NISTIR 4731

Alaska Marine Mammal Tissue Archival Project:

Sample Inventory and Results of Analyses of Selected Samples for Organic Compounds and Trace Elements

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Disclaimer

Certain commercial equipment, instruments, or materials are identified in this Report to specify adequately the experimental procedure. Such identification does not imply recommendation or endorsement by the National Institute of Standards and Technology, nor does it imply that the materials or equipment identified are necessarily the best available for the purpose.

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INTRODUCTION

Through funding from the Minerals Management Service (MMS) Environmental Studies Program, the *Alaska Marine Mammal Tissue Archival Project (AMMTAP)* was established in 1987 to archive a representative collection of Alaska marine mammal tissues for future chemical analyses and documentation of long-term trends in environmental quality. The resulting sample collection provides a source of material that, when analyzed for various toxicants or associated metabolites, can help evaluate impacts associated with oil and gas development, mining activities, and any future oil spills occurring in Alaska's coastal waters.

The *AMMTAP* is being conducted by the Arctic Environmental Assessment Center (AEAC) of the Office of Ocean Resources Conservation and Assessment (ORCA), National Oceanic and Atmospheric Administration (NOAA), and the Chemical Science and Technology Laboratory at the National Institute of Standards and Technology (NIST). The *Project* emphasizes the use of standardized and rigorous sampling and archival protocols, the latter which includes establishing the best conditions for maintaining sample integrity during storage for relatively long periods of time [1-2].

Collections of tissues are limited to freshly killed animals taken by researchers or taken in subsistence hunts. No dead and stranded animals nor old specimens archived from past programs are accepted by the *AMMTAP*. Samples are cataloged and archived at the *Alaska Marine Mammal Tissue Archive*, which is maintained by NIST in the *National Biomonitoring Specimen Bank (NBSB)*, Gaithersburg, Maryland. Sample storage is under liquid nitrogen vapor at -150 °C.

The principal tissues collected by the *AMMTAP* are liver, blubber, and kidney. Samples of other tissues and organs are sometimes collected for other purposes at special requests from outside investigators. In addition, ancillary samples that can aid in interpreting the results of chemical analyses of the principal tissues are collected routinely from the animals (Table 1).

As part of the *AMMTAP*, NIST analyzes 10-15 % of the specimens collected to determine the concentrations of selected organic and inorganic constituents. These analyses provide baseline data for: (1) evaluating the stability of the specimens during long-term storage, (2) providing some real-time measure of contaminant concentrations for monitoring purposes, (3) comparing with results from samples collected in the future to monitor long-term trends in pollution, and (4) comparing with data obtained by other laboratories on subsamples from the *AMMTAP* (or similar samples collected at the same time from the same sites),

Table 1. Samples collected routinely by the *AMMTAP*.

LN_2-Frozen Samples (shipped to the NBSB):
Blubber
Liver
Kidney
*Muscle
Ancillary Samples:
Liver, histological
Kidney, histological
Teeth and claws for age determination
Bile (LN_2-frozen) for PAH metabolite screening
Stomach contents for food identification

**No longer collected*

i.e., quality assurance. Additional samples may be analyzed by other laboratories as part of collaborative efforts with the *AMMTAP*.

The purpose of this report is to describe the current inventory of samples maintained by the *AMMTAP*, to present the data resulting from routine chemical analyses by NIST, and to describe the methods used in these analyses.

SAMPLE INVENTORY

The geographic locations of the species sampled by the *AMMTAP* are presented in Figure 1. Listings of the tissue samples archived for each of the geographic locations are presented in Tables 2-4. It is apparent that the *Project* has emphasized marine mammals from the Arctic. Since the interest of the sponsor is to obtain materials from areas of principal oil and gas industry interest, this emphasis on the Arctic will probably continue, at least in the near future.

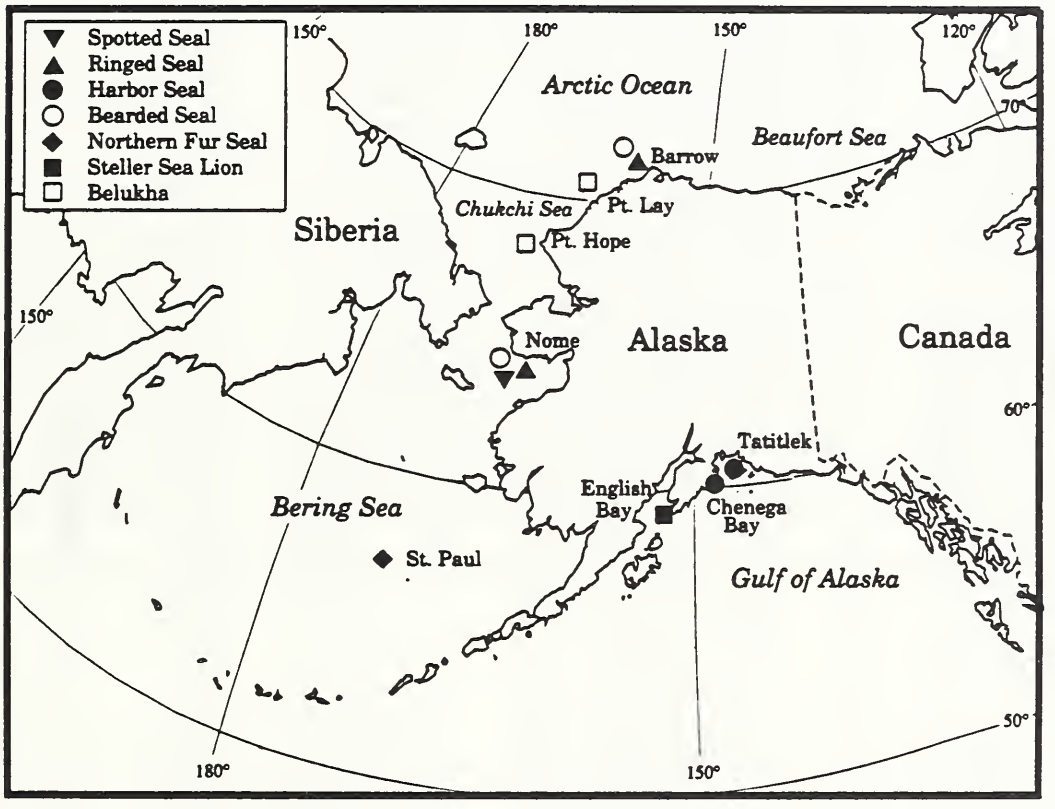

Figure 1. Geographic locations of sample collections.

Table 2. Marine mammals sampled in the Arctic Ocean. (x - samples archived. ▒ - subsample B homogenized and divided into aliquots for analyses)

Species	Sex	Individual ID	Location	Date	Tissue L	K	B	M
Ringed seal	M	692-RGSL-001	Barrow	7/88	x	x	x	
Ringed seal	F	692-RGSL-002	Barrow	7/88	x	x	x	
Ringed seal	M	692-RGSL-003	Barrow	7/88	x	x	x	
Ringed seal	M	692-RGSL-004	Barrow	7/88	▒	▒	▒	
Ringed seal	F	692-RGSL-005	Barrow	7/88	x	x	x	
Ringed seal	F	692-RGSL-006	Barrow	7/88	x	x	x	
Ringed seal	M	692-RGSL-007	Barrow	7/88	x	x	x	
Ringed seal	M	692-RGSL-008	Barrow	7/88	▒	▒	▒	
Ringed seal	M	692-RGSL-009	Barrow	7/88	x	x	x	
Ringed seal	F	692-RGSL-010	Barrow	7/88	x	x	x	
Ringed seal	M	692-RGSL-019	Barrow	7/91	x	x	x	
Ringed seal	M	692-RGSL-020	Barrow	7/91	x	x	x	
Ringed seal	M	692-RGSL-021	Barrow	7/91	x	x	x	
Ringed seal	M	692-RGSL-022	Barrow	7/91	x	x	x	
Ringed seal	F	692-RGSL-023	Barrow	7/91	x	x	x	
Ringed seal	M	692-RGSL-024	Barrow	7/91	x	x	x	
Ringed seal	F	692-RGSL-025	Barrow	7/91	x	x	x	
Ringed seal	M	692-RGSL-026	Barrow	7/91	x	x	x	
Ringed seal	M	692-RGSL-027	Barrow	7/91	x	x	x	
Ringed seal	F	692-RGSL-028	Barrow	7/91	x	x	x	
Bearded seal	M	692-BDSL-002	Barrow	7/89	x	x	x	
Bearded seal	M	692-BDSL-003	Barrow	7/89	x		x	
Belukha whale	F	692-BLKA-001	Pt. Hope	5/89	▒	x	▒	
Belukha whale	F	692-BLKA-002	Pt. Hope	5/89	▒	x	▒	
Belukha whale	F	692-BLKA-003	Pt. Hope	5/89	▒	x		
Belukha whale	M	692-BLKA-004	Pt. Hope	5/89	▒			
Belukha whale	F	692-BLKA-005	Pt. Lay	7/90	x	x	▒	
Belukha whale	M	692-BLKA-006	Pt. Lay	7/90	x	x	▒	
Belukha whale	F	692-BLKA-007	Pt. Lay	7/90	▒	x	▒	
Belukha whale	M	692-BLKA-008	Pt. Lay	7/90	x	x	▒	
Belukha whale	M	692-BLKA-009	Pt. Lay	7/90	x	x	▒	
Belukha whale	M	692-BLKA-010	Pt. Lay	7/90	x	x	▒	
Belukha whale	M	692-BLKA-011	Pt. Lay	7/90	x	x	▒	
Belukha whale	F	692-BLKA-012	Pt. Lay	7/90	▒	x	▒	
Belukha whale	M	692-BLKA-013	Pt. Lay	7/90	x	x	▒	
Belukha whale	F	692-BLKA-014	Pt. Lay	7/90	x	x	▒	

Table 3. Marine mammals sampled in the Bering Sea. (x - samples archived. ▒ - subsample B homogenized and divided into aliquots for analyses)

Species	Sex	Individual ID	Location	Date	Tissue L	K	B	M
Ringed seal	M	692-RGSL-011	Nome	5/89	▒	x	▒	
Ringed seal	F	692-RGSL-012	Nome	5/89	x	x	x	
Ringed seal	M	692-RGSL-013	Nome	5/89	▒	x	▒	
Ringed seal	M	692-RGSL-014	Nome	5/89	x	x	x	
Ringed seal	F	692-RGSL-015	Nome	5/89	x	x	x	
Ringed seal	M	692-RGSL-016	Nome	5/91	x	x	x	
Ringed seal	F	692-RGSL-017	Nome	5/91	x	x	x	
Ringed seal	F	692-RGSL-018	Nome	5/91	x	x	x	
Spotted seal	F	692-SPSL-001	Nome	5/91	x	x	x	
Bearded seal	M	692-BDSL-001	Nome	5/89	x	x	x	
N. fur seal	M	692-FRSL-001	St. Paul	7/87	x	x	x	x
N. fur seal	M	692-FRSL-002	St. Paul	7/87	x	x	x	x
N. fur seal	M	692-FRSL-003	St. Paul	7/87	x	x	x	x
N. fur seal	M	692-FRSL-004	St. Paul	7/87	▒	▒	▒	▒
N. fur seal	M	692-FRSL-005	St. Paul	7/87	▒	▒	▒	▒
N. fur seal	M	692-FRSL-006	St. Paul	7/90	x	x	x	
N. fur seal	M	692-FRSL-007	St. Paul	7/90	▒	x	x	
N. fur seal	M	692-FRSL-008	St. Paul	7/90	x	x	x	
N. fur seal	M	692-FRSL-009	St. Paul	7/90	x	x	x	
N. fur seal	M	692-FRSL-010	St. Paul	7/90	▒	x	x	
N. fur seal	M	692-FRSL-011	St. Paul	7/90	▒	x	x	
N. fur seal	M	692-FRSL-012	St. Paul	7/90	x	x	x	
N. fur seal	M	692-FRSL-013	St. Paul	7/90	x	x	x	
N. fur seal	M	692-FRSL-014	St. Paul	7/90	x	x	x	
N. fur seal	M	692-FRSL-015	St. Paul	7/90	x	x	x	

Table 4. Marine mammals sampled in the Gulf of Alaska. (x - samples archived. ▒ - subsample B homogenized and divided into aliquots for analyses)

Species	Sex	Individual ID	Location	Date	Tissue L	K	B	M
Harbor seal	M	692-HBSL-001	Prince William S.	3/90	x	x	x	
Harbor seal	F	692-HBSL-002	Prince William S.	4/90	x	x	x	
Harbor seal	M	692-HBSL-003	Prince William S.	4/90	x	x	x	
S. sea lion	F	692-STSL-001	Cook Inlet	3/90	x	x	x	

A detailed inventory of samples contained in the *Alaska Marine Mammal Tissue Archive* is presented on pages 7-31. This inventory lists the *AMMTAP* samples by species, presents meristic information on the animals sampled, lists additional samples taken by other researchers, where these additional samples are presently located, as well as other miscellaneous information regarding the individual samples or the animal sampled. Also those specimens for which one section has been homogenized and divided into aliquots for analysis are identified. The format used to present this data is explained in Table 5. A list of acronyms used in the inventory is presented in Table 6.

Table 5. *AMMTAP* sample inventory format.

INDIVIDUAL ID NO.	Geographic Area, Village			Lat.-Long. Date
age/sex		weight (W)		
standard length (SL)		fluke width (FW)		
blubber thickness (BT)		axillary girth (AG)		
NBSB Samples tissue type	NBSB ID number	subsample A weight / in grams	subsample B weight *in grams	Histo-Section yes or no
Additional Samples Collected for Other Researchers				
Organization, individual and *ID number*, if appropriate				
Present location of samples				
List of samples				

Table 6. Acronyms used in the *AMMTAP* sample inventory.

ADF&G - Alaska Department of Fish and Game
AEAC - Arctic Environmental Assessment Center (NOAA)
NBSB - National Biomonitoring Specimen Bank
NCRC - National Cancer Research Center
NMFS - National Marine Fisheries Service
NSB DWM - North Slope Borough Department of Wildlife Management
NWFC - Northwest Fisheries Center

**Those samples that have been homogenized and divided into aliquots for analyses are indicated by an asterisk (*).*

RINGED SEAL (*PHOCA HISPIDA*)

692-RGSL-001 Chukchi Sea, Barrow 71°19′ 156°50′
11July88

1-yr male W = 19.5 kg
SL = 99.0 cm AG = 60 cm BT = 3.5 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM2L021	187.5 / 163.5	Yes
Kidney	MM2K022	64.6 / 69.0	Yes
Blubber	MM2B023	121.0 / 137.0	
Tooth			
Stomach Contents (present location, AEAC, Anchorage)			

Additional Samples Collected for Other Researchers

NWFC NMFS; present location, NWFC NMFS, Seattle, WA:

Bile	1-10 mL	Liver	10 g
Blood	5-15 mL	Muscle	10 g

692-RGSL-002 Chukchi Sea, Barrow 71°19′ 156°50′
11July88

<1-yr female W = 12.7 kg
SL = 75.0 cm AG = 48 cm BT = 2.5 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM2L024	120.5 / 129.5	Yes
Kidney	MM2K025	45.0 / 42.0	Yes
Blubber	MM2B026	70.0 / 78.0	
Tooth			
Stomach Contents (present location, AEAC, Anchorage)			

Additional Samples Collected for Other Researchers

NWFC NMFS; present location, NWFC NMFS, Seattle, WA:

Bile	1-10 mL	Liver	10 g
Blood	5-15 mL	Muscle	10 g

692-RGSL-003 Chukchi Sea, Barrow 71°19′ 156°50′
11July88

2-yr male W = 35.4 kg
SL = 118.0 cm AG = 70 cm BT = 2.5 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM2L027	155.0 / 150.0	Yes
Kidney	MM2K028	110.0 / 110.5	Yes
Blubber	MM2B029	98.0 / 113.0	
Tooth			
Stomach Contents (present location, AEAC, Anchorage)			

Additional Samples Collected for Other Researchers

NWFC NMFS; present location, NWFC NMFS, Seattle, WA:

Bile	1-10 mL	Liver	10 g	Muscle	10 g

692-RGSL-004 Chukchi Sea, Barrow 71°19′ 156°50′
11July88

2-yr male W = 32.2 kg
SL = 108.0 cm AG = 84 cm BT = 2.0 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM2L030	154.0 /*187.0	Yes
Kidney	MM2K031	106.0 /*113.0	Yes
Blubber	MM2B032	98.3 / *98.9	
Tooth			
Stomach Contents (present location, AEAC, Anchorage)			

Additional Samples Collected for Other Researchers

NWFC NMFS; present location, NWFC NMFS, Seattle, WA:

Bile	1-10 mL	Muscle	10 g
Liver	10 g		

692-RGSL-005 Chukchi Sea, Barrow 71°19′ 156°50′
11July88

1-yr female W = 15.4 kg
SL = 84.5 cm AG = 63 cm BT = 2.7 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM2L033	127.0 / 130.6	Yes
Kidney	MM2K034	48.0 / 49.0	Yes
Blubber	MM2B035	141.4 / 150.2	
Tooth			
Stomach Contents (present location, AEAC, Anchorage)			

Additional Samples Collected for Other Researchers

NWFC NMFS; present location, NWFC NMFS, Seattle, WA:

Bile	1-10 mL	Muscle	10 g
Liver	10 g		

692-RGSL-006 Chukchi Sea, Barrow 71°19′ 156°50′
12July88

<1-yr female W = 15.4 kg
SL = 88.0 cm AG = 58 cm BT = 2.8 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM2L036	129.3 / 128.8	Yes
Kidney	MM2K037	54.5 / 58.0	Yes
Blubber	MM2B038	102.6 / 118.6	
Tooth			
Stomach Contents (present location, AEAC, Anchorage)			

Additional Samples Collected for Other Researchers

NWFC NMFS; present location, NWFC NMFS, Seattle, WA:

Bile	1-10 mL	Liver	10 g
Blood	5-15 mL	Muscle	10 g

692-RGSL-007 Chukchi Sea, Barrow 71°23′ 156°32′
12July88

2-yr male W = 23.1 kg
SL = 94.0 cm AG = 75 cm BT = 2.9 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM2L039	165.6 / 162.5	Yes
Kidney	MM2K040	86.6 / 84.8	Yes
Blubber	MM2B041	138.5 / 133.6	
Tooth			
Stomach Contents (present location, AEAC, Anchorage)			

Additional Samples Collected for Other Researchers
NWFC NMFS; present location, NWFC NMFS, Seattle, WA:

Bile	1-10 mL	Liver	10 g
Blood	5-15 mL	Muscle	10 g

692-RGSL-008 Chukchi Sea, Barrow 71°23′ 156°32′
13July88

2-yr male W = 23.1 kg
SL = 104.0 cm AG = 63.5 BT = 2.8 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM2L042	154.2 /*168.6	Yes
Kidney	MM2K043	89.5 / *95.5	Yes
Blubber	MM2B044	129.2 /*131.0	
Tooth			
Stomach Contents (present location, AEAC, Anchorage)			

Additional Samples Collected for Other Researchers
NWFC NMFS; present location, NWFC NMFS, Seattle, WA:

Bile	1-10 mL	Liver	10 g
Blood	5-15 mL	Muscle	10 g

692-RGSL-009 Chukchi Sea, Barrow 71°22′ 156°37′
14July88

<1-yr male W = 15.0 kg
SL = 75.0 cm AG = 63 cm BT = 2.4 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM2L045	128.1 / 130.8	Yes
Kidney	MM2K046	46.6 / 47.6	Yes
Blubber	MM2B047	86.9 / 94.1	
Tooth			
Stomach Contents (present location, AEAC, Anchorage)			

Additional Samples Collected for Other Researchers
NWFC NMFS; present location, NWFC NMFS, Seattle, WA:

Bile	1-10 mL	Liver	10 g
Blood	5-15 mL	Muscle	10 g

692-RGSL-010 Chukchi Sea, Barrow 71°22′ 156°37′
14July88

2-yr female W = 25.4 kg
SL = 98.0 cm AG = 83.5 BT = 3.0 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM2L048	168.5 / 146.7	Yes
Kidney	MM2K049	78.4 / 76.4	Yes
Blubber	MM2B050	146.7 / 161.0	
Tooth			

Additional Samples Collected for Other Researchers
NWFC NMFS; present location, NWFC NMFS, Seattle, WA:
Bile 1-10 mL Liver 10 g Blood 5-15 mL

692-RGSL-011 Norton Sound, Nome 64°19′ 165°15′
26May89

1-yr male W = 33.6 kg
SL = 119.5 cm AG = 82.5 cm BT = 4.0 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM3L054	142.2 /*147.0	Yes
Kidney	MM3K055	115.1 / 104.5	Yes
Blubber	MM3B056	128.0 /*145.0	
Tooth	(present location, ADF&G, Nome, AK)		
Stomach Contents	(present location, ADF&G, Nome, AK)		

Additional Samples Collected for Other Researchers
ADF&G; present location, ADF&G, Nome AK:
Front claws Reproductive organs

NWFC NMFS; present location, NWFC, NMFS, Seattle, WA:
Bile 1-10 mL Blood 5-15 mL

692-RGSL-012 Norton Sound, Nome 64°19′ 165°00′
26May89

2-yr female W = 36.3 kg
SL = 124.5 cm AG = 100.0 cm BT = 3.5 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM3L057	160.0 / 141.4	Yes
Kidney	MM3K058	104.8 / 104.4	Yes
Blubber	MM3B059	147.0 / 148.0	
Tooth	(present location, ADF&G, Nome, AK)		
Stomach Contents	(present location, ADF&G, Nome, AK)		

Additional Samples Collected for Other Researchers
ADF&G; present location, ADF&G, Nome, AK:
Front claws Reproductive organs

NWFC NMFS; present location, NWFC, NMFS, Seattle, WA:
Bile 1-10 mL Blood 5-15 mL

692-RGSL-013 Norton Sound, Nome 64°18′ 165°00′
31May89

1-yr male W = 31.75 kg
SL = 103.5 cm AG = 79 cm BT = 4.5 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM3L060	95.2 /*110.2	Yes
Kidney	MM3K061	93.2 / 101.3	Yes
Blubber	MM3B062	149.2 /*167.2	
Tooth	(present location, ADF&G, Nome, AK)		
Stomach Contents	(present location, ADF&G, Nome, AK)		

Additional Samples Collected for Other Researchers

ADF&G; present location, ADF&G, Nome, AK:
Front claws Reproductive organs

NWFC NMFS; present location, NWFC, NMFS, Seattle, WA:
Bile 1-10 mL Blood 5-15 mL

692-RGSL-014 Norton Sound, Nome 64°19′ 164°44′
31May89

1-yr male W = 29.5 kg
SL = 101.0 cm AG = 74 cm BT = 3.0 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM3L063	50.9 / 50.6	Yes
Kidney	MM3K064	67.5 / 62.6	Yes
Blubber	MM3B065	108.4 / 123.8	
Tooth	(present location, ADF&G, Nome, AK)		
Stomach Contents	(present location, ADF&G, Nome, AK)		

Additional Samples Collected for Other Researchers

ADF&G; present location, ADF&G, Nome, AK:
Front claws Reproductive organs

NWFC NMFS; present location, NWFC, NMFS, Seattle, WA:
Blood 5-15 mL

692-RGSL-015 Norton Sound, Nome 64°18′ 165°00′
31May89

<1-yr female W = 20.0 kg
SL = 83.2 cm AG = 66 cm BT = 3.25 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM3L066	123.8 / 114.9	Yes
Kidney	MM3K067	68.5 / 68.2	Yes
Blubber	MM3B068	110.1 / 103.0	
Tooth	(present location, ADF&G, Nome, AK)		
Stomach Contents	(present location, ADF&G, Nome, AK)		

Additional Samples Collected for Other Researchers

ADF&G; present location, ADF&G, Nome, AK:
Front claws Reproductive organs

NWFC, NMFS; present location, NWFC, Seattle, WA:
Bile 1-10 mL Blood 5-15 mL

692-RGSL-016 Norton Sound, Nome 64°30′ 166°10′
21May91

<1-yr male W = 13.6 kg
SL = 81.5 cm AG = 67 cm BT = 4.0 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM5L155	90.4 / 70.6	Yes
Kidney	MM5K156	30.5 / 30.3	Yes
Blubber	MM5B157	150.2 /*148.2	
Tooth	(present location, AEAC, Anchorage, AK)		

Additional Samples Collected for Other Researchers

Alaska Frozen Tissue Collection ID No. AF-0751;
present location, UA Museum, Fairbanks, AK:
Heart Muscle

692-RGSL-017 Norton Sound, Nome 64°30′ 166°10′
21May91

mature female W = 40.8 kg
SL = 113 cm AG = 92 cm BT = 7.0 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM5L158	176.5 / 175.4	Yes
Kidney	MM5K159	97.6 / 93.1	Yes
Blubber	MM5B160	145.8 / 158.5	
Tooth	(present location, AEAC, Anchorage, AK)		

Additional Samples Collected for Other Researchers

Alaska Frozen Tissue Collection ID No. AF-0752;
present location, UA Museum, Fairbanks, AK:
Heart Muscle Liver

692-RGSL-018 Norton Sound, Nome 64°09′ 165°26′
22May91

1-yr female W = 21.8 kg
SL = 87 cm AG = 75 cm BT = 2.0 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM5L161	162.8 / 173.0	Yes
Kidney	MM5K162	68.5 / 71.5	Yes
Blubber	MM5B163	151.2 / 148.1	
Tooth	(present location, AEAC, Anchorage, AK)		

