

Current-Use and Legacy Persistent Pollutants in Cook Inlet Beluga Whales:

**Results from the analysis of banked tissues
from the Alaska Marine Mammal Tissue
Archival Project (AMMTAP)**

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National Marine Mammal Tissue Bank (NMMTB)

Created by Federal Legislation in 1992 (Public Law 102-587)

- Specimens are provided to the NMMTB by the:
 - Alaska Marine Mammal Tissue Archival Project (AMMTAP)
 - Marine Mammal Health & Stranding Response Program (MMHSRP)
 - Bottlenose Dolphin Health Assessment (BDHA)
- Banked matrices:
 - fat or blubber, liver, kidney, blood, skin, milk, muscle,
biopsies (skin + blubber)
- Specimen sources:
 - strandings - individuals and mass events (MMHSRP)
 - incidental catches (MMHSRP)
 - unusual mortality events (MMHSRP)
 - Alaska Native subsistence takes (AMMTAP)
 - live captures and release (BDHA)
 - dart biopsy operations (BDHA)



Species represented in AMM-TAP

Polar bear

Bowhead whale

Beluga whale

Ringed seal

Bearded seal

Walrus



- 1992 - 1996 AMMTAP Cook Inlet beluga tissues (10 males & 10 females) had been analyzed previously for legacy organic contaminants & metals:

Marine Fisheries Review 62(3):81-98 (2000)

Legacy organic contaminants:

Polychlorinated biphenyl (PCB) congeners - 17

Hexachlorocyclohexane (HCH) isomers - 3

Hexachlorobenzene (HCB)

Chlordanes - 8

DDT compounds - 6

Dieldrin

Mirex

Toxaphene congeners – 19

Twenty heavy metals & other elements, including:

Mercury (& methylmercury)

Cadmium

Selenium

Arsenic

Silver

Copper

Zinc

- **1998 - 2005 AMMTAP Cook Inlet beluga tissues (5 males & 8 females) combined with the 1992-1996 samples and analyzed for:**

Legacy organic contaminants:

Polychlorinated biphenyl (PCB) congeners - 83

Hexachlorocyclohexane (HCH) isomers - 3

Chlorobenzenes - 2

Chlordanes - 7

DDT compounds - 6

Dieldrin

Mirex

Toxaphene congeners – 26

Twenty heavy metals & other elements, including:

Mercury

Cadmium

Selenium

Arsenic

Silver

Copper

Zinc

Chemicals of emerging concern:

Polybrominated diphenyl ether (PBDE) congeners - 28

Hexabromocyclododecane (HBCD) isomers - 3

Perfluorinated compounds (PFCs) - 14

Tissue of Choice

- **Blubber**
 - PCBs, Chlorinated Pesticides,
 - Brominated Flame Retardants (PBDE, HBCD)
- **Liver**
 - Heavy metals & trace elements, PFCs
- **Blood**
 - All of the above
- **Skin**
 - Heavy meals & trace elements

Wainwright Barrow
Point Lay

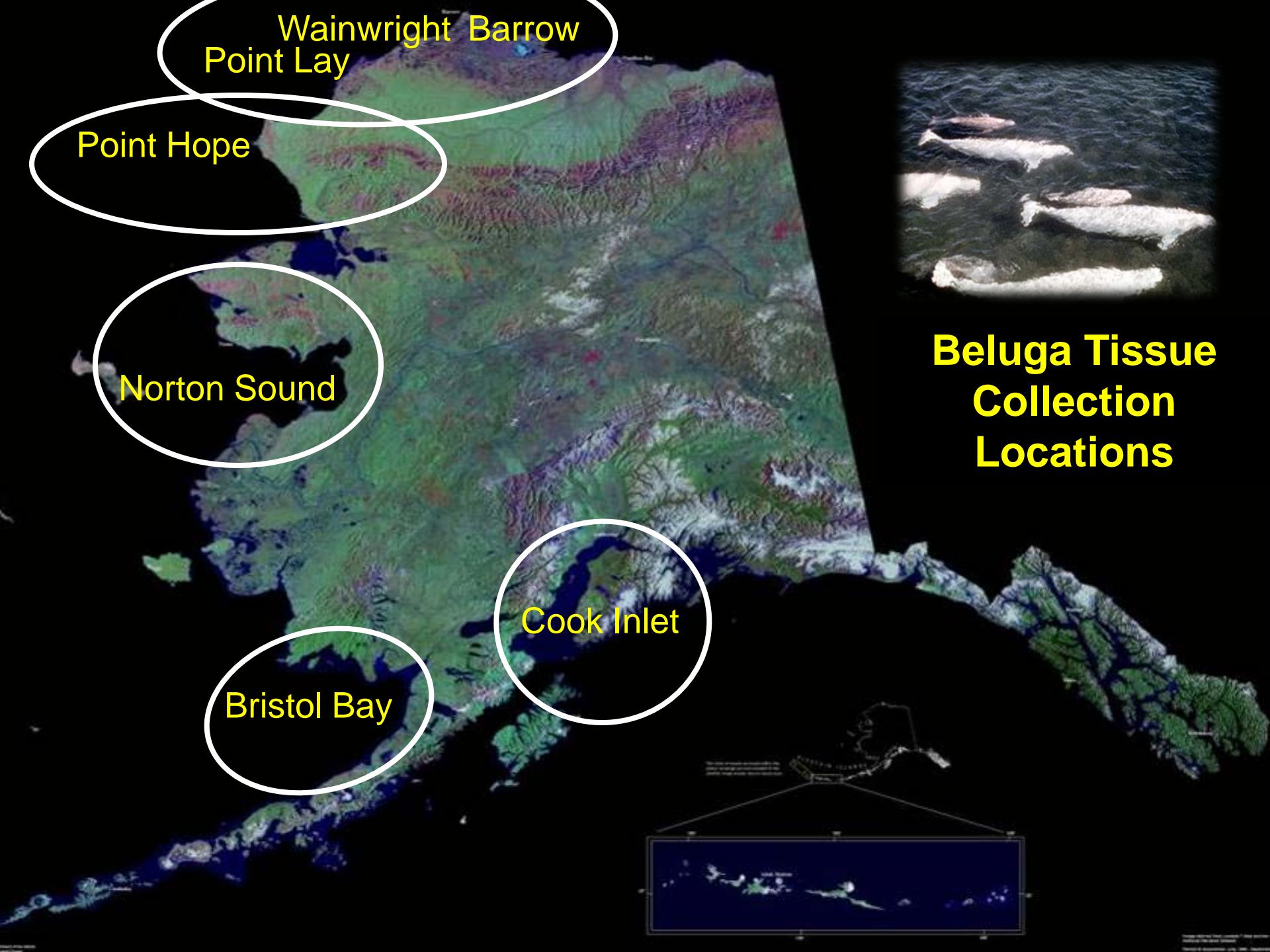
Point Hope

Norton Sound

Bristol Bay

Cook Inlet

Beluga Tissue Collection Locations



Number of individuals

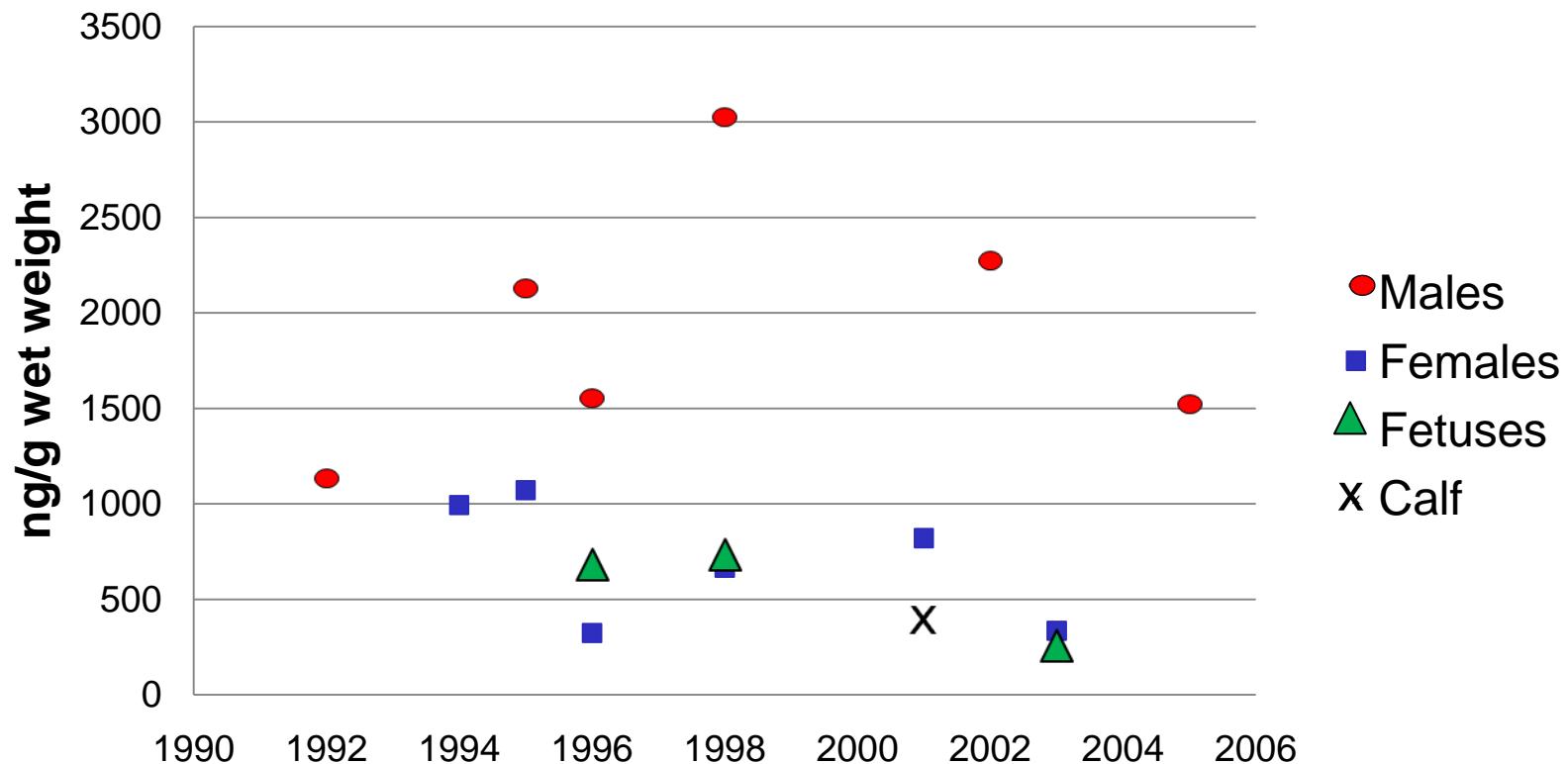
Location	Males	Females	Total	Year Span
Point Hope	2	4	6	1989-1997
Barrow	3	0	3	1997-1999
Wainwright	1	1	2	1999
Point Lay	19	11	30	1990-1999
Norton Sound	2	2	4	2000
Bristol Bay	1	0	1	2002
Cook Inlet	15	18	33	1992-2005
Total	43	53	98	

