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Trace elements and organic contaminants in tissues of minke whale (*Balaenoptera acutorotstrata*) and its feed from Icelandic waters

Objectives of the Icelandic research project 2003-2007

1 **Feed ecology is the main objective of the project**

Increase the knowledge on biology and feed consumption of whales in Icelandic waters to facilitate management of fisheries.

2 **Stock identity**

3 **Parasites and pathology**

4 **Biology**

5 **Research on contaminants**

6 **New research methods**

Research on contaminants: scientific questions

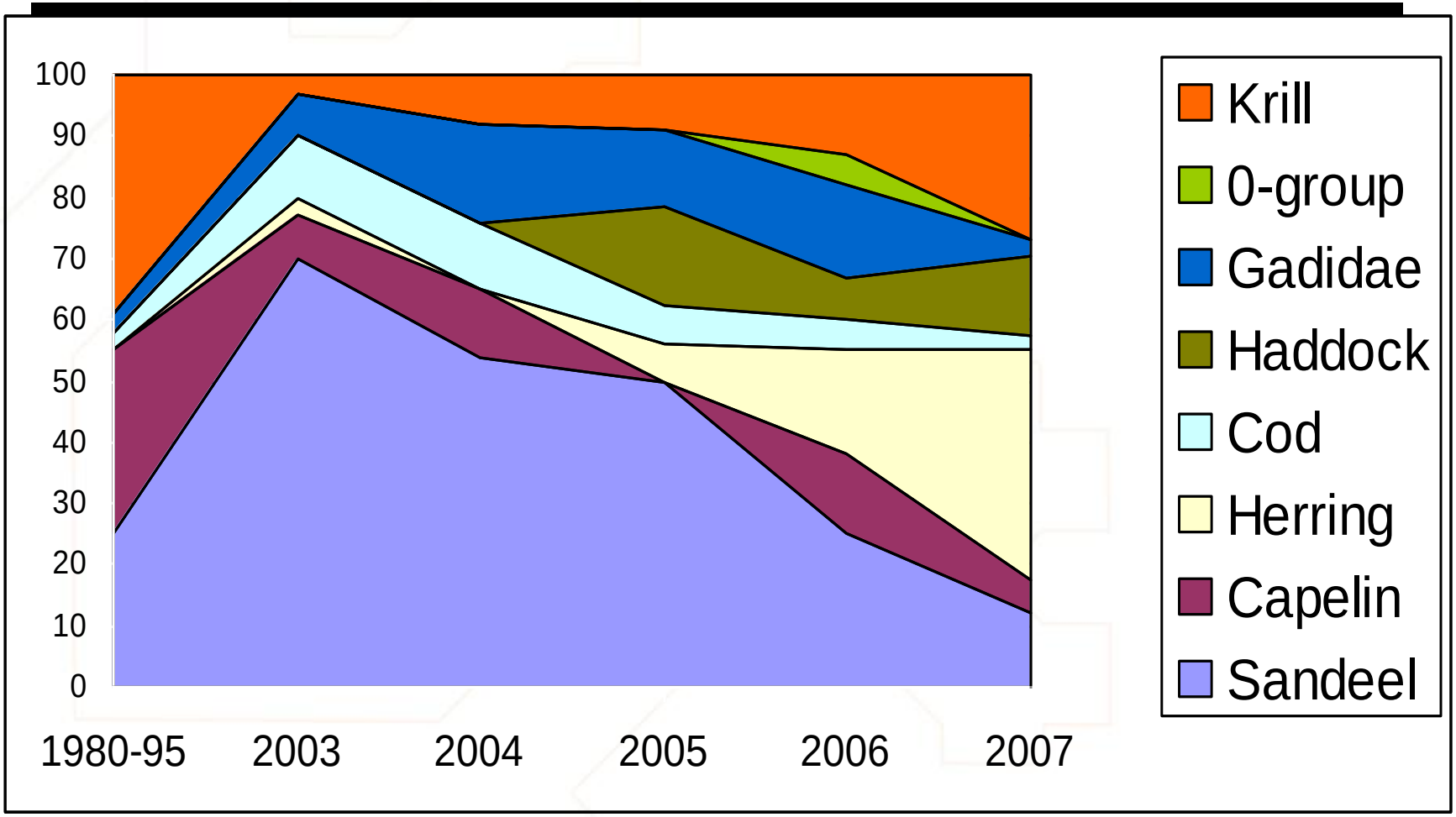
- What are the characteristics of the Icelandic minke whale compared with neighboring and distant stocks?
- Do biopsies provide information on the level and behaviour of contaminants in the organs of the minke whale?
- Can inorganic and organic contaminants provide answers regarding the prey species of the minke whales?
- Is it possible to estimate the food consumption of the minke whale by way of contaminants in its tissues and its prey species?
- Are the levels of environmental contaminants in tissues of minke whales detrimental to the health of the animals?
- Do the levels of contaminants restrict human consumption of minke whale products?

Research on contaminants: coverage

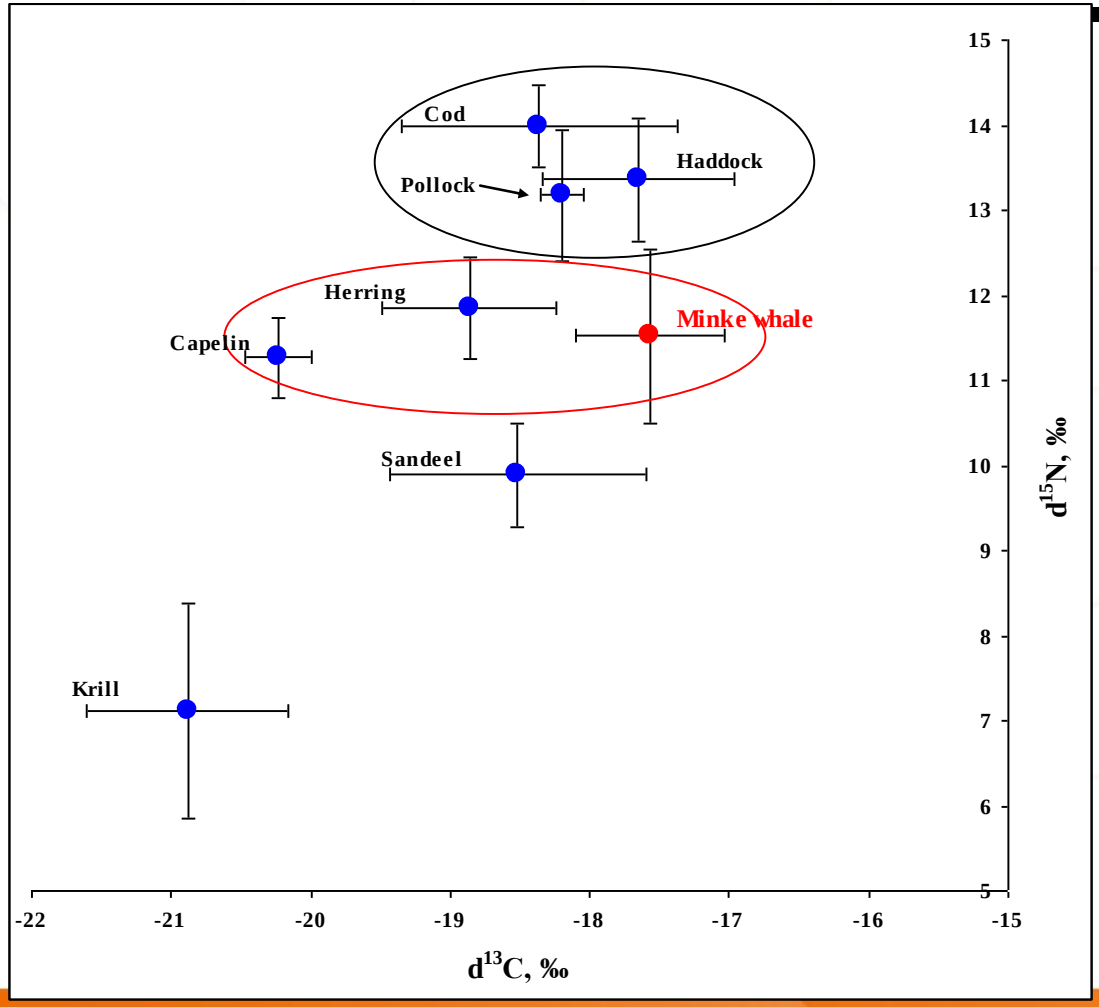
- Tissues (n≥25 each tissue) : skin, blubber, muscle, liver, kidneys, and ovaries/testes.
- Diet: krill, sandeel, capelin, herring, haddock, pollock and cod (N=50)
- Trace elements: Hg, Cd, Pb, As, Se, Fe, Mn, Cu, Zn, Cr and Ni.
- Organic contaminants: PCBs (11 congeners), PCDD/Fs (17 congeners), DL-PCB (12 congeners), pesticides (16 substances) and PBDEs (3 congeners).

Interpretation in terms of sex, age, length, stable isotopes (N and C), nutritional status, etc.

Diet composition (stomachs 2003-2007)

