BDEs	69.0	51.0	44.0	32.0
Total PBDEs	486	86.4	84.7	32.0

The concentration of PBDEs (pg/g wet weight) in poultry products.

Organic Poultry Products

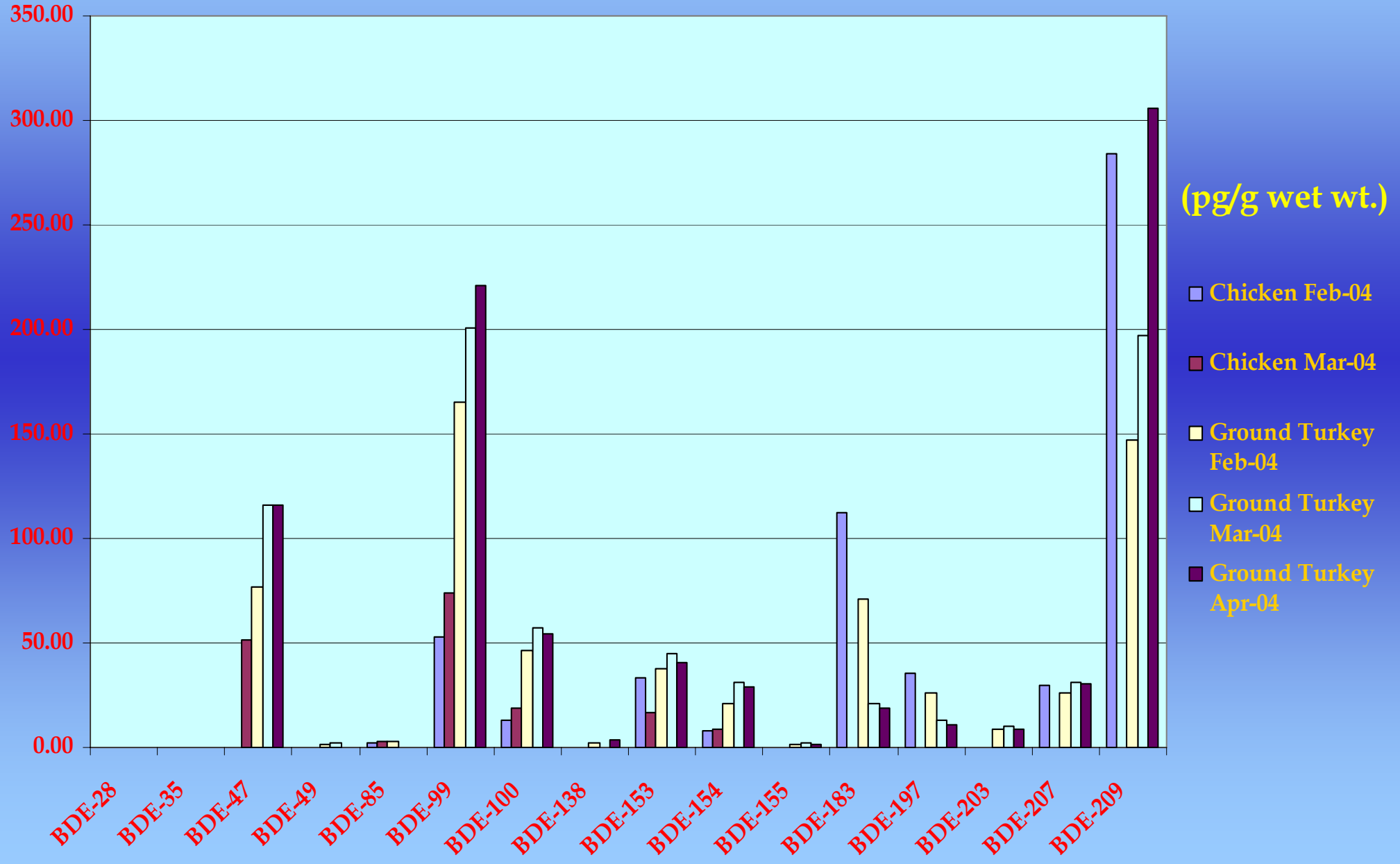


Conventionally-Raised Poultry

Analyte	Chicken		Ground Turkey		
	Feb-04	Mar-04	Feb-04	Mar-04	Apr-04
BDE-7	ND	ND	ND	ND	ND
BDE-13	ND	ND	ND	ND	ND
BDE-15	ND	ND	ND	ND	ND
BDE-17	ND	ND	ND	ND	ND
BDE-25	ND	ND	ND	ND	ND
BDE-28	ND	ND	0.359	ND	ND
BDE-35	ND	ND	ND	ND	ND
BDE-47	37.4	51.2	77.0	116	116
BDE-49	ND	ND	1.70	2.46	ND
BDE-66	ND	ND	ND	ND	ND
BDE-75	ND	ND	ND	ND	ND
BDE-85	1.85	2.82	2.85	ND	ND
BDE-99	52.8	73.9	165	201	221
BDE-100	13.4	18.6	46.5	56.9	54.2
BDE-126	ND	ND	ND	ND	ND
BDE-138	ND	ND	2.31	ND	3.38
BDE-153	33.3	16.4	37.6	45	40.4
BDE-154	7.78	9.03	21.2	30.9	28.7
BDE-155	ND	ND	1.31	2.01	1.54
BDE-181	ND	ND	ND	ND	ND
BDE-183	112	ND	70.7	21.3	18.6
BDE-197	35.4	ND	25.9	12.7	11.0
BDE-203	ND	ND	8.97	10.2	8.81
BDE-207	29.7	ND	25.8	31.2	30.6
BDE-209	284	ND	147	197	306
Total Mono-Nona BDEs	334	196	509	550	562
Total PBDEs	618	196	656	747	868

The concentration of PBDEs (pg/g wet weight) in poultry products.