One could expect the following:

- **Males > Females**
- **Older animals > younger animals**
- **For legacy contaminants:**
 - Cook Inlet < Eastern Chukchi Sea
- **For contaminants of emerging concern:**
 - Cook Inlet > Eastern Chukchi Sea
- **Concentration differences affected by prey**
- **Sources of contaminants:**
 - Atmospheric transport
 - Oceanic transport
 - Local sources

Legacy Organic Contaminants

*Total PCBs in Cook Inlet Belugas



From 2000 paper:

$$\text{Males} = 1490 \pm 700$$

$$\text{Females} = 790 \pm 560$$

Recent analyses:

$$\text{Males} = 1954 \pm 824.9$$

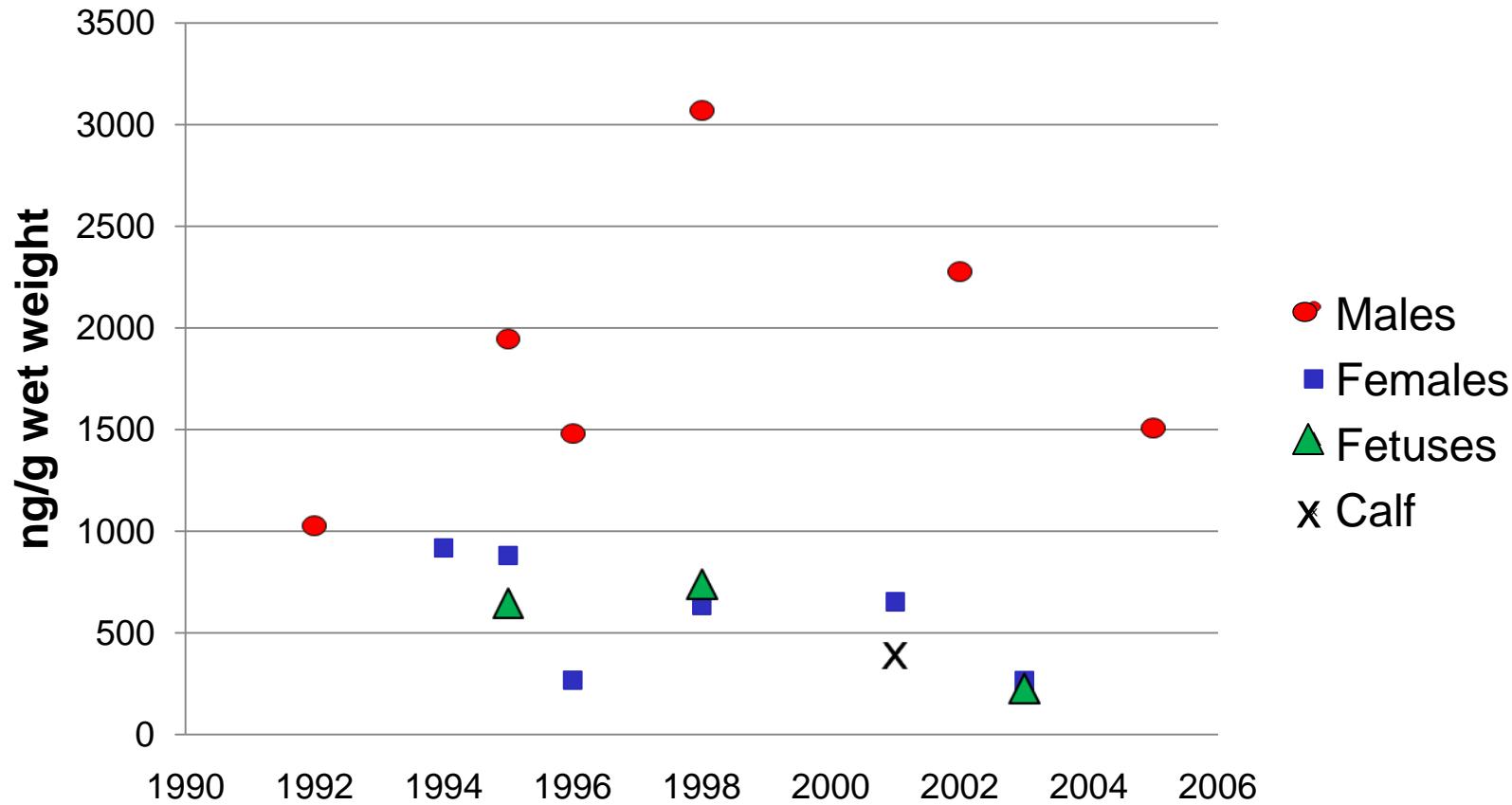
$$\text{Females} = 736.6 \pm 536.1$$

$$\text{Calf} = 437$$

$$\text{Fetuses} = 484.5 \pm 261.9$$

*Total PCBs = 2 (Σ 18,28, 44, 52, 66, 101, 105, 118, 128, 138, 153, 170, 180, 187, 195, 206, 209)

ΣDDT in Cook Inlet Belugas



From 2000 paper:

$$\text{Males} = 1350 \pm 730$$

$$\text{Females} = 590 \pm 450$$

Recent analysis:

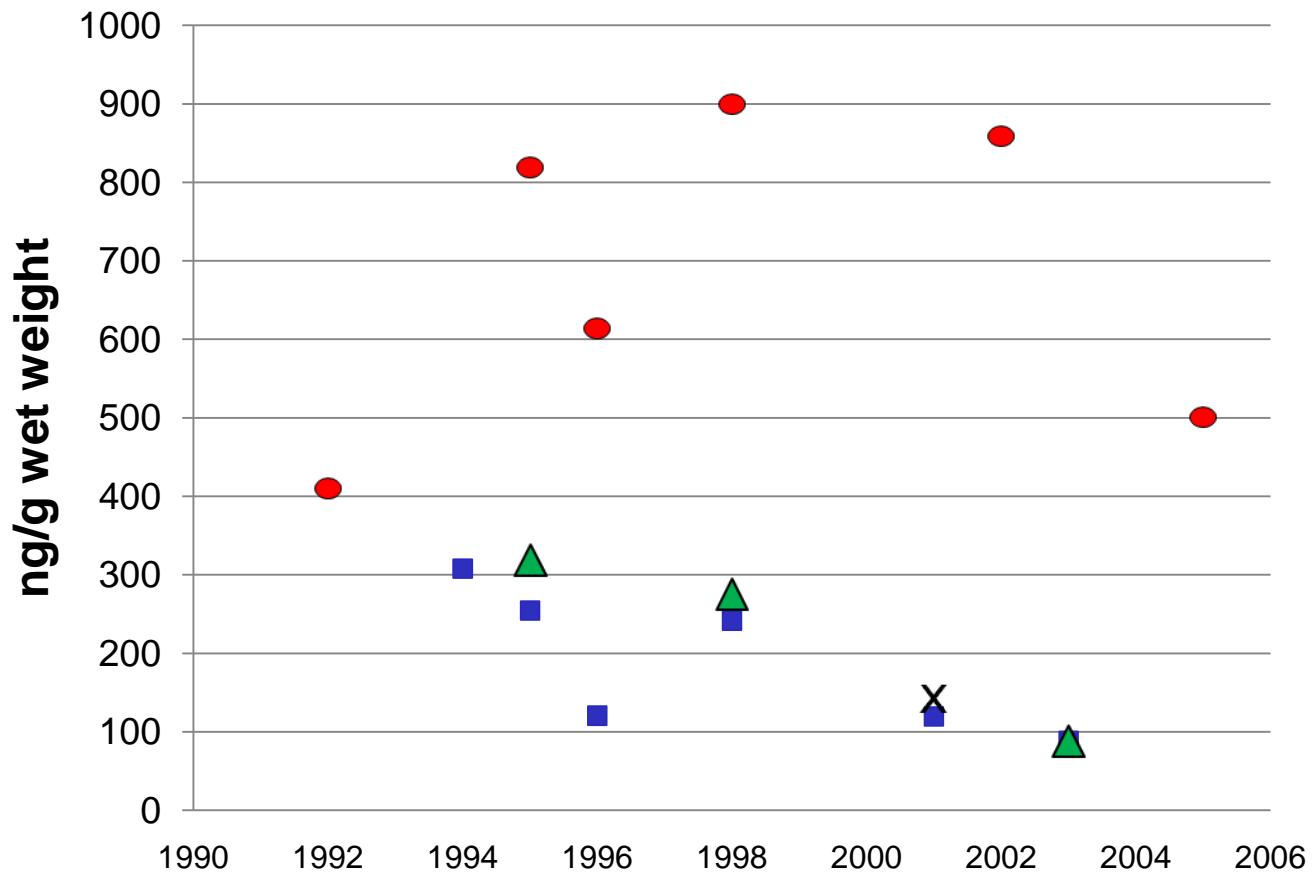
$$\text{Males} = 1869 \pm 839.9$$

$$\text{Females} = 632.7 \pm 504.6$$

$$\text{Calf} = 428.2$$

$$\text{Fetuses} = 470.8 \pm 273.6$$

Σ Chlordane in Cook Inlet Belugas



From 2000 paper:

$$\text{Males} = 560 \pm 250$$

$$\text{Females} = 300 \pm 220$$

Recent analysis:

$$\text{Males} = 714 \pm 232$$

$$\text{Females} = 234 \pm 175$$

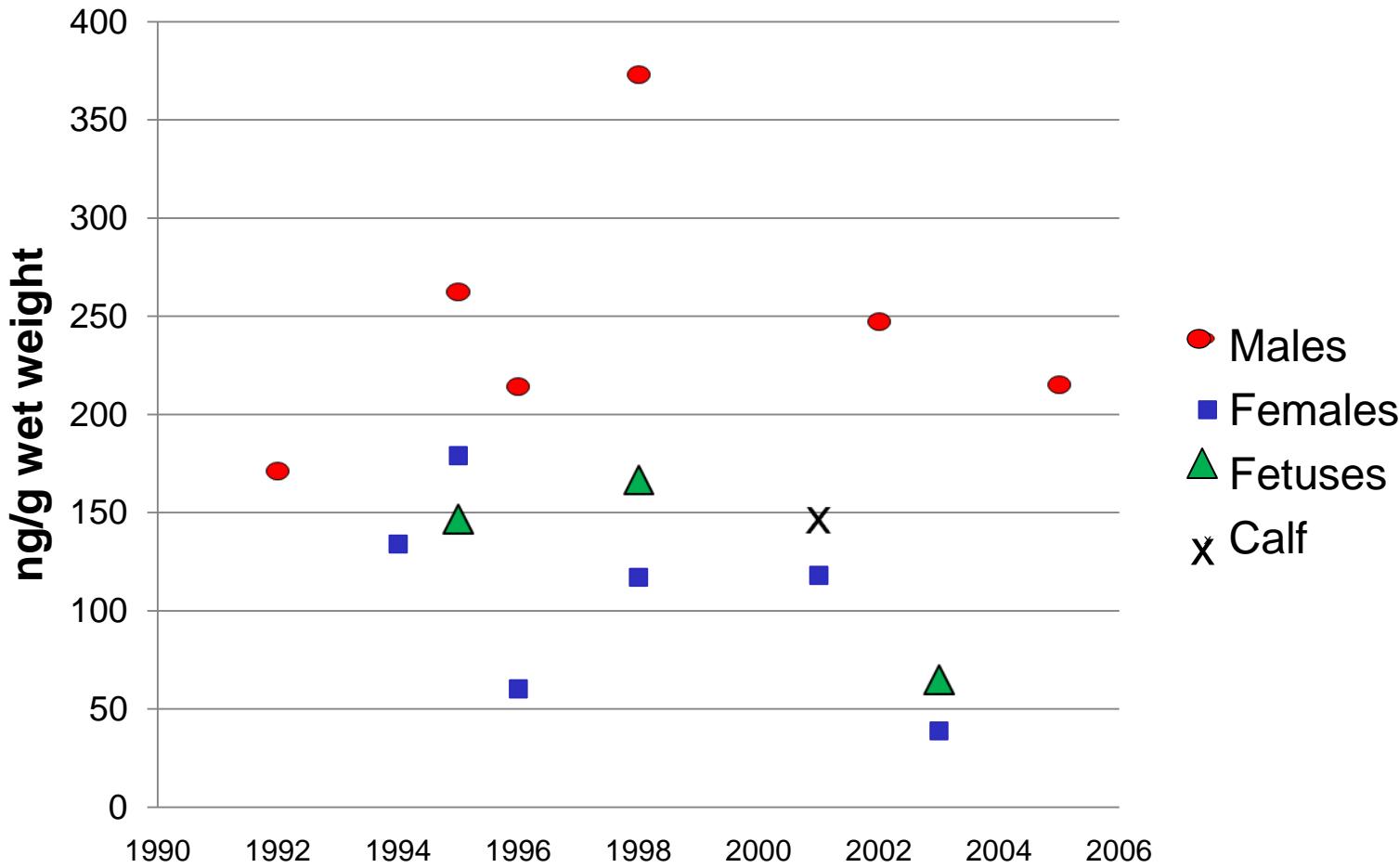
$$\text{Calf} = 152.7$$

$$\text{Fetuses} = 209 \pm 122$$

heptachlor
oxychlordane
heptachlor epoxide
trans-chlordan
cis-chordane
trans-nonachlor
cis-nonachlor

- Males
- Females
- ▲ Fetuses
- ✖ Calf

HCB in Cook Inlet Belugas



From 2000 paper:

$$\text{Males} = 220 \pm 90$$

$$\text{Females} = 150 \pm 130$$

Recent analysis:

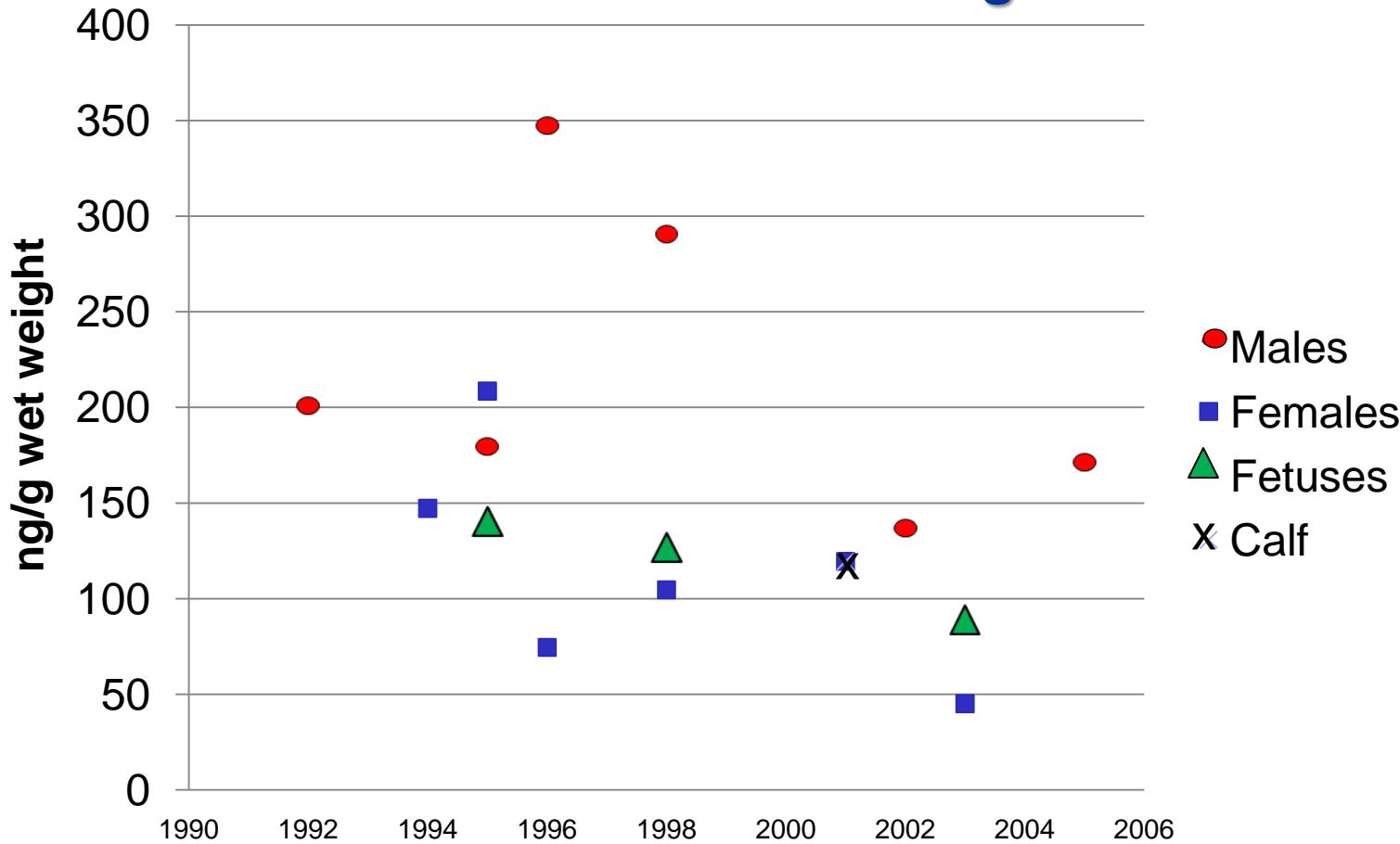
$$\text{Males} = 250 \pm 87.8$$

$$\text{Females} = 116 \pm 88.8$$

$$\text{Calf} = 150$$

$$\text{Fetuses} = 119 \pm 54.0$$

ΣHCH in Cook Inlet Belugas



From 2000 paper:

$$\text{Males} = 210 \pm 70$$

$$\text{Females} = 170 \pm 50$$

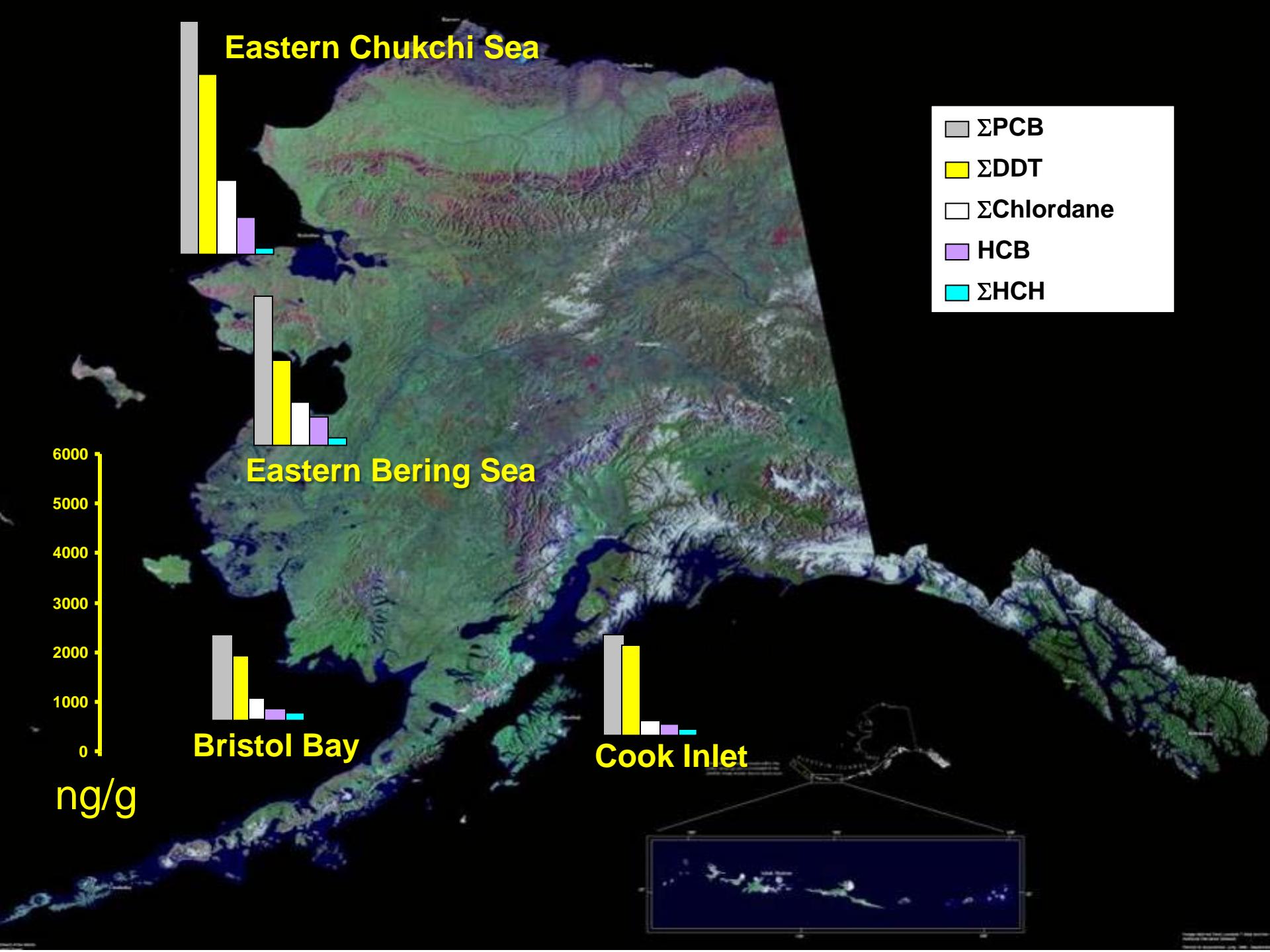
Recent analysis:

$$\text{Males} = 227 \pm 151$$

$$\text{Females} = 129 \pm 81.2$$

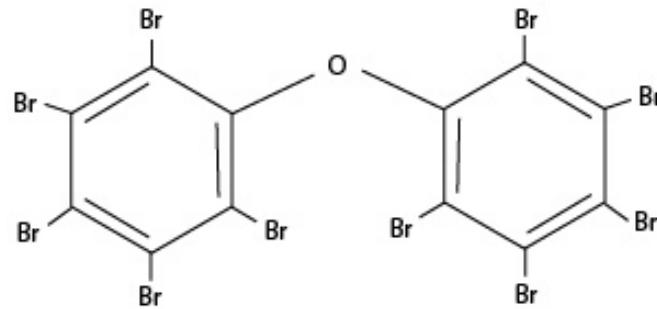
$$\text{Calf} = 119$$

$$\text{Fetuses} = 112 \pm 26.5$$



Chemicals of Emerging Concern

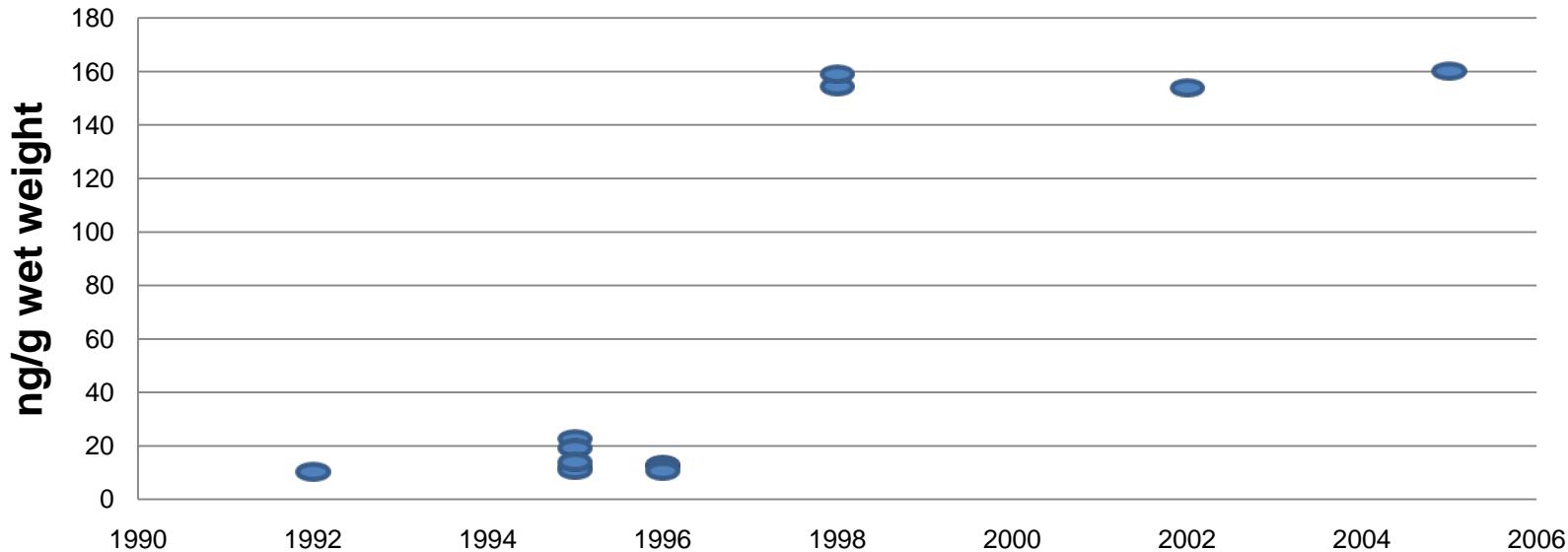
Polybrominated Diphenyl Ethers (PBDES)