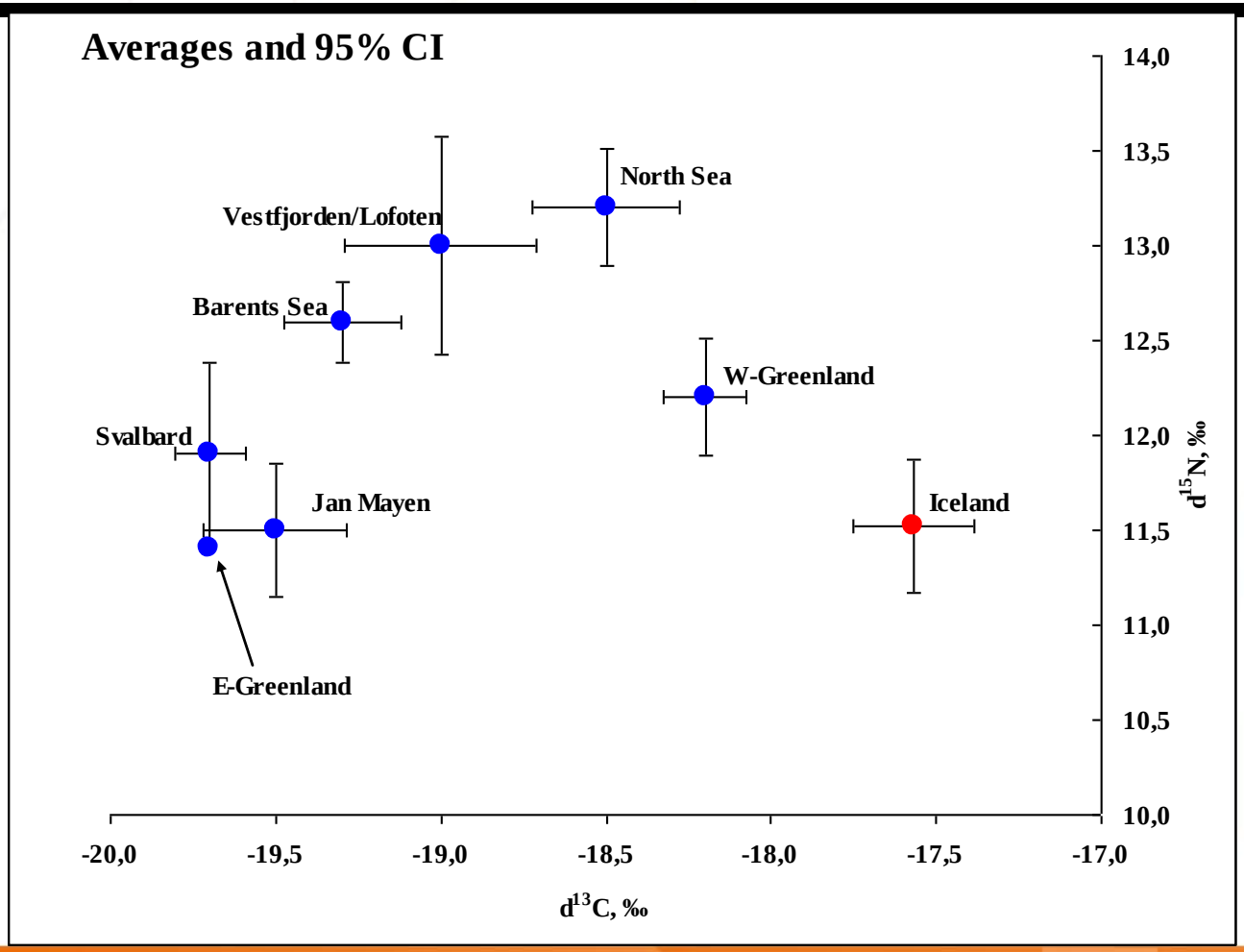


Trophic level



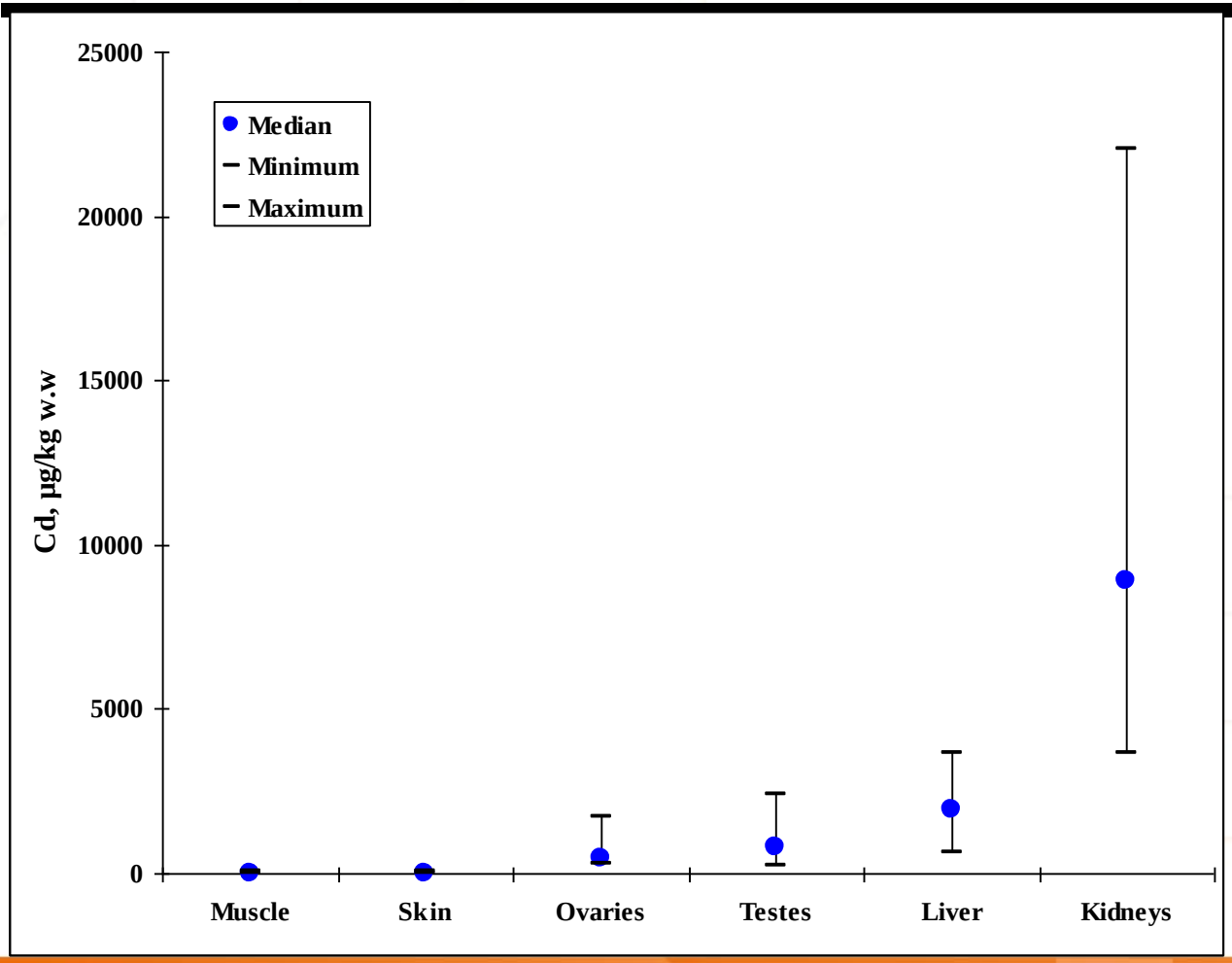
Averages and standard deviations

Stable isotopes in minke whale in the N-Atlantic

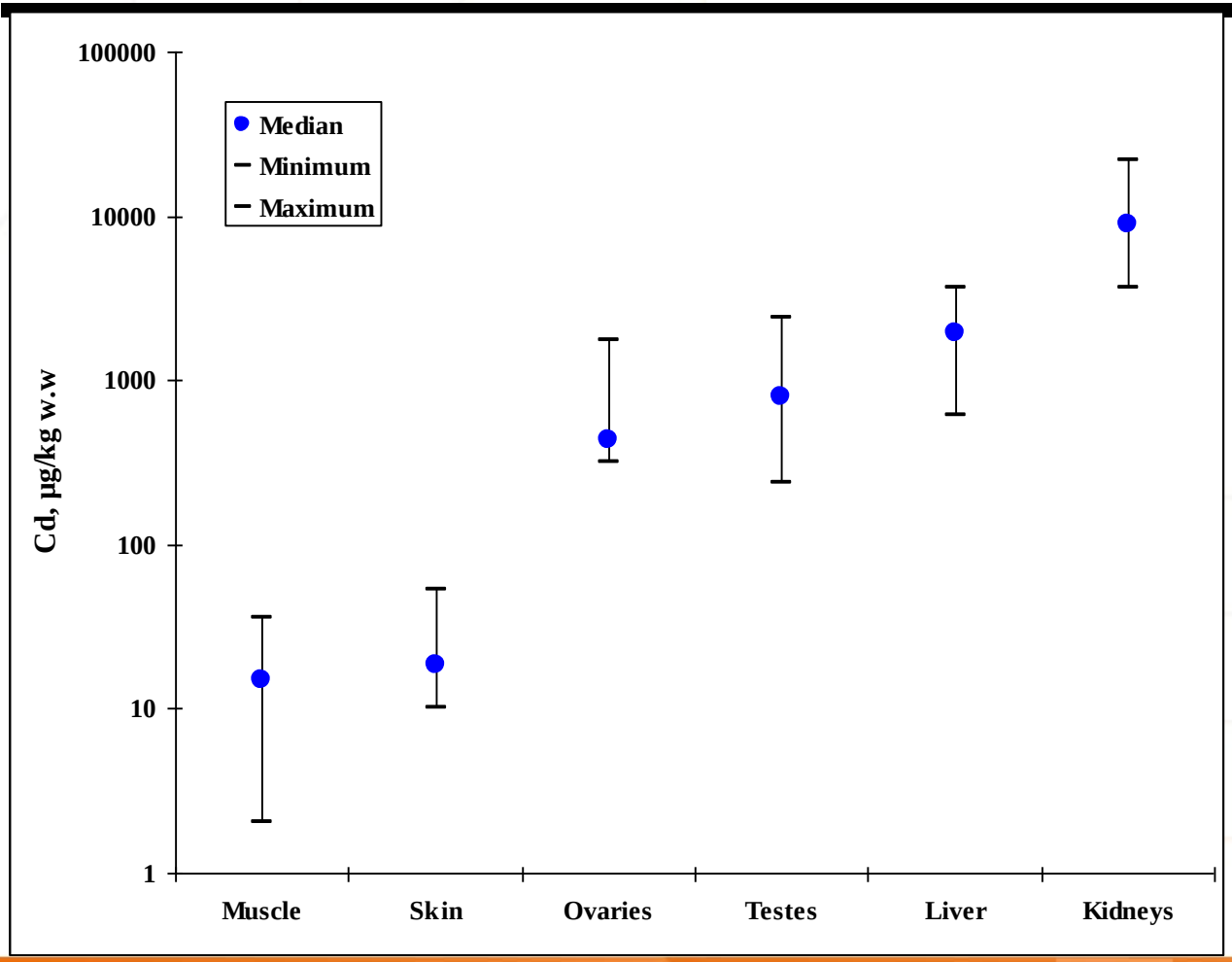


Blue points: Born *et al.* 2003. J.Mar.Syst.

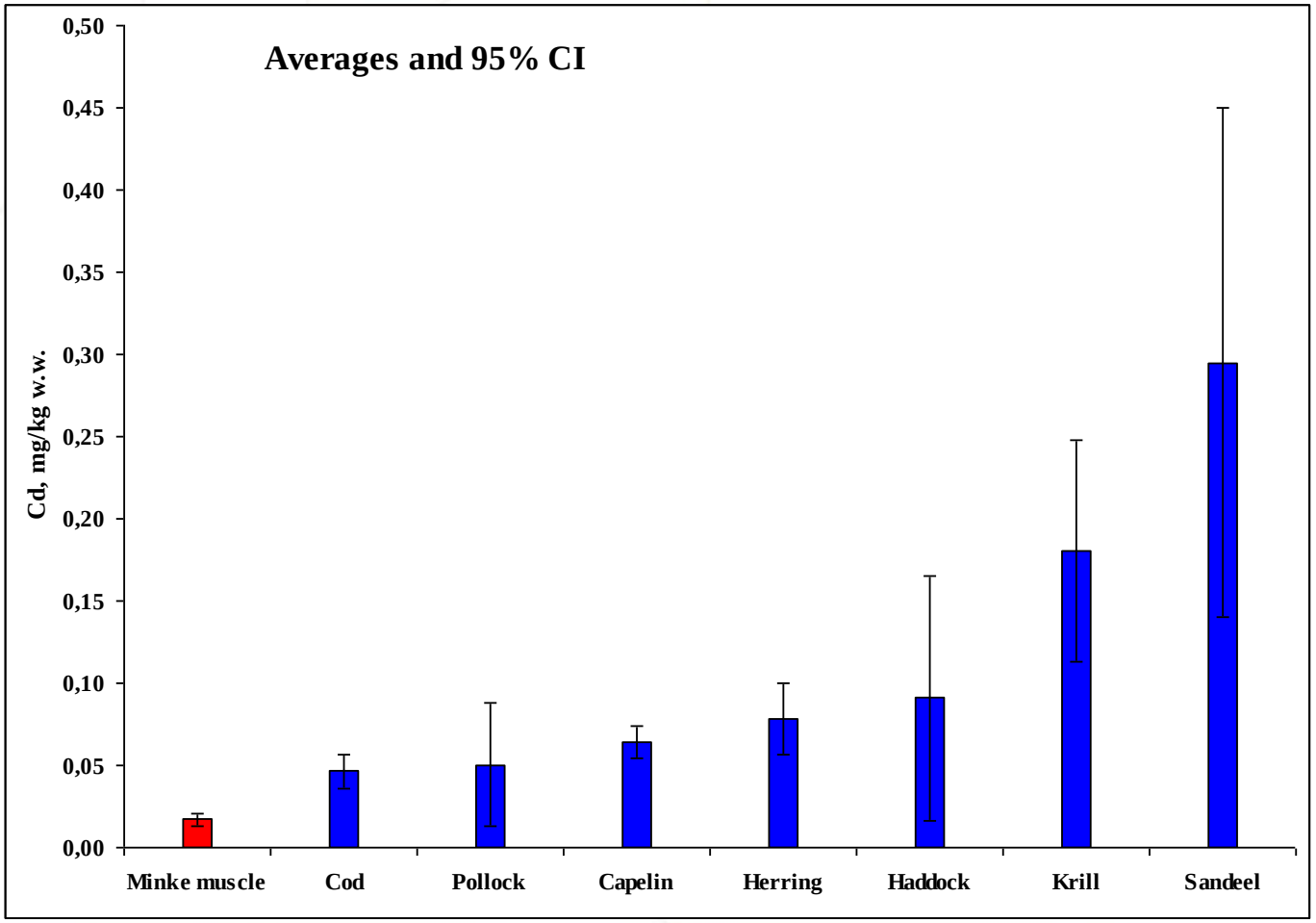
Cadmium in tissues of minke whale 1



Cadmium in tissues of minke whale 2

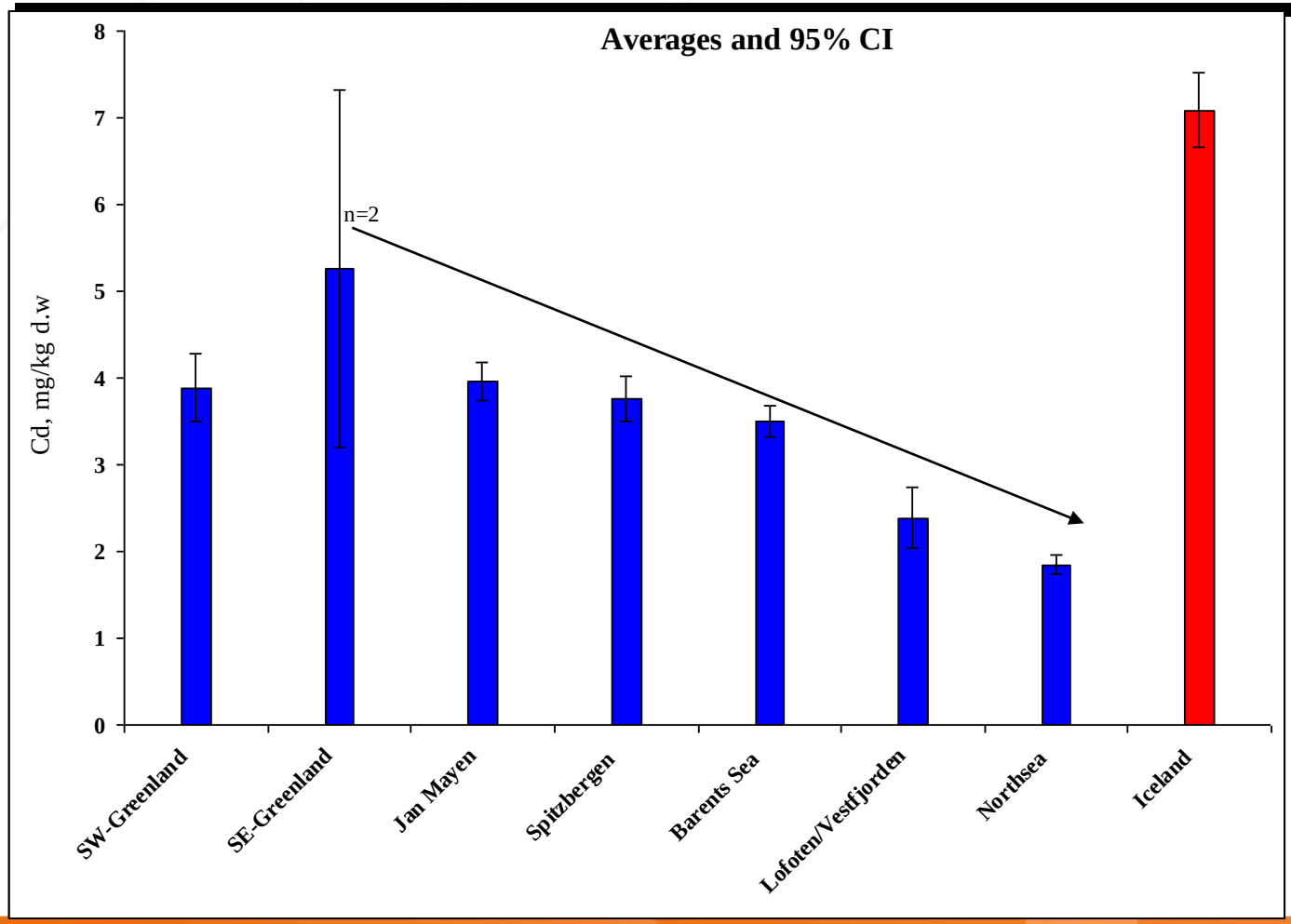


Cadmium in minke whale and diet



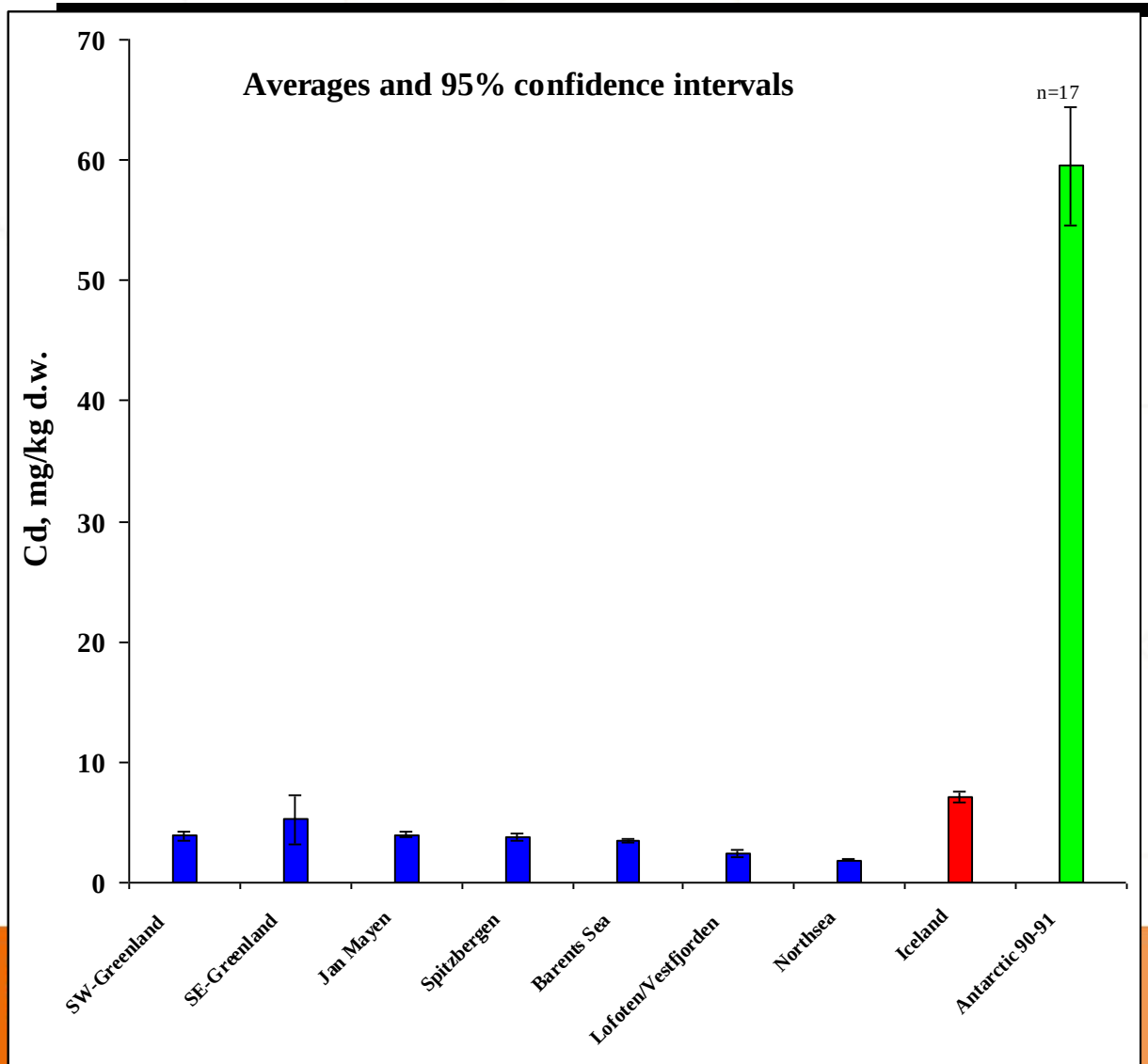
Cd does not accumulate in muscle tissue of minke whale

Cadmium in livers of minke whale of the N-Atlantic



Blue columns: Born *et al.* 2003. J.Mar.Syst.

Cadmium in livers of minke whale from the N-Atlantic and Antarctic



Green bar: Kunito *et al*. 2002. Mar.Env.Res.