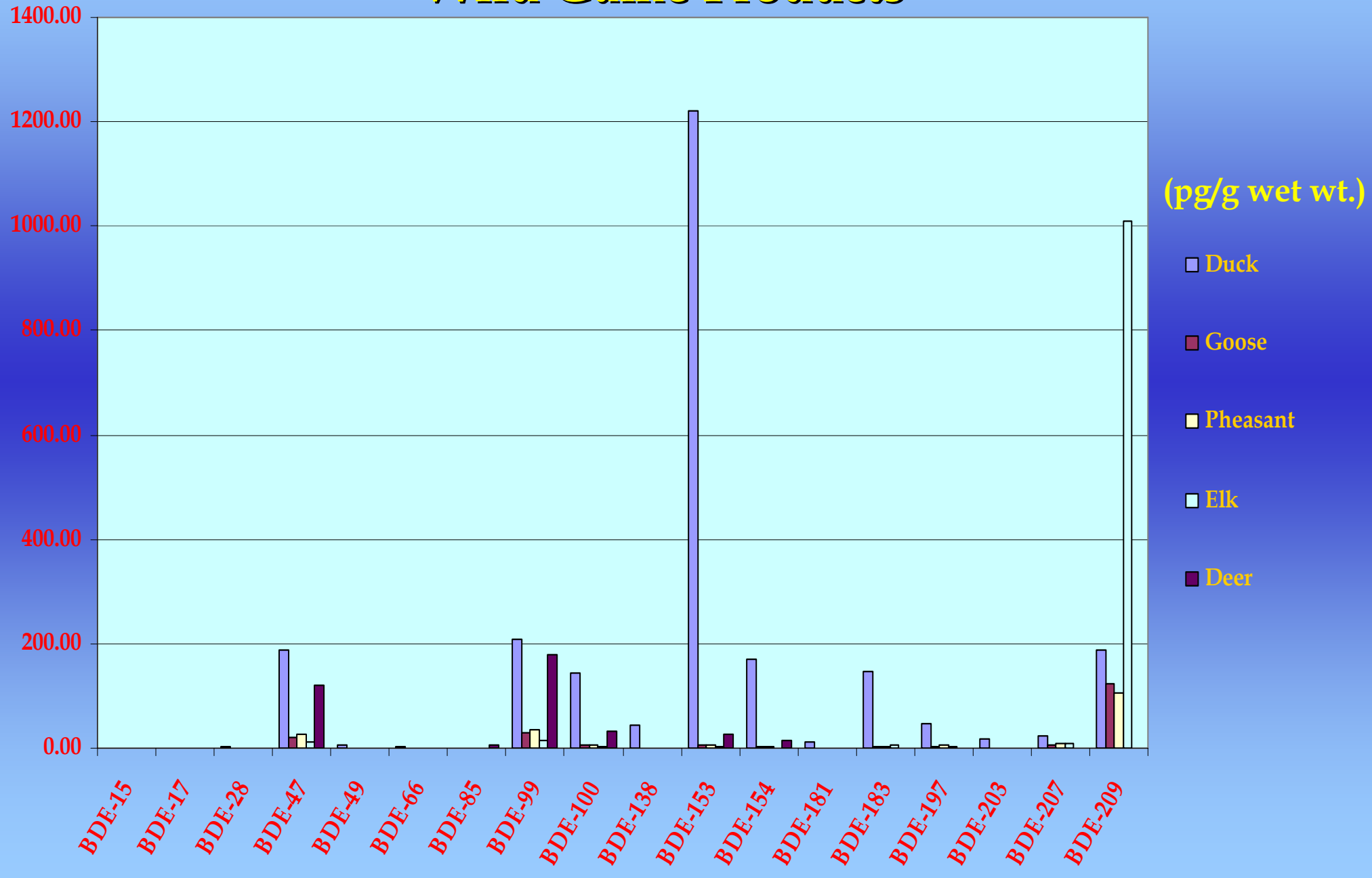
Conventionally-Raised Poultry



Analytes	Wild Game Products				
	Duck	Goose	Pheasant	Elk	Deer
BDE-7	ND	ND	ND	ND	ND
BDE-13	ND	ND	ND	ND	ND
BDE-15	0.60	ND	ND	ND	ND
BDE-17	1.30	ND	ND	ND	ND
BDE-25	ND	ND	ND	ND	ND
BDE-28	4.20	0.40	0.55	ND	ND
BDE-35	ND	ND	ND	ND	ND
BDE-47	187	20.0	26.0	12.9	120
BDE-49	7.30	ND	0.75	ND	ND
BDE-66	2.80	ND	ND	ND	ND
BDE-75	ND	ND	ND	ND	ND
BDE-85	ND	1.30	1.20	0.59	6.51
BDE-99	209	29.0	34.0	14.2	179
BDE-100	144	5.40	7.30	3.47	32.5
BDE-126	ND	ND	ND	ND	ND
BDE-138	44.0	ND	ND	ND	ND
BDE-153	1220	5.30	5.90	1.61	27.1
BDE-154	170	1.90	2.90	1.10	13.9
BDE-155	ND	ND	ND	ND	ND
BDE-181	11.0	ND	ND	ND	ND
BDE-183	146	2.50	3.50	5.67	ND
BDE-197	46.0	1.60	5.80	2.32	ND
BDE-203	17.0	ND	ND	ND	ND
BDE-207	23.0	5.90	8.70	8.70	ND
BDE-209	188	123	106	1010	ND
Total Mono-Nona BDEs	2328	73	101	83.0	379
Total PBDEs	2516	196	207	1093	379

The concentration of PBDEs (pg/g wet weight) in fowl meat.

Wild Game Products



Analytes	Method Blanks			
	February 2004	March 2004	April 2004	May 2004
BDE-7	ND	ND	ND	ND
BDE-13	ND	ND	ND	ND
BDE-15	ND	ND	ND	ND
BDE-17	ND	ND	ND	ND
BDE-25	ND	ND	ND	ND
BDE-28	ND	ND	4.85	ND
BDE-35	ND	ND	ND	ND
BDE-47	5.46	6.02	5.28	8.15
BDE-49	ND	ND	ND	ND
BDE-66	ND	ND	ND	ND
BDE-75	ND	ND	ND	ND
BDE-85	ND	ND	ND	ND
BDE-99	12.3	10.3	9.00	20.3
BDE-100	2.96	2.62	1.99	4.22
BDE-126	ND	ND	ND	ND
BDE-138	ND	ND	ND	ND
BDE-153	1.15	ND	ND	ND
BDE-154	0.929	ND	ND	1.50
BDE-155	ND	ND	ND	ND
BDE-181	ND	ND	ND	ND
BDE-183	2.19	17.7	ND	ND
BDE-197	ND	ND	ND	ND
BDE-203	ND	ND	ND	ND
BDE-207	6.08	ND	ND	ND
BDE-209	219	36.4	ND	ND
Total PBDEs	250	73.0	16.3	34.2

Screening Exposure Model

- The theoretical daily intake of PBDEs calculated using a screening-level USEPA dietary exposure model
  - U.S. Environmental Protection Agency, Dietary Exposure Potential Model, v. 5, April. (2003).