Additional Samples Collected for Other Researchers
Alaska Frozen Tissue Collection ID No. AF-0753;
present location, UA Museum, Fairbanks, AK:
Muscle Liver

692-RGSL-019 Chukchi Sea, Barrow 71°18.7′ 156°53.2′
9July91

<1-yr male W = 13.6 kg
SL = 77 cm AG = 64 cm BT = 2.5 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM5L167	127.2 / 123.7	Yes
Kidney	MM5K168	47.9 / 46.3	Yes
Blubber	MM5B169	127.9 / 134.2	
Tooth	(present location, AEAC, Anchorage, AK)		

Additional Samples Collected for Other Researchers
Alaska Frozen Tissue Collection ID No. AF-0757;
present location, UA Museum, Fairbanks, AK:
Muscle Liver

692-RGSL-020 Chukchi Sea, Barrow 71°18.7′ 156°53.2′
9July91

11-12 yr male W = 41.7 kg
SL = 119.4 cm AG = 92 cm BT = 2.5 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM5L170	158.7 / 173.7	Yes
Kidney	MM5K171	123.2 / 123.2	Yes
Blubber	MM5B172	163.5 / 158.9	
Tooth	(present location, AEAC, Anchorage, AK)		

Additional Samples Collected for Other Researchers
Alaska Frozen Tissue Collection ID No. AF-0758;
present location, UA Museum, Fairbanks, AK:
Muscle Liver

ADF&G; present location, ADF&G, Fairbanks, AK:
blood serum

692-RGSL-021 Chukchi Sea, Barrow 71°18.7′ 156°53.2′
10July91

8-9 yr male W = 36.3 kg
SL = 108 cm AG = 85.5 cm BT = 2.0 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM5L173	173.0 / 177.3	Yes
Kidney	MM5K174	132.0 / 129.3	Yes
Blubber	MM5B175	94.4 / 88.7	
Tooth	(present location, AEAC, Anchorage, AK)		

Additional Samples Collected for Other Researchers
Alaska Frozen Tissue Collection ID No. AF-0760;
present location, UA Museum, Fairbanks, AK:
Muscle Liver

692-RGSL-022 Chukchi Sea, Barrow 71°18.7′ 156°53.2′
10July91

5-yr male W = 22.2 kg
SL = 97.8 cm AG = 70 cm BT = 2.0 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM5L176	137.2 / 157.3	Yes
Kidney	MM5K177	61.4 / 56.6	Yes
Blubber	MM5B178	119.5 / 121.8	
Tooth	(present location, AEAC, Anchorage, AK)		

Additional Samples Collected for Other Researchers
Alaska Frozen Tissue Collection ID No. AF-0761;
present location, UA Museum, Fairbanks, AK:
Muscle Liver

692-RGSL-023 Chukchi Sea, Barrow 71°22′ 156°37′
14July88

5-6 yr female W = 29.0 kg
SL = 103.9 cm AG = 76.5 cm BT = 2.3 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM5L179	183.1 / 169.5	Yes
Kidney	MM5K180	97.6 / 89.3	Yes
Blubber	MM5B181	149.3 / 112.5	
Tooth	(present location, AEAC, Anchorage, AK)		

Additional Samples Collected for Other Researchers
Alaska Frozen Tissue Collection ID No. AF-0762;
present location, UA Museum, Fairbanks, AK:
Muscle Liver

692-RGSL-024 Chukchi Sea, Barrow 71°20.1′ 156°41.7′
11July91

6-yr male W = 38.1 kg
SL = 118 cm AG = 87 cm BT = 2.7 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM5L182	170.7 / 176.0	Yes
Kidney	MM5K183	137.1 / 130.1	Yes
Blubber	MM5B184	149.1 / 145.3	
Tooth	(present location, AEAC, Anchorage, AK)		

Additional Samples Collected for Other Researchers

Alaska Frozen Tissue Collection ID No. AF-0763;
present location, UA Museum, Fairbanks, AK:
Muscle Liver

ADF&G; present location, ADF&G, Fairbanks, AK:
blood serum

692-RGSL-025 Chukchi Sea, Barrow 71°20.1′ 156°41.7′
11July91

1-2 yr female W = 27.2 kg
SL = 104 cm AG = 77.5 cm BT = 2.4 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM5L185	160.7 / 167.3	Yes
Kidney	MM5K186	67.0 / 75.3	Yes
Blubber	MM5B187	160.5 / 152.8	
Tooth	(present location, AEAC, Anchorage, AK)		

Additional Samples Collected for Other Researchers

Alaska Frozen Tissue Collection ID No. AF-0764;
present location, UA Museum, Fairbanks, AK:
Muscle Liver

ADF&G; present location, ADF&G, Fairbanks, AK:
blood serum

692-RGSL-026 Chukchi Sea, Barrow 71°24.1′ 156°31.5′
12July91

5-6 yr male W = 36.3 kg
SL = 109 cm AG = 72 cm BT = 2.0 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM5L188	139.1 / 123.4	Yes
Kidney	MM5K189	87.5 / 86.9	Yes
Blubber	MM5B190	154.9 / 154.2	
Tooth	(present location, AEAC, Anchorage, AK)		

Additional Samples Collected for Other Researchers

Alaska Frozen Tissue Collection ID No. AF-0765;
present location, UA Museum, Fairbanks, AK:
Muscle Liver

692-RGSL-027 Chukchi Sea, Barrow 71°18.5′ 156°53.2′
15July91

2-3 yr male W = 23.6 kg
SL = 101.6 cm AG = 74 cm BT = 2.0 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM5L191	168.3 / 162.6	Yes
Kidney	MM5K192	87.4 / 83.5	Yes
Blubber	MM5B193	151.4 / 151.5	
Tooth	(present location, AEAC, Anchorage, AK)		

Additional Samples Collected for Other Researchers

Alaska Frozen Tissue Collection ID No. AF-0759;
present location, UA Museum, Fairbanks, AK:
Muscle Liver

ADF&G; present location, ADF&G, Fairbanks, AK:
blood serum

692-RGSL-028 Chukchi Sea, Barrow 71°18.5′ 156°53.2′
15July91

9-yr female W = 21.8 kg
SL = 110 cm AG = 90.7 cm BT = 2.5 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM5L194	170.7 / 152.8	Yes
Kidney	MM5K195	92.0 / 84.1	Yes
Blubber	MM5B196	140.7 / 153.5	
Tooth	(present location, AEAC, Anchorage, AK)		

Additional Samples Collected for Other Researchers

Alaska Frozen Tissue Collection ID No. AF-0766;
present location, UA Museum, Fairbanks, AK:
Muscle Liver

ADF&G; present location, ADF&G, Fairbanks, AK:
blood serum

HARBOR SEAL (*PHOCA VITULINA*)

692-HBSL-001 Prince William Sound 60°10.9′ 147°55.3′
New Year Island 10Mar90

1-yr male W = 28 kg
SL = 105.4 cm AG = 74.5 cm BT = 4.0 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM4L083	165.3 / 163.1	Yes
Kidney	MM4K084	72.05 / 37.3	Yes
Blubber	MM4B085	136.0 / 153.4	
Tooth	(present location, AEAC, Anchorage)		

[1]Additional Samples Collected for Other Researchers

NWFC NMFS; present location, NWFC NMFS, Seattle, WA:

Bile	1-10 mL	Muscle	10 g
Liver	10 g	Lung	10 g
Blubber	10 g	Rt. Cerebrum	10 g
Kidney	10 g	Cerebellum	10 g

692-HBSL-002 Prince William Sound 60°55.45′ 146°36.2′
Galena Bay 22April90

2-yr female W = 47.6 kg
SL = 125.1 cm AG = 94.5 cm BT = 3.8 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM4L092	138.1 / 139.05	Yes
Kidney	MM4K093	120.3 / 94.3	Yes
Blubber	MM4B094	149.4 / 151.85	
Tooth	(present location, AEAC, Anchorage)		

[1]Additional Samples Collected for Other Researchers

NWFC NMFS; present location, NWFC NMFS, Seattle, WA:

Bile	1-10 mL	Lung	10 g
Liver	10 g	Ovaries	10 g
Muscle	10 g	Blubber	10 g

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[1]*These samples were collected for analysis of petroleum hydrocarbon compounds as part of the ADF&G sponsored Subsistence Foods Monitoring Program.*

692-HBSL-003 Prince William Sound 60°55.45′ 146°36.2′
Galena Bay 22April90

2-yr male W = 39.9 kg
SL = 125.1 cm AG = 85.0 cm BT = 3.0 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM4L089	160.35 / 164.4	Yes
Kidney	MM4K090	80.2 / 112.9	Yes
Blubber	MM4B091	125.4 / 105.3	
Tooth	(present location, AEAC, Anchorage)		

2Additional Samples Collected for Other Researchers

NWFC NMFS; present location, NWFC NMFS, Seattle, WA:

Bile	1-10 mL	Lung	10 g
Liver	10 g	Blubber	10 g
Muscle	10 g	Kidney	10 g

[2]*These samples were collected for analysis of petroleum hydrocarbon compounds as part of the ADF&G sponsored Subsistence Foods Monitoring Program.*

SPOTTED SEAL (*PHOCA LARGHA*)

692-SPSL-001 Norton Sound, Nome 64°9′ 165°26′
22May91

mature female W = ? kg
SL = 157.5 cm AG = 98.4 cm BT = 8.5 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM5L164	143.5 / 145.2	Yes
Kidney	MM5K165	161.8 / 161.7	Yes
Blubber	MM5B166	153.7 / 159.3	
Tooth (present location, AEAC, Anchorage)			

Additional Samples Collected for Other Researchers
Alaska Frozen Tissue Collection ID No. AF-0754;
present location, UA Museum, Fairbanks, AK:
Liver

BEARDED SEAL (*ERIGNATHUS BARBATUS*)

692-BDSL-001 Norton Sound, Nome 64°19′ 165°0′ 26May89

1-yr male W = 60-90 kg
SL = 166.7 cm AG = 99 cm BT = 4.5 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM3L051	154.0 / 159.0	Yes
Kidney	MM3K052	147.0 / 129.5	Yes
Blubber	MM3B053	158.0 / 163.0	
Tooth	(present location, ADF&G, Nome, AK)		
Stomach Contents	(present location, ADF&G, Nome, AK)		

Additional Samples Collected for Other Researchers

ADF&G; present location, ADF&G, Nome, AK:
Front claws Reproductive organs

NWFC NMFS; present location, NWFC NWFC, Seattle, WA:
Bile 1-10 mL Blood 5-15 mL

692-BDSL-002 Chukchi Sea, Barrow 71°31′ 157°00′ 20July89

4-yr male W = 200 kg
SL = 210 cm AG = 130 cm BT = 4.5 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM3L078	149.9 / 157.2	Yes
Kidney	MM3K079	152.6 / 166.9	Yes
Blubber	MM3B080	126.9 / 125.1	

Additional Samples Collected for Other Researchers

NWFC NMFS; present location, NWFC NMFS, Seattle, WA:
Liver 10 g Kidney 10 g

692-BDSL-003 Chukchi Sea, Barrow 71°31′ 157°00′ 20July89

5-yr male W = 225 kg
SL = 240 cm AG = 138 cm BT = 5 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM3L081	155.4 / 167.8	Yes
Blubber	MM3B082	128.5 / 119.7	

Additional Samples Collected for Other Researchers

NWFC NMFS; present location, NWFC, NMFS, Seattle, WA:
Liver 10 g

NORTHERN FUR SEAL (*CALLORHINUS URSINUS*)

692-FRSL-001 Bering Sea, St. Paul I. 57°10.5′ 170°09.5′
Polovina 28July87

3-yr male W = 56.3 kg SL = 114.0 cm BT = 1.5 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM1L001	135.0 / 125.0	Yes
Kidney	MM1K002	93.0 / 97.0	Yes
Muscle	MM1M003	125.0 / 132.5	
Blubber	MM1B004	119.0 / 114.5	
Tooth			

Additional Samples Collected for Other Researchers
L. Rotterman; present location, NCRC, Frederick, MD:
Blood 5-15 mL Heart 10 g Liver 10 g Spleen 10 g

692-FRSL-002 Bering Sea, St. Paul I. 57°10.5′ 170°09.5′
Polovina 28July87

3-yr male W = 77.6 kg SL = 117.3 cm BT = 2.5 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM1L005	117.8 / 110.5	Yes
Kidney	MM1K006	137.2 / 137.0	Yes
Muscle	MM1M007	170.0 / 143.0	
Blubber	MM1B008	156.0 / 158.0	
Tooth			

Additional Samples Collected for Other Researchers
L. Rotterman; present location, NCRC, Frederick, MD:
Blood 5-15 mL Heart 10 g Muscle 10 g
Spleen 10 g Liver 10 g Skin (genetics)

692-FRSL-003 Bering Sea, St. Paul I. 57°10.5′ 170°09.5′
Polovina 28July87

3-yr male W = 84.0 kg SL = 124.0 cm BT = 3.0 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM1L009	132.0 / 140.0	Yes
Kidney	MM1K010	112.0 / 103.0	Yes
Muscle	MM1M011	152.5 / 136.0	
Blubber	MM1B012	156.5 / 144.5	
Tooth			

Additional Samples Collected for Other Researchers
L. Rotterman; present location, NCRC, Frederick, MD:
Blood 5-15 mL Heart 10 g Muscle 10 g
Spleen 10 g Liver 10 g Skin (genetics)

692-FRSL-004 Bering Sea, St. Paul I. 57°14.85′ 170°05.9′
Northeast Point 29July87

3-yr male W = 64.7 kg SL = 111.4 cm BT = 2.5 cm

NBSB Samples	NBSB ID	A (g)	/ B (g)	Histo-Section
Liver	MM1L013	129.5	/*149.0	Yes
Kidney	MM1K014	92.0	/ *93.5	Yes
Muscle	MM1M015	129.2	/*148.0	
Blubber	MM1B016	105.5	/*101.0	
Tooth				

Additional Samples Collected for Other Researchers

L. Rotterman; present location, NCRC, Frederick, MD:

Blood	5-15 mL	Heart	10 g
Spleen	10 g	Skin (genetics)	

692-FRSL-005 Bering Sea, St. Paul I. 57°14.85′ 170°05.9′
Northeast Point 29July87

2-yr male W = 58.7 kg SL = 110.4 cm BT = 3.0 cm

NBSB Samples	NBSB ID	A (g)	/ B (g)	Histo-Section
Liver	MM1L017	145.0	/*136.0	Yes
Kidney	MM1K018	118.5	/*112.0	Yes
Muscle	MM1M019	103.0	/*105.0	
Blubber	MM1B020	157.0	/*141.0	
Tooth				

Additional Samples Collected for Other Researchers

L. Rotterman; present location, NCRC, Frederick, MD:

Blood	5-15 mL	Heart	10 g	Skin (genetics)
Spleen	10 g	Liver	10 g	

692-FRSL-006 Bering Sea, St. Paul I. 57°09′ 170°20.1′
Zapadni 23July90

Subadult male W = 21.8 kg SL = 97.8 cm BT = 1.2 cm

NBSB Samples	NBSB ID	A (g)	/ B (g)	Histo-Section
Liver	MM4L095	138.0	/ 166.3	Yes
Kidney	MM4K096	88.0	/ 95.3	Yes
Blubber	MM4B097	144.4	/ 145.8	
Tooth				

Additional Samples Collected for Other Researchers

NWFC NMFS; present location, NWFC NMFS, Seattle, WA:

Blubber	10 g	Liver	10 g

692-FRSL-007 Bering Sea, St. Paul I. 57°09′ 170°20.1′
Zapadni 23July90

Subadult male W = 23.0 kg SL = 103.5 cm BT = 0.9 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM4L098	56.9 / *68.2	Yes
Kidney	MM4K088	97.5 / 98.6	Yes
Blubber	MM4B100	150.8 / 142.9	
Tooth			

Additional Samples Collected for Other Researchers

NWFC NMFS; present location, NWFC NMFS, Seattle, WA:

Bile	1-10 mL	Blubber	10 g

692-FRSL-008 Bering Sea, St. Paul I. 57°09′ 170°20.1′
Zapadni 23July90

Subadult male W = 21.3 kg SL = 103.5 cm BT = 1.1 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM4L101	124.2 / 126.0	Yes
Kidney	MM4K102	81.2 / 80.3	Yes
Blubber	MM4B103	140.0 / 141.7	
Tooth			

Additional Samples Collected for Other Researchers

NWFC NMFS; present location, NWFC, NMFS, Seattle, WA:

Bile	1-10 mL	Liver	10 g
Blubber	10 g		

692-FRSL-009 Bering Sea, St. Paul I. 57°09′ 170°20.1′
Zapadni 23July90

subadult male W = ? kg SL = ? cm BT = ? cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM4L104	137.5 / 144.5	Yes
Kidney	MM4K105	90.2 / 86.1	Yes
Blubber	MM4B106	139.8 / 156.2	
Tooth			

Additional Samples Collected for Other Researchers

NWFC NMFS; present location, NWFC NMFS, Seattle, WA:

Bile	1-10 mL	Liver	10 g
Blubber	10 g		

692-FRSL-010 Bering Sea, St. Paul I. 57°66′ 170°17.6′
Reef 24July90

Subadult male W = 15.8 kg SL = 94.6 cm BT = 0.8 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM4L107	146.0 /*101.9	Yes
Kidney	MM4K108	66.6 / 68.5	Yes
Blubber	MM4B109	90.0 / 96.7	
Tooth			

Additional Samples Collected for Other Researchers
NWFC NMFS; present location, NWFC NMFS, Seattle, WA:
Bile 1-10 mL Blubber 10 g

692-FRSL-011 Bering Sea, St. Paul I. 57°66′ 170°17.6′
Reef 24July90

Subadult male W = 17.3 kg SL = 43.2 cm BT = 0.7 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM4L110	71.6 / *89.1	Yes
Kidney	MM4K111	70.8 / 69.8	Yes
Blubber	MM4B112	64.1 / 54.4	
Tooth			

Additional Samples Collected for Other Researchers
NWFC NMFS; present location, NWFC NMFS, Seattle, WA:
Bile 1-10 mL Blubber 10 g

692-FRSL-012 Bering Sea, St. Paul I. 57°66′ 170°17.6′
Reef 24July90

Subadult male W = 20.2 kg SL = 99.1 cm BT = 1.0 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM4L113	136.0 / 132.4	Yes
Kidney	MM4K114	92.0 / 90.3	Yes
Blubber	MM4B115	94.4 / 107.6	
Tooth			

Additional Samples Collected for Other Researchers
NWFC NMFS; present location, NWFC NMFS, Seattle, WA:
Bile 1-10 mL

692-FRSL-013 Bering Sea, St. Paul I. Reef 57°66′ 170°17.6′ 24July90

Subadult male W = 20.2 kg SL = ? cm BT = 1.0 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM4L116	154.1 / 127.0	Yes
Kidney	MM4K117	90.7 / 98.0	Yes
Blubber	MM4B118	129.3 / 98.6	
Tooth			

Additional Samples Collected for Other Researchers

NWFC NMFS; present location, NWFC NMFS, Seattle, WA:
Bile 1-10 mL

692-FRSL-014 Bering Sea, St. Paul I. Reef 57°66′ 170°17.6′ 24July90

Subadult male W = 15.9 kg SL = 95.9 cm BT = 0.9 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM4L119	119.3 / 124.2	Yes
Kidney	MM4K120	92.4 / 91.5	Yes
Blubber	MM4B121	100.0 / 103.7	
Tooth			

Additional Samples Collected for Other Researchers

NWFC NMFS; present location, NWFC NMFS, Seattle, WA:
Liver 10 g Blubber 10 g

692-FRSL-015 Bering Sea, St. Paul I. Reef 57°66′ 170°17.6′ 24July90

subadult male W = 17.4 kg SL = 104.1 cm BT = 1.2 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM4L122	117.2 / 148.3	Yes
Kidney	MM4K123	70.3 / 70.2	Yes
Blubber	MM4B124	126.0 / 116.5	
Tooth			

Additional Samples Collected for Other Researchers

NWFC NMFS; present location, NWFC NMFS, Seattle, WA:
Bile 1-10 mL

STELLER (NORTHERN) SEA LION (*EUMETOPIAS JUBATUS*)

692-STSL-001 Cook Inlet, English Bay 59°19.9′ 151°59.7′
Flat Island 26March 90

Mature female (with fetus) W = 250 kg
SL = 254 cm AG = ? cm BT = 3.0 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM4L086	142.5 / 152.9	Yes
Kidney	MM4K087	155.2 / 154.9	Yes
Blubber	MM4B088	141.4 / 156.0	
Tooth	(present location, AEAC, Anchorage, AK)		

[3]Additional Samples Collected for Other Researchers

NWFC NMFS; present location, NWFC, NMFS, Seattle, WA:

Bile	1-10 mL	Lung	10 g
Liver	10 g	Muscle	10 g
Kidney	10 g	Blubber/Skin	10 g
Blubber	10 g	Left Cerebrum	10 g

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[3]*These samples were collected for analysis of petroleum hydrocarbon compounds as part of the ADF&G sponsored Subsistence Foods Monitoring Program.*

BELUKHA WHALE (*DELPHINAPTERUS LEUCAS*)

692-BLKA-001 Chukchi Sea, Pt. Hope 68°20′ 166°50′ 26May89

<5-yr female - light gray (immature)
SL = 342.9 cm FW = 74.9 cm BT = ? cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM3L069	178.6 /*169.6	Yes
Kidney	MM3K070	148.0 / 169.0	Yes
Blubber	MM3B071	121.9 /*132.5	
Tooth	(present location, DWM, Barrow, AK)		

Additional Samples Collected for Other Researchers
NSB DWM, ID No. *HDL-5-89*;
present location, DWM, Barrow, AK:

Lower jaw with teeth	Blubber	Liver
Reproductive organs	Kidney	Skin (genetics)

692-BLKA-002 Chukchi Sea, Pt. Hope 68°20′ 166°50′ 25May89

>5-yr female - mottled (mature)
SL = 303.9 cm FW = 71.1 cm BT = 7.6 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM3L072	178.3 /*166.6	Yes
Kidney	MM3K073	155.6 / 163.1	Yes
Blubber	MM3B074	129.9 /*132.0	
Tooth	(present location, DWM, Barrow, AK)		

Additional Samples Collected for Other Researchers
NSB, DWM, ID No. *HDL-3-89*;
present location, DWM, Barrow, AK:

Lower jaw with teeth	Blubber	Liver
Reproductive organs	Kidney	Skin (genetics)

692-BLKA-003 Chukchi Sea, Pt. Hope 68°20′ 166°50′ 25May89

>5-yr female - mottled (mature)
SL = 348 cm FW = ? cm BT = ?cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM3L075	156.1 /*170.1	Yes
Kidney	MM3K076	176.3 / 175.0	Yes
Tooth	(present location, DWM, Barrow, AK)		

Additional Samples Collected for Other Researchers
NSB DWM, ID No. *HDL-2-89*;
present location, DWM, Barrow, AK:

Lower jaw with teeth	Liver
Reproductive organs	Kidney

692-BLKA-004 Chukchi Sea, Pt. Hope 68°20′ 166°50′
19May89

>5-yr male - mottled (mature)
SL = 348 cm FW = ? cm BT = 7 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM3L077	125.1 /*130.4	Yes
Tooth	(present location, DWM, Barrow, AK)		

Additional Samples Collected for Other Researchers
NSB DWM, ID No. *HDL-5-89*;
present location, DWM, Barrow, AK:
Lower jaw with teeth Blubber Stomach contents
Reproductive organs Liver Skin (genetics)

692-BLKA-005 Chukchi Sea, Pt. Lay 69°05′ 163°45′
11July90

>5-yr male - white (mature)
SL = 394 cm FW = 103 cm BT = 3.7 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM4L125	175.75 / 169.6	Yes
Kidney	MM4K126	169.2 / 160.85	Yes
Blubber	MM4B127	131.1 /*131.85	
Tooth	(present location, DWM, Barrow, AK)		

Additional Samples Collected for Other Researchers
NSB DWM, ID No. *LDL-2-90*;
present location, DWM, Barrow, AK:
Lower jaw with teeth Skin (genetics)

692-BLKA-006 Chukchi Sea, Pt. Lay 69°05′ 163°45′
11July90

>5-yr male - white (mature)
SL = 430 cm FW = 102 cm BT = 6.5 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM4L128	184.9 / 180.8	Yes
Kidney	MM4K129	154.65 / 176.75	Yes
Blubber	MM4B130	152.8 /*146.2	
Tooth	(present location, DWM, Barrow, AK)		

Additional Samples Collected for Other Researchers
NSB DWM, ID No. *LDL-31-90*;
present location, DWM, Barrow, AK:
Lower jaw with teeth

692-BLKA-007 Chukchi Sea, Pt. Lay 69°05′ 163°45′ 11July90

>5-yr female - white (mature)
SL = 363 cm FW = 88 cm BT = 7.7 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM4L131	174.5 /*158.25	Yes
Kidney	MM4K132	159.75 / 159.8	Yes
Blubber	MM4B133	140.9 /*137.2	
Tooth	(present location, DWM, Barrow, AK)		

Additional Samples Collected for Other Researchers
NSB DWM, ID No. *LDL-10-90*; present location, DWM, present location, DWM, Barrow, AK:
Lower jaw with teeth Reproductive organs

692-BLKA-008 Chukchi Sea, Pt. Lay 69°05′ 163°45′ 11July90

>5-yr male - white (mature)
SL = 364 cm FW = ? cm BT = ? cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM4L134	172.0 / 160.15	Yes
Kidney	MM4K135	149.6 / 139.25	Yes
Blubber	MM4B136	130.0 /*135.9	
Tooth	(present location, DWM, Barrow, AK)		