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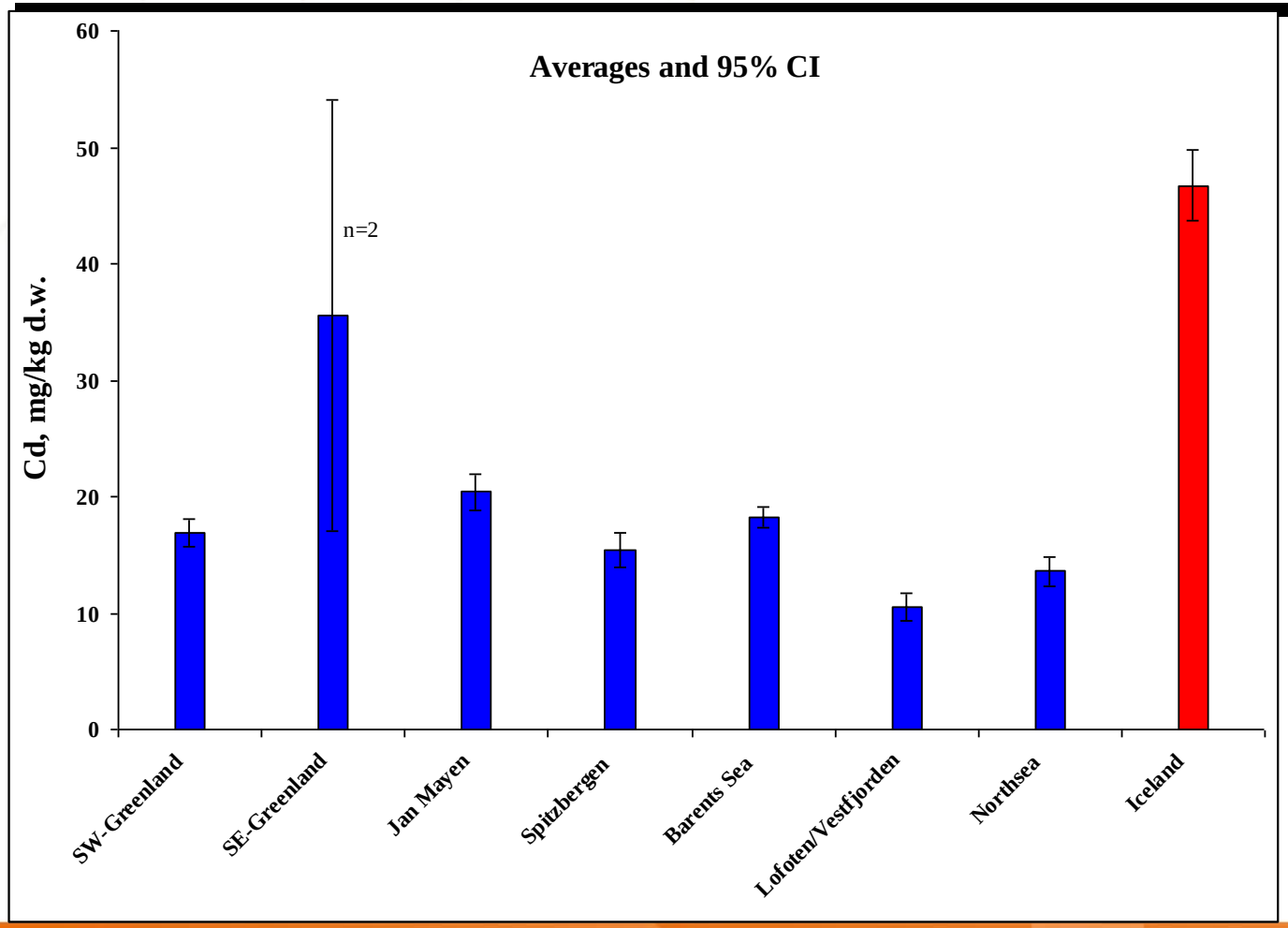
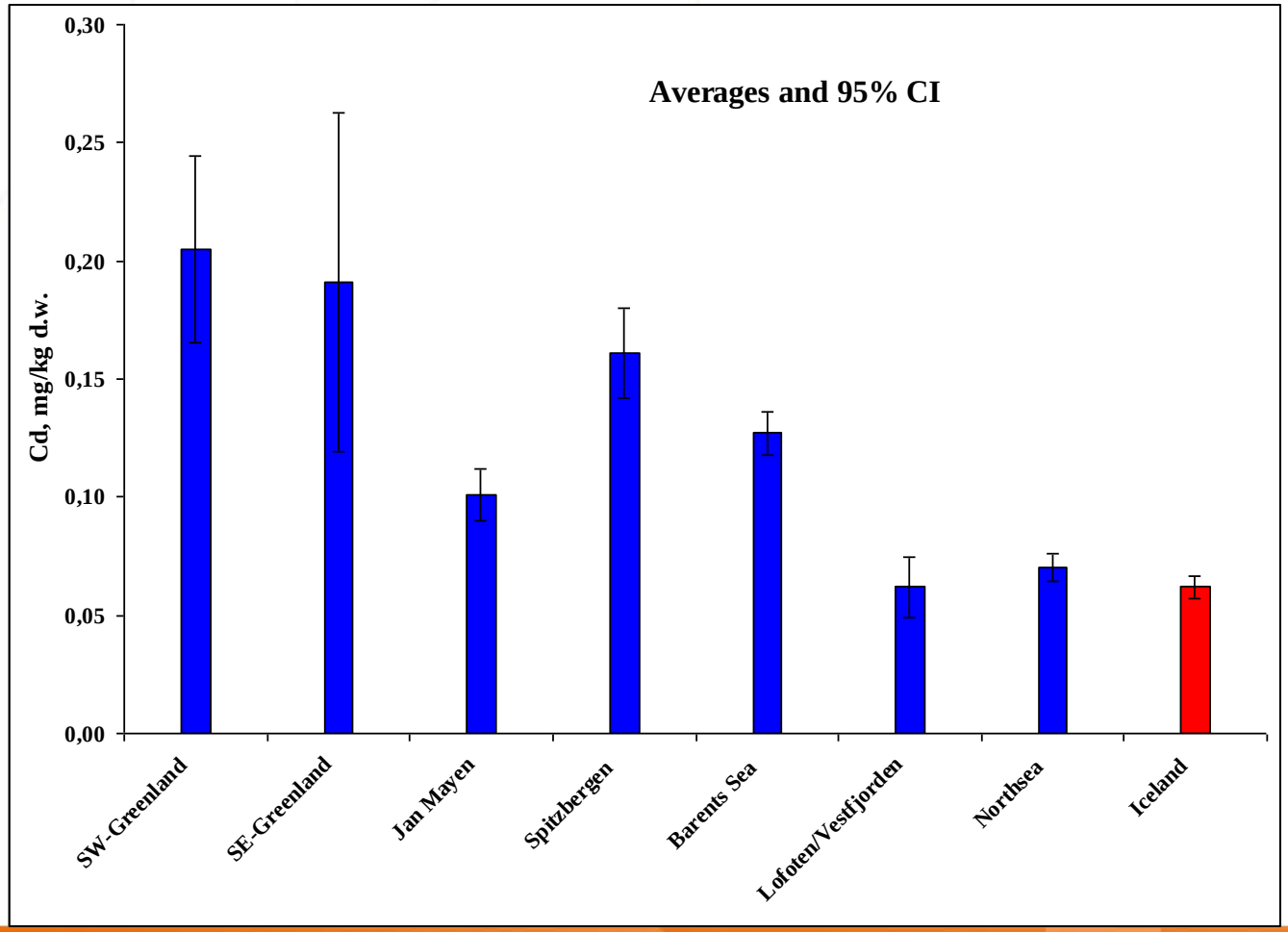
Cadmium in kidneys of minke whale from the N-Atlantic



Blue columns: Born *et al.* 2003. J.Mar.Syst.

Cadmium in muscle of minke whale from the N-Atlantic



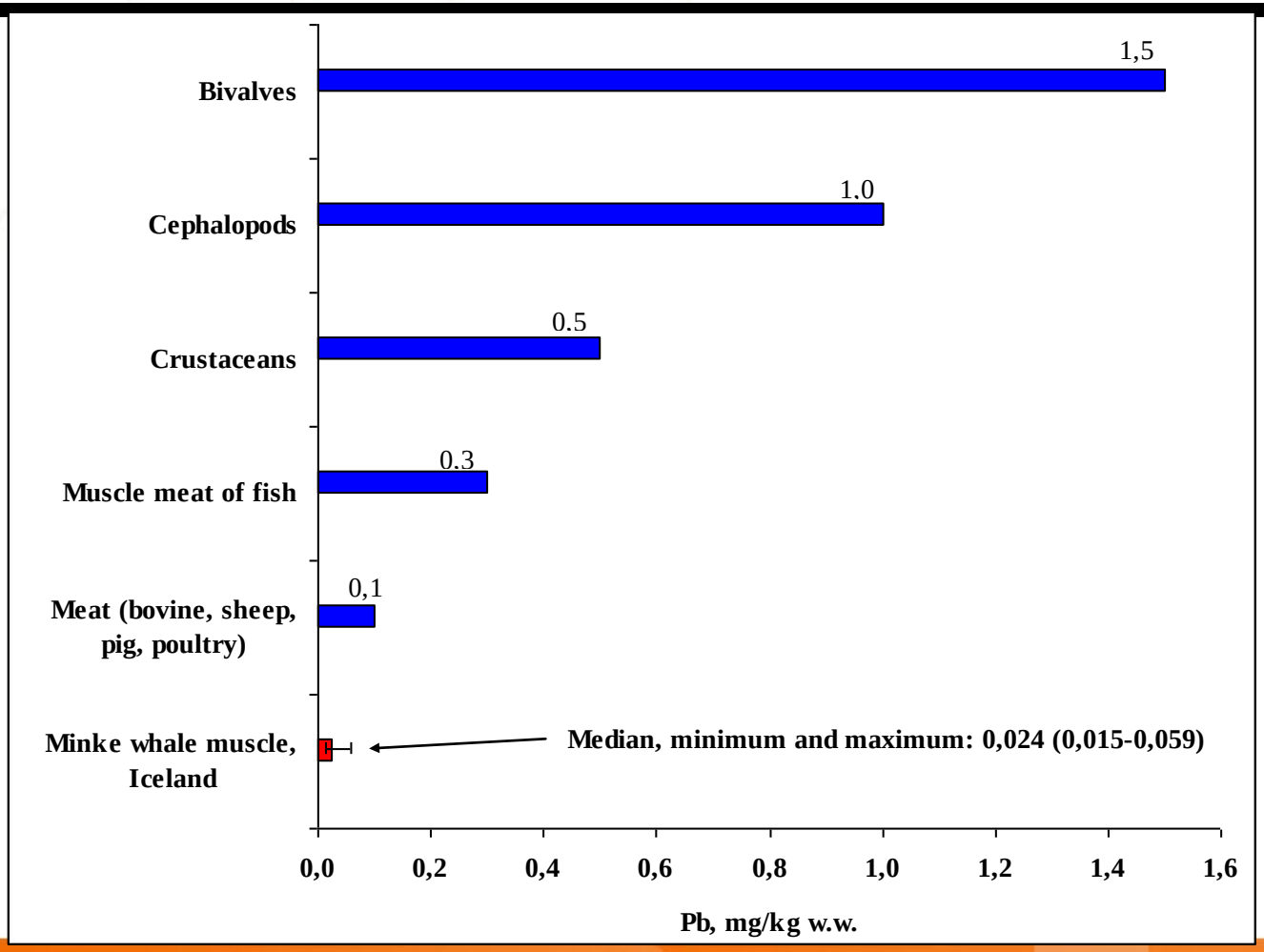
Blue columns: Born *et al.* 2003. J.Mar.Syst.

Cadmium and maximum limits in EU (Reg. 1881/2006/EC)

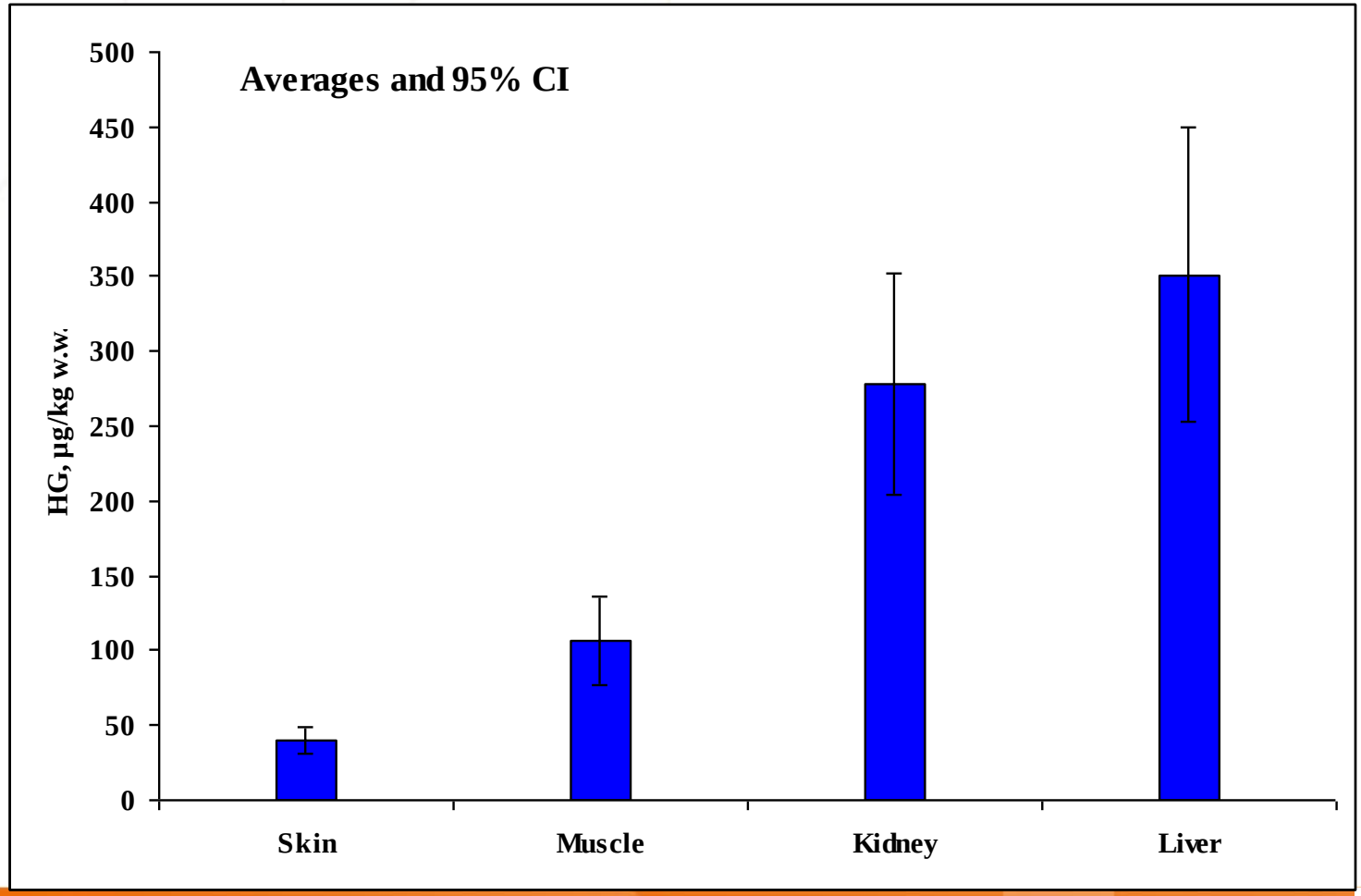
Muscle tissue of fish, general	0,05 mg/kg
Muscle tissue of fish, e.g. eel, anchovy, sardines and tuna	0,1 mg/kg
Muscle meat of swordfish	0,3 mg/kg
Meat of bovine animals, sheep, pig and poultry	0,05 mg/kg
Horse meat	0,2 mg/kg
Crustaceans	0,5 mg/kg
Bivalves and cephalopods	1,0 mg/kg