**Flame retardant compound
Molecular structure similar to
PCBs
Bioaccumulates in fat**

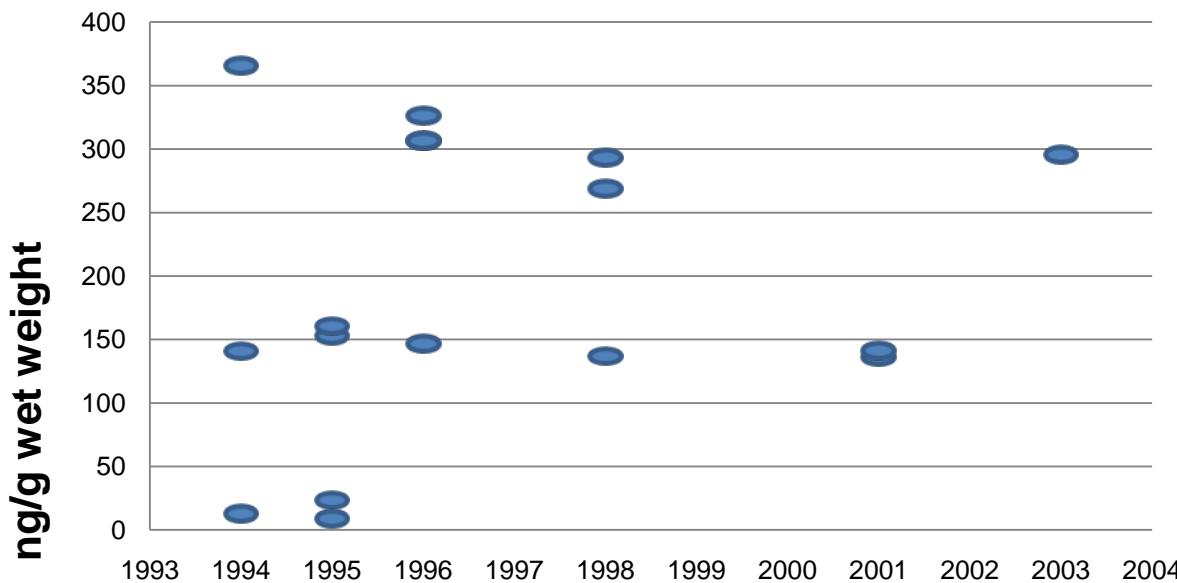


Σ PBDEs in Cook Inlet males

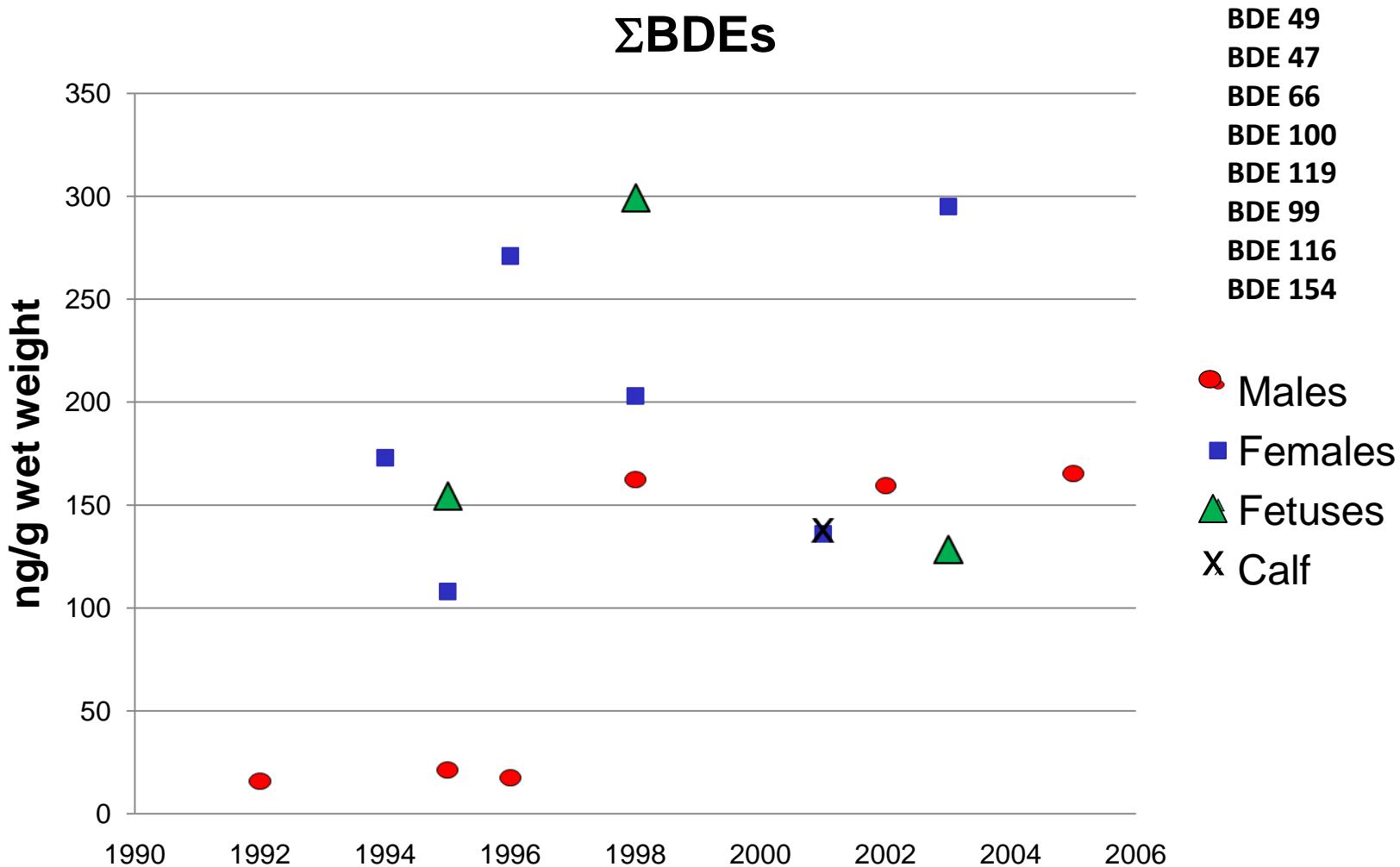


BDE 49
BDE 47
BDE 66
BDE 100
BDE 119
BDE 99
BDE 116
BDE 154

Σ PBDEs in Cook Inlet females

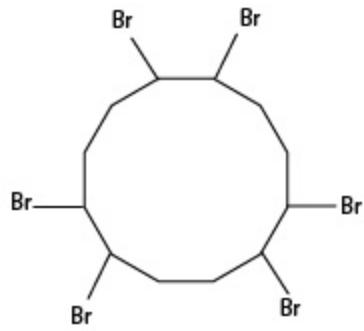


Σ BDEs



Males = 115 ± 127
Females = 186 ± 119
Calf = 141
Fetuses = 188 ± 91.1

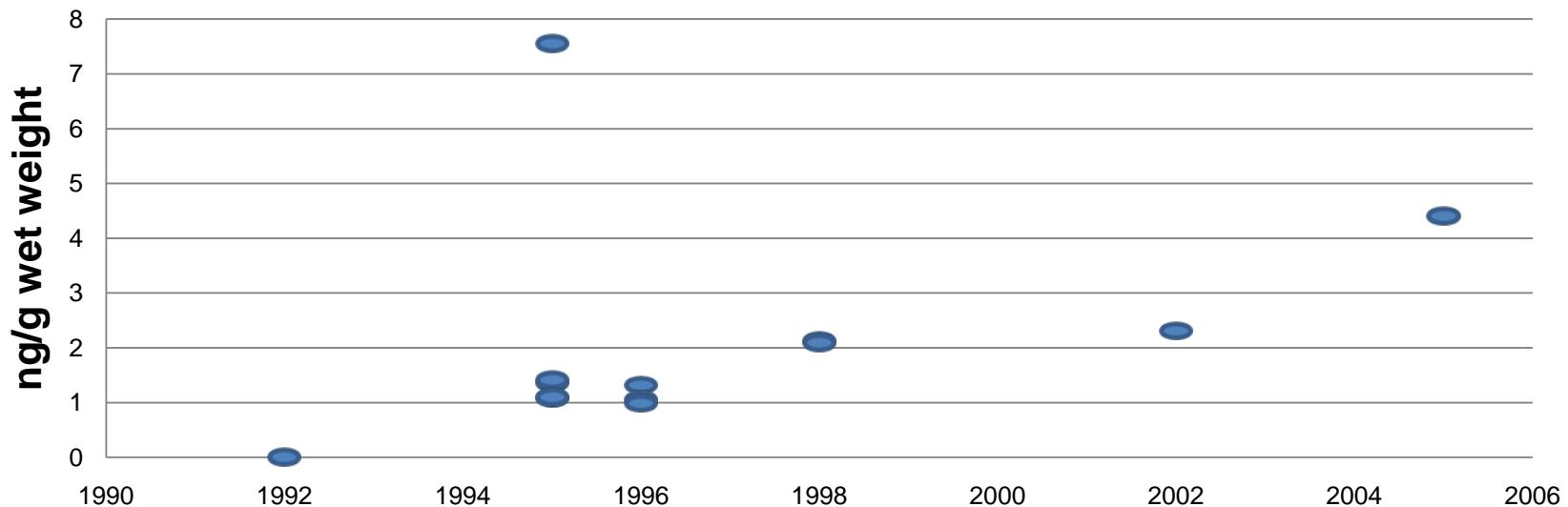
Hexabromocyclododecane **(HBCD)**



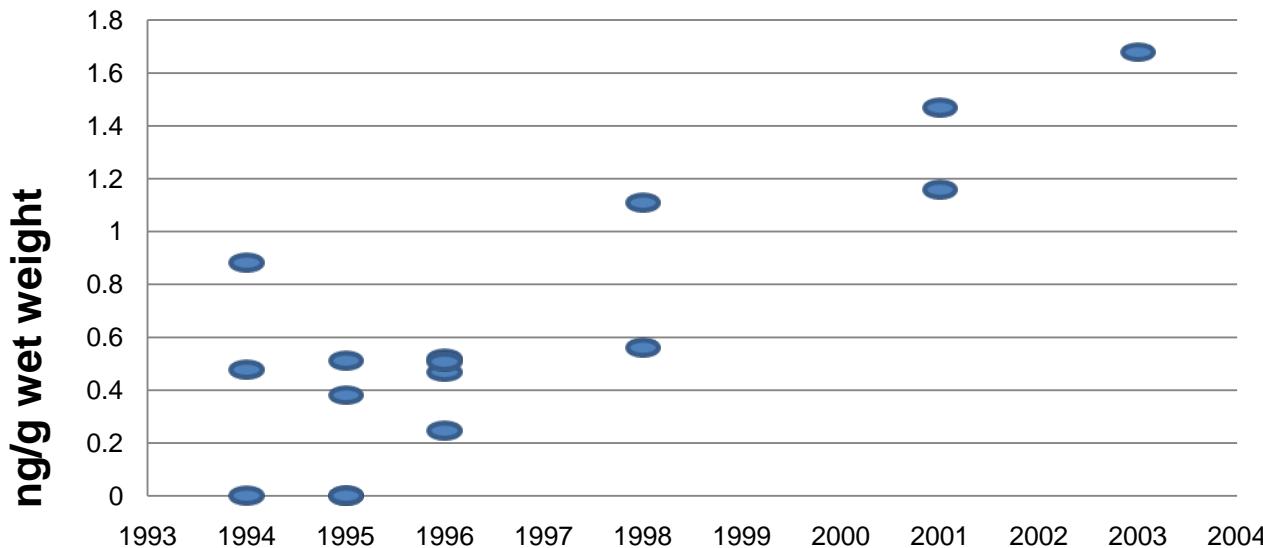
**Flame retardant compound
Bioaccumulates in fat**