Additional Samples Collected for Other Researchers
NSB DWM, ID No. *LDL-62-90*;
present location, DWM, Barrow, AK:
Lower jaw with teeth

692-BLKA-009 Chukchi Sea, Pt. Lay 69°05′ 163°45′ 11July90

>5-yr male - grey-white (mature)
SL = 348 cm FW = 82 cm BT = 3.7 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM4L137	169.3 / 168.1	Yes
Kidney	MM4K138	167.3 / 160.9	Yes
Blubber	MM4B139	139.0 /*141.9	
Tooth	(present location, DWM, Barrow, AK)		

Additional Samples Collected for Other Researchers
NSB DWM, ID No. *LDL-34-90*;
present location, DWM, Barrow, AK:
Lower jaw with teeth

692-BLKA-010 Chukchi Sea, Pt. Lay 69°05′ 163°45′ 11July90

>5-yr male - white (mature)
SL = 400 cm FW = 105 cm BT = ? cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM4L140	164.7 / 173.5	Yes
Kidney	MM4K141	176.2 / 171.5	Yes
Blubber	MM4B142	116.3 /*116.9	
Tooth	(present location, DWM, Barrow, AK)		

Additional Samples Collected for Other Researchers
NSB DWM, ID No. *LDL-60-90*; present location, DWM, present location, DWM, Barrow, AK:
Lower jaw with teeth

692-BLKA-011 Chukchi Sea, Pt. Lay 69°05′ 163°45′ 11July90

>5-yr male - white (mature)
SL = 433 cm FW = 100 cm BT = ? cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM4L143	162.7 / 143.0	Yes
Kidney	MM4K144	154.35 / 165.6	Yes
Blubber	MM4B145	95.5 / *80.6	
Tooth	(present location, DWM, Barrow, AK)		

Additional Samples Collected for Other Researchers
NSB DWM, ID No. *LDL-59-90*;
present location, DWM, Barrow, AK:
Lower jaw with teeth

692-BLKA-012 Chukchi Sea, Pt. Lay 69°05′ 163°45′ 11July90

>5-yr female - white (mature)
SL = 375 cm FW = 84 cm BT = ? cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM4L146	185.2 /*169.75	Yes
Kidney	MM4K147	156.6 / 172.25	Yes
Blubber	MM4B148	142.55 /*133.45	
Tooth	(present location, DWM, Barrow, AK)		

Additional Samples Collected for Other Researchers
NSB DWM, ID No. *LDL-8-90*;
present location, DWM, Barrow, AK:
Lower jaw with teeth Reproductive organs

692-BLKA-013 Chukchi Sea, Pt. Lay 69°05′ 163°45′
11July90

>5-yr male - white (mature)
SL = 434 cm FW = 98 cm BT = 8.4 cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM4L149	161.0 / 168.1	Yes
Kidney	MM4K150	179.8 / 160.95	Yes
Blubber	MM4B151	147.1 /*148.25	
Tooth	(present location, DWM, Barrow, AK)		

Additional Samples Collected for Other Researchers
NSB DWM, ID No. *LDL-16-90*;
present location, DWM, Barrow, AK:
Lower jaw with teeth Skin (genetics)

692-BLKA-014 Chukchi Sea, Pt. Lay 69°05′ 163°45′
11July90

>5-yr female - white (mature)
SL = 351 cm FW = 82 cm BT = ? cm

NBSB Samples	NBSB ID	A (g) / B (g)	Histo-Section
Liver	MM4L152	169.4 / 172.85	Yes
Kidney	MM4K153	158.1 / 156.2	Yes
Blubber	MM4B154	146.7 /*149.9	
Tooth	(present location, DWM, Barrow, AK)		

Additional Samples Collected for Other Researchers
NSB DWM, ID No. *LDL-9-90*;
present location, DWM, Barrow, AK:
Lower jaw with teeth Reproductive organs

ANALYSES OF SELECTED SAMPLES FOR ORGANIC COMPOUNDS AND TRACE ELEMENTS

In selecting the constituents to be measured, emphasis was placed initially on those elements and organic compounds that may be linked to the oil and gas industry in Alaska. These include higher molecular weight polycyclic aromatic hydrocarbons (PAHs) and trace elements such as barium, chromium, nickel, and vanadium. However, other contaminants that are known to occur at elevated levels in tissues of marine mammals, e.g., cadmium, mercury, copper, polychlorinated biphenyls (PCBs), and chlorinated pesticides, are also monitored routinely.

PAHs are readily metabolized by vertebrates and excreted; therefore, they do not readily accumulate in marine mammal tissues. Initial analyses of northern fur seal tissues collected in the *AMMTAP* indicated PAH concentrations below detection limits. This is to be expected unless animals have been recently exposed to relatively high levels of PAHs in the environment. PAHs are at present not routinely measured in the *AMMTAP* samples.

PCBs and chlorinated pesticides have been the focus of the organic analyses since they readily accumulate in the fatty tissues and are generally measured in monitoring programs for marine mammals.

Analytical Approach

Organic Analysis

Selected PCB congeners and chlorinated pesticides were determined using gas chromatography with electron capture detection (GC-ECD). The general analytical approach for the determination of these compounds in marine sediment and animal tissue has been described previously [3-4].

Inorganic Analysis

Instrumental neutron activation analysis (INAA) was selected for determining concentrations of inorganic constituents because of its ability to provide multi-element results on a single sample. Typically, results for as many as 30 elements are obtained for marine mammal tissues using INAA. However, some elements of interest are either difficult (e.g., mercury) or impossible (e.g., lead) to determine using INAA; therefore, additional analytical methods were required. Hence, INAA has been complemented previously with X-ray fluorescence (XRF) and prompt gamma activation analysis

(PGAA) for the characterization of more than 40 elements in marine bivalve molluscs [5]. We selected differential pulse anodic stripping voltammetry (DPASV) to determine nickel and lead, and to obtain supplemental measurements of cobalt, copper, zinc, and cadmium [6-7]. The use of both INAA and DPASV provided results for cobalt, copper, and zinc, from two independent techniques, and the opportunity to deduce whether any errors occurred in the determination of the other elements. Cold vapor atomic absorption spectrometry (CVAAS) was used to determine mercury [8] and CVAAS coupled with ion exchange chromatography was used to determine methyl mercury [9].

Sample Selection and Homogenization

Since 1987, tissue samples have been collected from 65 animals as part of the *AMMTAP*. Selected tissues have been analyzed from 12 of these 65 animals. Specimens of liver, kidney, muscle, and blubber from two northern fur seals (*Callorhinus ursinus*) collected on St. Paul Island (Bering Sea) in 1987 were analyzed for both organic contaminants and trace elements (excluding blubber). Liver, kidney, and blubber samples from two ringed seals (*Phoca hispida*) collected at Barrow (Chukchi Sea) in 1988 were analyzed for organic compounds and trace elements (excluding blubber). Liver and blubber samples from two ringed seals harvested near Nome (Norton Sound) in 1989 were analyzed in 1990 (both tissues for organic constituents and only liver for trace elements). Analyses of specimens since 1990 have focused on analyzing only liver tissue for trace elements and only blubber for organic constituents. Blubber samples from four belukha whales (*Delphinapterus leucas*), two harvested near Point Hope (Chukchi Sea) in 1989 and two harvested near Point Lay (Chukchi Sea) in 1990, and liver samples from six belukha whales, four harvested near Point Hope in 1989 and two harvested near Point Lay in 1990, were analyzed in 1991.

The B sections (100-150 g) of each of the tissue samples to be analyzed were cryogenically homogenized, using a cryogenic grinding procedure designed to reduce the likelihood of changes in sample composition due to thawing and refreezing [10]. The sample homogenate for each specimen was divided into subsamples of approximately 6-8 g and placed in Teflon jars for storage in the LN_2 freezers until required for analysis.

Determination of Organic Constituents

Materials

Several Standard Reference Materials (SRMs) were used as calibration solutions or analyzed during the analysis of the marine mammal tissues as control materials. SRM 2261 (Chlorinated Pesticides in Hexane, Nominal Concentration 2μg/mL), SRM 2262 (Chlorinated Biphenyl Congeners in 2,2,4-Trimethylpentane, Nominal Concentration 2 μg/mL), and SRM 1588 (Organics in Cod Liver Oil) were obtained from the Standard Reference Materials Program, NIST. Perdeuterated 4,4′-DDT was obtained from MSD Isotopes (St. Louis, MO) while PCB 103 (2,2′4,5′,6-pentachlorobiphenyl) and PCB 198 (2,2′3,3′4,5,5′6-octachlorobiphenyl) were obtained from Ultra Scientific (New Kingston, RI). All solvents were HPLC-grade.

Determination of Chlorinated Pesticides and Polychlorinated Biphenyl Congeners

The following detailed procedures are specific for the 1990 analyses of liver and blubber specimens; similar procedures, with minor modifications, were used for the earlier analyses of muscle and kidney. The analytical scheme for determining chlorinated pesticides and polychlorinated biphenyl (PCB) congeners in the liver and blubber samples is shown in Figure 2. Duplicate portions of 13-17 g (wet weight) of each liver homogenate or 2-3 g (wet weight) of each blubber homogenate were mixed with approximately 100 g of pre-extracted sodium sulfate. These mixtures were then placed in glass extraction thimbles, spiked with an internal standard solution (containing perdeuterated 4,4′-DDT, PCB 103 and PCB 198), and Soxhlet extracted for 18 h using 250 mL of methylene chloride. The extracts were concentrated to about 30 mL in a rotary evaporator and then further concentrated under a stream of nitrogen to about 1 mL. Size exclusion chromatography (SEC) on a preparative-scale divinylbenzene-polystyrene column (10 μm particle size, 100 Å pore size, 2.5 cm i.d x 60 cm, PL-Gel, Polymer Labs, Inc., Amherst, MA) was used to remove the majority of the lipid and biogenic material [11]. Using a mobile phase of 100% methylene chloride at 9.9 mL/min for the SEC, the majority of the lipid and biogenic material elutes immediately after the void volume of the column while the chlorinated pesticides and PCB congeners are retained longer.

The eluant (approximately 70 mL) was concentrated using an automated evaporation system to approximately 500 μL for the liver samples and approximately 1 mL for the blubber samples. Because of the high lipid content, the blubber

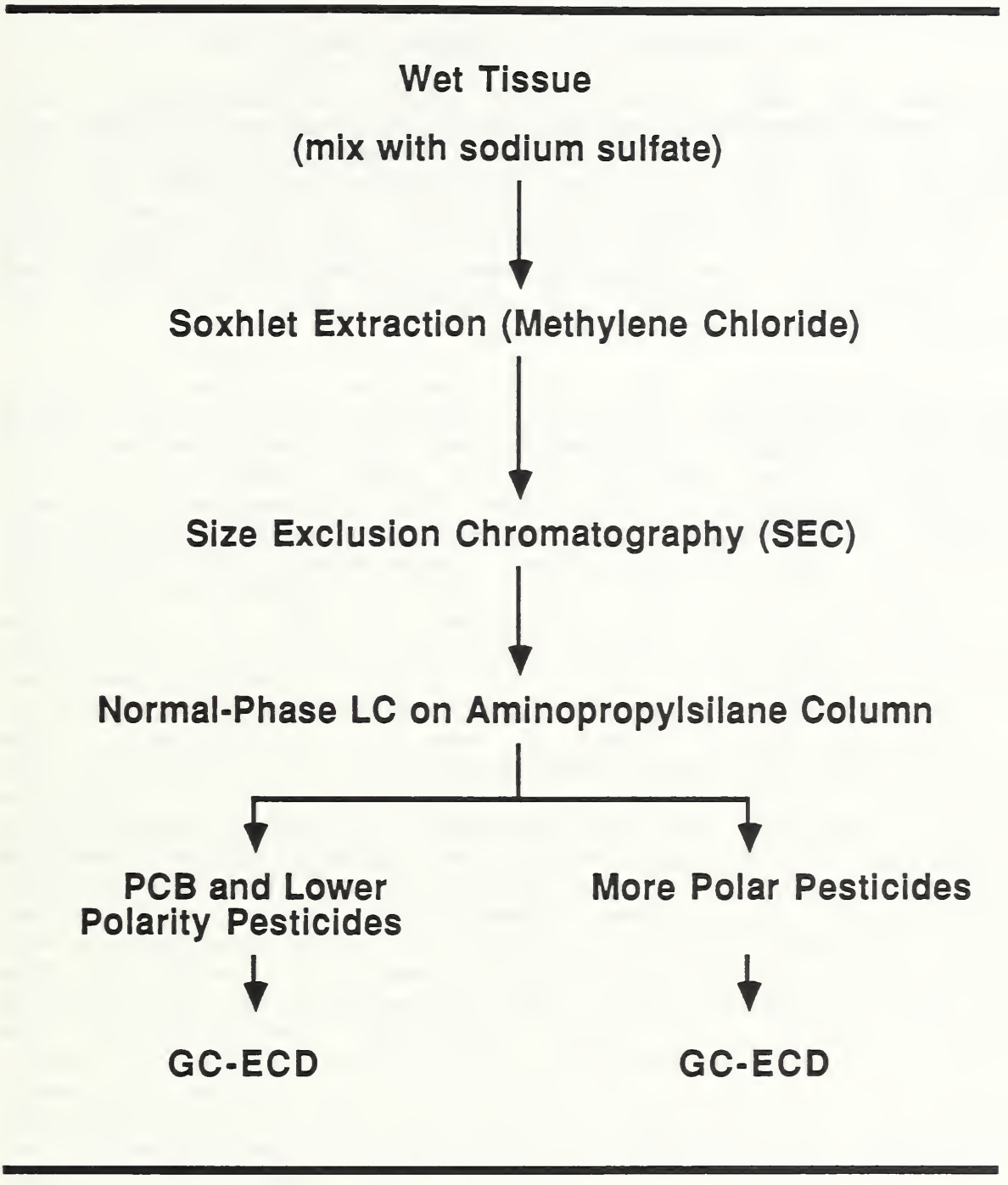


Figure 2. Analytical scheme for determining chlorinated pesticides and polychlorinated biphenyl (PCB) congeners.

samples were then reinjected onto the SEC column, and the fractionation was repeated as described above. The blubber eluant was then concentrated to approximately 500 μL.

Following the SEC, normal-phase liquid chromatography (LC) on a semi-preparative-scale aminopropylsilane column was used to isolate two fractions containing (1) the PCB congeners and lower polarity chlorinated pesticides and (2) the more polar chlorinated pesticides. For the normal-phase LC fractionation, hexane was used as the mobile phase for the isolation of the PCB and lower polarity pesticides, and 5 % methylene chloride in *n*-hexane was used for the isolation of the second fraction.

Gas chromatography (GC) with electron capture detection (ECD) was performed using a 0.25 mm x 60 m fused silica capillary column containing a 5% phenyl-substituted polysiloxane phase (DB-5), 0.25 μm film thickness. For the analysis of the first fraction (PCB congeners and lower polarity pesticides), the column was held isothermal at 200 °C for 30 min and then temperature programmed at 2 °C/min to 270 °C where it was held isothermal for 10 min. The injection port was maintained at 280 °C. For the analysis of the more polar pesticide fraction, the column was held isothermal at 190 °C for 50 min, then programmed at 1.5 °C/min to 215 °C, and then temperature programmed at 45 °C/min to 270 °C where it was held for 15 min. The injection port was maintained at 250 °C.

Starting with 1990 analyses, aliquots of SRM 1588 (Organics in Cod Liver Oil) were included as quality control samples during the analysis of the marine mammal blubber samples. The aliquots were either mixed with sodium sulfate and Soxhlet extracted as described above, or the aliquots were not Soxhlet extracted but were processed as an extract. The remainder of the procedure was the same as for the blubber samples. These experiments indicated that the SRM 1588 aliquots could be processed using either method to obtain equivalent results. Response/recovery solutions were prepared by gravimetrically diluting SRM 2261 and SRM 2262 and adding a known amount of the internal standard solution. Blanks were prepared by adding a known amount of internal standard solution to hexane. The response/recovery solutions and blanks were processed in the same manner as the tissue samples.

Determination of Percent-Extractable Components

The "percent extractable fat" (%EF) was determined for each tissue extract [11]. A 90 μL aliquot of known mass (M_1) of the extract was transferred to a tared foil pan. The methylene chloride was allowed to evaporate at room temperature until a constant weight was obtained, and the

mass of the remaining residue (M_2) was determined. The formula used is:

$$\%EF = (100 \times M_2 \times E)/ (M_1 \times W)$$

where E is the mass of the total extract and W is the mass of the liver or blubber extracted.

Determination of Inorganic Constituents

Materials

Several certified reference materials were analyzed during the analysis of the marine mammal tissues as control materials. Fish Tissue IAEA MA-B-3/TM, was obtained from the International Atomic Energy Agency (Vienna, Austria); SRM 1577 and SRM 1577a Bovine Liver were obtained from the National Institute of Standards and Technology (Gaithersburg, MD).

Determination of Inorganic Constituents by INAA

The following detailed procedures are specific for the 1990 analyses of liver specimens; similar procedures, with minor modifications, were used for the earlier analyses of muscle and kidney. Subsamples of tissue selected for analysis by INAA were dried in a freeze-dryer at 1 Pa, -10 °C shelf temperature and -50 °C condenser temperature for five days. The dry/wet ratios (C.F. or concentration factor values) were determined from the weight loss during freeze drying. Two pellets, approximately 200 mg each, were formed from each of the dried subsamples using a Perkin-Elmer pellet press (#186-0025). Pellets were also formed from powdered reference materials and from standards consisting of solutions dried on filter paper. The mass of each pellet was recorded and all pellets were packaged in acid-washed linear polyethylene film (LPE).

For the assay of short-lived nuclides, the samples and controls were irradiated, one each together with one of the standards, for 120 s in the NIST reactor pneumatic facility RT-4 at 19 MW reactor power. The samples and controls were repackaged in clean LPE after the short irradiation for counting and the subsequent long irradiation. The high count rate gamma-spectrometer system in conjunction with the pneumatic shuttle system was used for the counting of the short half-life nuclides. The sample-to-counter distance was 10 cm. Counting was started after approximately 90 s of decay. Spectral data collections were controlled via

the VAX 730 computer and a Nuclear Data micro-multichannel analyzer system (ND μMCA). The counting time was 300 s clock time, a 16384 channel fixed conversion time ADC (ND 581) was used in conjunction with a ND 599 loss free counting module linked to the ND μMCA.

For the assay of intermediate and long-lived nuclides, the samples, controls, and standards were re-irradiated in sets for 16 h in the NBSR pneumatic facility RT-4 at 19 MW reactor power. The GAMMAX-2 gamma spectrometer/sample changer system was used for counting the intermediate half-life nuclides. Counting was started after six days of decay to assay for nuclides with intermediate half-lives. The counting time was 4 h, sample geometry was 10 cm, and a 16384 channel fixed conversion time ADC (ND 581) was used linked to a ND μMCA multichannel analyzer system. The samples were counted again after four to eight weeks decay for the assay of longer-lived nuclides on the "Albert" sample changer gamma spectrometer at 2.5 cm, 16384 channels ADC conversion gain and live time corrected counting. Counting times were 4 h for each sample, 1 to 2 h for standards.

Quantitative evaluation was done by the comparator method using all standards from the individual irradiations. Nuclear Data software was used to calculate "standard constants" (the ratio of the amount of activity of a given nuclide that is present immediately after irradiation to the mass of the element, A_o/g) and these constants were used to determine the element concentrations of the samples. Since the values for the standard constants did not vary from one irradiation to another (i.e., variations were within the uncertainties associated with counting statistics, 0.2 - 2 % relative uncertainty), no corrections were used to account for temporal variations in the neutron fluence rate. Hence, all standards and samples were treated as if they were from one irradiation, corrected for the different decay times.

Determination of Inorganic Constituents by Voltammetry and Atomic Absorption Spectrometry

Three portions from each jar of the freeze-dried tissue subsample were analyzed at KFA Jülich by DPASV to determine cobalt, nickel, zinc, copper, cadmium, and lead and by CVAAS to determine mercury. The voltammetric determinations were carried out according to previously published procedures for biological and environmental samples [6], after high pressure ashing digestion with nitric acid. CVAAS was performed after wet digestion in completely closed quartz vessels [8]. The reported values for CVAAS and DPASV are based on three sample dissolutions, where each was analyzed in duplicate. Methyl mercury was determined using the procedure of May et al. (1987) [9]. This procedure consists

of extraction with HCl followed by anion-exchange chromatography to separate mercury and methyl mercury. The mercury and methyl mercury, after decomposition with acid to Hg, are measured using CVAAS.

Results

Organic Constituents

Fifteen PCB congeners, 2,4′-DDE, 4,4′-DDE, 2,4′-DDD, 4,4′-DDD, 2,4′-DDT, 4,4′-DDT, hexachlorobenzene (HCB), *gamma*-HCH, dieldrin, heptachlor epoxide, *cis*-chlordane, and *trans*-nonachlor concentrations were determined in the various marine mammal tissues. These results are summarized in the Appendices (Tables A.1 - A.3). The results for the four different tissue types (liver, kidney, muscle, and blubber) from two northern fur seals (2 and 3 year-old males) sampled at St. Paul Island (Bering Sea) in 1987 are presented in Table A.1. The results for liver, kidney,and blubber from two ringed seals (2 year-old males) sampled at Barrow (Chukchi Sea) in 1988, and the results for liver and blubber from two ringed seals (1 year-old males) sampled at Nome (Norton Sound) in 1989 are summarized in Table A.2. Results are summarized in Table A.3 for four belukha whale blubber samples collected from two animals sampled at Point Hope (Chukchi Sea) in 1989 (BLKA-001 was < 5 year-old immature female and BLKA-002 was > 5 year-old mature female), and from two > 5 year-old females sampled at Point Lay (Chukchi Sea) in 1990. A comparison of PCB and chlorinated hydrocarbon levels in blubber from all 10 samples is provided in Table A.4.

All results in Tables A.1 - A.4 are reported on the basis of wet weight of the sample; however, organic contaminant results are often reported on the basis of "extractable fat" since the absolute levels of PCBs and chlorinated hydrocarbons are related to the amount of fat or lipid material present in the sample. Thus, the percent "extractable fat" or "nonvolatile extractables" reported in the tables for each sample analyzed can be used to normalize the results from the various tissue types.

Inorganic Constituents

A total of 40 trace elements were measured in the various tissues from the same individual animals analyzed for the organic constituents, except for the belukha whales. In the case of the latter species, tissues from two additional animals from Point Hope (a total of four animals from Point Hope) were analyzed for trace elements: BLKA-003, > 5 year-old female, and BLKA-004, > 5 year-old male.

Instrumental neutron activation analysis (INAA) was used to determine 37 trace elements. Differential pulse anodic stripping voltammetry (DPASV) was used to determine nickel, cobalt, copper, zinc, cadmium, and lead, and cold vapor atomic absorption spectrometry (CVAAS) was used to determine mercury. Several trace elements (i.e., cadmium, cobalt, copper and zinc) were measured using both INAA and DPASV, thereby providing the opportunity to compare the results from independent procedures. The concentrations of trace elements in the various marine mammal samples are summarized in the Appendices (Tables A.5 - A.7). The results for the analysis of three different tissue types (i.e., liver, kidney, and muscle) from the two northern fur seals are summarized in Table A.5. Results for the analysis of liver and kidney samples from the two ringed seals from Barrow, and results for liver from the two ringed seals from Nome are summarized in Table A.6. Results from the analysis of six belukha whale liver specimens are summarized in Table A.7. A comparison of the results from all 12 liver specimens analyzed is presented in Table A.8.

The results for selected elements (cadmium, cobalt, copper, and zinc) as determined by DPASV and CVAAS are summarized in Table A.9 for 12 liver specimens. Comparison of these two techniques shows good comparability for copper, zinc, and cadmium (Figure 3). Although there appeared to be greater variability in the paired measurements for cobalt, the difference in the two techniques was not significant (based on the Wilcoxon Signed Rank Test). Analytical precision was better for zinc and cobalt using INAA and better for copper and cadmium using DPASV (Figure 3).

Since all of the samples used for inorganic analysis were freeze dried prior to analysis, the percent water loss for each sample was determined. The results for the percent water in each of the tissues analyzed are summarized in Table A.10. These results can be used to convert the results to a dry weight basis if required.

Discussion

Before beginning a discussion of the results of the analyses conducted on the *AMMTAP* samples, a word of caution is in order. The amount of data generated for samples from *AMMTAP* so far is very limited and is not yet conducive to rigorous statistical analysis. At this point in the Project, a discussion of the results can only be directed to suggesting trends and items of interest that might be worthy of additional attention as the analyses of the archived samples continue.