Muscle meat of minke whale, Iceland **0,017 (0,002-0,047) mg/kg**

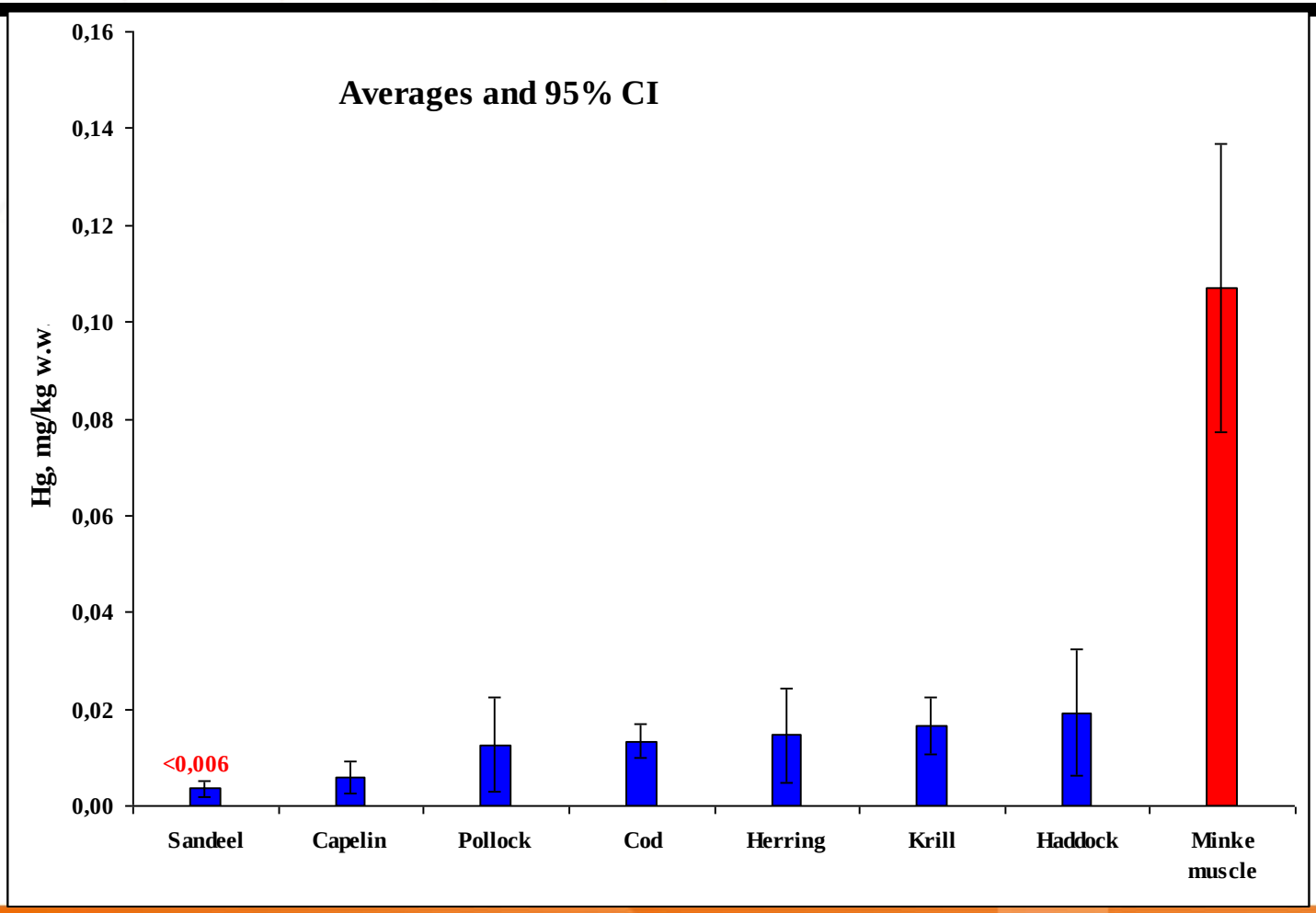
Lead: maximum limits in EU (Reg. 1881/2006/EC)



Mercury in tissues of minke whale

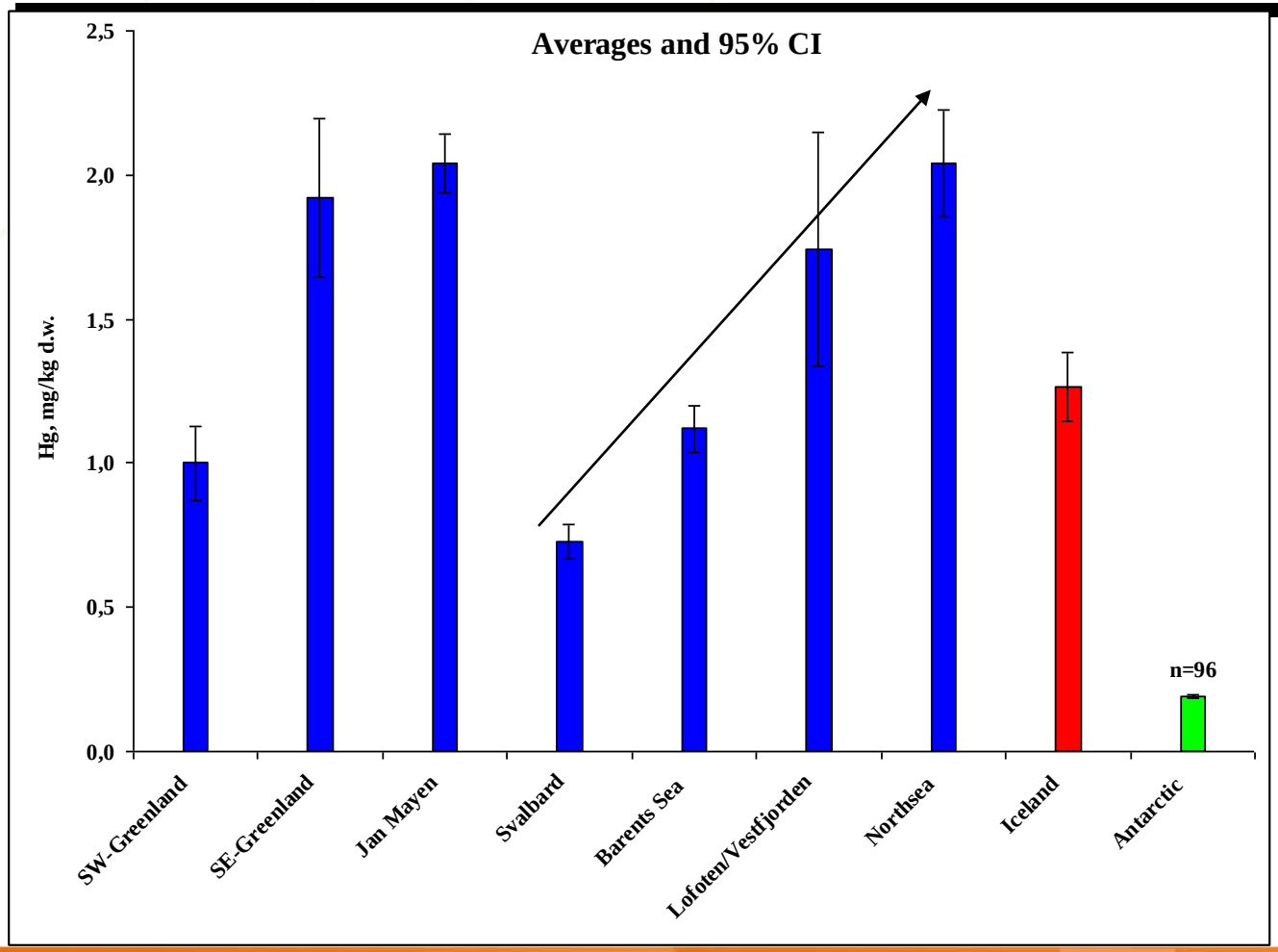


Mercury in minke whale and diet



Hg accumulates in muscle of minke whale (unlike Cd)

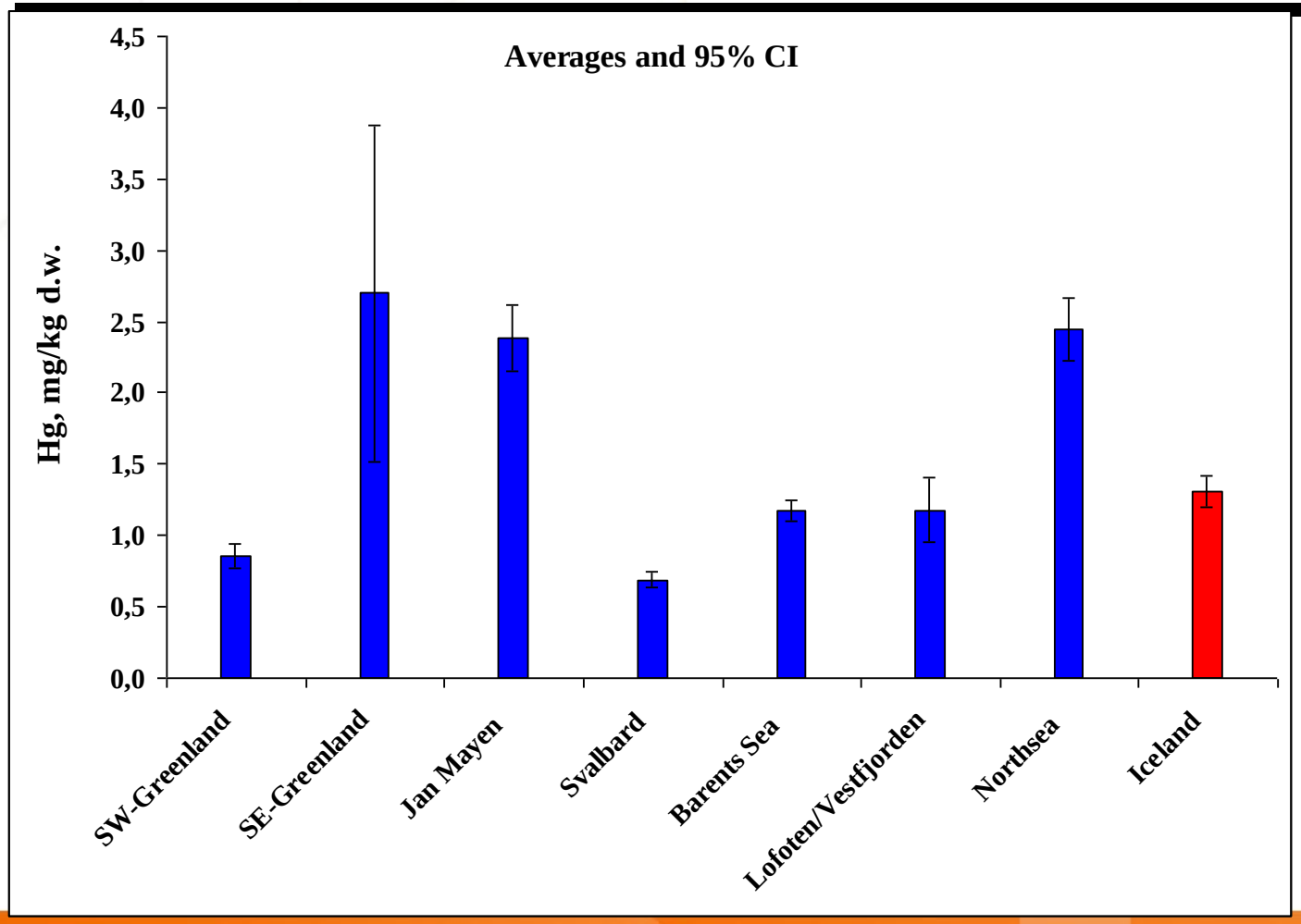
Mercury in *livers* of minke whale from the N-Atlantic and Antarctic



Blue columns: Born *et al.* 2003. J.Mar.Syst.

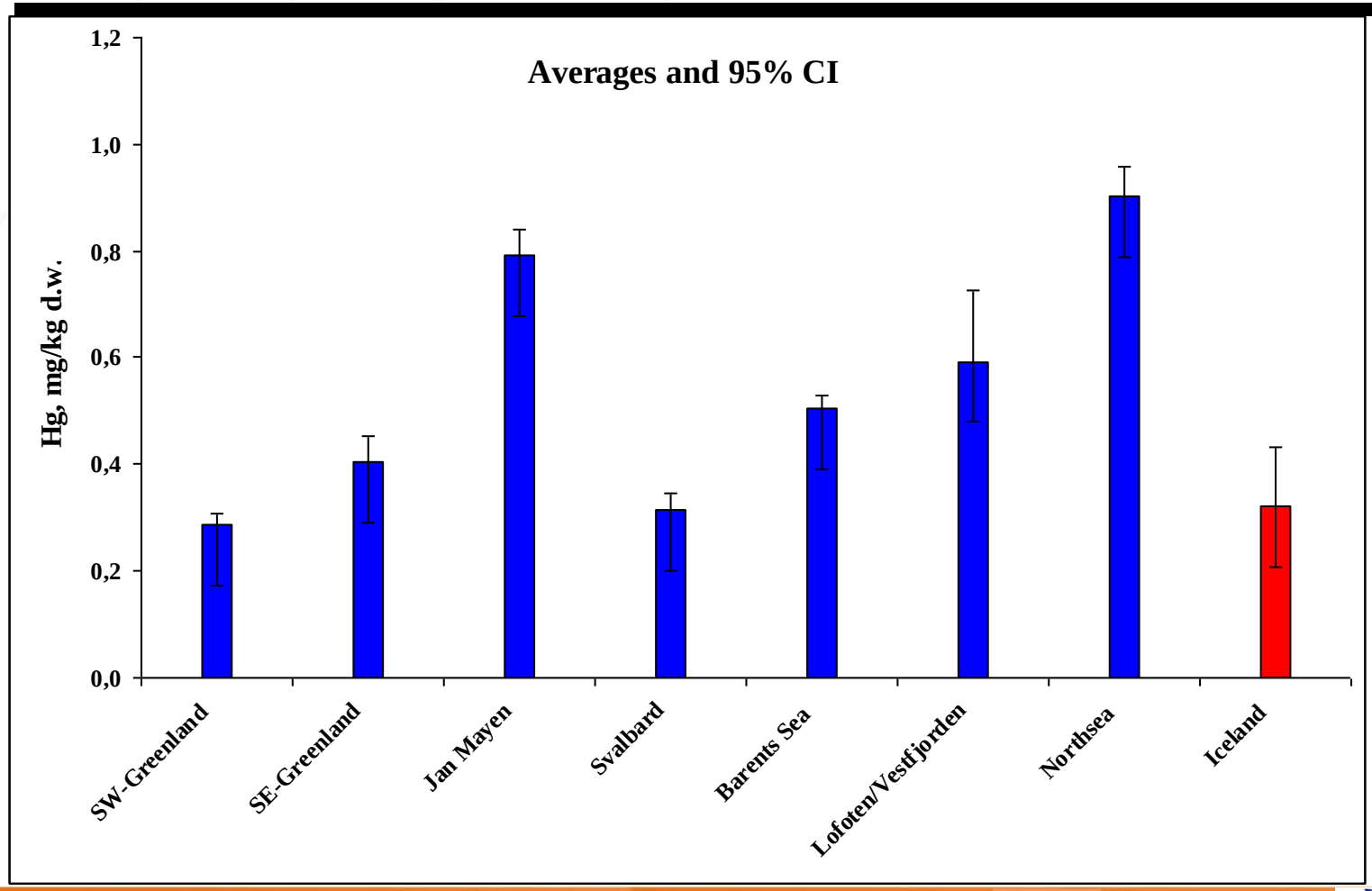
Green column: Honda *et al.* 1987. Arch.Env.Cont.Tox.

Mercury in *kidneys* of minke whale from the N-Atlantic



Blue columns: Born *et al.* 2003. J.Mar.Syst.