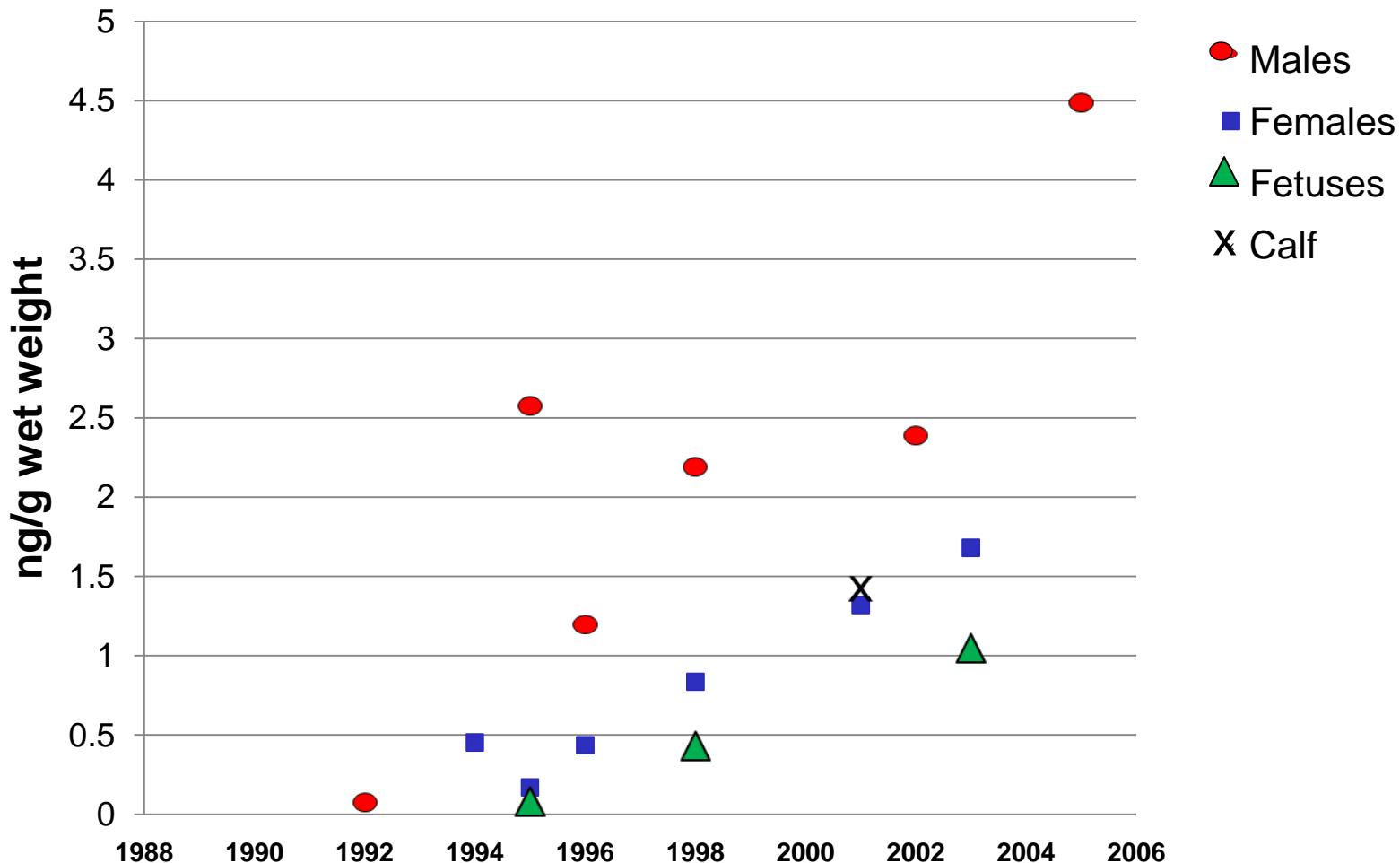
α HBCD in Cook Inlet male belugas



α HBCD in Cook Inlet female belugas

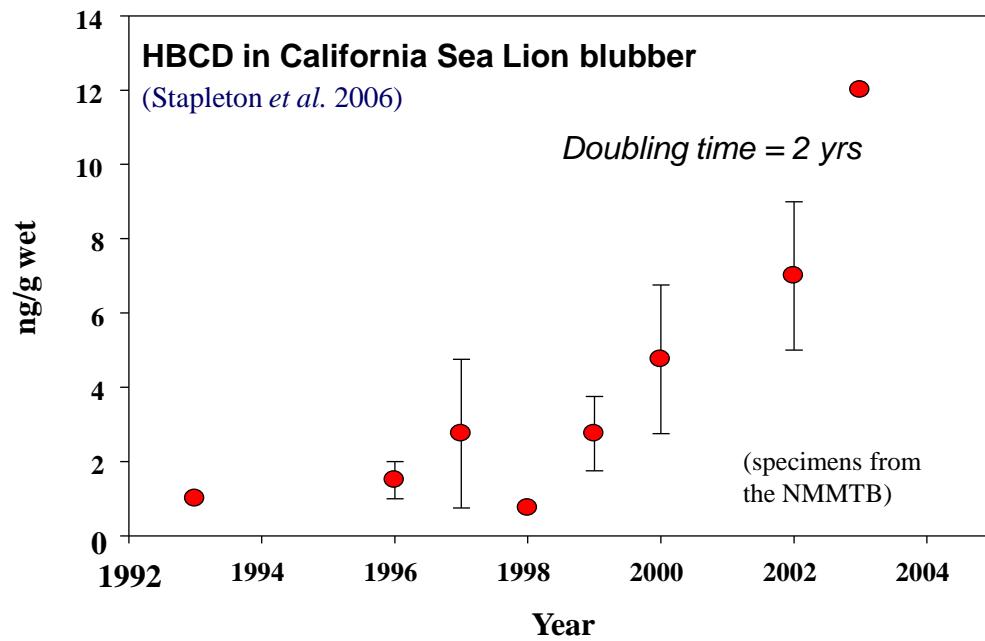
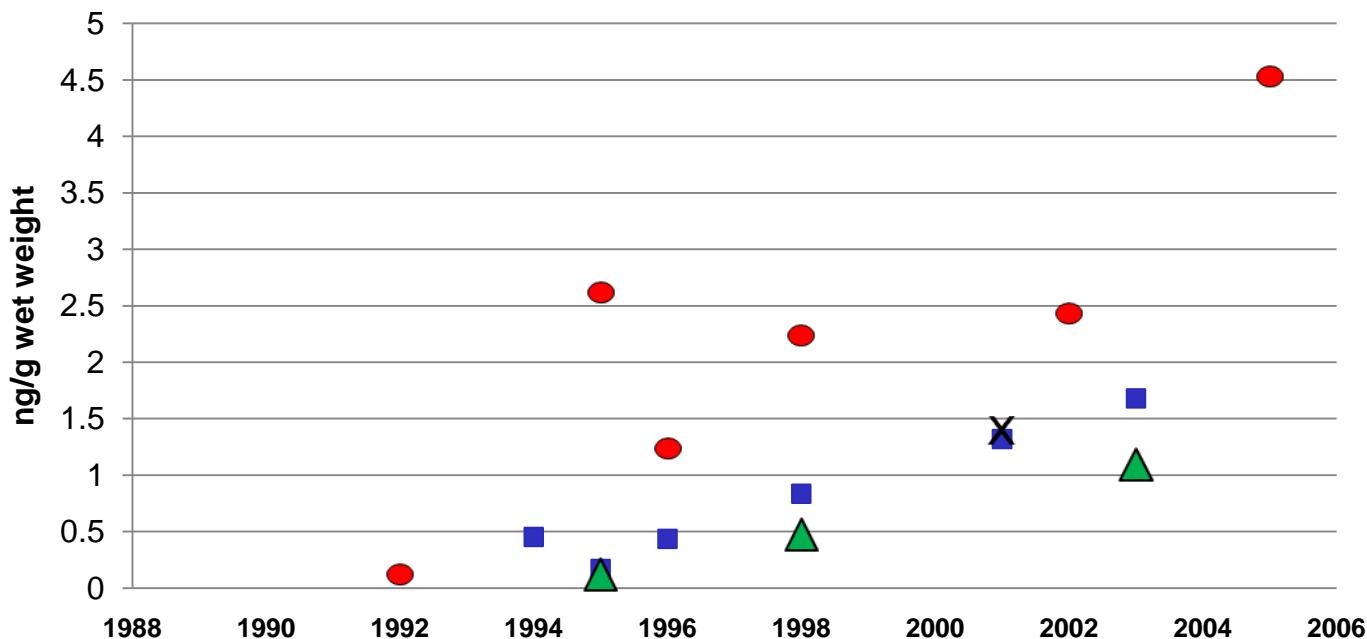


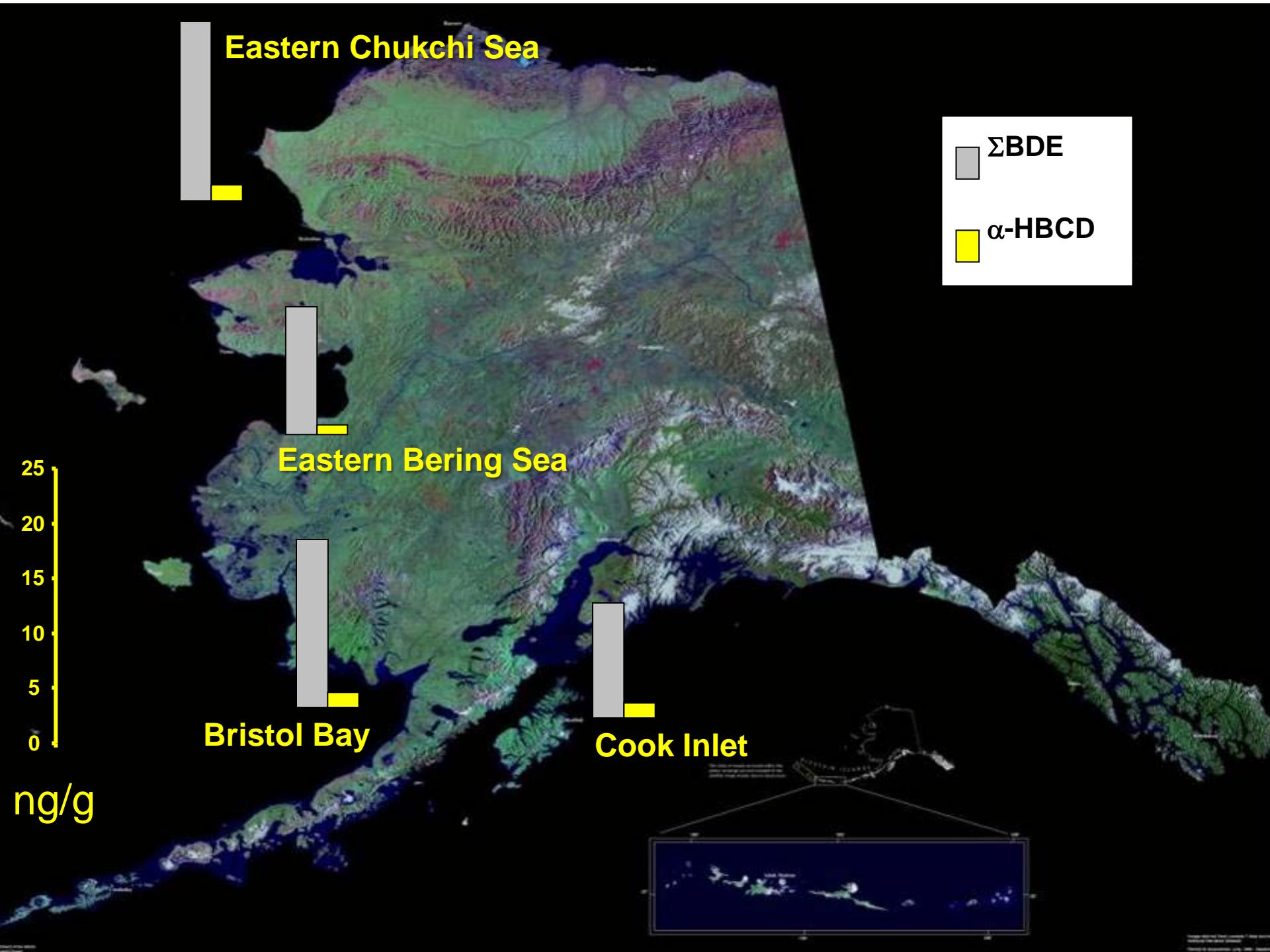
α HBCD in Cook Inlet Belugas



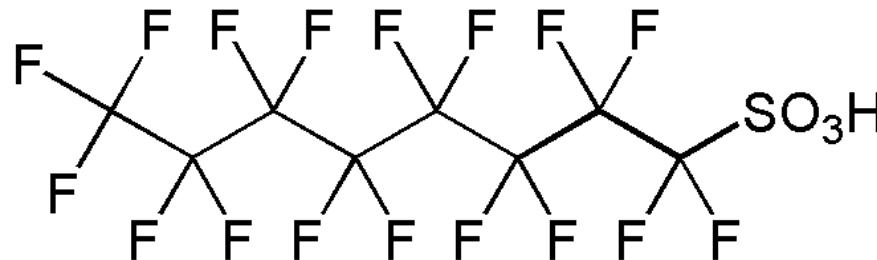
Males = 2.06 ± 1.95
Females = 0.624 ± 0.508
Calf = 1.47
Fetuses = 0.440 ± 0.491

α HBCD in Cook Inlet belugas





Perfluorinated Compounds (PFCs)