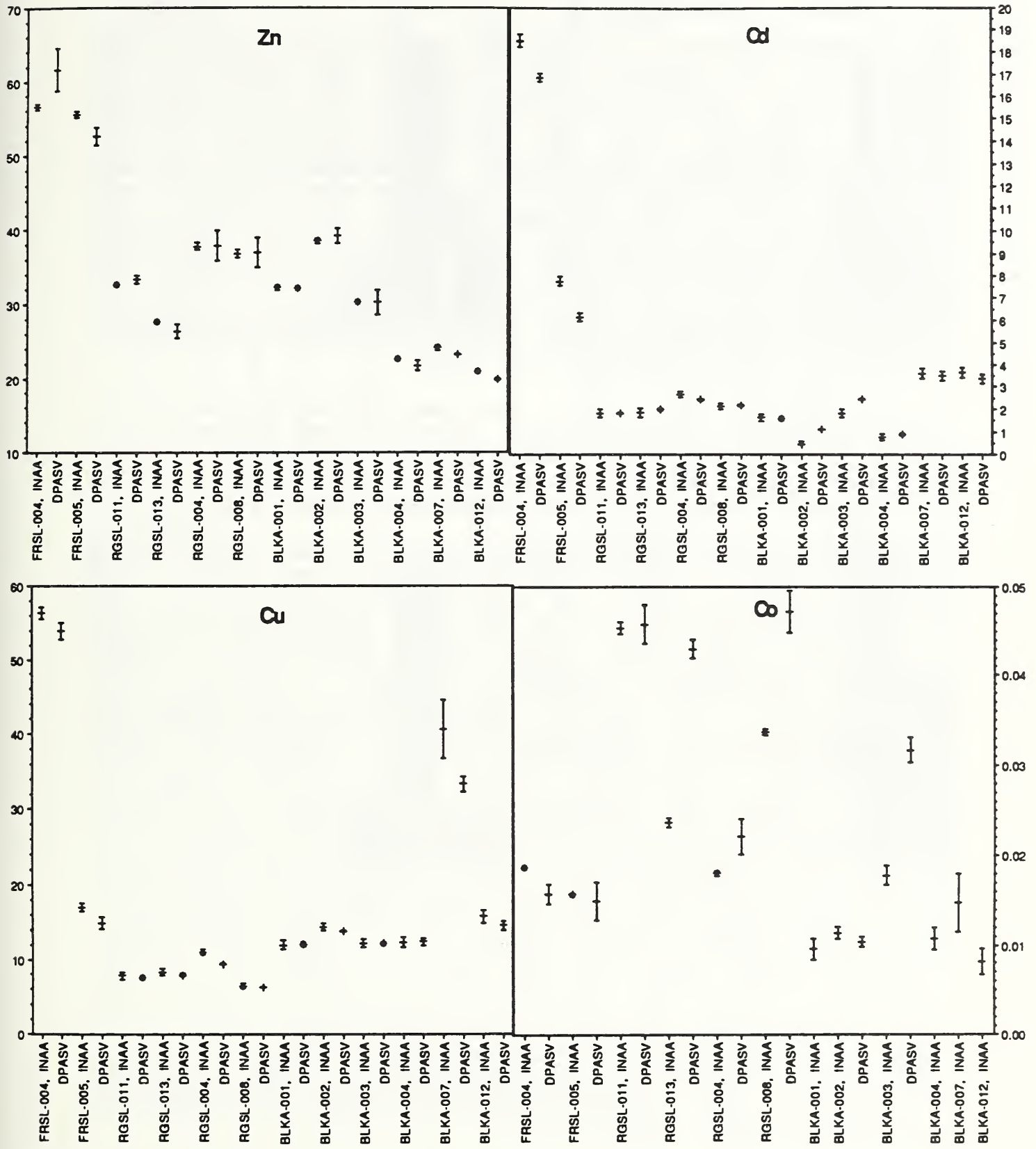


Figure 3. Comparison of Cu, Zn, Cd, and Co measurements in liver using INAA and DPASV. Values are μg/g wet weight; error bars represent uncertainity estimates (SD) of the values.

Organic Compounds

The concentrations of selected chlorinated hydrocarbons measured in the *AMMTAP* tissue samples are summarized in Figures 4-7. Total PCB (the sum of the 15 congeners measured) and total DDT (the sum of all DDT, DDD, and DDE isomers) generally had the highest concentration values (based on wet weight comparisons). An exception to this was for one of the ringed seals sampled in Norton Sound. The level of total PCB in the blubber of RGSL-013 was substantially lower than that of *trans*-nonachlor, heptachlor epoxide and *gamma*-HCH (Figure 6). Although this animal had the highest levels of these three organochlorine compounds as well as total DDT, HCB and dieldrin in its blubber as compared to any other ringed seals analyzed by the *AMMTAP*, its level of PCBs was relatively small.

For all species where tissue-type comparisons were made, the concentration of organochlorine compounds was substantially higher in the lipid-rich blubber than in the liver, kidney, or muscle. The relative concentration values in these three tissue types varied, however, among the individual animals.

Comparison of the organochlorine levels in four tissue types (blubber, liver, kidney, and muscle) of two northern fur seals sampled in 1987 are presented in Figure 4. The relative concentration values for both animals and for all four tissue types were: total DDT > total PCB > *trans*-nonachlor > heptachlor epoxide > *gamma*-HCH > dieldrin > *cis*-chlordane (no values are available for HCB). For the ringed seals, however, the relative concentration differences for the organochlorine compounds were not consistent among tissue types. Comparison of the organochlorine levels in blubber, liver, and kidney of two ringed seals sampled at Barrow in 1988, and blubber and liver of two ringed seals sampled in Norton Sound in 1989, are shown in Figures 5 - 6. For liver and kidney in both animals from Barrow, total PCB > total DDT, followed by heptachlor epoxide, dieldrin, HCB and *trans*-nonachlor at relative levels varying among animals and among tissue types (Figure 5). This variability increases when comparing the blubber concentrations with these two tissue types. In the case of the two ringed seals from Norton Sound, the relatively consistent patterns in the liver concentration patterns of the two animals (total PCB > total DDT > HCB > *gamma*-HCH, followed by *trans*-nonachlor, heptachlor epoxide, *cis*-chlordane, and dieldrin) is not reflected in the concentration values of the blubber of these two animals (Figure 6).

It is difficult to explain why relative concentration values are consistent among tissue types in the northern fur seals and not in the ringed seals. The number of animals sampled is too small to be confident that this consistency in the

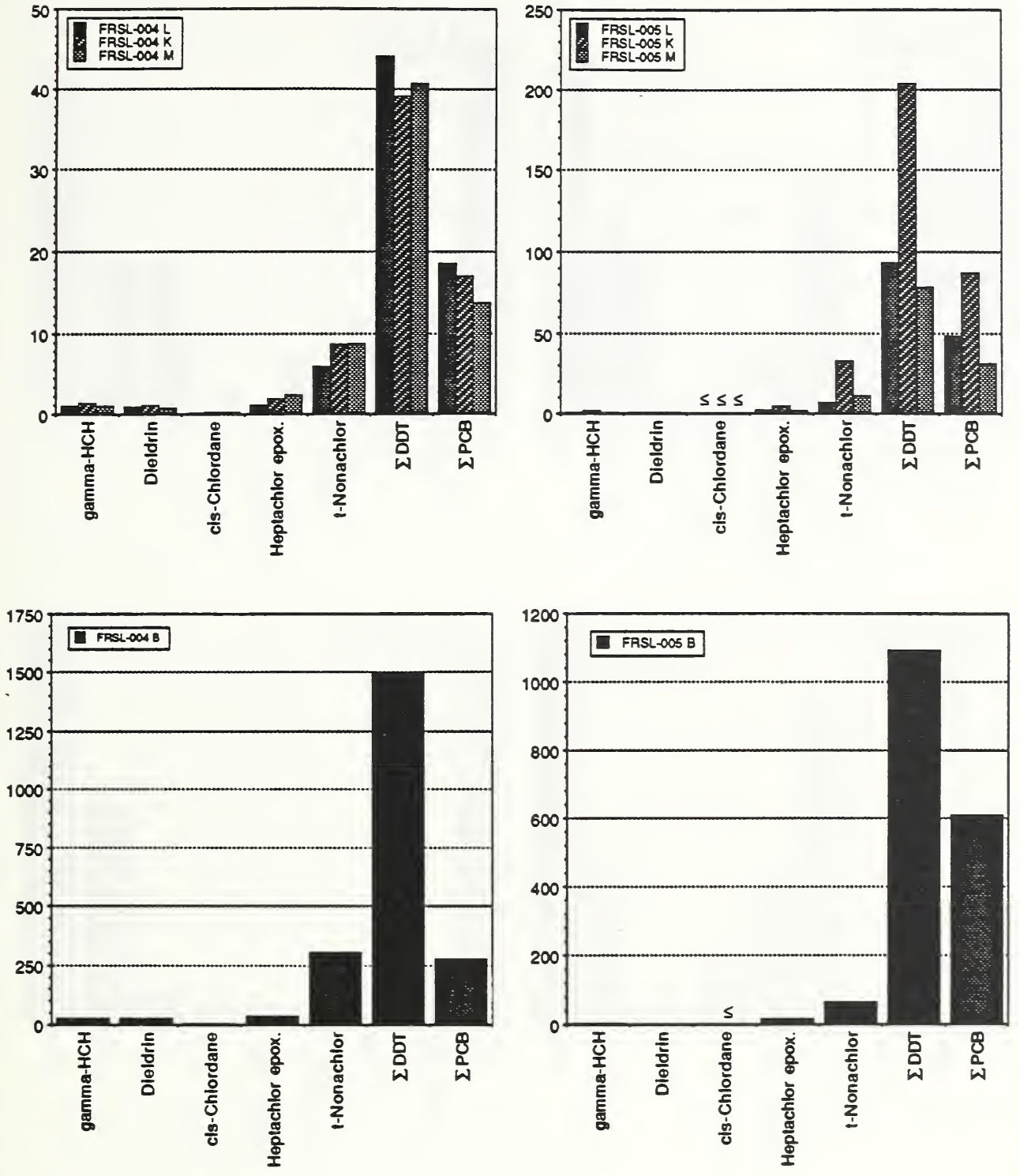


Figure 4. Concentrations (ng/g wet weight) of selected organochlorine compounds in tissues of northern fur seals from St. Paul Island, Bering Sea, 1987.

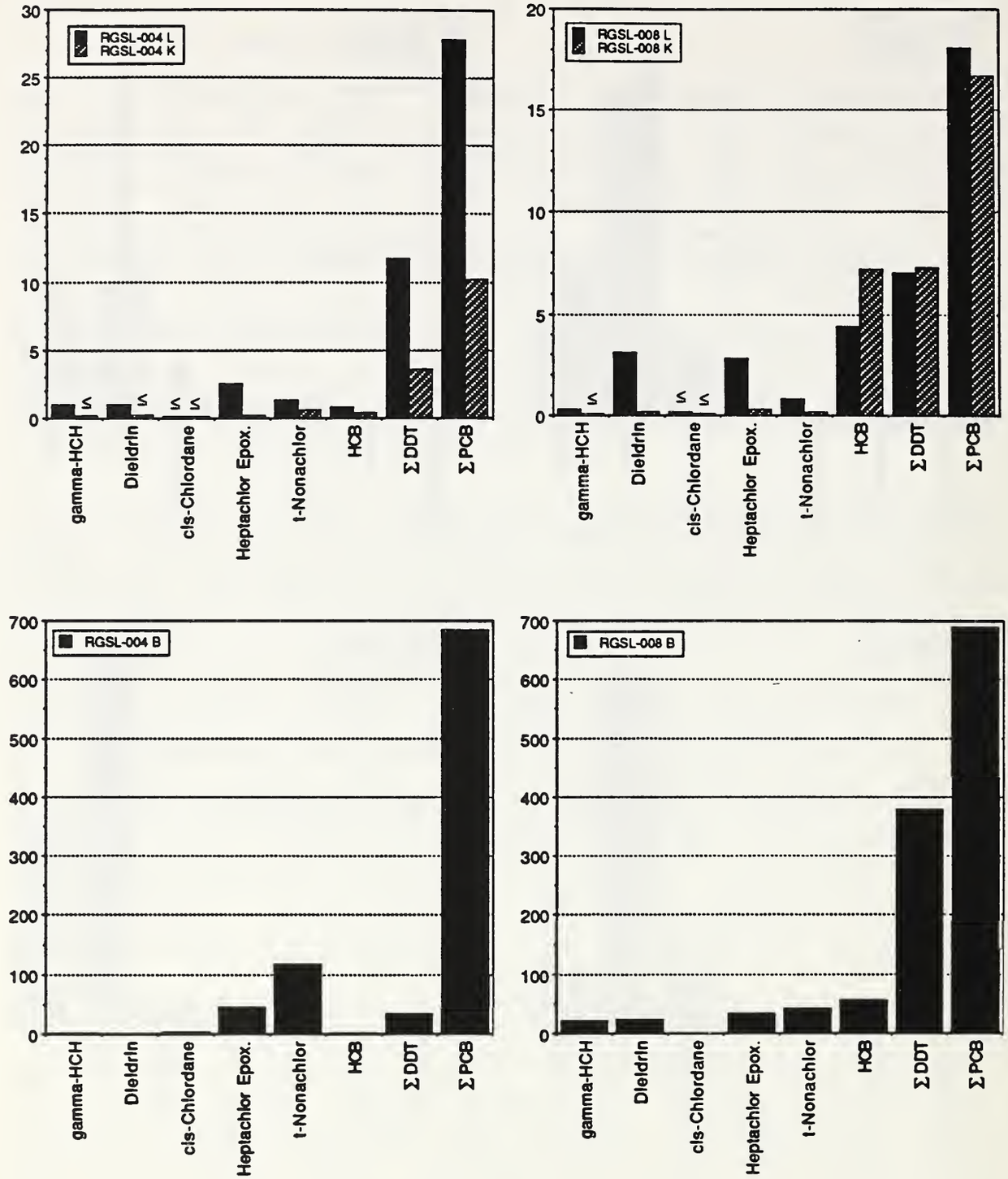


Figure 5. Concentrations (ng/g wet weight) of selected organochlorine compounds in tissues of ringed seals from Barrow, Chukchi Sea, 1988.

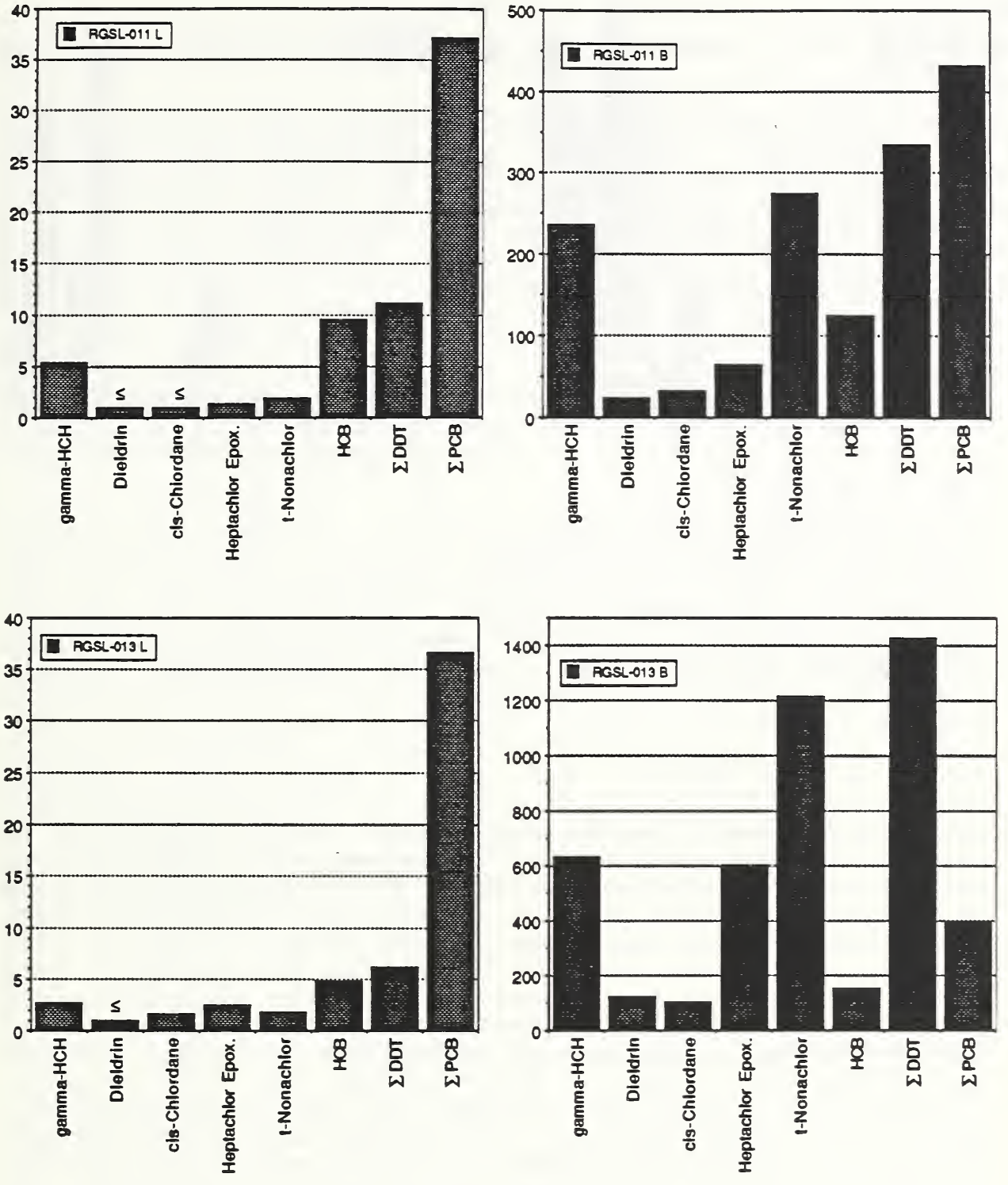


Figure 6. Concentrations (ng/g wet weight) of selected organochlorine compounds in tissues of ringed seals from Nome, Norton Sound, 1989.

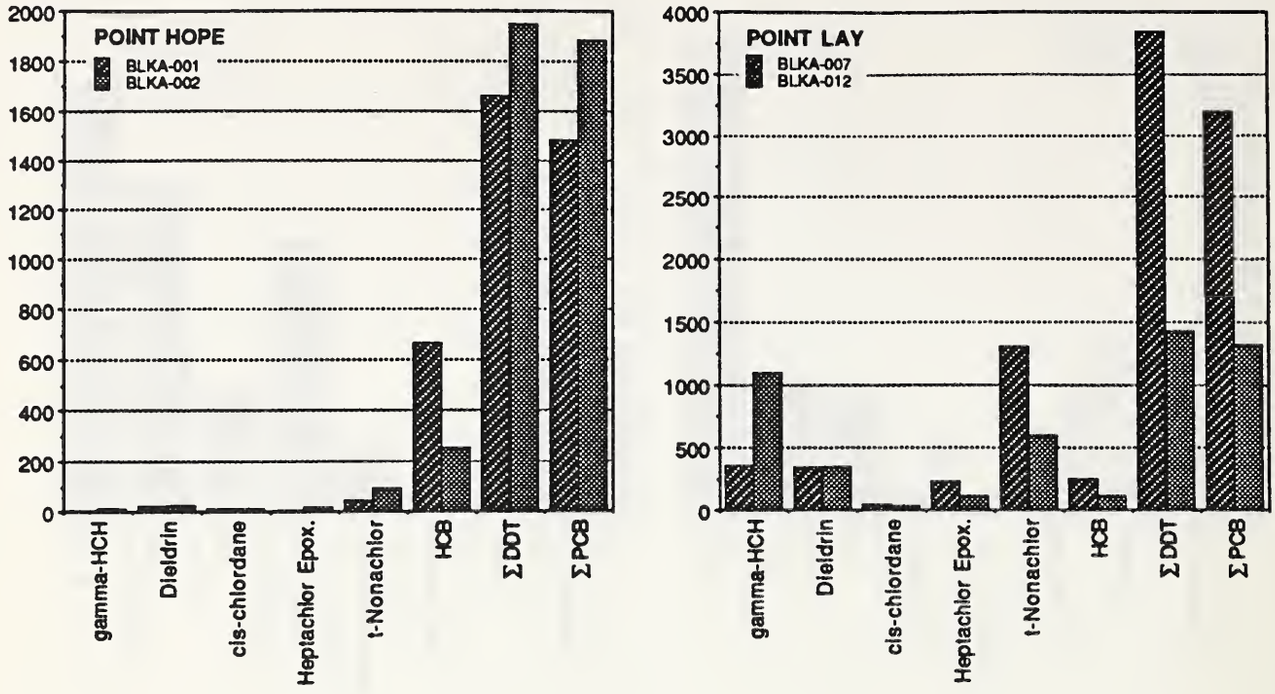


Figure 7. Concentrations (ng/g wet weight) of selected organochlorine compounds in blubber of belukha whales from Point Hope, 1989, and Point Lay, 1990, Chukchi Sea.

northern fur seals is normal. However, these comparisons do suggest that the pattern in the northern fur seal might be reflective of conditions in which the concentration levels in the tissues have come to equilibrium relative to each other, while they have not in the ringed seals. This suggests that these conditions could be the result of more recent exposure of the ringed seals to the organochlorines or species-specific differences in the ability to metabolize these compounds. Although age difference could be a factor, sex difference is not. The northern fur seals and the ringed seals (from both areas) were all males and were approximately the same age (1-3 years old), although the Norton Sound animals were the youngest (both 1 year old) and showed the greatest variability in tissue distribution. Age might have been a factor in these pattern differences, but this is certainly unclear.

Another explanation for these pattern differences might be seasonal changes in stored energy (lipid) reserves of the animals. The northern fur seals were sampled in mid-summer (July), while the ringed seals were sampled in Norton Sound in early spring (May) and in Barrow in summer (July). The period of ringed seal sampling, particularly in Norton Sound, coincided with the period of active feeding by these

seals to replenish stored energy reserves (the blubber layer).

In the case of the belukhas, only the blubber samples were analyzed for organochlorine compounds; therefore, no comparison of tissue types can be made for these animals. Blubber samples from two females (BLKA-002, > 5 years old; BLKA-001, < 5 years old) were analyzed from animals sampled at Point Hope (Chukchi Sea) in 1989, and from two mature females (> 5 years old) from animals sampled at Point Lay (Chukchi Sea) in 1990. Based on size and coloration, the two Point Lay animals were probably older than either of the Point Hope animals. For the Point Hope animals, concentration values were dominated by PCBs, DDTs, and HCB (Figure 7). For the Point Lay animals concentration values were dominated by PCBs and DDTs.

DDT and Metabolites. Although many different compounds have been identified in various organisms as metabolic products of DDT (dichlorodiphenyltrichloroethane), the predominant ones in mammals are DDD (dichlorodiphenyldichloroethane), DDE (dichlorodiphenyldichloroethylene), and DDA (dichlorodiphenyl acetic acid) [12-13]. DDD is rarely stored as a metabolite. It is unstable and readily degrades through a series of intermediates to DDA, which is water soluble and excreted in urine. DDE is a degradation product of DDT through the loss of one molecule of HCL (dehydrohalogenation) [14]. Metabolism of DDT to either DDE or DDD is considered to be quite fast in terms of years. Although DDE further degrades to DDA by the loss of two more molecules of HCL, this reaction is very slow. DDE is relatively stable and tends to persist. This persistence of DDE results in a portion of the parent compound (DDT) accumulating in the tissues as DDE.

The individual isomers of DDT and its metabolites also vary in the rates of degradation depending on the molecular arrangement of the chlorine atoms. The ratio of 2,4'-DDT to 4,4'-DDT in the technical mixture is 1:4. The missing 1,4-disubstitution in one of the phenyl rings of 2,4'-DDT facilitates its degradation. The metabolites 2,4'-DDD and 2,4'-DDE are rarely found to be enhanced to the same extent as are the 4,4'-derivatives [15].

The degradation of DDT begins in the soil through the activity of microorganisms. DDE has a greater volatility than DDT; therefore, it is probably more easily transported through the atmosphere into areas where application has not taken place. One would expect the ratio, DDE/DDT, to be generally higher in the open-ocean environment and the organisms inhabiting this environment than in the coastal environment [16]. As the DDT is metabolized and passed

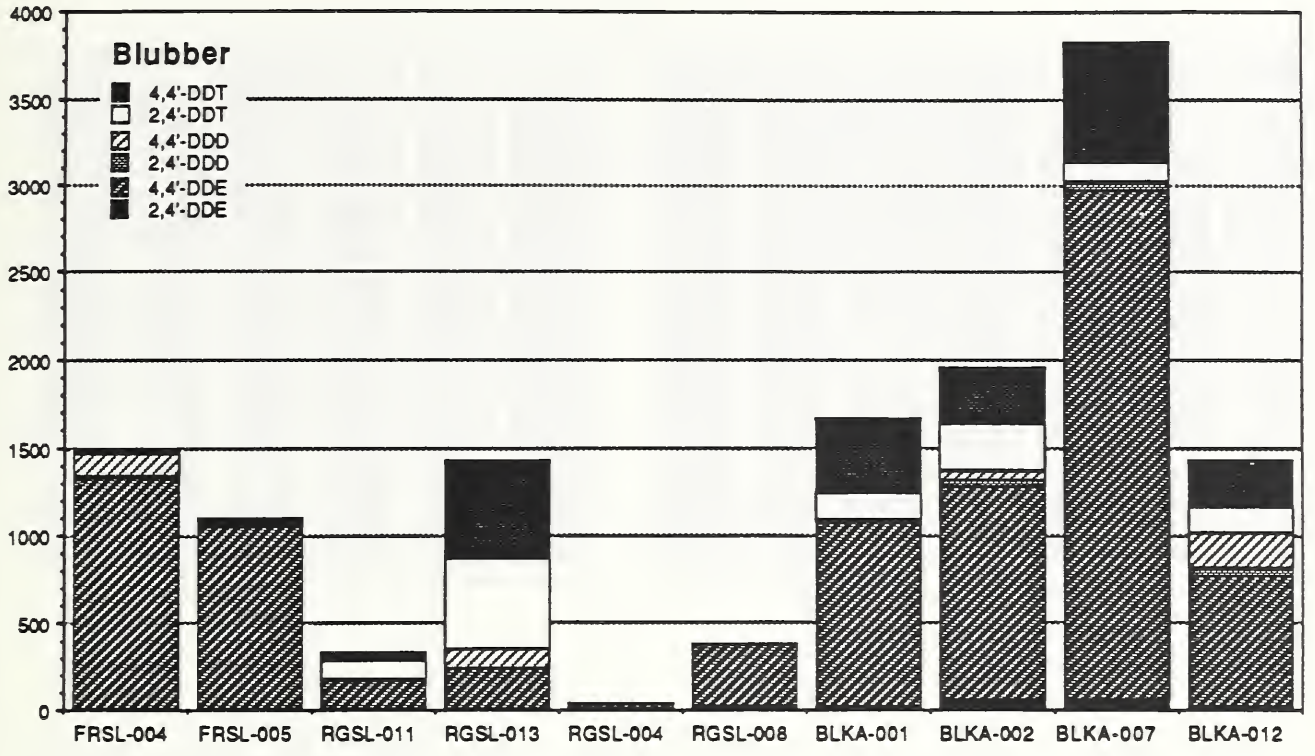
along the food chain, one would also expect the ratio to be higher at the upper trophic levels.