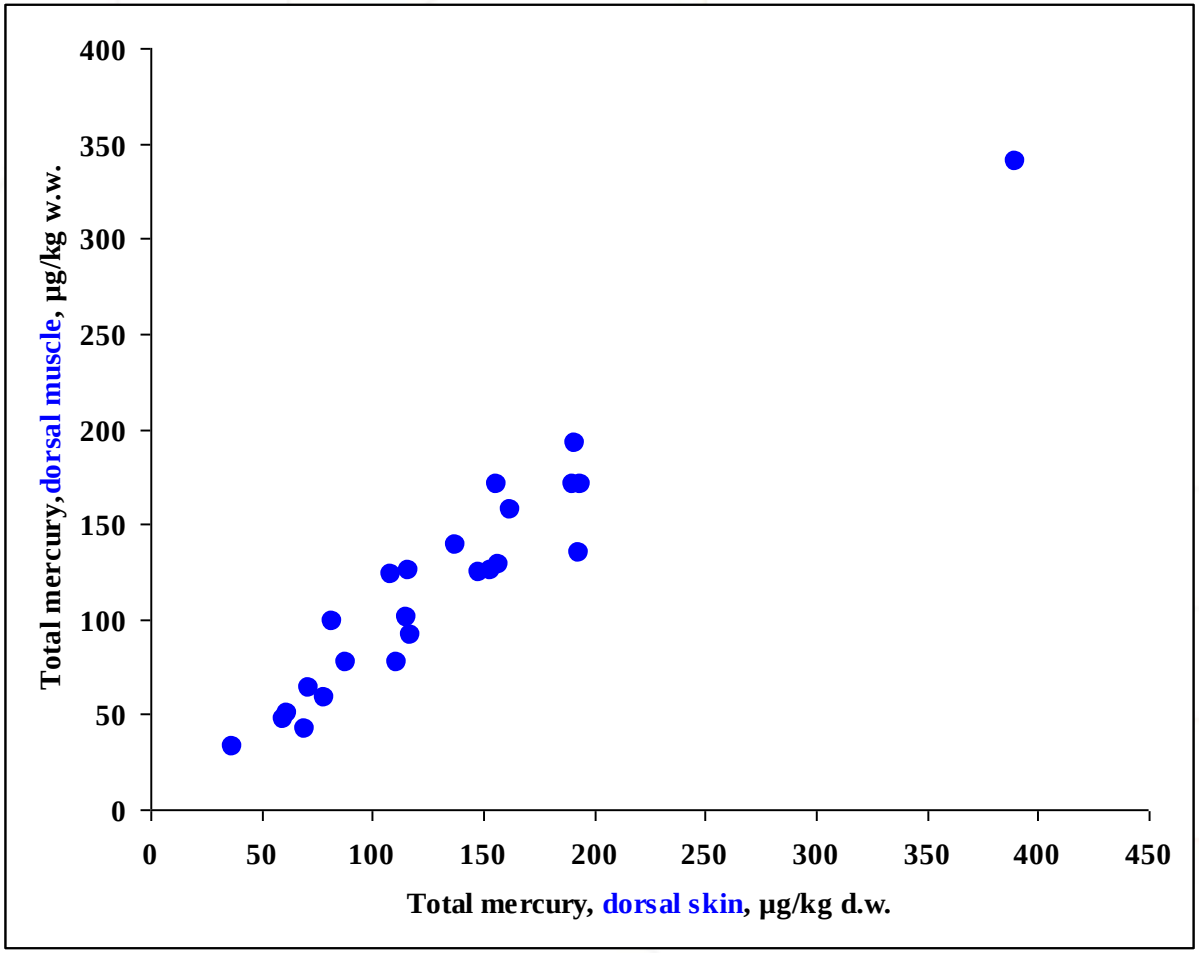
Mercury in *muscle tissue* of minke whale from the N-Atlantic



Blue columns:

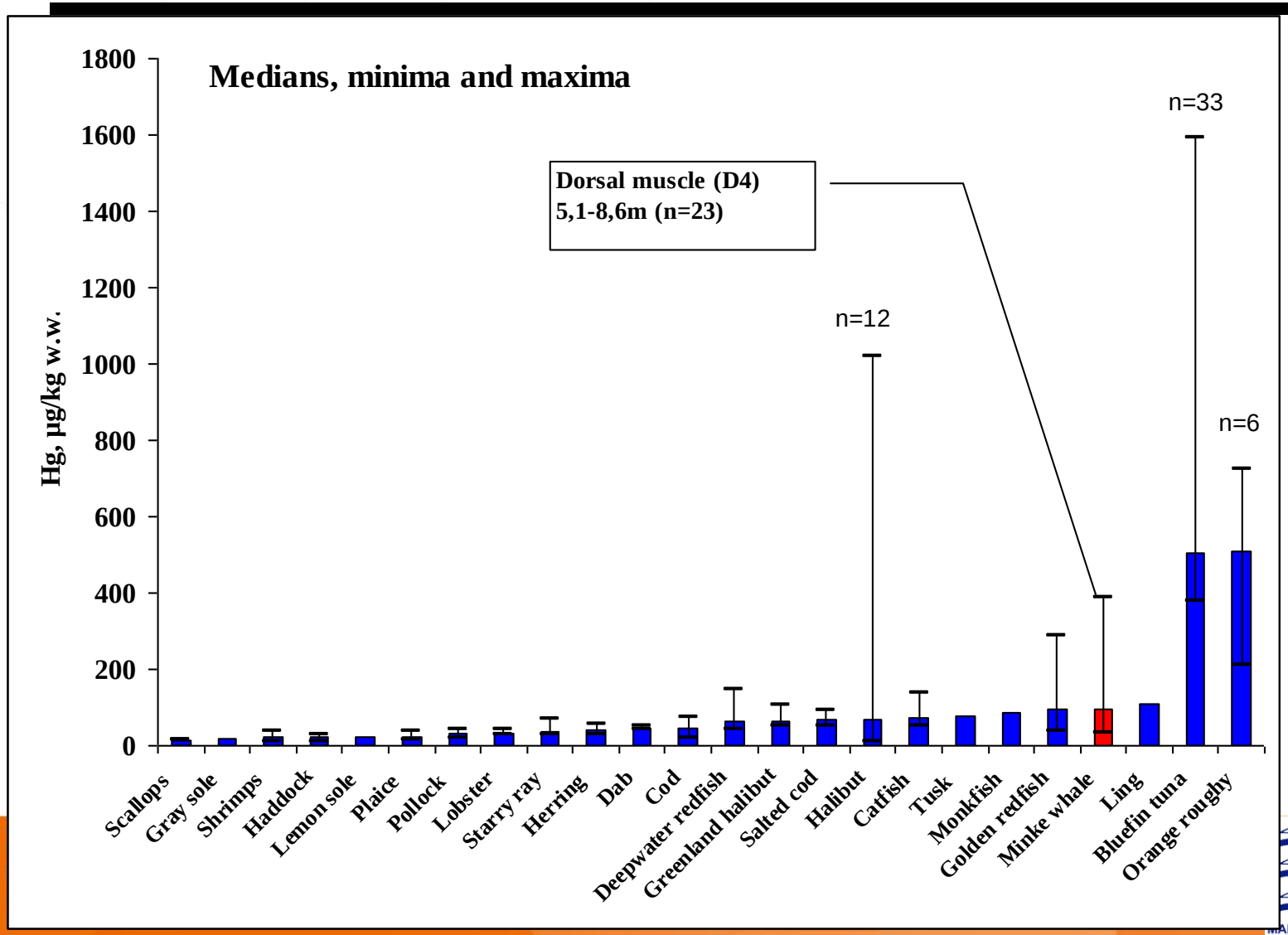
Born *et al.* 2003. J.Mar.Syst.

Biopsies: Hg in skin and muscle

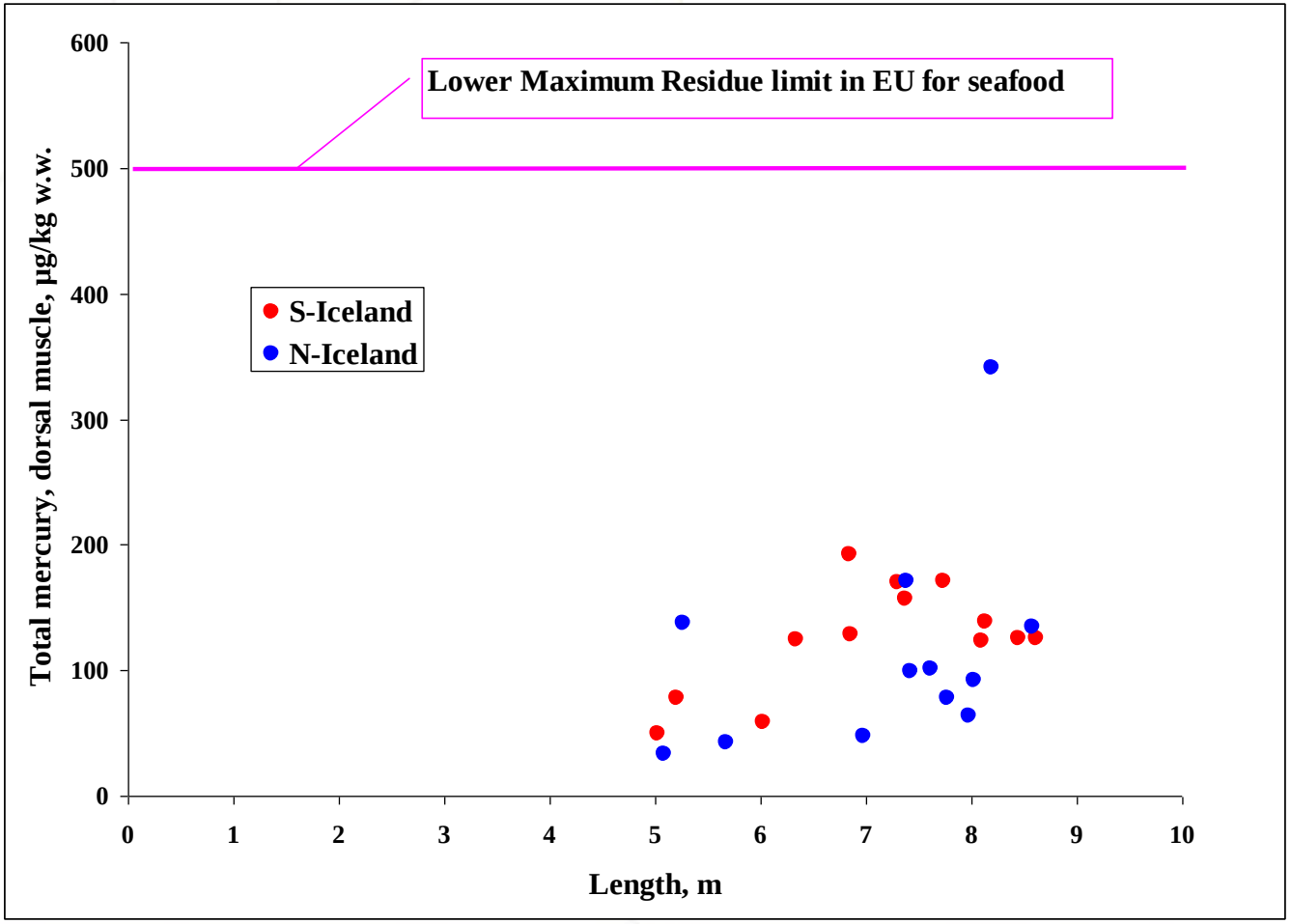


Of the trace elements, only Hg shows correlation between skin and muscle (Hg in skin also correlates with Hg in kidney and liver).

Mercury in Icelandic seafood



Maximum limits for Hg in seafood (Reg. 1881/2006/EC)



Dietary consumption of minke whale estimated by way of Hg 1

$$\frac{dB}{dt} = \alpha \times I \times C_d \times M - k \times B$$

B: body burden of Hg in the animal (mg)

α: assimilation ratio (≈0,95)

I: consumption (kg feed per kg animal and year)

C_d: Concentration of Hg in feed (mg/kg ww)

M: body mas of animal (kg)

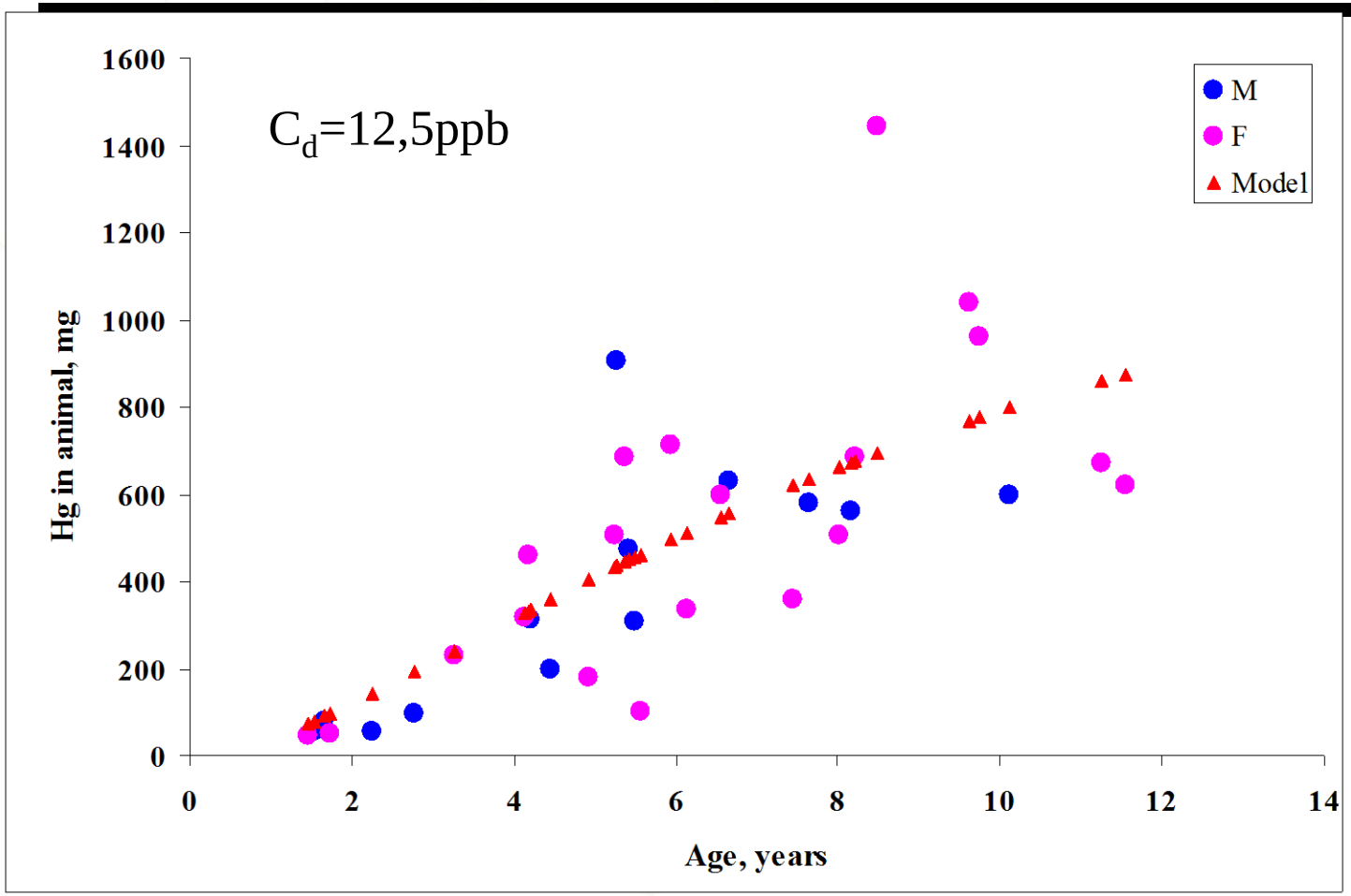
k: elimination rate (y^{-1})

Dietary consumption of minke whale estimated by way of Hg 2

I and k are estimated where the following information is used to solve the equation (in addition to levels of Hg in tissues and diet):

1. Relationship bewteen length and age.
2. Weight-length relationship (Folkow and Blix, 1992. Acta Physiol. Scand.)
3. Relative weight of tissues from fin whale studies in ‘86-’89.
4. Relative composition of diet and (stomach contents, organochlorines, fatty acids etc.)