Perfluorooctanesulfonic acid (PFOS)



Surfactant
Fire fighting foams
Water & stain repellent
Non-stick surfaces
Insecticides
Semiconductor industry
Bioaccumulates in liver (proteins)



PFNA = Perfluorononanoic acid

PFDA = Perfluorodecanoic acid

PFUnA = Perfluoroundecanoic acid

PFDoA = Perfluorododecanoic acid

PFTriA = Perfluorotridecanoic acid

PFTA = Perfluorotetradecanoic acid

PFHxS = Tridecafluorohexaze-1-sulfonic acid Potassium salt

PFOS = Perfluorooctane Sulfonate

PFOSA = Perfluorooctane Sulfonamide

PFNA = Perfluorononanoic acid

PFDA = Perfluorodecanoic acid

PFUnA = Perfluoroundecanoic acid

PFDoA = Perfluorododecanoic acid

PFTriA = Perfluorotridecanoic acid

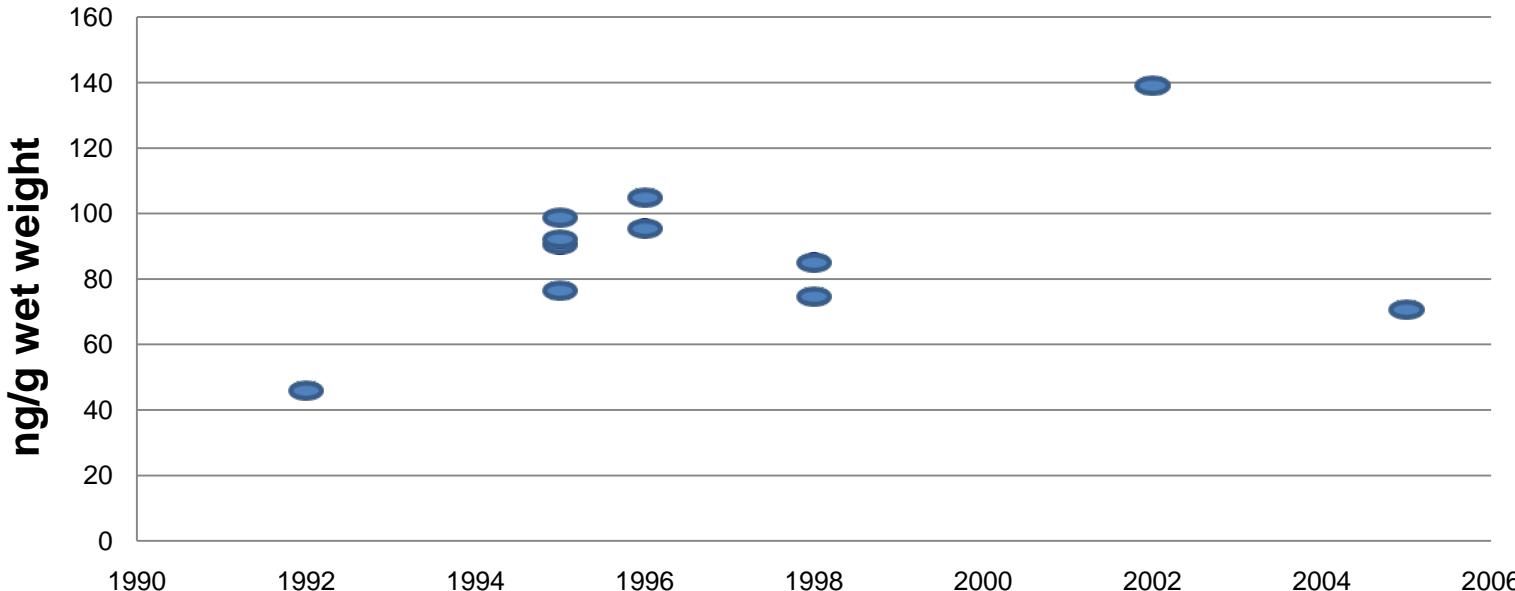
PFTA = Perfluorotetradecanoic acid

PFHxS = Tridecafluorohexaze-1-sulfonic acid Potassium salt

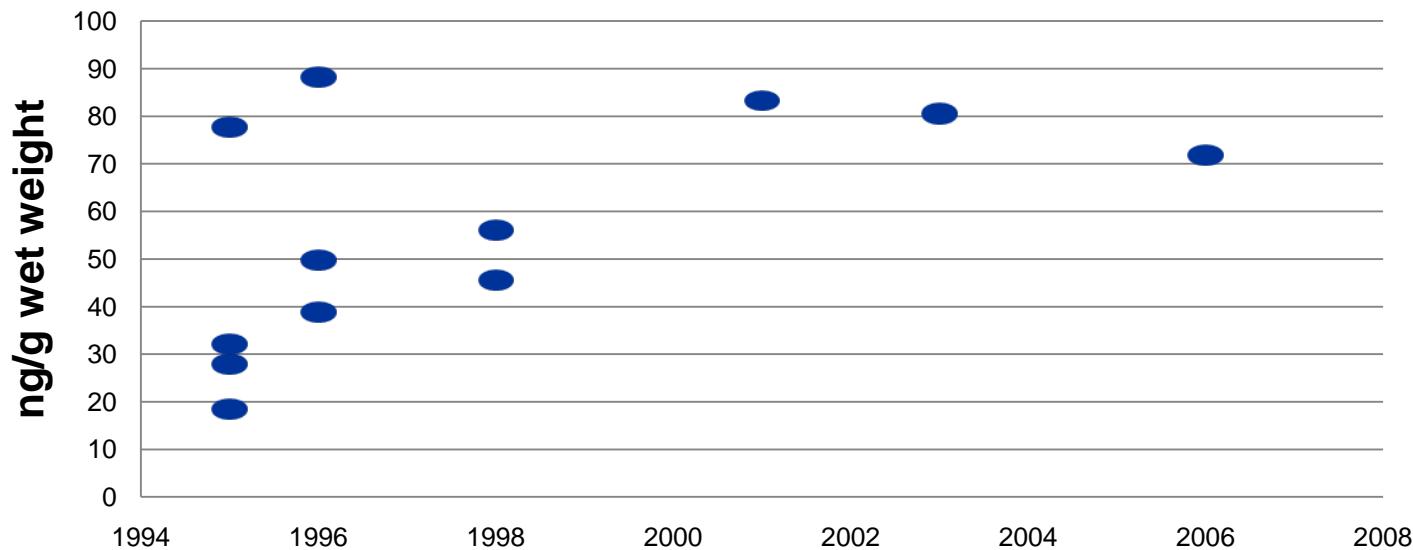
PFOS = Perfluorooctane Sulfonate

PFOSA = Perfluorooctane Sulfonamide

Σ PFCs in male Cook Inlet belugas

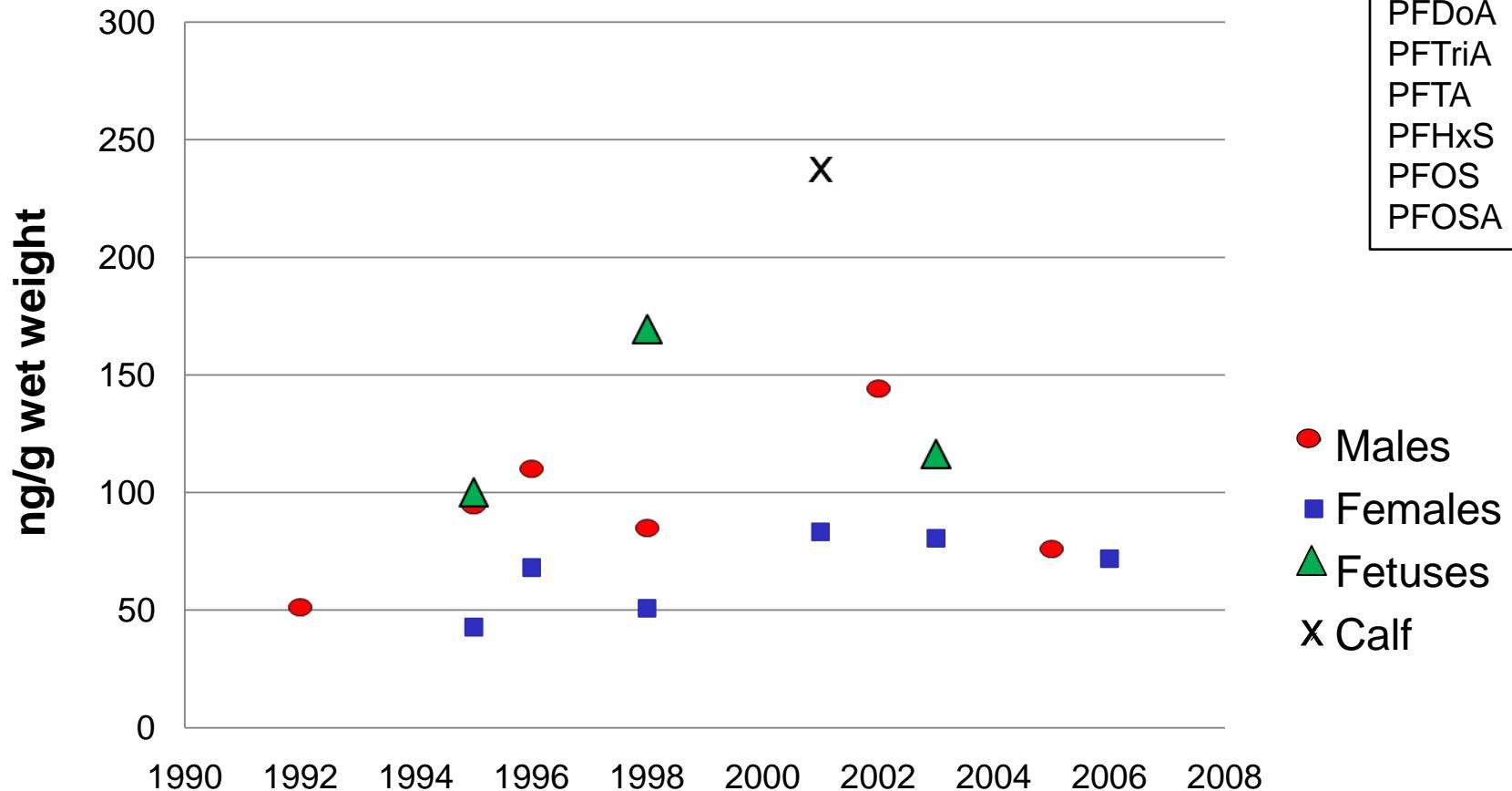


Σ PFCs in female Cook Inlet belugas



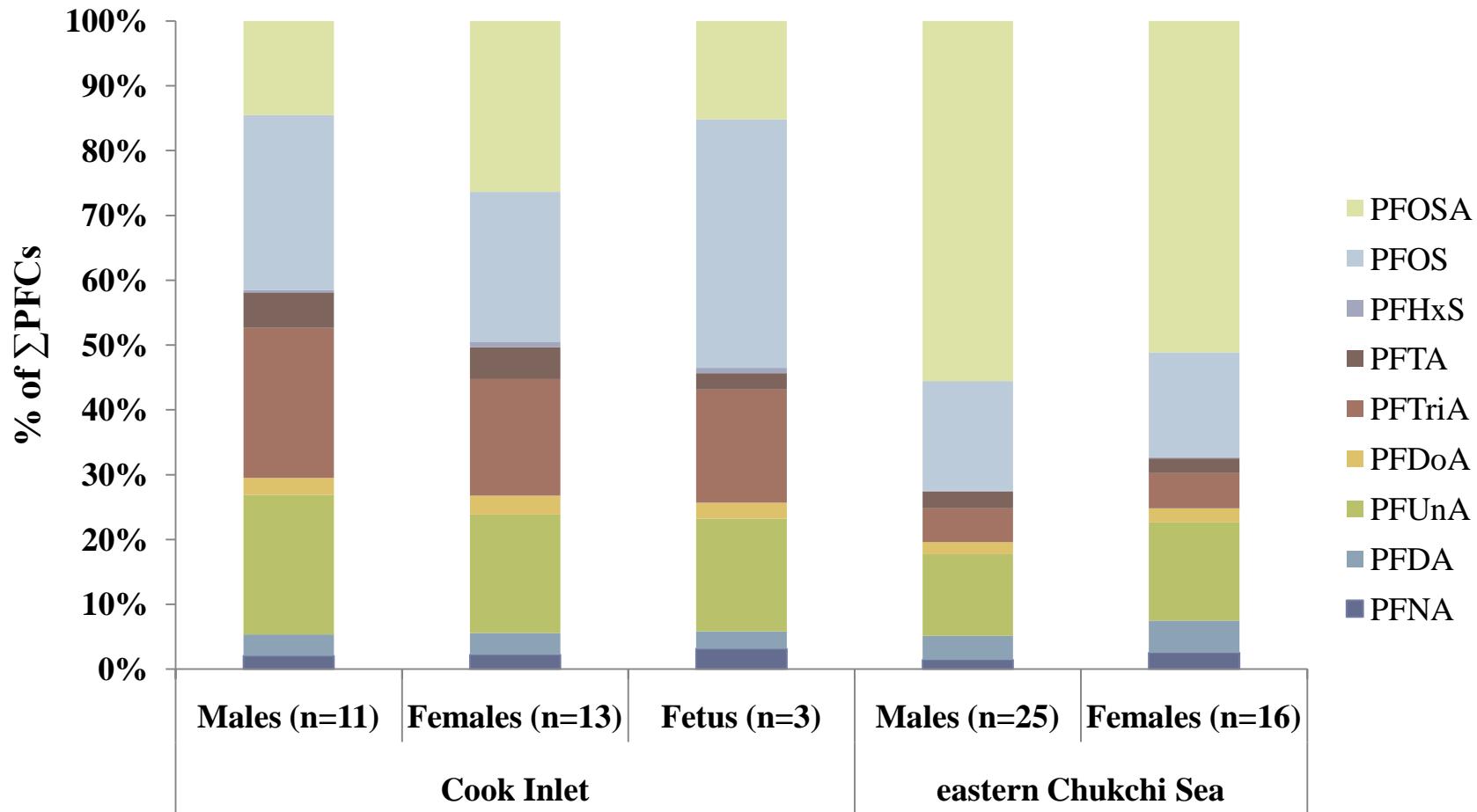
PFNA
PFDA
PFUnA
PFDmA
PFTriA
PFTA
PFHxS
PFOS
PFOSA

Σ PFCs in Cook Inlet belugas



Males = 87.8 ± 24.5
Females = 59.0 ± 25.4
Calf = 240
Fetuses = 123 ± 36.3

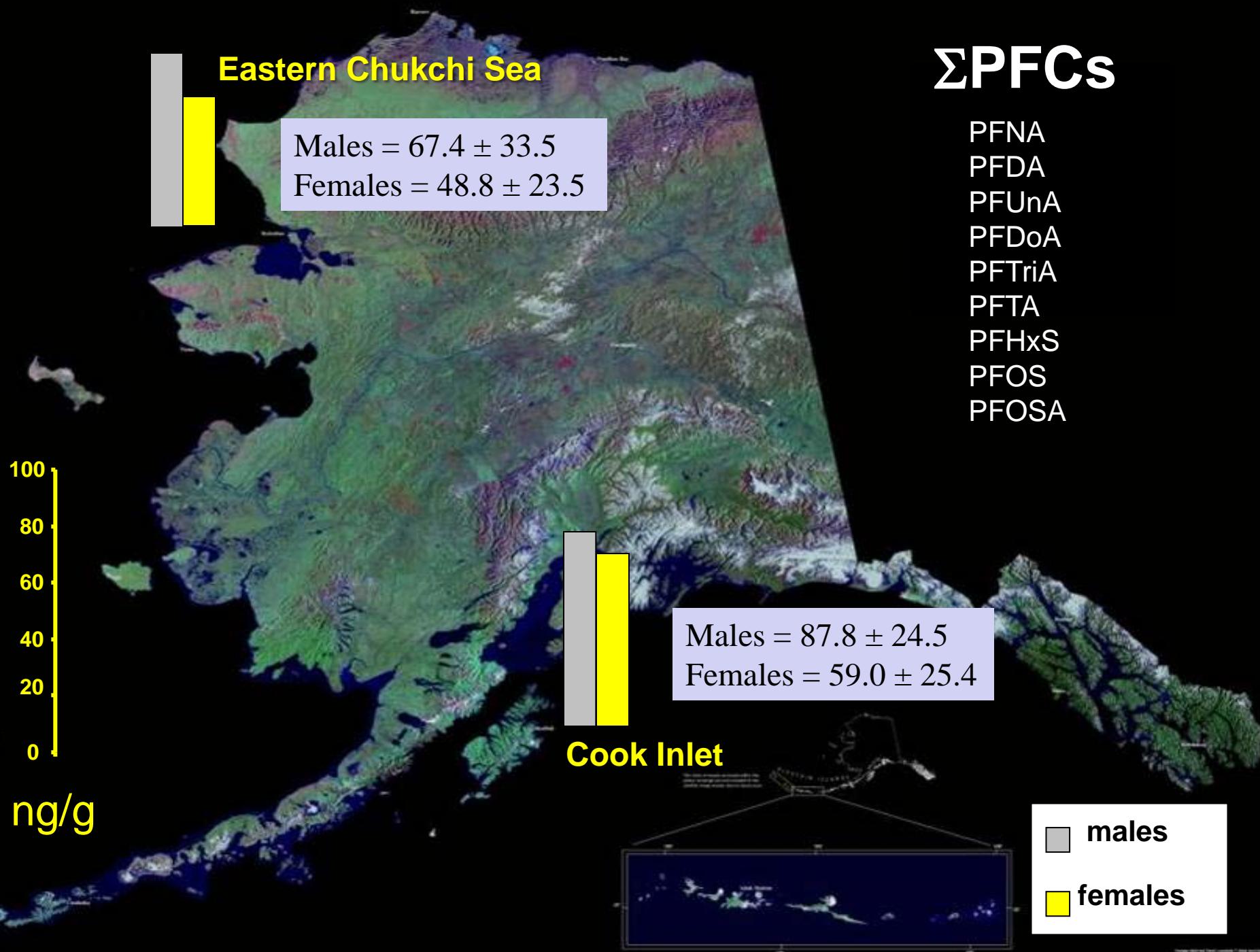
Beluga Whales: Spatial trends



Concentration ranges of PFCs (ng/g wet weight) in belugas