The world-wide environmental concentration of DDT appears to be declining. A decline of 80 to 100-fold in DDT concentrations on a nationwide basis apparently occurred in estuarine bivalves and coastal fish between 1965-72 and 1984-86 [17]. The concentration of total DDT (DDT + DDD + DDE) in the blubber of most North Atlantic marine mammals has decreased in the last two decades and the ratio of DDE to total DDT appears to have increased [18-23], suggesting no new input of DDT into the marine environment and a continuing metabolism of that which is already there. Declines in the DDT concentrations have also been reported in ringed seals of the Canadian western Arctic [24], grey and harp seals (*Halichoerus grypus* and *Pagophilus groenlandicus*) of eastern Canada [25], and the Baltic ringed seal (*Phoca hispida botnica*) [26]. However, Muir and his co-workers recently reported a larger percentage of DDE in the blubber of belukhas from the Gulf of St. Lawrence, Canada, than in the blubber of belukhas from the Arctic, suggesting that DDT inputs into the Arctic might be more recent [27].

The DDT concentrations in blubber of the animals sampled by the *AMMTAP* are compared in Figure 8. The highest concentration was found in one of the belukha whales sampled at Point Lay (BLKA-007). The greatest percentage (> 80 %) of the metabolite, 4,4′-DDE, was found in the tissues of the northern fur seals and the ringed seals sampled at Barrow (Figure 9). The ringed seals from Barrow also had the lowest total DDT concentration as compared to the animals sampled in the other areas (Figure 8).

A larger percentage of unmetabolized DDT was found in the belukha whales, particularly the animals sampled at Point Lay, and the ringed seals sampled in Norton Sound (Figure 9). Unmetabolized DDT contributed a large amount to the total DDT in these two pinnipeds in both blubber and liver. This suggests more recent exposure to unmetabolized DDT in these animals than in any of the other animals that we sampled. In the case of the belukhas, 4,4′-DDE contributed 53 - 76 % of the total-DDT. Muir and associates recently reported 47 - 57 % of 4,4′-DDE in belukha whales from the Canadian Arctic [27].

The range of total-DDT values reported for marine mammals from the Arctic and North Pacific is presented in Figure 10. The *AMMTAP* values for the two fur seals from St. Paul Island are lower than concentrations previously reported for this species from this location [28-32]. However, *AMMTAP* values for the ringed seals and belukha whales are within the same range as previously reported for these species in the Arctic [24, 27, 33-43].



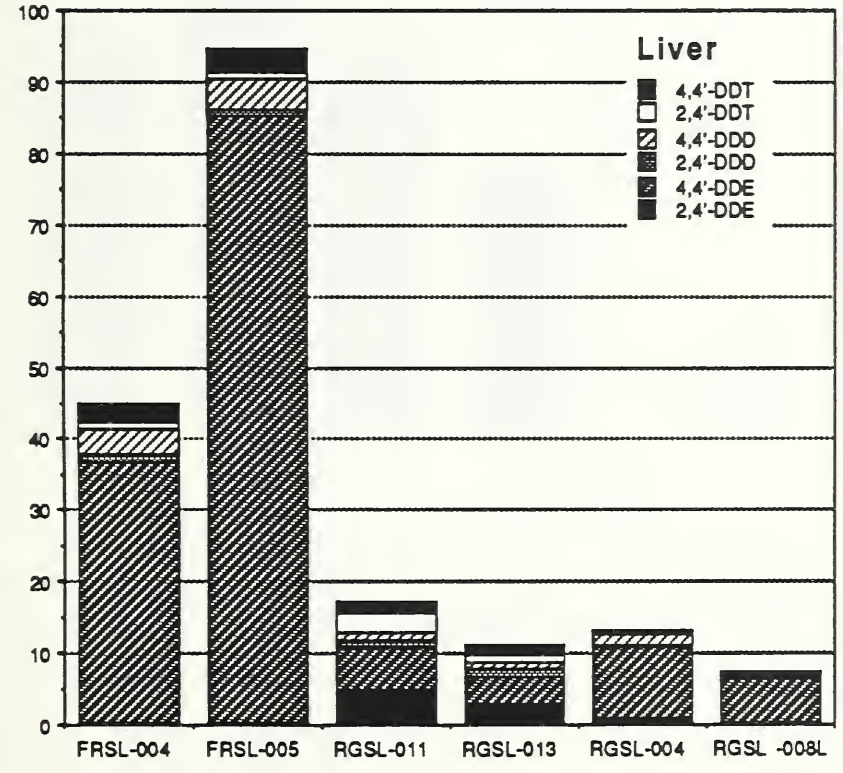


Figure 8. Concentration (ng/g wet weight) of DDT measured in marine mammal blubber and liver samples from the *AMMTAP*.

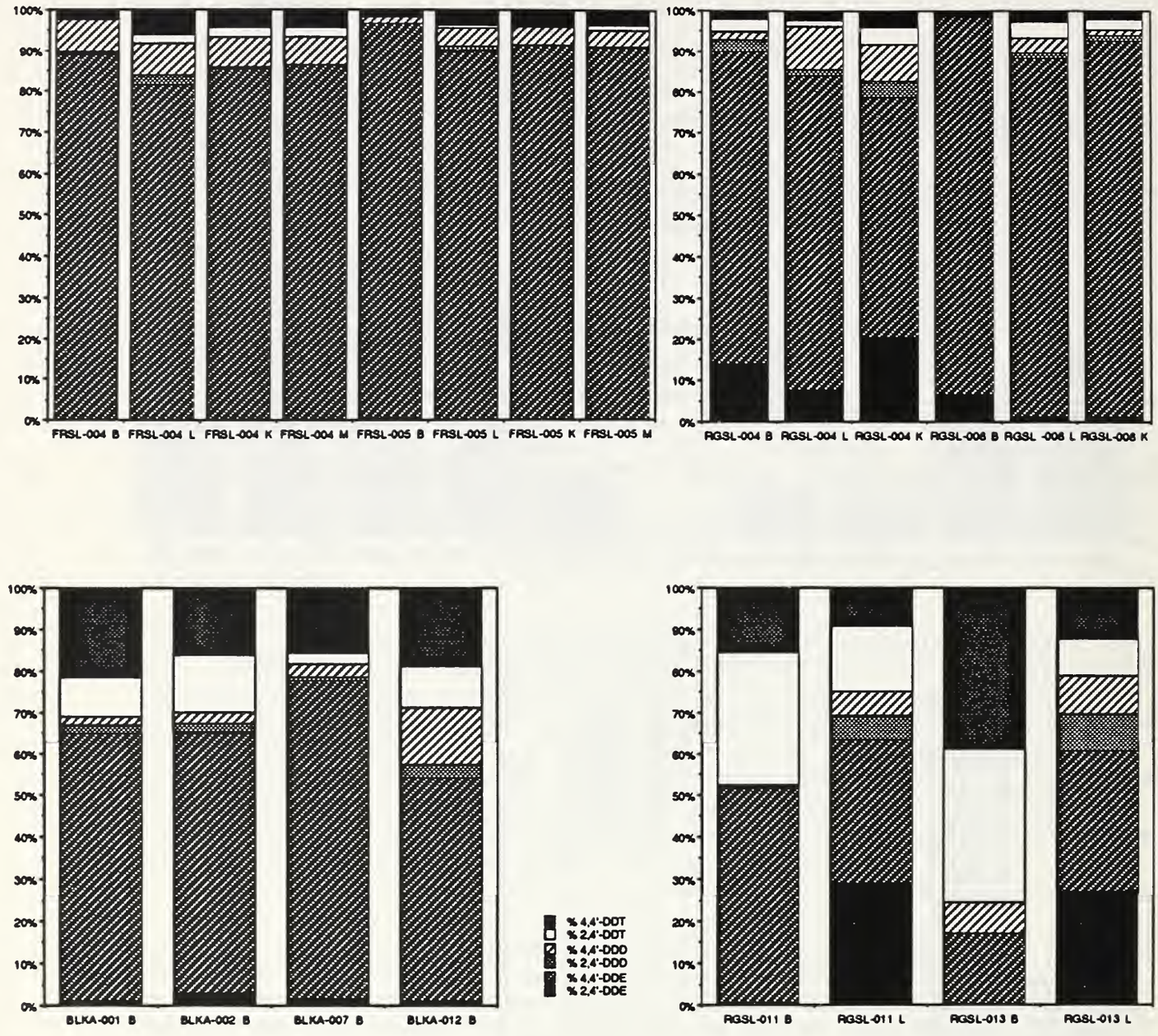


Figure 9. Contribution of 2,4'DDT, 4,4'-DDT, 2,4'-DDD, 4,4'-DDD, 2,4'-DDE, and 4,4'-DDE to the total DDT concentration measured in marine mammal tissue samples from the *AMMTAP*.

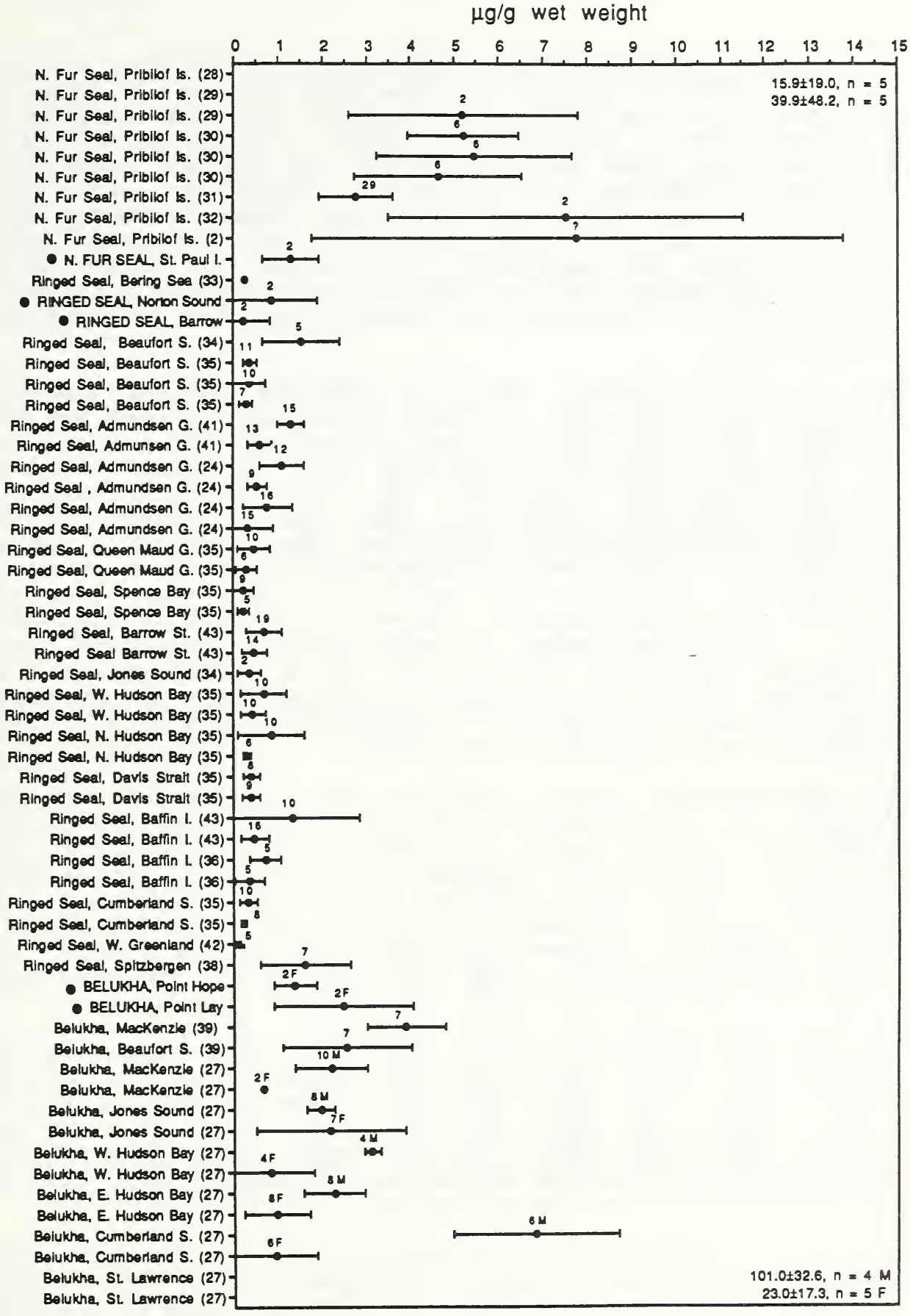


Figure 10. Total DDT reported in blubber of northern fur seals, ringed seals, and belukha whales (mean ± SD, *n* above mean, F = female, M = male). ● indicates *AMMTAP* samples.

Polychlorobiphenyls (PCBs). Much of the past data on PCBs in environmental samples is presented as "total" PCBs or represented as the amount of technical mixtures (Arochlors, Clophens, etc.). Expressing the data in terms of technical mixtures has come about through the use of commercial technical mixtures as reference materials. With the development of high resolution gas chromatography with electron capture detection (GC-ECD), the individual PCBs congeners can be separated, identified, and quantified. Rather than using technical mixtures as reference materials, the individual congeners of interest can then be used for comparison.

The value of congener specific analysis becomes apparent when one considers that, although technical mixtures are the original source of PCBs in the environment, the composition of various commercial mixtures with different overall chlorine contents differs from those of environmental mixtures [44-45]. Although the sum of PCBs may be appropriate for identification of hot spots and trend monitoring, a real understanding of the "trends" and the ability to interpret the meaning of the data requires identification and quantification of individual congeners [45]. This requirement is emphasized by the fact that, although PCBs are metabolized by a wide variety of organisms, not all congeners are metabolized at the same rate, nor are all congeners labile [46]. In addition, some congeners are more toxic than others.

The more recent congener specific data (such as that of the *AMMTAP*) is not directly comparable with older PCB data reported on the basis of Arochlors or Clophens. In addition, if all the congeners present in a sample were analyzed, their sum would be equal to the total PCBs. However, not all congeners can be clearly separated nor are there reference compounds available for all congeners. In most cases this sum does not equal the total, but something less; how much less is usually unknown.

The highest concentrations of PCBs in animals sampled by the *AMMTAP* were found in the belukha whales, particularly the older animals sampled at Point Lay (Figure 11a). However, these values are still within the range reported for belukhas from the Mackenzie River Delta, Beaufort Sea [27]. Among the pinnipeds, the lowest concentrations were found in the ringed seals from Norton Sound.

Of the 15 congeners shown in Figure 11, six might have some contribution from coeluting congeners under the GC-ECD conditions used, e.g., PCB 15 with PCB 18, PCB 95 with PCB 66, PCB 90 with PCB 101, PCBs 164 and 163 with PCB 138, PCB 190 with PCB 170, and PCBs 159 and 182 with PCB 187. The extent of the contribution of the coeluting congeners has been shown to vary in marine samples [45]. For example, the

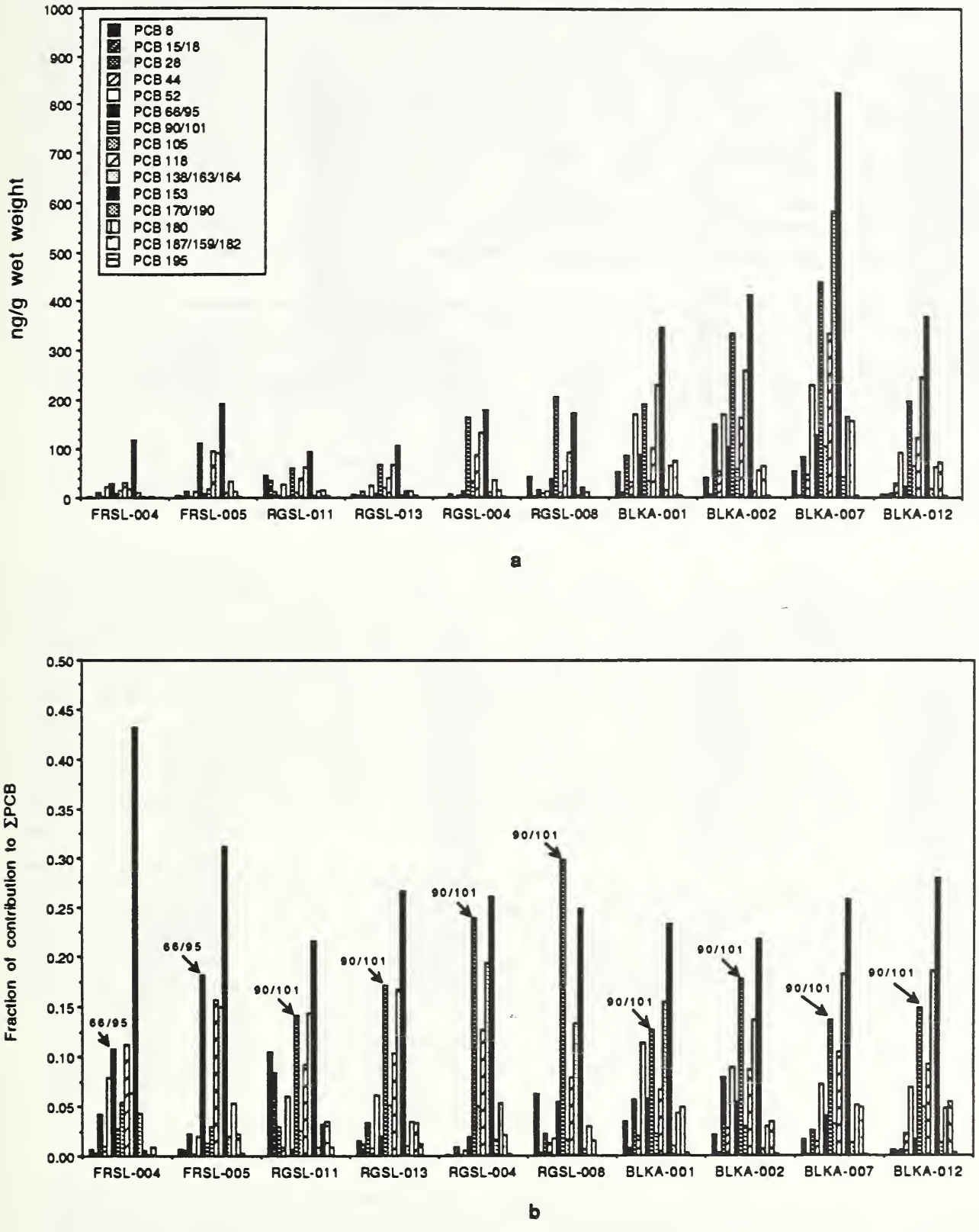


Figure 11. PCBs measured in marine mammal blubber samples from the *AMMTAP*.

ratio of PCB 163 to PCB 138 in various environmental and technical samples has been found to vary from 1:10 to 3:10 [47]. In a mussel tissue Standard Reference Material, PCB 15 did not contribute significantly to PCB 18, PCB 95 was about 21 % of PCB 66; PCB 90 was approximately 19 % of PCB 101; and PCB 159 did not contribute significantly to PCB 187 [4]. Despite these coelution problems, PCBs 28, 52, 101, 138, 153, and 180 (i.e., the peaks eluting at the retention of these standard compounds including any coeluting congeners) are widely used as representative congeners for quantitation of complex PCB mixtures [48].

There appear to be some interesting differences between species regarding the relative importance of individual congeners to the total PCB concentration. In the northern fur seals, PCBs 153, 138, 118, and 66 dominated the concentration in all four tissue types (blubber, liver, kidney, and muscle). In individual FRSL-004, PCB 52 was a major contributor to all four tissue types, PCB 180 was more significant in kidney, liver, and muscle than blubber, and PCB 138 was proportionately smaller in blubber.

For the ringed seals sampled in both Norton Sound and at Barrow, PCBs 153, 138, 118, and 101 dominated the concentration in blubber. For liver and kidney, PCBs 66, 8, and 28 were also significant. Concentrations in blubber samples from the belukha whales (from both Point Hope and Point Lay) were dominated by PCBs 153, 138, and 101. PCB 52 was also a significant contributor, particularly in the animals from Point Hope. The PCB congener patterns in the blubber of the belukha whales sampled by the *AMMTAP* in the Chukchi Sea are very similar to that reported for belukhas from East Hudson Bay, Canada [27].

Comparing blubber samples for all three species from all five geographical areas (Figure 11b), the dominant PCB congeners were: 153, 138, 101 (except for the northern fur seals), and 66 (in the northern fur seals). As has been reported for other vertebrates, the highest concentration congener was PCB 153, a relatively non-toxic form which is not easily metabolized in vertebrates. This congener contributed 20-25 % of the total PCB in the blubber of both the ringed seals and belukhas, and 30-43 % of the total PCB in all four tissue types of the northern fur seals.

Other Organochlorine Compounds. Blubber concentrations of HCB, *gamma*-HCH, dieldrin, and the chlordane-related compounds (*cis*-chlordane, *trans*-nonachlor, and heptachlor epoxide) for the animals analyzed by the project are shown in Figure 12. Levels of *gamma*-HCH, dieldrin, and the chlordane-related compounds were higher in the belukha whales sampled at Point Lay and the ringed seals from Norton Sound, than for any of the other animals. No values are

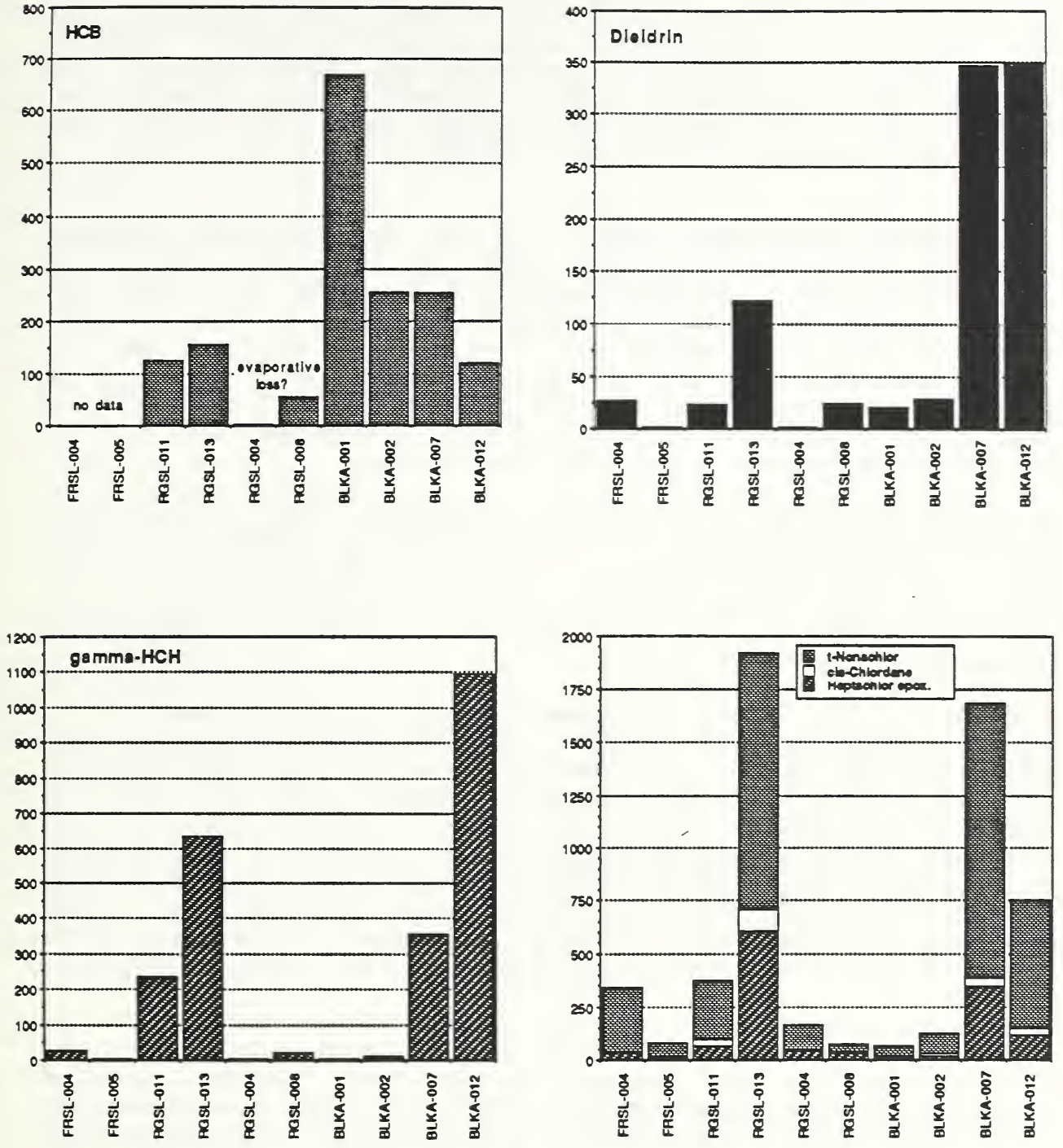


Figure 12. Concentrations (ng/g wet weight) of organochlorine compounds measured in marine mammal blubber samples from the *AMMTAP*.

available for HCB concentration in the northern fur seals and the values for the ringed seals from Barrow might be too low because of evaporative losses during analysis. Due to some changes in analytical methodology (described in the section, Determination of Organic Constituents), evaporative loss was not a problem for the belukha whale samples and the ringed seal samples from Norton Sound.