Dietary consumption of minke whale estimated by way of Hg-example



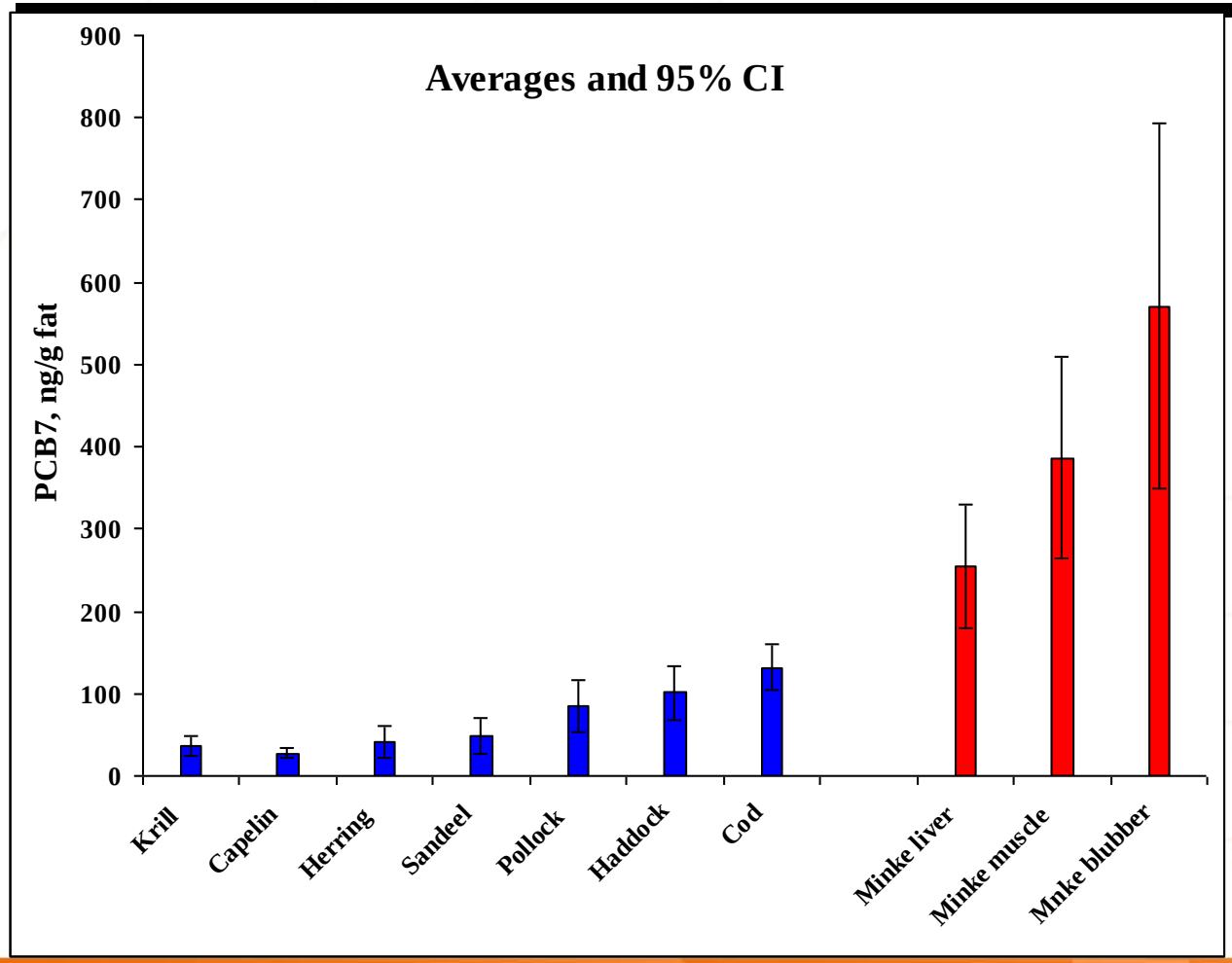
Results:

I=2,4 % d^{-1}

and

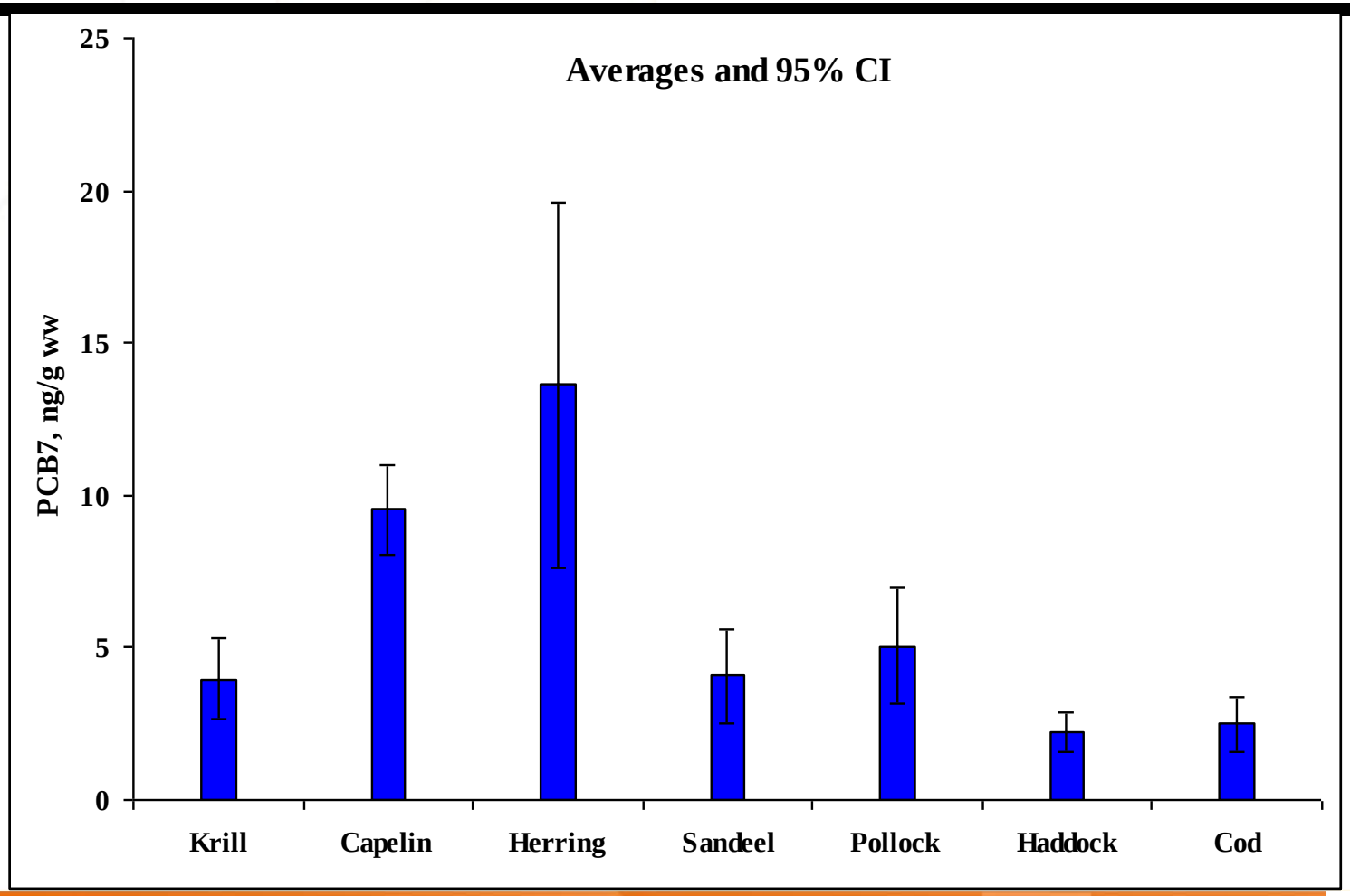
$t_{1/2}$=310 days

PCB7* in fat of minke whale tissues and diet

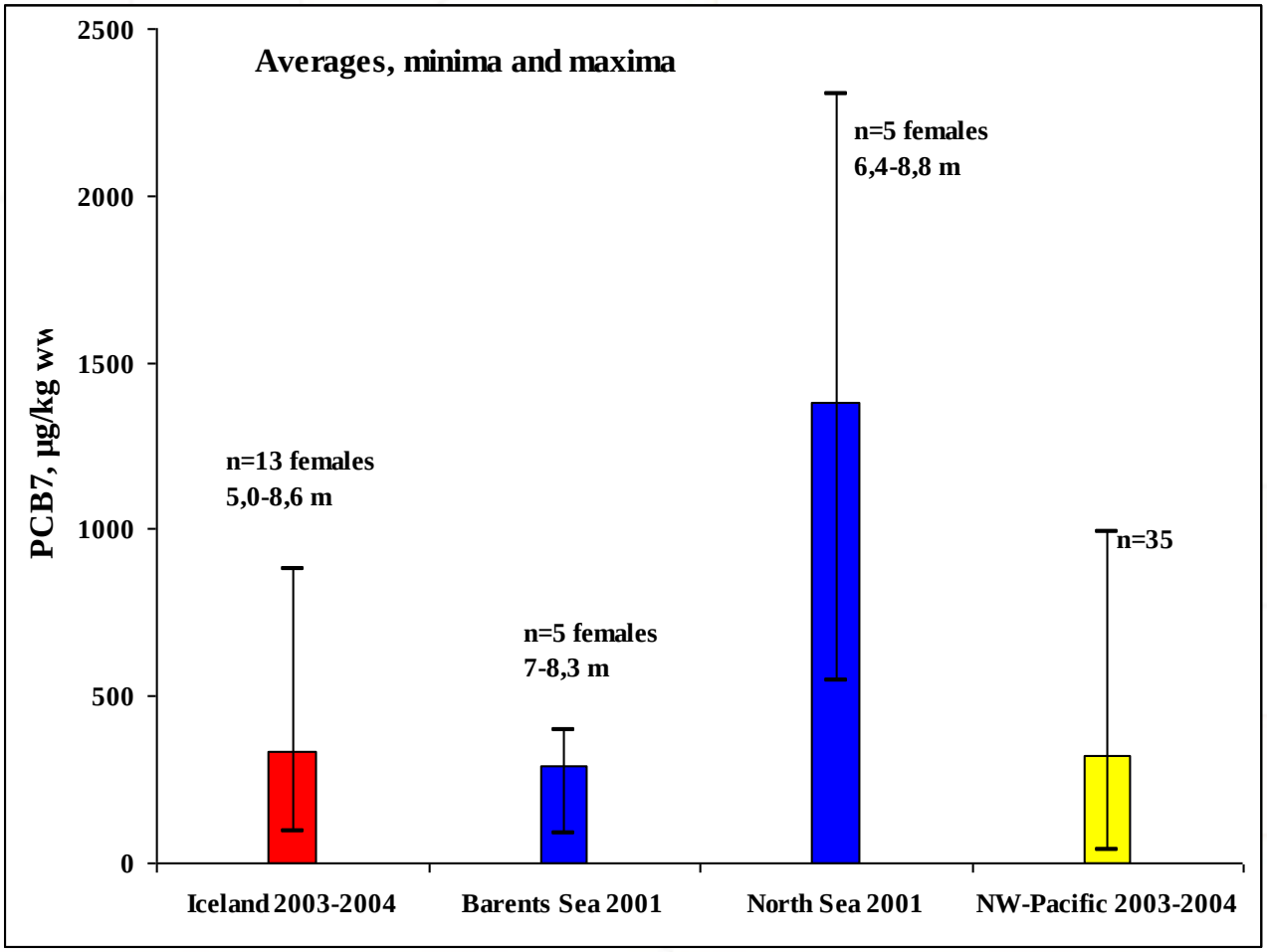


*PCB 28, 52, 101, 118, 138, 153, og 180

PCB7 in diet (wet weight)



PCB7 in dorsal blubber of minke whale



° Blue columns: Utne-Skåre, J., Berg, V., Kleivane, L., Julshamn, K., and Haldorsen, A.-K. Dioksin, dioksinlignende PCB og ikke-dioksinlignende PCB i spekk fra vågehval (*Balaenoptera acutorostrata*) fanget i Nordsjøen og Barentshavet under fangstsesongen 2001.

Yellow bar: Fujita *et al.* 2009. Validation of high-throughput measurement system with microwave-assisted extraction, fully automated sample preparation device, and gas chromatography-electron capture detectorfor determination of polychlorinated biphenyls in whale blubber. Chemosphere, 74: 1069-1078.

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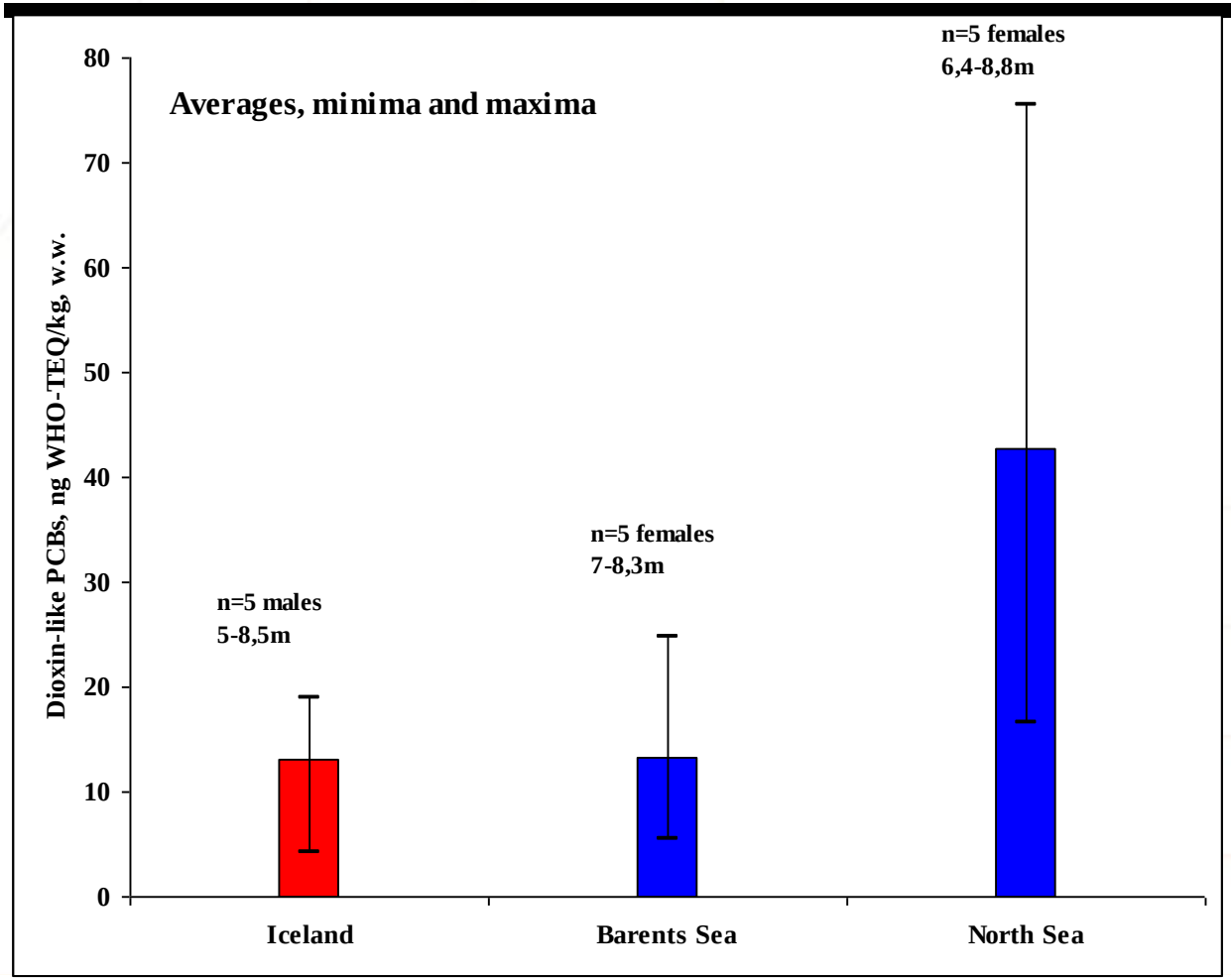
DL-PCBs in ventral grooves of minke whale



Norwegian data:
Utne-Skåre, J., Berg, V., Kleivane, L., Julshamn, K., and Haldorsen, A.-K. Dioksin, dioksinlignende PCB og ikke-dioksinlignende PCB i spekk fra vågehval (*Balaenoptera acutorostrata*) fanget i Nordsjøen og Barentshavet under fangstsesongen 2001.