	Cook Inlet (n = 27) 1992 - 2006	E. Chukchi Sea (N = 41) 1989 - 2000	Hudson Bay (n = 22) 1999 - 2003	Hedrickson Sound (N = 10)
PFDA	0.309 – 6.98	0.514 – 14.3	2.0 – 18.9	5.87 – 33.9
PFUnA	<LOD – 41.6	<LOD – 49.0	3.8 – 39.6	6.47 – 30.7
PFTriA	<LOD – 82.8	<LOD – 17.6	0.27 – 2.35	-----
PFOS	4.61 – 70.3	1.81 – 38.1	3.0 – 109	4.25 – 20.3
PFOSA	4.52 – 27.8	11.2 – 65.7	4.94 - 156	7.76 – 24.5

Σ PFCs



Cook Inlet Males

Compound	Trend	Significance
Σ PCB	➡	n.s.
Σ DDT	➡	n.s.
Σ Chlordane	➡	n.s.
Σ Chlordane	➡	n.s.
HCB	➡	n.s.
Σ HCH	➡	n.s.
Σ BDE	⬆	p<0.001
HBCD	⬆	P<0.001
Σ PFCS	⬆	P<0.05

Cook Inlet Females

Compound	Trend	Significance
Σ PCB	➡	n.s.
Σ DDT	➡	n.s.
Σ Chlordane	➡	n.s.
Σ Chlordane	➡	n.s.
HCB	➡	n.s.
Σ HCH	➡	n.s.
Σ BDE	➡	p<0.001
HBCD	⬆	P<0.001
Σ PFCS	➡	n.s.

Conclusions

- **Spatial differences evident–**
 - Adding additional, more recent AMMTAP samples to the database did not change significantly the concentration values of the previously reported legacy organic contaminants
 - Cook Inlet belugas generally < than other Alaska locations except for some PFCs (PFOS & PFTrIa)
 - BDEs and HBCD not statistically diff. among locations
- **Time trends evident for some compounds:**
 - BDEs & PFCs increasing in Cook Inlet males
 - HBCD increasing in both Cook Inlet males & females

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John Kucklick , Jennifer Houget, Jennifer Keller, and Jessica Reiner

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