Hexachlorobenzene (HCB). Of the various chlorobenzene compounds, hexachlorobenzene (HCB) is the most toxic and most persistent. Although once of concern, HCB does not appear to be a present pollutant concern in the coastal waters of the contiguous U.S [17]. This may not be the case, however, for the polar regions. This is a very volatile compound which has the potential for long distance atmospheric transport. Ottar (1981) indicates that HCB is readily transported to northern latitudes.

Although persistent in lipids of mammals, HCB is gradually metabolized in mammals to a wide variety of metabolites that appear in the feces and urine, the main metabolite reported from rats and rhesus monkeys being pentachlorophenol [49]. Levels of HCB in fat are usually an order of magnitude higher than those of liver.

Gaskin, et al. (1983) reported levels of HCB in the liver, muscle, cerebrum, and blubber of six harbor porpoise (1-8 years of age, males and females) from the Bay of Fundy in eastern Canada [50]. The highest concentration (at least an order of magnitude above the other tissues) was in the blubber, where concentrations ranged from 0.12 - 0.43 ppm wet weight. The levels of HCB were strongly correlated with levels of total PCBs. The authors suggest that this compound might be metabolized by the same routes and stored and released from tissues at about the same rate as PCBs.

The HCB concentration values reported for Arctic marine mammals are presented in Figure 13. As mentioned above, the HCB values for the Barrow ringed seal blubber samples analyzed by the *AMMTAP* might be too low due to evaporation loss during sample preparation for analysis. The values for the ringed seals from Nome (Norton Sound) and for the belukha whales from Point Hope and Point Lay are of the same order of magnitude as reported for harbor porpoises from Bay of Fundy (1983) and for belukha whales from the Canadian Arctic (1990) [50, 27].

Hexachlorocyclohexane (*gamma*-HCH). Hexachlorocyclohexane (HCH) occurs as several isomers, alpha-HCH, beta-HCH, and gamma-HCH (lindane). The levels in fat are an order of magnitude higher than in the liver. Kawano and associates determined the levels of total HCH (alpha-HCH + beta-HCH +

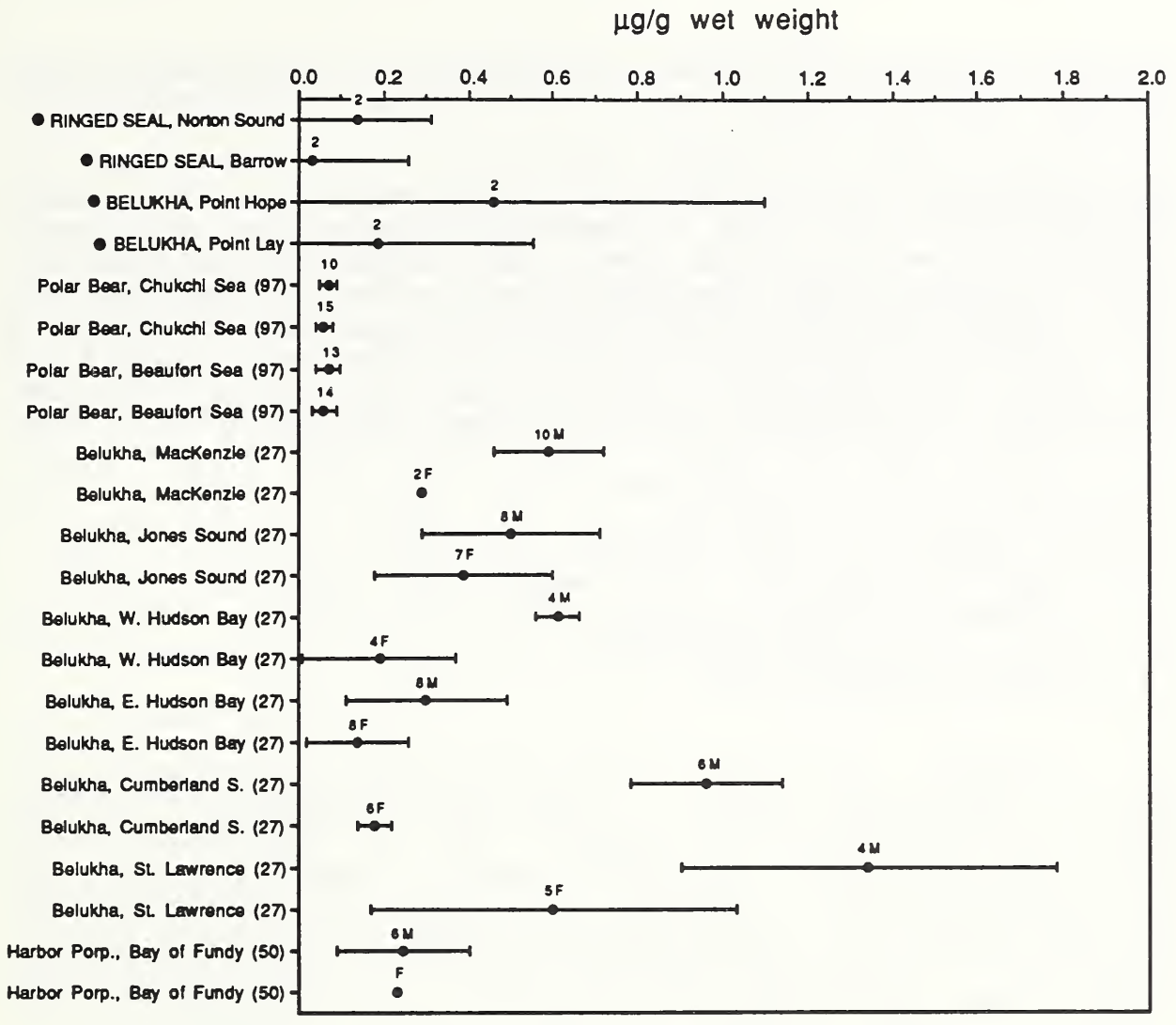


Figure 13. Concentration of HCB reported in blubber of marine mammals from the Arctic. Values (mean ± SD, *n* above mean) are listed geographically from the Bering Sea eastward to Spitzbergen (F = female, M = male). *AMMTAP* samples are indicated by ●.

gamma-HCH) in the fat of three Dall's porpoise collected in the North Pacific and Bering Sea in 1980-82 [51]. The mean value was 800 ng/g on a fat weight basis or 0.671 ppm wet weight. *Gamma*-HCH represented the smallest proportion of the total, 9% or 0.060 ppm wet weight. The rest was equally divided between the alpha-HCH (46%) and beta-HCH (45%).

Gamma-HCH is less stable than *alpha*-HCH and may be transformed to the latter during atmospheric transport. One might, therefore, expect a proportionately smaller amount occurring in Arctic organisms than in animals from lower latitudes. Muir and his associates reported a smaller proportion of *gamma*-HCH to *alpha*-HCH in the blubber of belukhas from the Arctic as compared to those from the Gulf

of St. Lawrence which they attributed to continued use of lindane as a pesticide and its possible introduction into the St. Lawrence River [27].

Concentrations of *gamma*-HCH in the fat of northern fur seals (0.0028 and 0.0257 ppm wet weight) sampled by the *AMMTAP* (Figure 12) were somewhat lower than the values reported for Dall's porpoise [51] from the Aleutian chain. These levels were comparable with those for the ringed seals sampled by the *AMMTAP* in Barrow (0.0023 and 0.021 ppm wet weight) and an order of magnitude lower than reported by Muir and associates for ringed seals from the Canadian Arctic [43]. The levels for the ringed seals from Nome, Norton Sound, were much higher (0.236 and 0.633 ppm wet weight). The concentration of gamma-HCH in the blubber of the belukha whales sampled by the project was quite variable (0.003 - 1.094 ppm wet weight). As a comparison, *gamma*-HCH values in the blubber of belukhas from across the Canadian Arctic was reported recently to range from as low as 0.07 to as high as 0.34 ppm wet weight [27].

Dieldrin. Dieldrin, which accumulates in animal tissue and is eliminated slowly, is the most frequently detected cyclodiene pesticide in coastal fish and shellfish in the U.S. [17] and one of the most commonly reported pesticides for marine mammals. Dieldrin concentrations reported in the fat and liver of Alaska marine mammals are presented in Figure 14. Concentrations are usually an order of magnitude less in the liver than in the lipid-rich fat tissue. The levels of many members of the aldrin pesticide group, including dieldrin, appear to be declining nationwide in the coastal waters of the U.S [17].

The concentration of dieldrin was very consistent between the two belukha whales sampled at Point Lay and an order of magnitude higher than the belukhas from Point Hope. The values for the Point Lay animals were of the same order as reported for northern fur seals (1985), for walrus from the Soviet Bering Sea (1989), and for belukha whales from the Mackenzie Delta, Beaufort Sea (1990) [32, 52, 27].

Chlordane-Related Compounds. Technical chlordane is a mixture of related cyclopentadienes usually described as including two isomers of chlordane (*trans-*, or *alpha*), two of nonachlor (*trans-* and *cis-*), and heptachlor. Heptachlor has been used as a pesticide separate from technical chlordane. The National Research Council describes one study in which GC analysis identified 26 peaks in technical chlordane [53]. Helle and associates mention 45 components [54]. Some components appear to volatilize readily. It is therefore very difficult to assess chlordane trends because it is not always clear which of the different chlordane

group compounds were measured to derive the total chlordane value [17].

Individual isomers of chlordane differ in their degree of persistence and, therefore, their ability to accumulate in the food web. Based on evidence of relative concentrations in marine vertebrates, their prey, and in sea water [55-56], the same measurements in freshwater systems [57-58], and correlations between octanol/water partition coefficients and bioconcentration values [56], it appears that of the two prominent isomers of technical chlordane, *trans*-chlordane is metabolized much more readily than *cis*-chlordane. However,

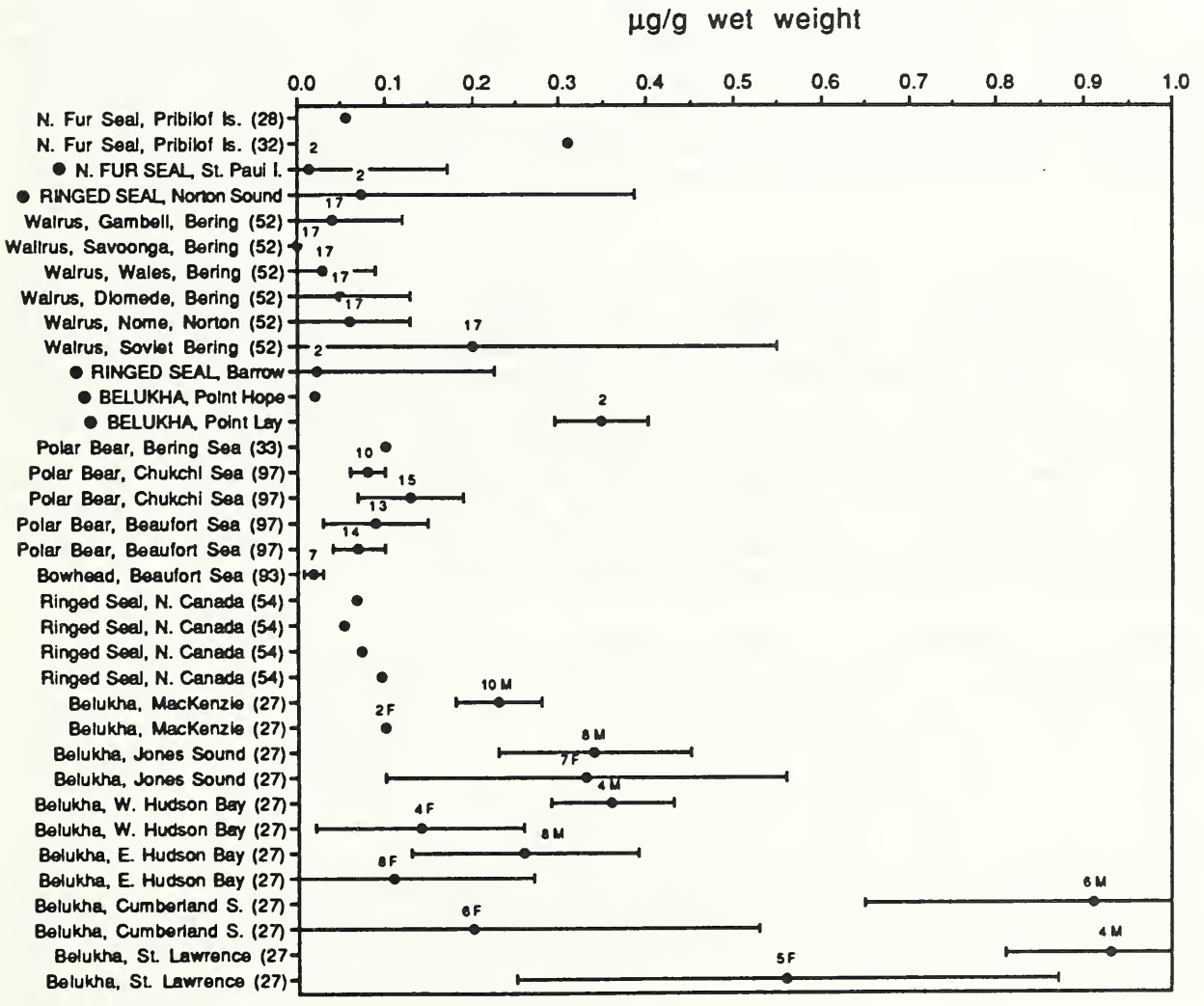


Figure 14. Concentration of dieldrin reported in blubber of marine mammals from the Arctic. Values (mean ± SD, *n* above mean) are listed geographically from the Bering Sea eastward to Eastern Canada (F = female, M = male). *AMMTAP* samples are indicated by ●.

the most prominent chlordane metabolite in animal tissues is oxychlordane; heptachlor in animal tissues is metabolized and deposited in fat as heptachor epoxide [12-13].

Chlordane readily volatilizes following soil application. Long-range atmospheric transport appears to be an important mechanism for the global spreading of this compound [59-61]. Chlordane was second only to DDT and PCBs in abundance in 1981-82 samples of marine life from the Gulf of Alaska and Bering Sea [51], and in contrast to DDT and PCB, chlordane increased in concentration during 1971-82 in fishes in the Baltic Sea [62]. Chlordane-related compounds have also been found in Weddell seals (*Leptonychotes weddelli*) from the Antarctic [63].

Muir and his co-workers found the total chlordane concentrations in both ringed seals and polar bear tissues to be comparable to total PCB and total DDT concentrations in these animals [43]. They suggest that relatively high chlordane levels (as compared to PCBs and DDT) might be unique to polar regions as compared to mid-latitude regions. Similar findings have been reported for Weddell seals and benthic fish (*Trematomus bernacchii*) from the Antarctic [63, 51].

It is useful to determine the concentrations and composition of individual chlordanes in order to understand the biodegradability and behavior of the pesticide in wildlife [51]. Some researchers have reported the parent compound, *trans*-nonachlor, as contributing substantially to the chlordane body burden of pinnipeds and cetaceans [27, 43, 56]. The blubber of three Dall's porpoise collected in the North Pacific and Bering Sea in 1980-82, was found to have *trans*-nonachlor concentrations exceeding that of the persistent metabolite oxychlordane [56].

Heptachlor-epoxide, oxychlordane, *cis*- and *trans*-nonachlor, *cis*-chlordane, non-nonachlor III, and eight minor chlordane components were measured in the fat and liver of ringed seals in the Beaufort Sea [43]. Oxychlordane contributed 36% to the total chlordane, *trans*-nonachlor, 26 %, heptachlor epoxide, 14%, nonachlor-III, 15%, *trans*-chlordane, <1%, and *cis*-chlordane, 2%. *Trans*-nonachlor constituted 30 - 40 % of the total chlordane load of belukha whales from the Canadian Arctic and 50 - 52 % of the total chlordane in the same species from the Gulf of St. Lawrence [27].

Of those chlordane compounds measured by the *AMMTAP* (*cis*-chlordane, *trans*-nonachlor, and heptachlor epoxide), the most prominent compound in all samples was *trans*-nonachlor (Figure 12). Concentrations of *trans*-nonachlor reported in blubber of marine mammals from the Arctic and North Pacific are presented in Figure 15. The highest concentrations in

the *AMMTAP* blubber samples were from the ringed seals from Nome, Norton Sound, and the belukha whales from Point Lay. The ringed seals from Nome had substantially higher levels than those reported by Muir and his associates for ringed seals from the Canadian Arctic [43] and than those we found for the ringed seals from Barrow. The levels in the belukhas from Point Lay were within the range reported for belukhas from Jones Sound and substantially less than levels reported for belukhas from the Gulf of St. Lawrence [27].

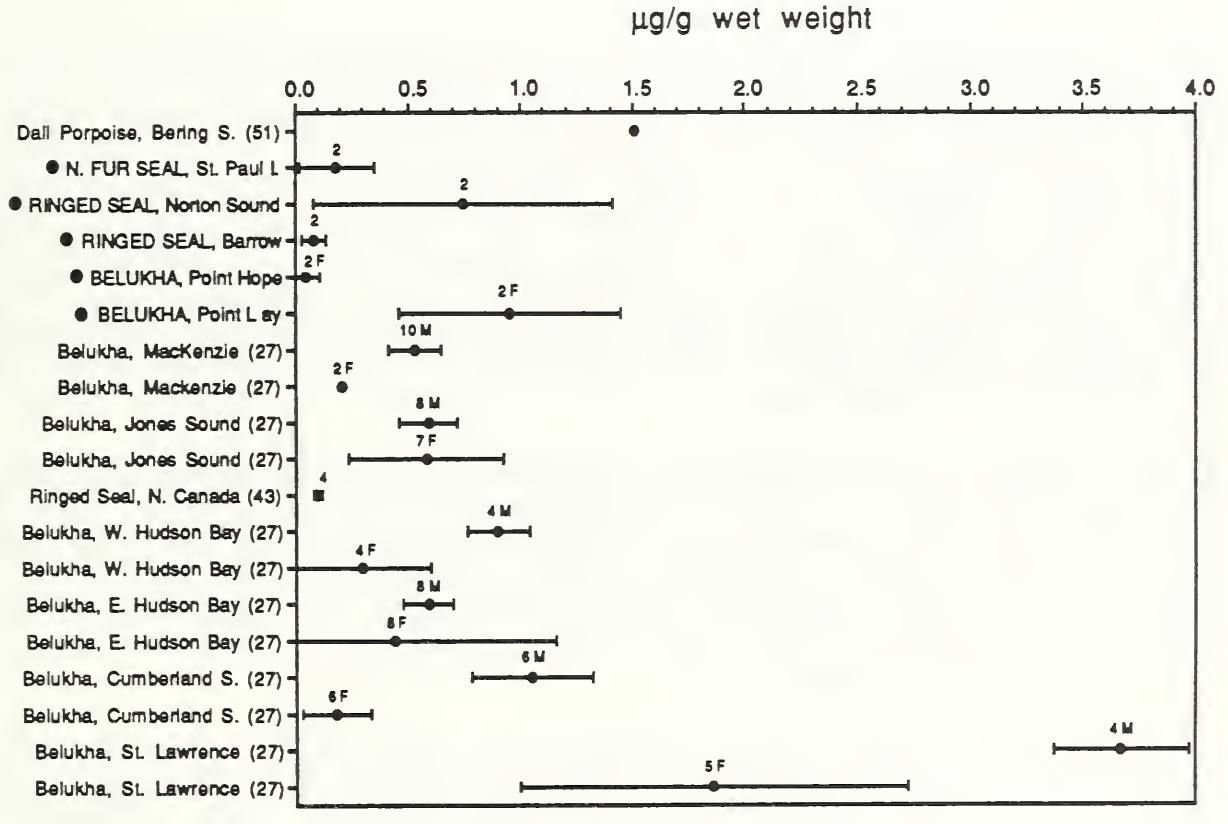


Figure 15. Concentration of *trans*-nonachlor reported in blubber of marine mammals from the Arctic. Values (mean ± SD, *n* above mean) are listed geographically from the Bering Sea eastward to Eastern Canada (F = female, M = male). *AMMTAP* samples are indicated by ●.

Trace Elements

The concentration values for 25 trace elements plus methyl mercury measured in liver samples of northern fur seals, ringed seals, and belukha whales from the *AMMTAP* are presented in Figure 16. Fifteen additional trace elements (scandium, titanium, strontium, tin, barium, lanthanum, cerium, samarium, europium, terbium, hafnium, tantalum, gold, thorium, and uranium) were measure and found to be at or below detection limits (Appendices, Tables A.5 - A.8). Of most interest to the project were arsenic, cadmium, mercury, and lead, since these are non-essential toxic elements which at high levels can result in multiple effects. In addition to these four elements, essential elements with potential for toxicity or those related to the toxicity of the non-essential elements were also of high interest. Most prominent were: zinc, copper, chromium, and selenium.

Some preliminary comparisons of trace element concentrations in liver samples analyzed by the *AMMTAP* can be made with published range values for marine mammals from other areas of the Arctic, North Pacific, and Antarctic. One must be cautious, however, in that improvement in sampling and analytical techniques over the last couple of decades has made older data for some trace elements (e.g., mercury and lead) somewhat suspect when compared with recent data. In addition, direct comparison of data resulting from different analytical techniques with different levels of sensitivity is often quite tenuous.

Zinc. Zinc is an essential element regulated metabolically by vertebrates. Liver concentration values vary little between species, generally ranging between 20 and 60 ppm [64]. Some of the highest values, occurring far above this range, have been reported from pinnipeds from the Antarctic (Figure 17) which might be a reflection of a natural dietary source for this element [64].

Of the three tissue types sampled by the *AMMTAP*, the highest levels of zinc were found in liver, followed by kidney, and then muscle (see Appendices, Tables A.5 and A.6). This is consistent with what has been reported for other species. The liver concentration values were all within the range of 20 - 60 ppm (Figure 16). Zinc concentrations have been shown by several investigators to be positively correlated with cadmium levels [64-66]. However this might be a reflection of an age-related increase in both trace elements rather than a direct relationship between the two elements [64]. With this in mind, it is not surprising that we found no correlation between cadmium and zinc concentrations in liver tissue of the animals we sampled, since most of these animals were relatively young and cadmium levels were relatively low.

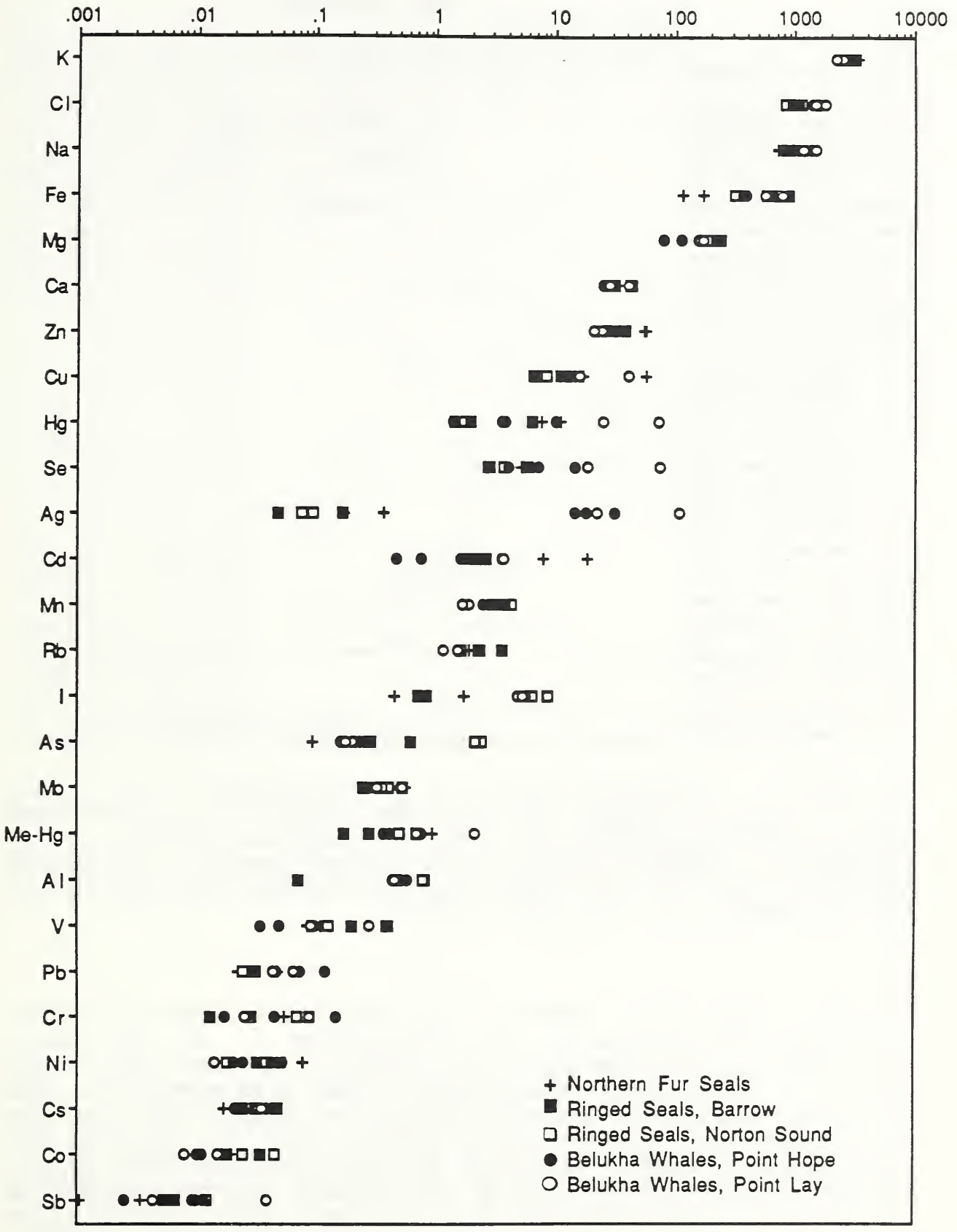


Figure 16. Concentration values (µg/g wet weight) for trace elements measured in the *AMMTAP* liver samples. Elements are listed in order of decreasing range values.