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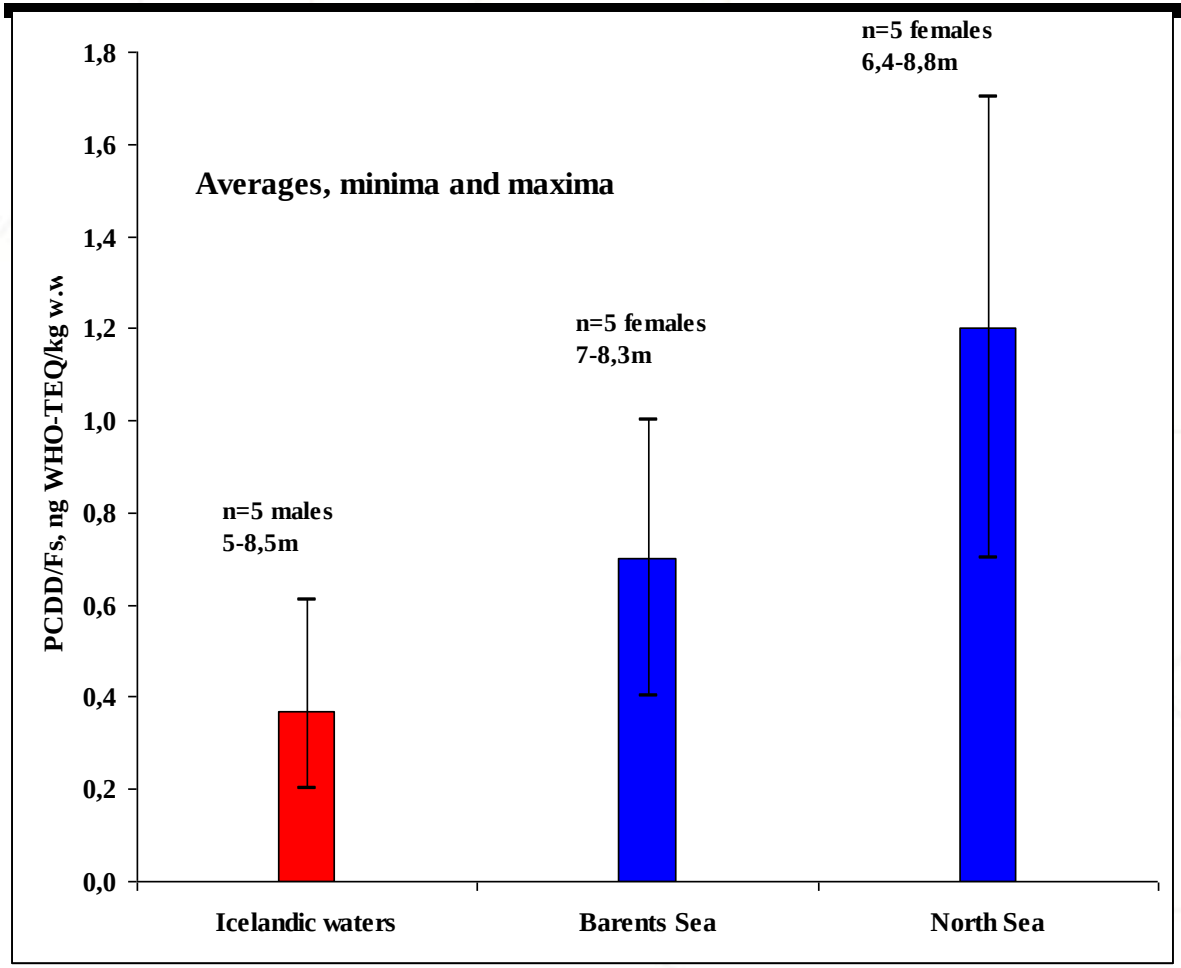
Dioxins in ventral grooves of minke whale



Norwegian data:
Utne-Skåre, J., Berg, V., Kleivane, L., Julshamn, K., and Haldorsen, A.-K. Dioksin, dioksinlignende PCB og ikke-dioksinlignende PCB i spekk fra vågehval (*Balaenoptera acutorostrata*) fanget in Nordsjøen og Barentshavet under fangstsesongen 2001.

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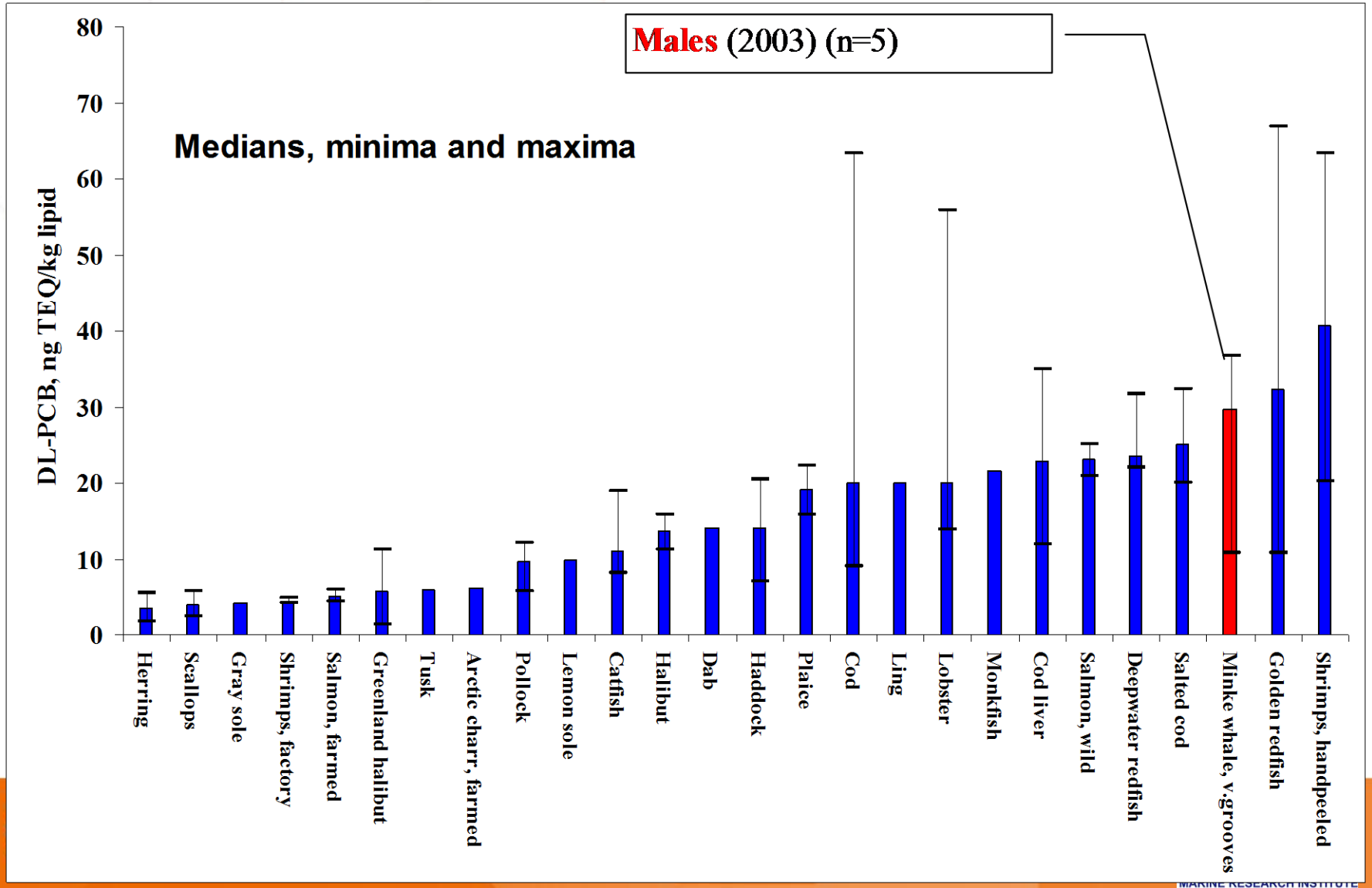
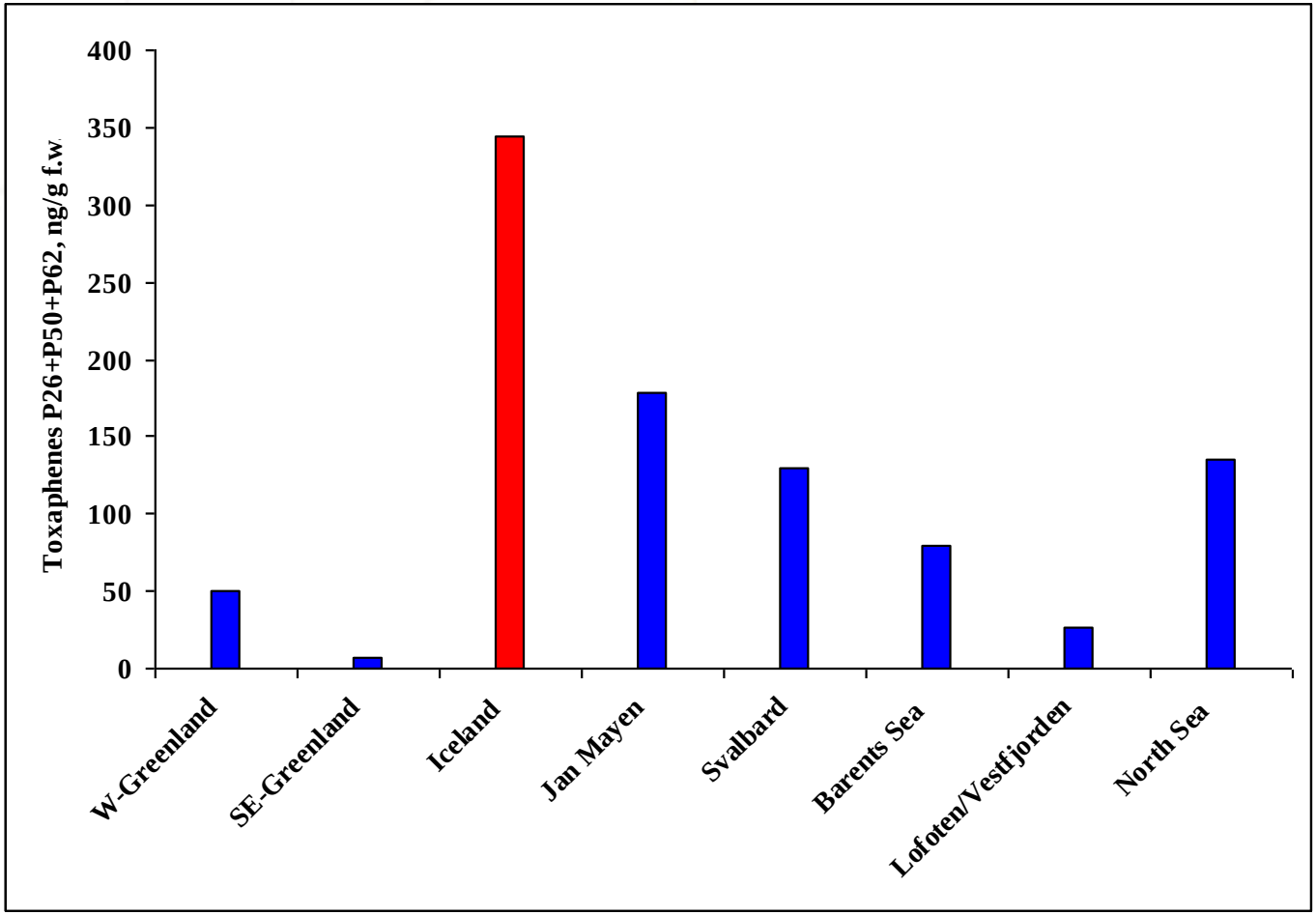
DL-PCBs in fat of ventral groove of minke whale and seafood from Icelandic waters ’03-’04

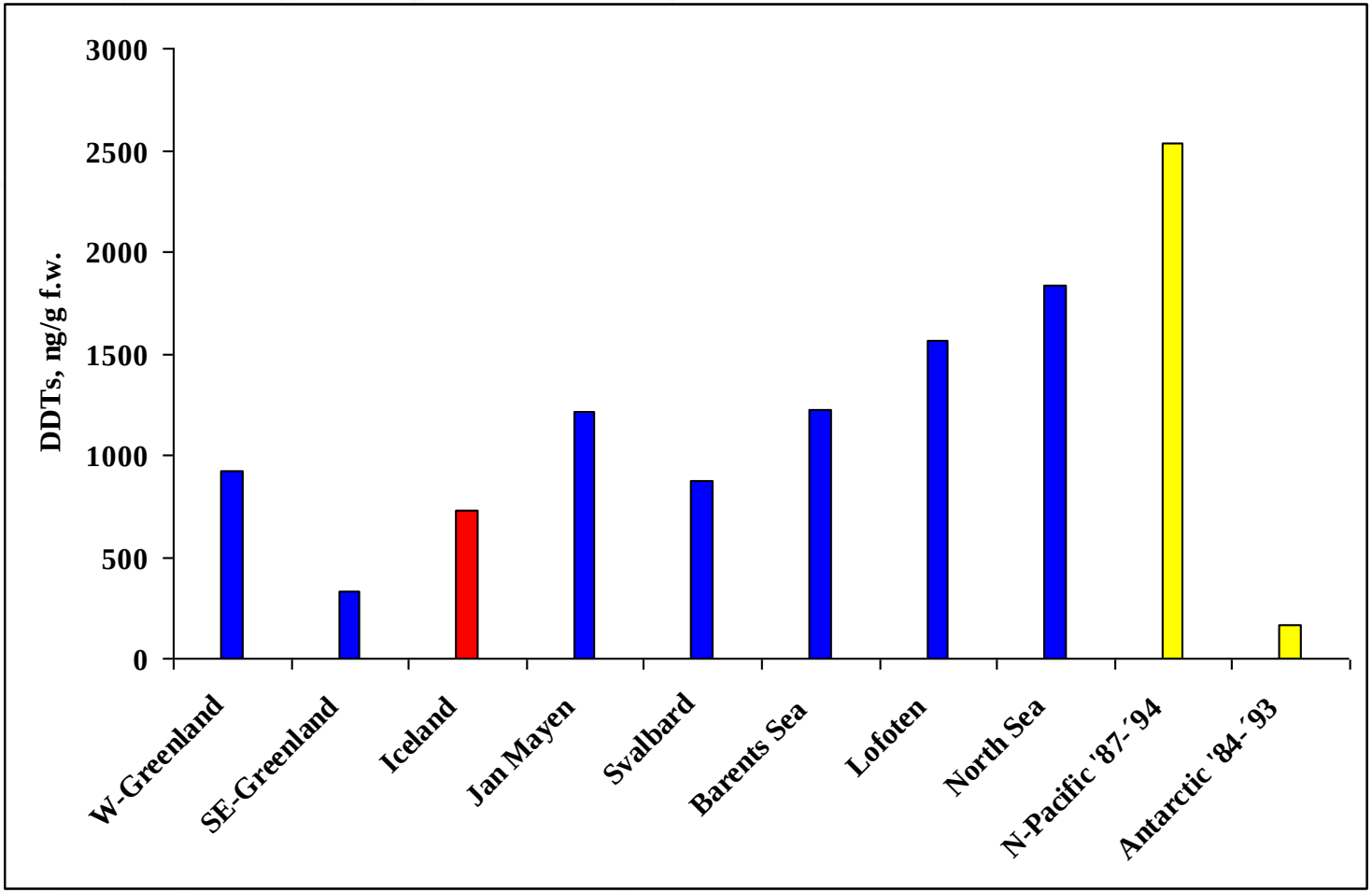


Toxaphenes in blubber (lipid weight)



Blue columns: Gouteux *et al.* 2008. Toxaphene in minke whale (*Balaenoptera acutorostrata*) from North Atlantic. Env.Poll., 153: 71-83.