- Default USEPA exposure assumptions for adults and children
  - U.S. Environmental Protection Agency, Exposure Factors Handbook, (1997).
- Oral absorption factor for all PBDEs = 90% (high end of range of bioavailability in animal studies for different congeners)
- Fish ingestion rates:
  - children aged <1 to 18 years (1 to 11.5 g/day)
  - adults (20 g/day)
- Meat and fowl ingestion rates
  - children aged <1 to 18 years (54 to 318 g/day)
  - adults (400 g/day)

Screening Exposure Results

- For highest and lowest total PBDE concentrations in wild or farm-raised fish, theoretical ADIs ranged:

- between 6×10^{-8} and 1×10^{-6} mg/kg/day in children aged <1-18 years
  - between 8×10^{-8} and 1×10^{-6} mg/kg/day in adults

- **For highest and lowest total PBDE concentrations in beef and chicken products, theoretical ADIs ranged:**
  - between 1×10^{-6} and 4×10^{-6} mg/kg/day in children aged <1-18 years
  - between 8×10^{-7} and 3×10^{-6} mg/kg/day in adults

Conclusions

- More variability seen in wild meat products than in farm raised products.
- Congener pattern seen in salmon food and salmon tissue are similar.

Conclusions (cont'd)

- Assuming the concentrations reported in this study are representative of levels in fish and meat products consumed in northern California
- Assuming default exposure factors and ingestion rates
- Assuming health benchmarks derived from studies of the commercial pentaBDE product are appropriate for evaluation of the BDE mixture found in food products.

- Human exposure to PBDEs through the consumption of fish, meat, and fowl products purchased in 3 northern California food markets is well below health effects benchmark values.

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