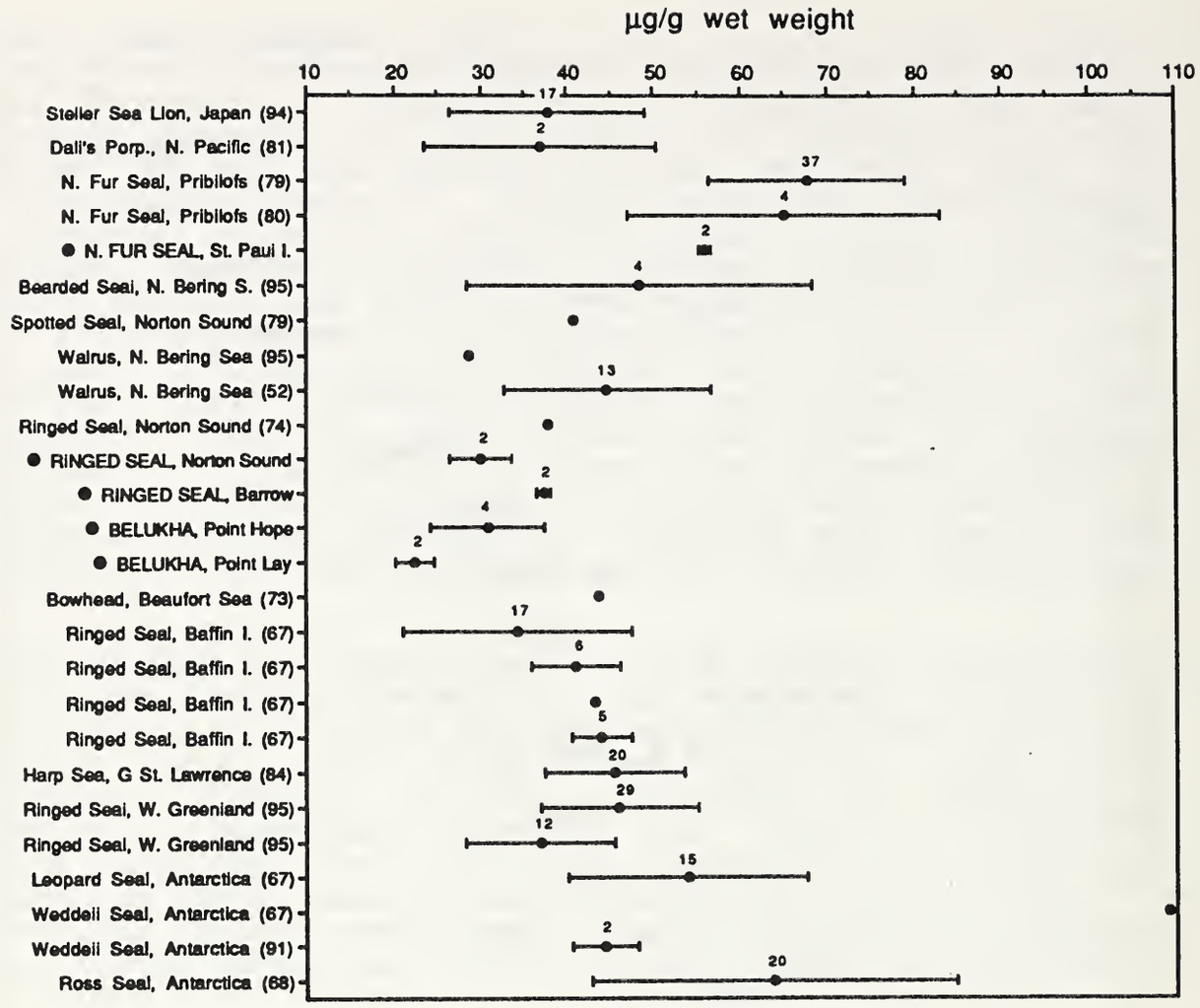


Figure 17. Concentration of zinc reported in liver of marine mammals from the North Pacific, Arctic, and Antarctic. Values (mean ± SD, *n* above mean) are listed geographically from the North Pacific eastward to Greenland. *AMMTAP* samples are indicated by ●.

Copper. Like zinc, copper is an essential element and is regulated metabolically in vertebrates. As has been reported for other mammals, we found the highest values to occur in the liver, followed by kidney and muscle. Most marine mammal liver values have been reported to be below 20 ppm (Figure 18). Among the animals that we sampled the highest liver values were for the northern fur seals (17 - 56 ppm) from St. Paul Island and belukha whales from Point Lay (16 - 41 ppm) (Figure 16). These values approach the relatively high levels reported for some Antarctic species: leopard seal as high as 68 ppm [67] and Ross seal as high as 74 ppm [68].

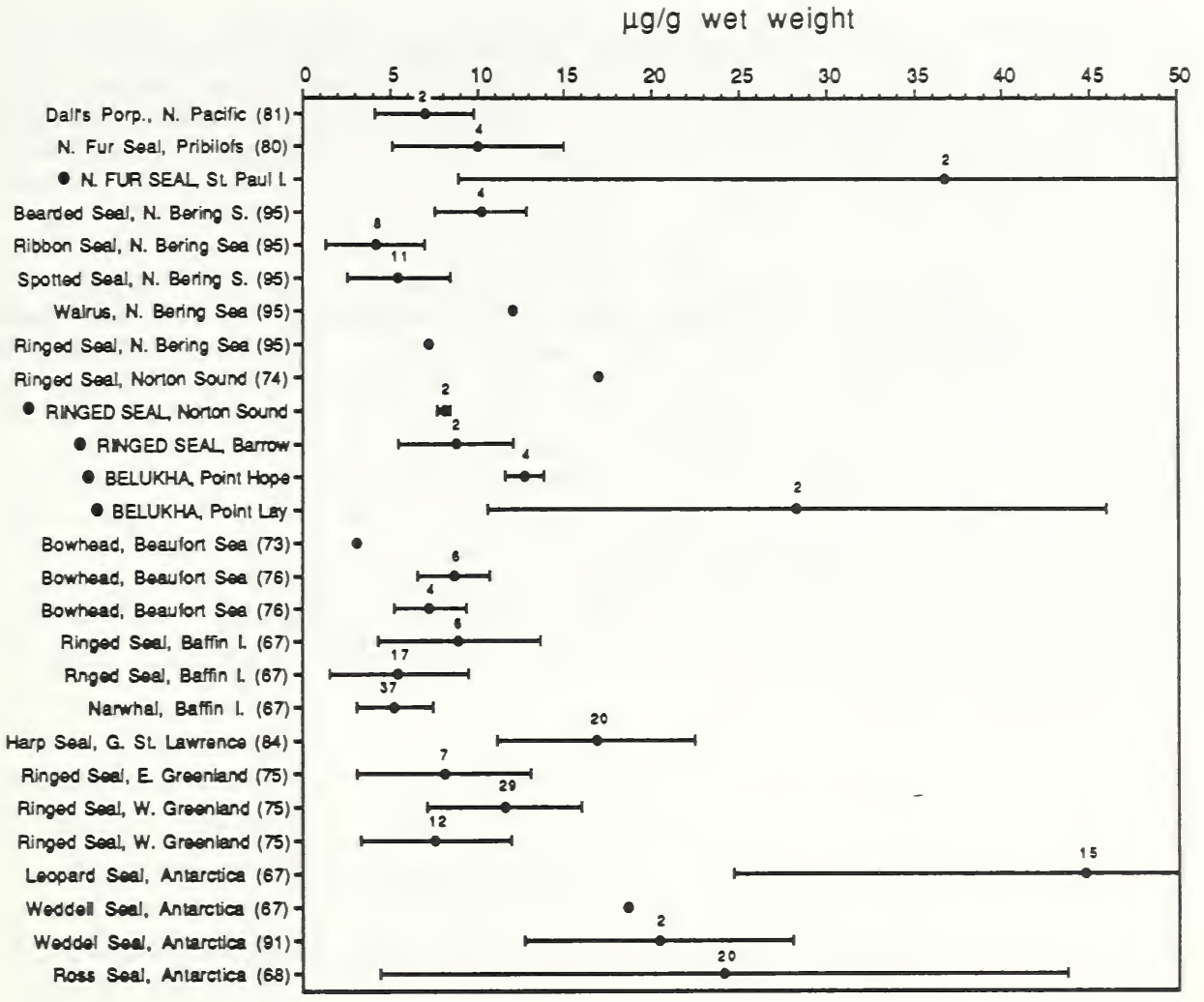


Figure 18. Concentration of copper reported in liver of marine mammals from the North Pacific, Arctic, and Antarctic. Values (mean ± SD, *n* above mean) are listed geographically from the North Pacific eastward to Greenland. *AMMTAP* samples are indicated by ●.

The levels that we found in both the Point Hope and Point Lay belukha whales fall within the large range reported recently by Wagemann and associates for Arctic belukhas from Canada [69], 3.0 - 1241 µg/g dry weight (n = 109) as compared to 43.4 - 57.1 µg/g dry weight for the Point Hope animals and 65.3 - 160.6 µg/g dry weight for the Point Lay animals.

Copper concentration tends to vary among and within species and attempts to correlate copper concentration in marine mammal tissues with areas of pollution have not been successful [64]. Diet appears to be important in

determining copper levels. McClurg suggested that the relatively high levels in the Ross seal from the Antarctic is a reflection of the naturally higher levels of this trace element in its principal prey, squid [68]. Dietary intake also may control levels of copper for the northern fur seals and belukha whales that we sampled.

Nickel. Although data on the levels of this element in marine mammals are limited, the reported nickel values tend to be less than 0.5 ppm, wet weight [64]. The concentration of nickel in liver tissue from the animals that we sampled were all an order of magnitude less than 0.5 ppm (Figures 16 and 19). All of the *AMMTAP* values were at the lower end of the range for human liver samples archived in the National Biomonitoring Specimen Bank (i.e.,< 0.01 - 0.1 ppm, wet weight) [70]. These lower values might be reflective of the procedures used by the *AMMTAP* (and the NBSB) to minimize contamination of the specimens during sampling, handling, and analysis (e.g., use of titanium tools, Teflon containers, etc.).

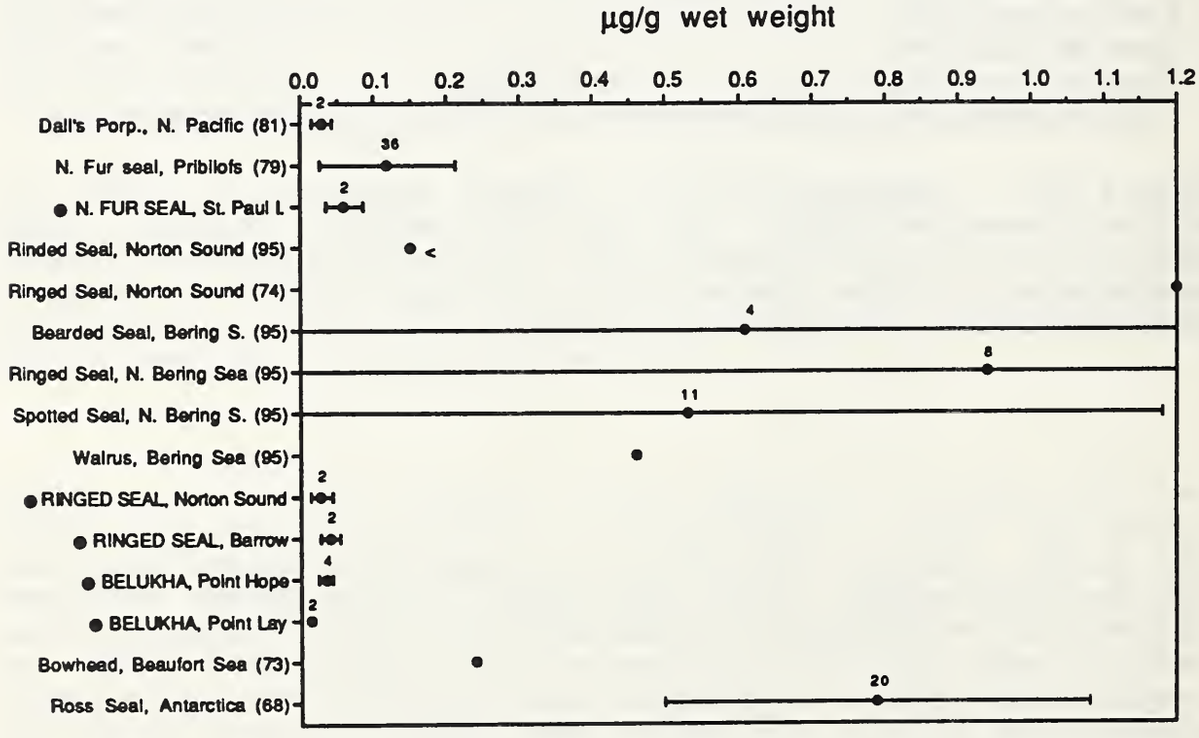


Figure 19. Concentration of nickel reported in liver of marine mammals from the North Pacific, Arctic, and Antarctic. Values (mean ± SD, *n* above mean) are listed geographically from the North Pacific eastward to Canada. *AMMTAP* samples are indicated by ●.

Chromium. Chromium is an essential element involved in glucose and lipid metabolism in animals. Although existing data are somewhat limited, the levels reported in marine mammals have been usually less than 1 ppm [68, 71-74] (Figure 20). The levels reported for liver tissue in the *AMMTAP* are mostly less than 0.1 ppm, falling within the range reported for human liver samples archived in the National Biomonitoring Specimen Bank (i.e., < 0.01 - 0.234 ppm, wet weight) [70]. As with nickel, the lower values of chromium for the *AMMTAP* samples might be reflective of the procedures used in the NBSB to minimize sample contamination.

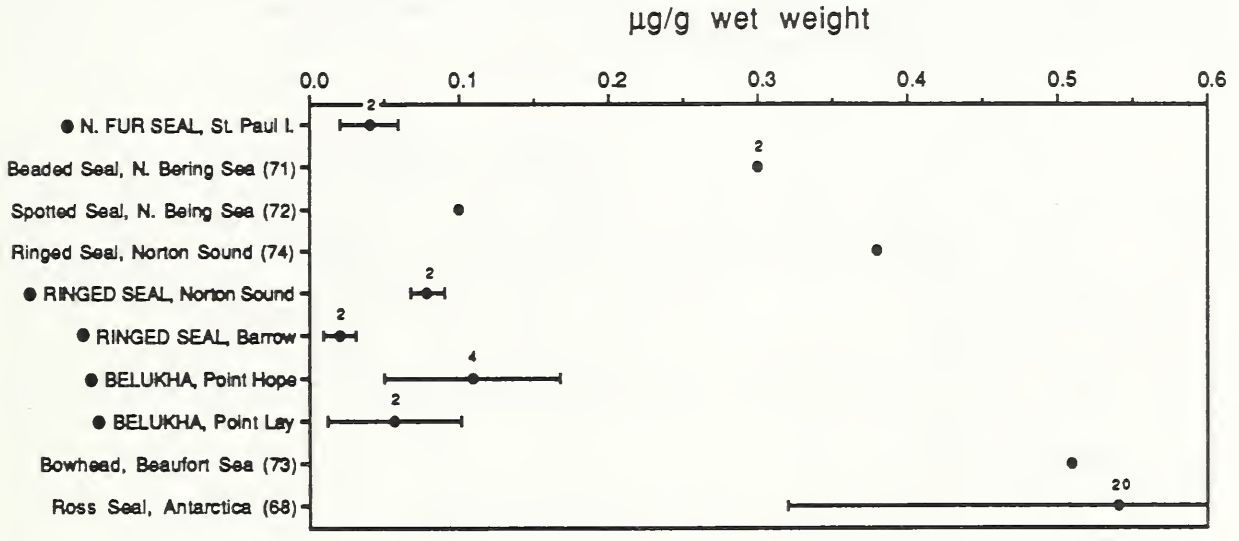


Figure 20. Concentration of chromium reported in liver of marine mammals from the Arctic and Antarctic. Values (mean ± SD, *n* above mean) are listed geographically from the Bering Sea eastward to Canada. *AMMTAP* samples are indicated by ●.

Lead. Lead is a non-essential element that has probably increased markedly in the environment in recent decades due to anthropogenic sources. Although most of the environmental exposure is probably of lead in its inorganic form, the organic alkyl lead, which is lipid soluble results in a more severe toxic response. Although tetraethyl- and tetramethyl-lead degrade rapidly, triethyl-lead is relatively stable and once absorbed by mammals, it becomes rapidly distributed among brain, liver, kidney, and blood. Lead particles are readily absorbed in mammals via the respiratory system (90 %). Gastrointestinal absorption is age dependent in humans and is probably age dependent for

most mammals: 5-10% in adults and 30-40 % in young. The principal route of excretion is urinary.

The highest lead concentrations in livers for the animals analyzed were for belukha whales taken at Point Hope (0.046 - 0.118 μg/g wet weight) and Point Lay (0.43 - 0.0651 μg/g wet weight) which are in the mid-range of values reported for both Arctic and Antarctic marine mammals [52, 67, 68, 73, 75-77] (Figure 21) and are an order of magnitude lower than that reported for human liver: 0.12-1.66 ppm wet weight [70]. Higher levels of lead occur in animals that are closest to anthropogenic sources. For example, liver levels in otters from Orkney Islands, British Isles, were found to have lead levels ranging from 0.13 to 3.65 ppm wet weight [78], and the upper level values for belukha liver samples from the Gulf of St. Lawrence were reported to be an order of magnitude higher than the values we measured in the Point Hope and Point Lay animals [69].

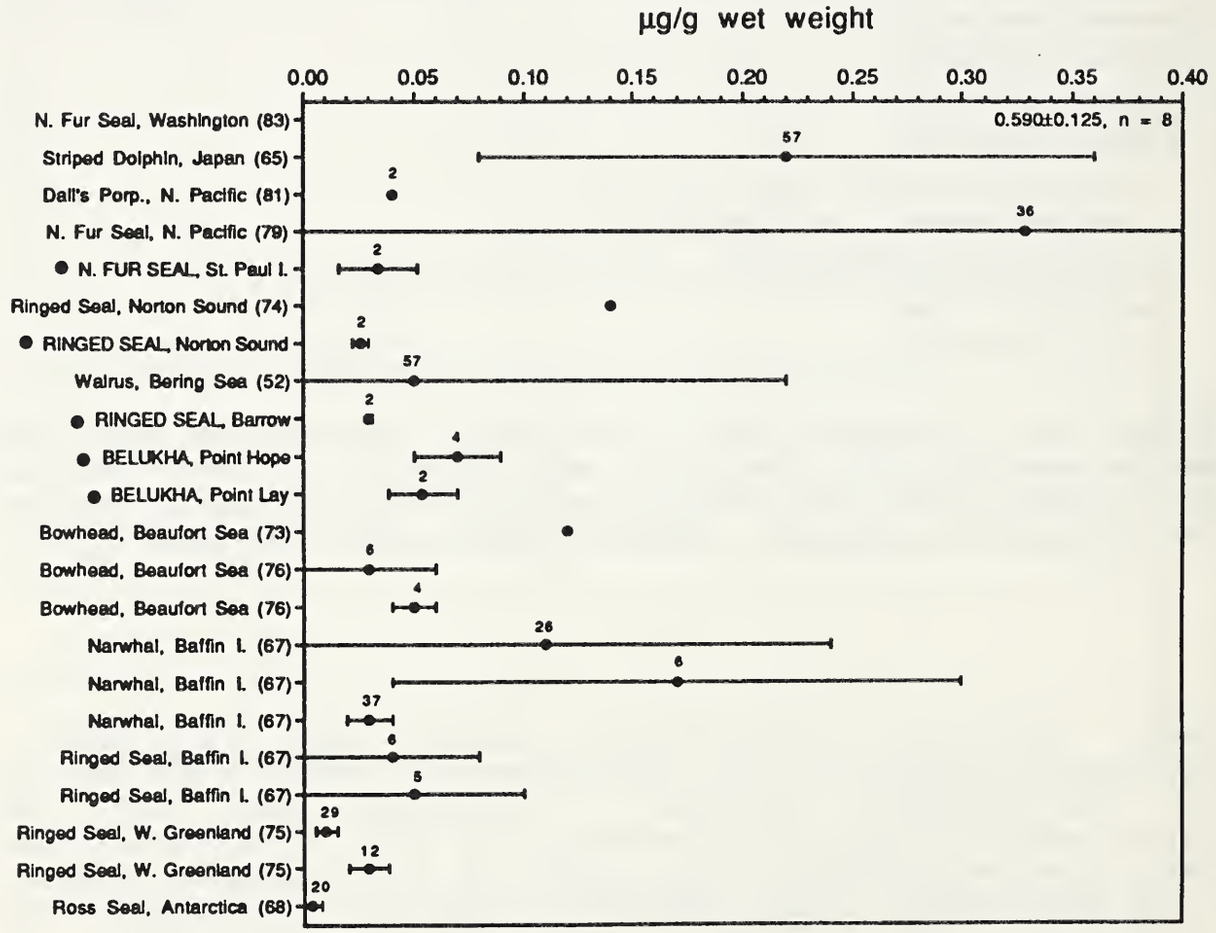


Figure 21. Concentration of lead reported in liver of marine mammals from the North Pacific, Arctic and Antarctic. Values (mean ± SD, *n* above mean) are listed geographically from the North Pacific eastward to Greenland *AMMTAP* samples are indicated by ●.

Cadmium. Cadmium is a non-essential element, with limited metabolic regulation by mammals. Highest concentrations occur in kidney and liver of mammals and birds, with most of the body burden occurring in the kidney. It has an extremely long half-life (30 years in humans) and unlike other metals, including mercury, little or no cadmium is transferred from females to newborn via lactation. As in the case of mercury, cadmium is incorporated in a metallothionein complex in the liver and kidney and may combine with selenium to form an insoluble cadmium selenide complex, thereby reducing the toxicity of the metal.

Existing data on cadmium in marine mammals is quite extensive and is probably exceeded only by the database on mercury. Most recently cadmium levels of walrus sampled in the northern Bering Sea have been reported to be relatively high: 1.4 - 50 ppm wet weight in liver [52] (Figure 22). Cadmium levels in the liver of bowhead whales sampled in the Beaufort Sea have been reported recently [73,76].

For the samples that we analyzed, the concentration of cadmium was highest in northern fur seal liver and kidney, the values being the same order of magnitude as previously reported for this species [79-80] (Figure 22). The concentrations (based on wet weight) that we found in liver (8.01 - 18.51 ppm), muscle (0.26 - 0.39 ppm), and kidney (29.02 - 66.6 ppm) are similar to levels reported for two Dall's porpoise (*Phocoenoides dalli*) taken at the end of the Aleutian chain in 1982: liver, 3.86 - 20.6 ppm; muscle, 0.09 - 0.35 ppm; kidney, 20.1 - 34.0 ppm [81]. Both species are found in the same geographic area and have similar food habits, preying on squid and deep-water fish.

For other species sampled by the *AMMTAP*, cadmium levels were relatively low (Figure 16). The highest levels were measured in the liver samples from the belukha whales from Point Lay: 3.6 - 3.65 μg/g wet weight or 14.22 - 15.09 μg/g dry weight. These values are within the range of cadmium values published recently for belukha liver samples from Western Greenland (<0.015 - 8.54 μg/g wet weight) [82] and are consistent with values reported for belukhas from the MacKenzie River Delta (0.28 - 23.6 μg/g dry weight) [69].