DDTs* in blubber (lipid weight)

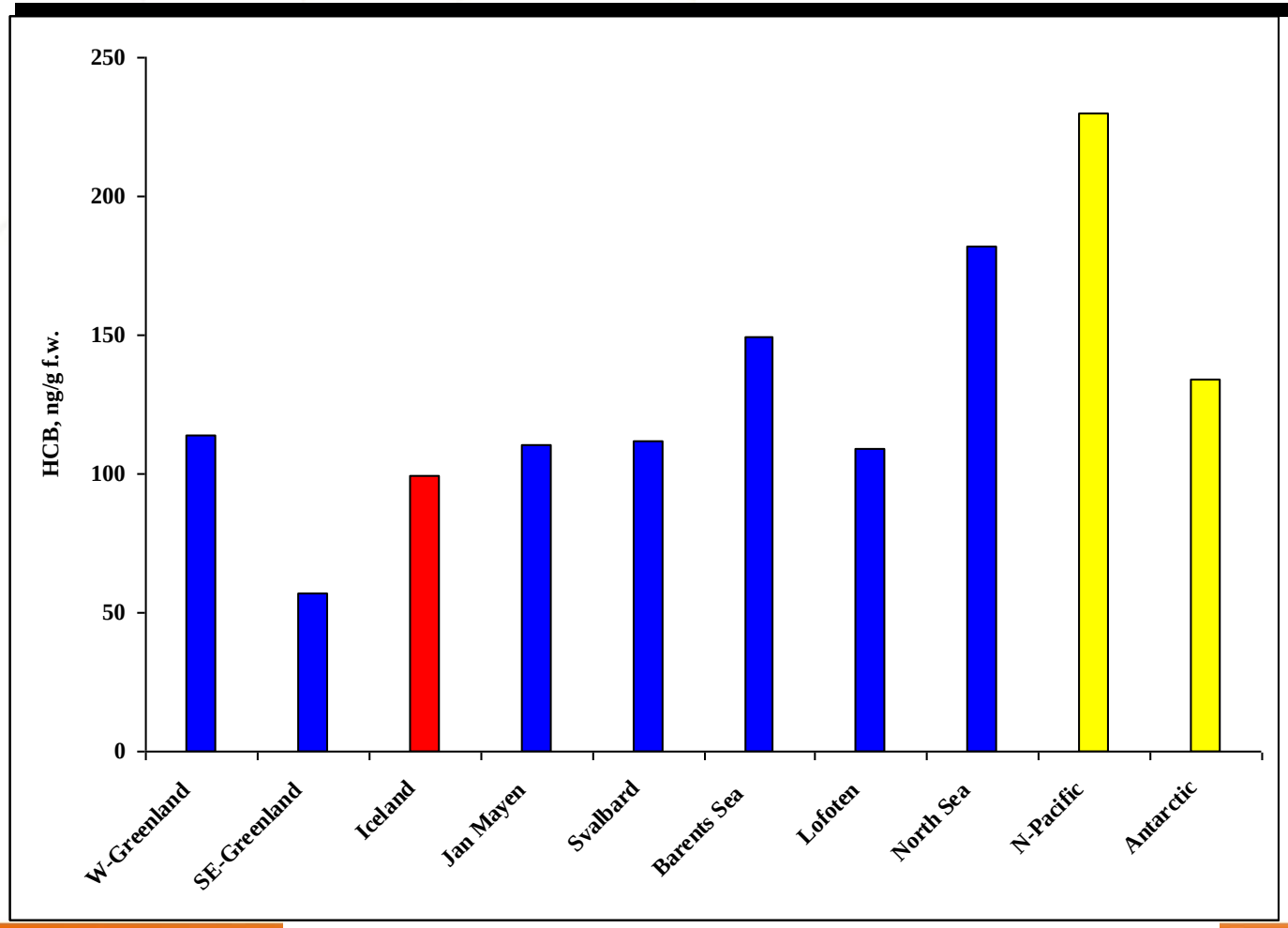


*DDT, DDE, DDD

Blue columns: Hobbs *et al.* 2003. Env.Poll., 121: 239-252.

Yellow columns: Aono *et al.* 1997. Env.Poll., 98: 81-89.

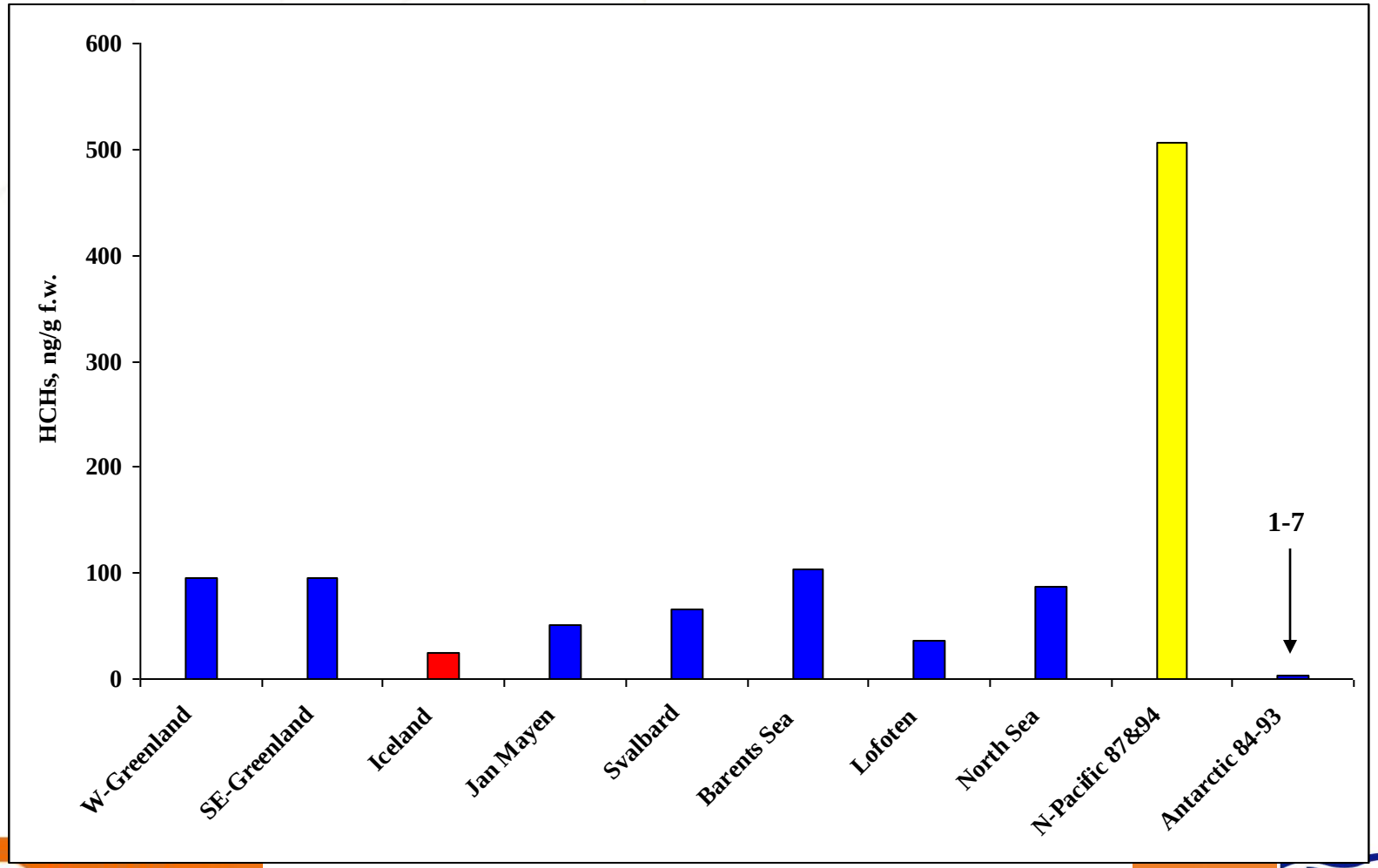
HCB in blubber (lipid weight)



Blue columns: Hobbs *et al.* 2003. Env.Poll., 121: 239-252.

Yellow columns: Aono *et al.* 1997. Env.Poll., 98: 81-89.

HCHs in blubber (lipid weight) (α, β & γ)



Blue columns: Hobbs *et al.* 2003. Env.Poll., 121: 239-252.

Yellow columns: Aono *et al.* 1997. Env.Poll., 98: 81-89.

Biopsies

In the case of blubber there is a fairly good correlation between organic contaminants in cross sectional cut and biopsy (1,5 cm deep) but all OCs except HCB are 18-25% higher in the biopsy than in the whole core.

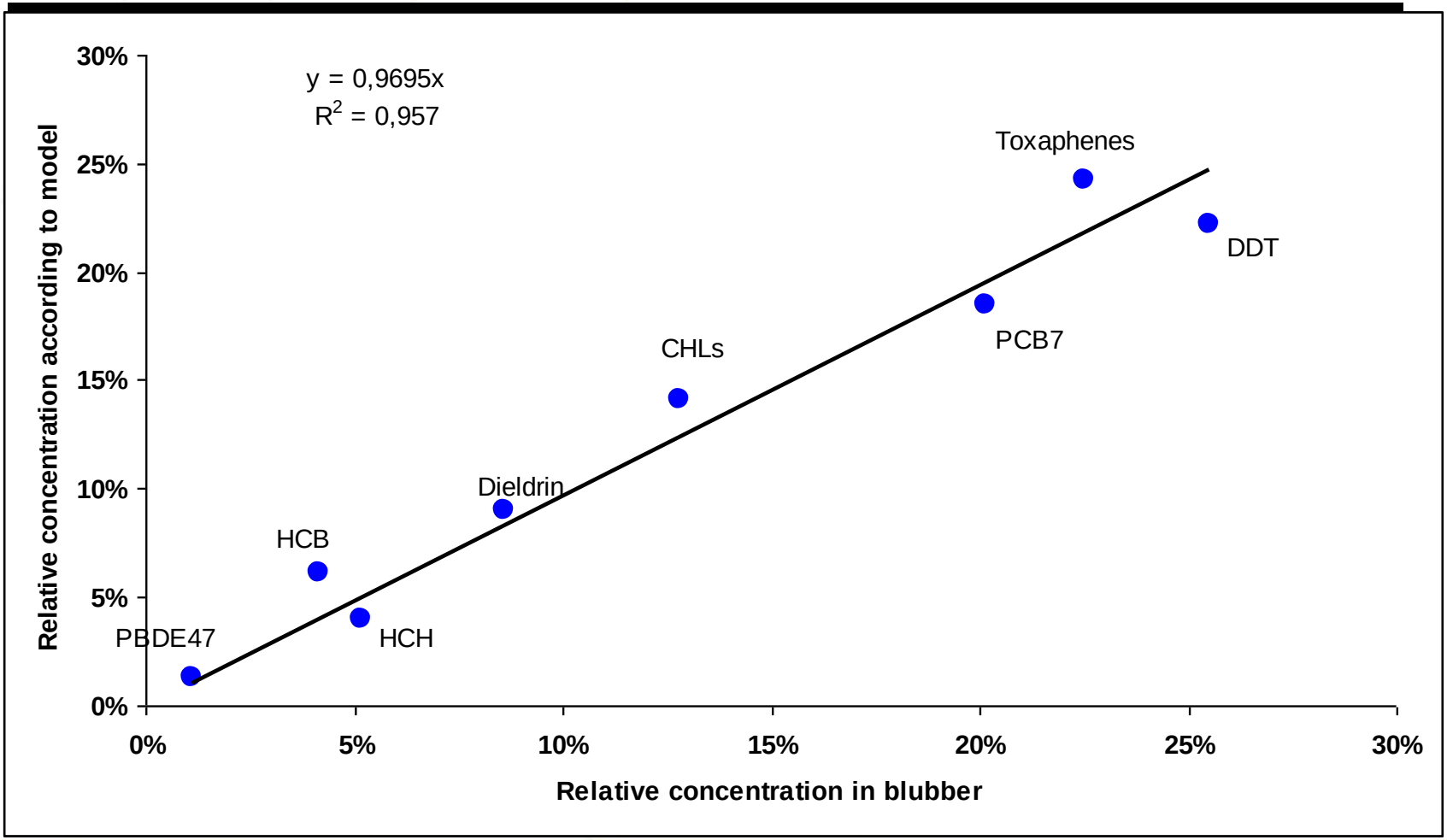
The level of HCB in both the biopsy and the whole core is the same.

Biopsies are therefore, strictly speaking, only applicable to HCB but biopsies give a good idea of the levels of other OCs in the whole blubber core.

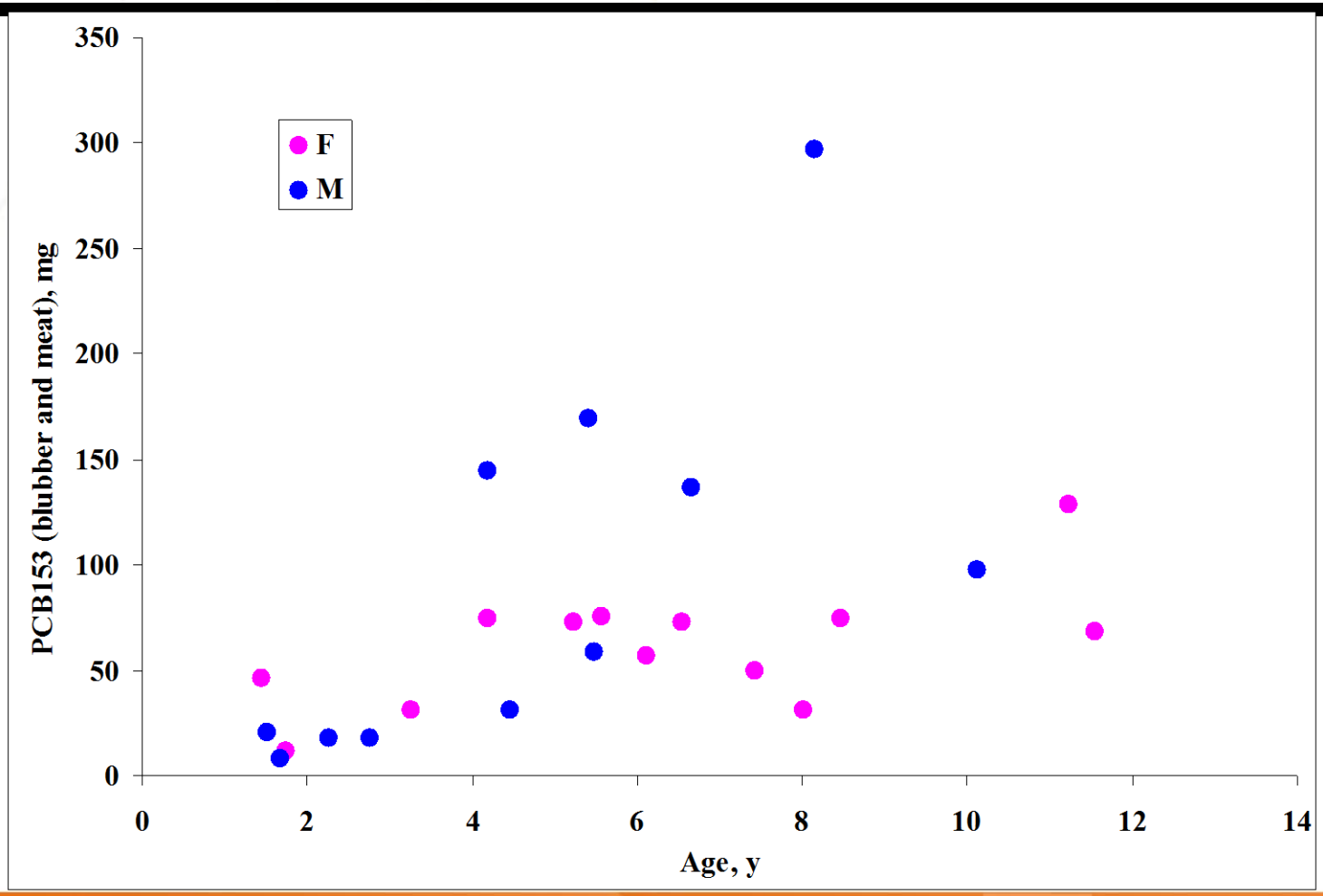
OCs in biopsies do not predict levels in liver and muscle.

Food consumption estimates by way of organic contaminants

Example: 70 % krill and 30 % sandeel ("Kullback-Leibler divergence")



Food consumption estimates by way of organic contaminants



Acknowledgement

The research on organic contaminants was funded by the Fisheries Project Fund in Iceland.