Mercury. Mercury is a non-essential, toxic trace element that tends to concentrate to its highest level in liver tissue. The relatively high concentration values for this element in marine mammal tissues is quite well known. The database on mercury in marine mammals is probably the largest of all the heavy metals. Concentration values of mercury among species, within species, and among geographical areas vary quite widely. This trace element tends to bioaccumulate quite readily, since it is not easily regulated internally by vertebrates. The organic form,

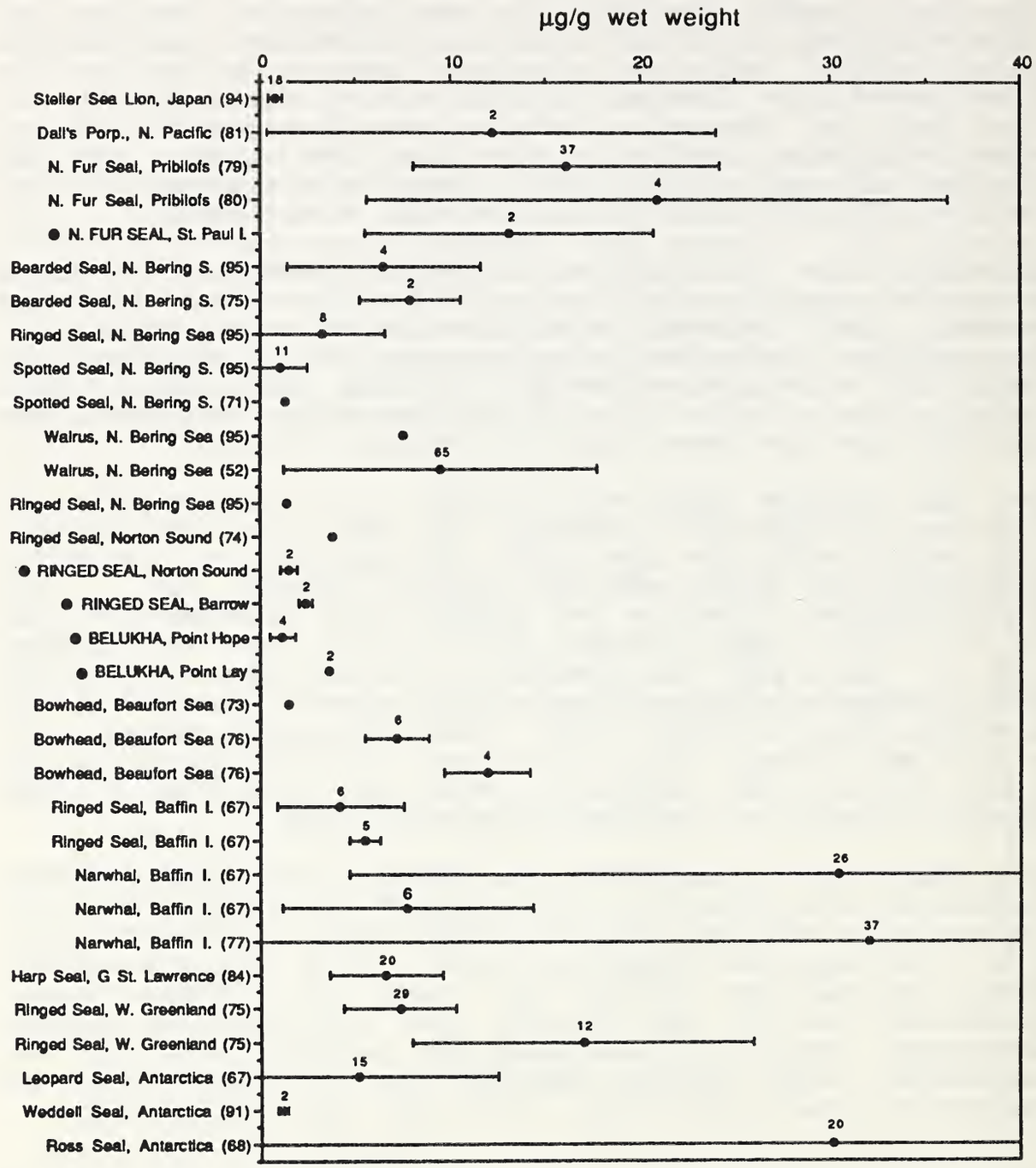


Figure 22. Concentration of cadmium reported in liver of marine mammals from the North Pacific, Arctic and Antarctic. Values (mean ± SD, *n* above mean) are listed geographically from the North Pacific eastward to Greenland. *AMMTAP* samples are indicated by ●.

particularly methyl mercury, has a relatively long half-life and is relatively toxic. There is evidence to support the idea that both seabirds and marine mammals have the metabolic ability to de-methylate the methyl mercury, converting it to inorganic mercury which is less toxic, can be stored in relatively high levels within a metallothionein complex or selenium complex, and is eventually excreted. This ability to de-methylate organic mercury appears to be an adaptive means of maintaining high body burdens derived from fish prey high in mercury content. The de-methylation ability may not be present in newborn and young animals; at least this appears to be the case for some pinnipeds.

The northern fur seals had values ranging from 7.65 - 10.8 μg/g wet weight (Figure 23). These results are consistent with total mercury levels published in 1974 for northern fur seals from the Pribilof Islands, but on the lower end of the range reported for this species a decade later (4.09 - 42.9 μg/g) [83, 79]. As compared to values for other marine mammals in the Arctic [52, 67, 74, 77, 84], values for the ringed seal tissues analyzed by the *AMMTAP* were relatively low (1.4 - 6.35 μg/g). The beluga samples from Point Lay had the highest *AMMTAP* values for mercury in liver (24.6 - 72.9 μg/g wet weight or 102.0 - 287.9 μ/g dry weight), which were much higher than those found in the liver samples from Point Hope belugas (1.40 - 10.2 μg/g wet weight or 5.6 - 36.3 μg/g dry weight). The values from the Point Lay animals were in the upper range of liver concentration values reported recently from a large number of belugas sampled in western Greenland (0.07 - 30.8 μg/g wet weight, n = 40) [82] and in the Mackenzie Delta, Beaufort Sea (0.46 - 182 μg/g dry weight, n = 42) [69]. Some of the highest recently published mercury values for beluga liver samples are for animals from the St. Lawrence Estuary in eastern Canada (1.42 - 756 μg/g dry weight, n = 30) [69].

To put the *AMMTAP* mercury values into perspective, the highest value reported for marine mammal liver tissue from the western Arctic (Greenland, Canada, and Alaska) was 143 ppm (wet weight mean value with standard deviation of 170 ppm) for bearded seals from Victoria Island [85]. In 1978, Kari and Kauranen reported maximum values of 300 and 510 ppm for ringed seals from Bothnian Bay and Western Finland [86], and an earlier publication by Henriksson (1969) reported a maximum value of 210 ppm for ringed seals from the Baltic Sea [87]. The concentration of methyl mercury in the liver tissue of the animals that we sampled were all below 1 ppm, except for one belukha whale (BLKA-007) sampled at Point Lay which had a concentration of 2.15 ppm wet weight (Figure 24). According to Dietz and his co-workers, methyl mercury concentrations in liver tissue of healthy seals and whales rarely exceed 2 ppm wet weight [88].

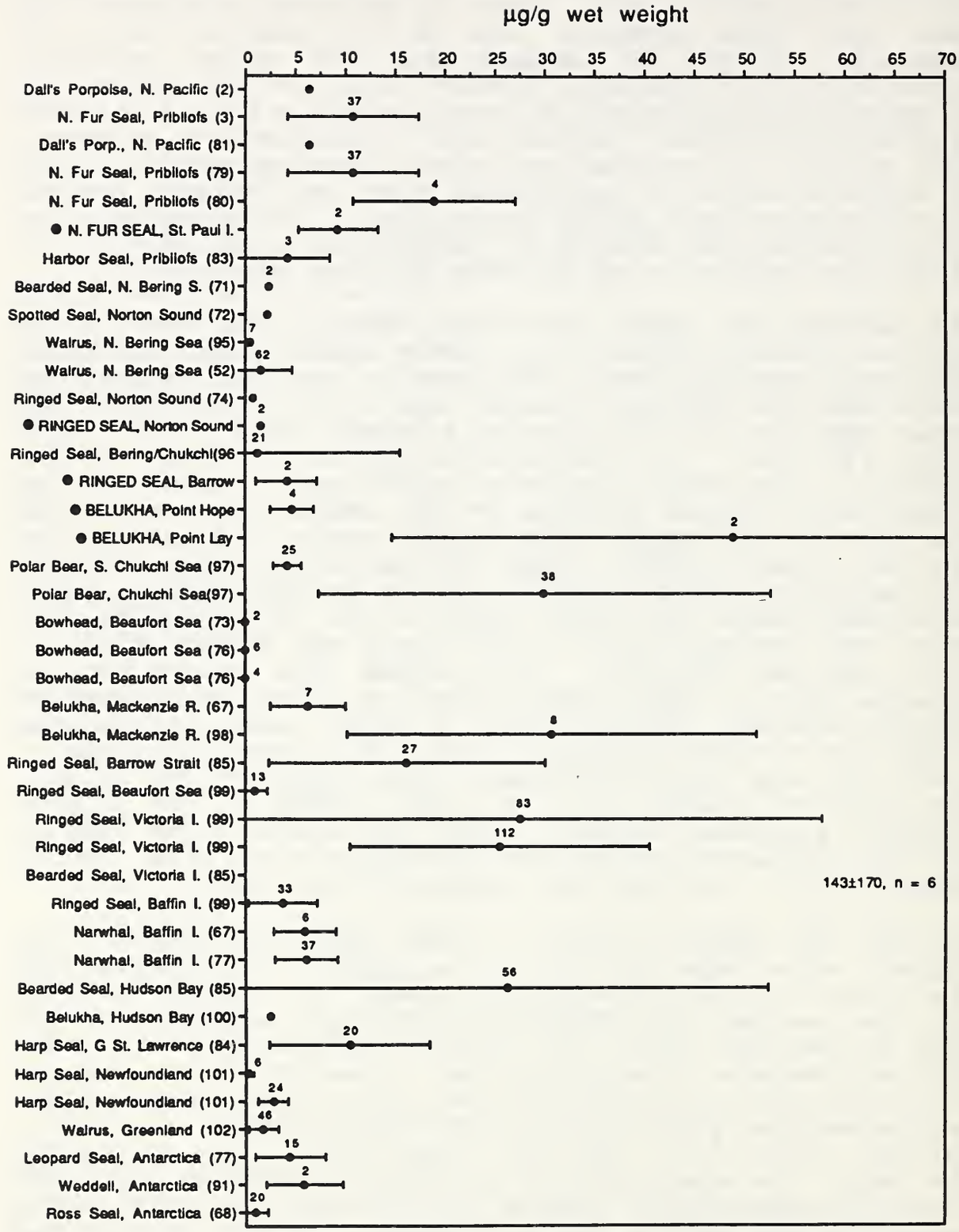


Figure 23. Concentration of total mercury reported in liver of marine mammals from the North Pacific, Arctic and Antarctic. Values (mean ± SD, *n* above mean) are listed geographically from the North Pacific eastward to Greenland. *AMMTAP* samples are designated by ●.

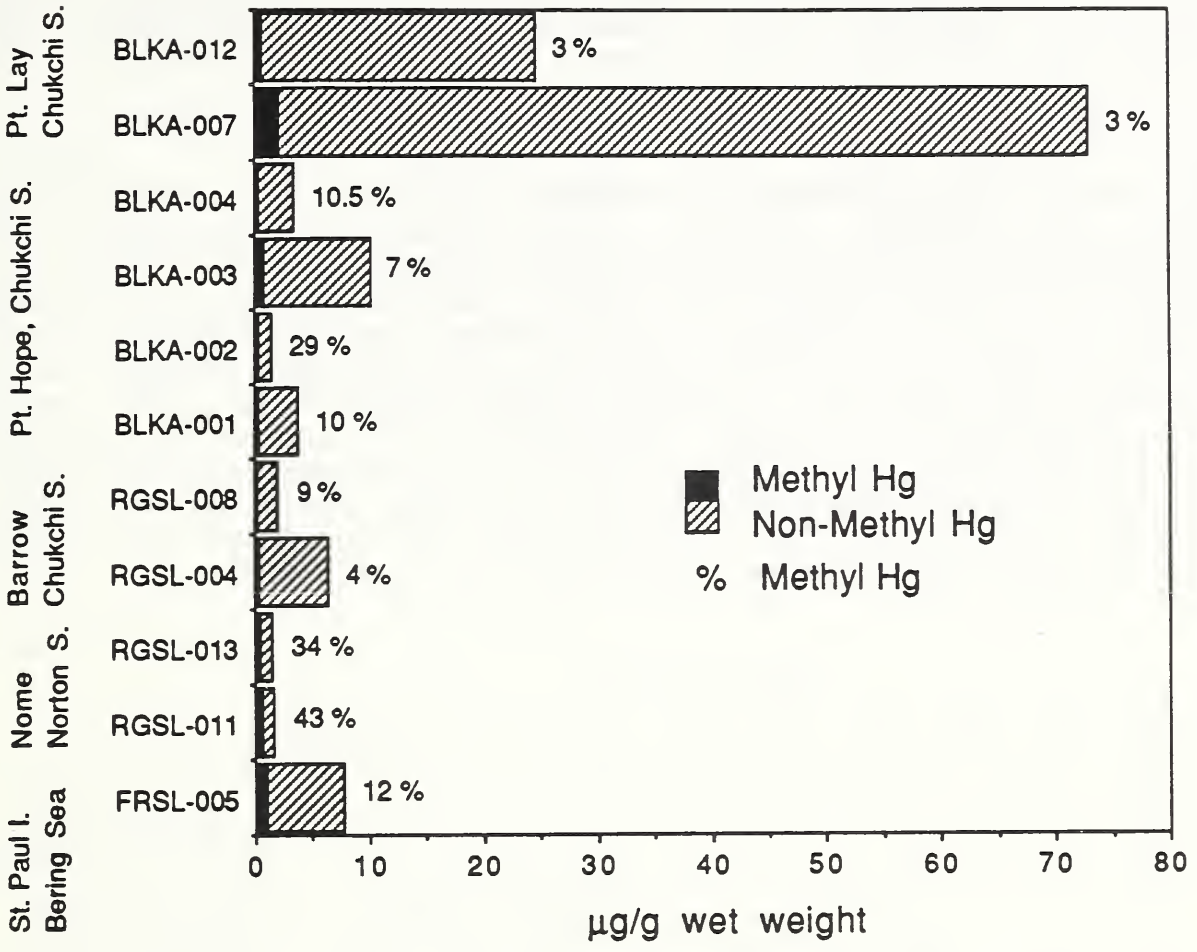


Figure 24. Mercury concentration measured in marine mammal liver tissue from the *AMMTAP*.

When one compares the ringed seals from the Chukchi Sea with those from Nome, the lowest concentration of total mercury was for those animals from Nome, while the lowest concentration of methyl mercury were for those animals from the Chukchi Sea. This relationship is shown even more clearly when comparing the percentages of methyl to total mercury (Figure 24). The ability to de-methylate organic mercury appears to be greater in mature animals than in young immature individuals [65, 89]. These differences, therefore, might be age related since the animals from Norton Sound were younger than those from the Chukchi Sea and there were higher levels of total mercury in the livers of the older animals. This age-related difference is probably also reflected in the difference in concentrations of methyl and total mercury in the belukhas from Point Lay

and Point Hope. Although absolute ages of these animals have yet to be determined, based on size and coloration the Point Lay animals appear to be older than those from Point Hope. The apparently older Point Lay animals have much higher concentrations of total mercury when compared to the Point Hope animals, with a small fraction of the total being in the form of methyl mercury.

Arsenic. The database for arsenic is limited as compared to that for cadmium, mercury, zinc, copper, lead, etc. The concentration range of arsenic in liver is shown in Figure 25 for several species of Arctic marine mammals including those that we sampled. All arsenic concentrations were below 1 ppm, wet weight, except for the two ringed seals sampled in Norton Sound which had relatively high concentrations. Arsenic in seabirds and marine mammals rarely exceed 1 ppm, wet weight, in any tissue, while levels in fish muscle are commonly one or two orders of magnitude higher [64]. The two animals from Norton Sound had liver values approaching those reported for fish muscle.

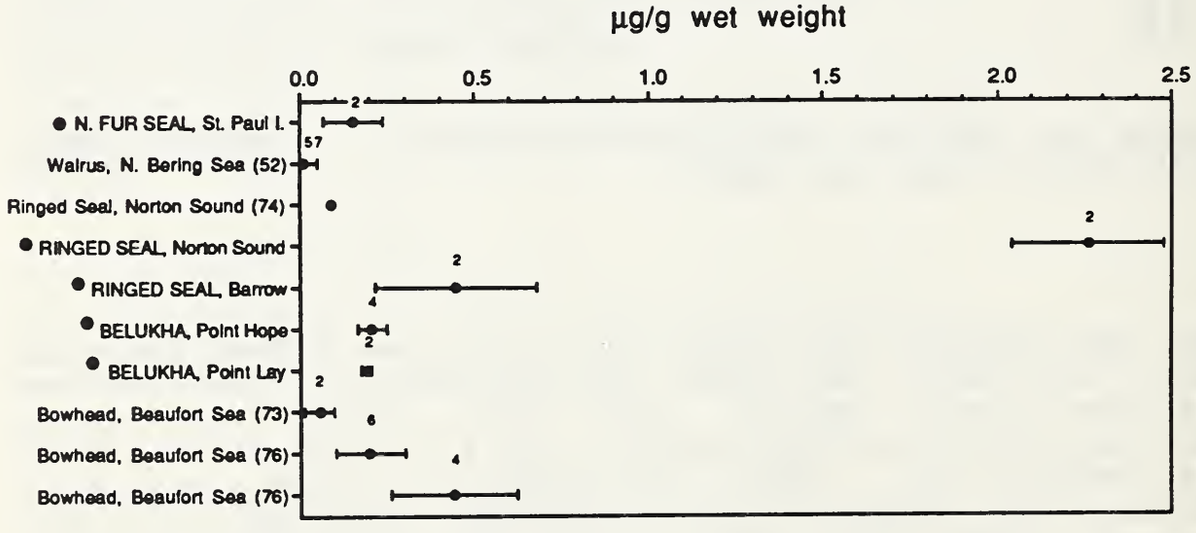


Figure 25. Concentration of arsenic reported in liver of marine mammals from the Arctic. Values (mean ± SD, n above mean) are listed geographically from the Bering to the Beaufort Sea. *AMMTAP* samples are indicated by ●.

Silver. Silver is not generally considered an essential element. In mammals, the principal organ of accumulation is the liver. Once absorbed into the circulatory system, silver complexes with serum albumin and then accumulates in the liver. A small fraction is excreted via the gastrointestine.

There is very little data on the levels of silver in marine mammals. Liver levels that have been reported are substantially higher than those for humans (Figure 26). For the pinnipeds that we analyzed, silver values ranged from 0.05 ppm to 0.36 ppm wet weight. Concentrations for humans range from < 0.005 to 0.018 ppm wet weight [70]. We found high levels of silver in the belukha whale livers, for both those animals sampled at Point Hope and for those sampled at Point Lay. Values ranged from 14 - 107 ppm wet weight (Figures 16 and 26). Although high, these values, like those of mercury, appear to be correlated with selenium (refer to the following discussion on selenium).

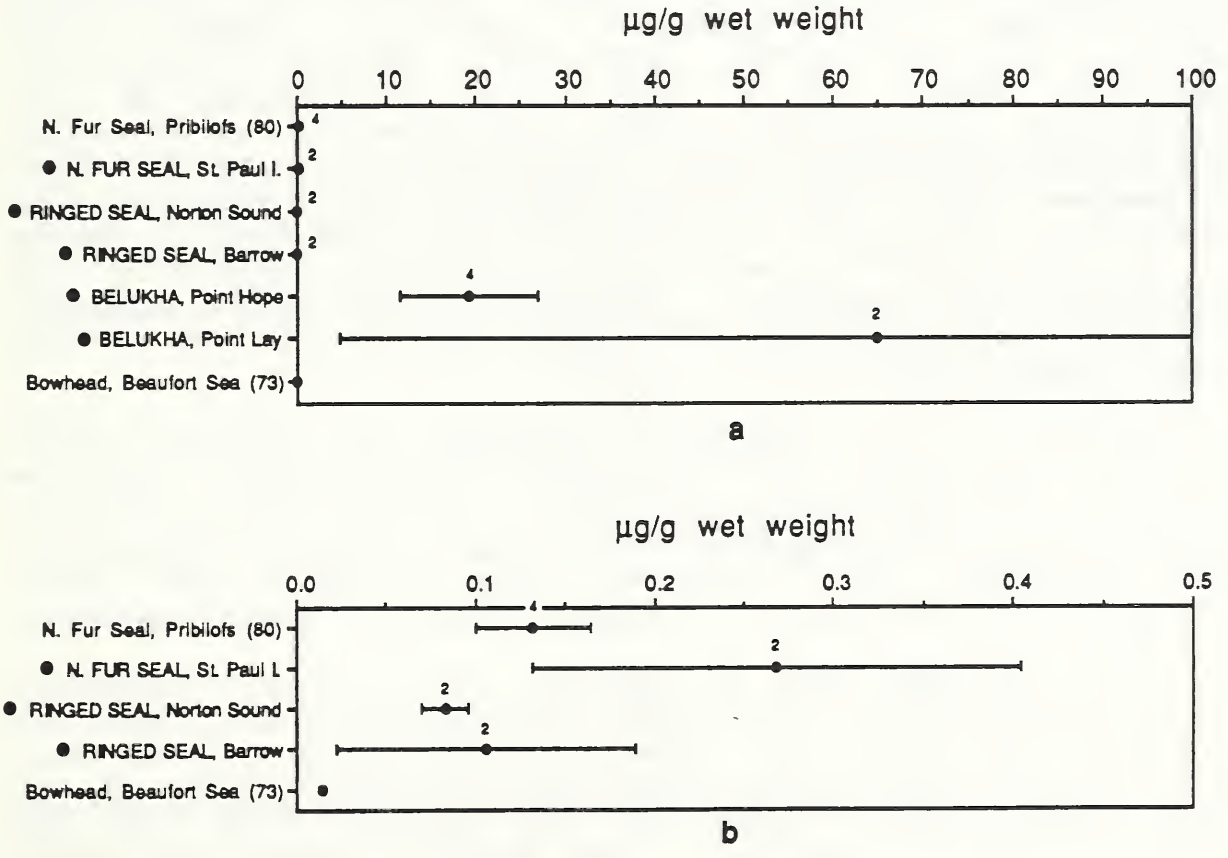


Figure 26. Concentration of silver reported in liver of marine mammals from the Arctic. Values (mean ± SD, *n* above mean) are listed geographically from the Bering to the Beaufort Sea. *AMMTAP* samples are indicated by ●. The *AMMTAP* belukha samples are not included in b.

Selenium. Selenium is an essential element believed to have an antidotal action on the toxic effects of mercury, cadmium, arsenic, copper, and thallium. Although the mechanism for this action is not clear, two possibilities are that the selenium stimulates the formation of metallothioneins or that heavy metals are tied-up in insoluble selenide compounds. Concentrations of silver and selenium can also be related. The case of silver differs from other selenium-metal interactions in that silver can cause the symptoms of selenium deficiency in vitamin E-deficient animals by the formation of a silver-selenium complex that may reduce the available selenium required for normal cellular processes [90]. Within physiologic limits, mammals appear to have a homeostatic mechanism for retaining trace amounts of selenium and excreting the excess material. Toxic effects can occur when rate of intake exceeds the excretory capacity.

Selenium levels in marine mammals tend to vary quite widely and many researchers have been able to demonstrate a positive correlation of selenium levels in liver and kidney with levels of mercury and cadmium. Correlation analysis was conducted on the *AMMTAP* liver data for the following inter-related trace elements: selenium, copper, zinc cadmium, arsenic, silver, and total mercury (Table 7). Since the data set is small, the reliability of the correlation coefficients were estimated by determining confidence intervals based on Fishers *z* transformation procedures [103]. The 99 % confidence intervals for the apparently significant correlations are presented in Table 8. For the *AMMTAP* liver samples selenium levels were not correlated with cadmium. Selenium levels were, however, strongly and positively correlated with total mercury and silver levels (Figure 27).

The levels of liver selenium reported for various marine mammals, including those measured in the animals that we sampled, were generally at least an order of magnitude higher than those reported for human liver tissue [70]. This parallels the situation with mercury and other selenium-related elements in human vs marine mammal tissues.

For those animals that we sampled, the highest levels of selenium occurred in the belukha whales from the Chukchi Sea (animals from both Point Hope and Point Lay) (Figure 28). These levels are in the same range as those reported for ringed seals from Finland [26, 86], animals that also had elevated levels of mercury. The belukha whales from Point Hope did not have elevated levels of mercury; however, those from Point Lay did. Elevated levels of selenium in the belukha whales might be related to both mercury and silver.

Table 7. Correlation matrix for selected trace elements in *AMMTAP* liver samples. Significant values at 5% > 0.576 and at 1% > 0.708 (d.f. = 10).

	Se	Cu	Zn	Cd	As	Ag	Hg
Se	**1.000**	0.481	-0.366	-0.016	-0.237	**0.974**	**0.987**
Cu	0.481	**1.000**	0.389	**0.821**	-0.377	0.399	0.545
Zn	-0.366	0.389	**1.000**	**0.722**	-0.181	-0.450	-0.309
Cd	-0.016	**0.821**	**0.722**	**1.000**	-0.246	-0.139	0.089
As	-0.237	-0.377	-0.181	-0.246	**1.000**	-0.289	-0.273
Ag	**0.974**	0.399	-0.450	-0.139	-0.289	**1.000**	**0.936**
Hg	**0.987**	0.545	-0.309	0.089	-0.273	**0.936**	**1.000**

Table 8. Confidence intervals for r values in Table 17 that appear to be positively correlated. Significant r values at 5% > 0.576 and at 1% > 0.708.

	r	z	$sigma_z$	99 % Confidence Interval
Se:Hg	.987	2.515	.999	.908 < r < .997
Se:Ag	.974	2.165	.999	.823 < r < .995
Hg:Ag	.936	1.705	.999	.640 < r < .992
Cu:Cd	.821	1.157	.999	.158 < r < .974
Cd:Zn	.722	0.908	.999	.090 < r < .962

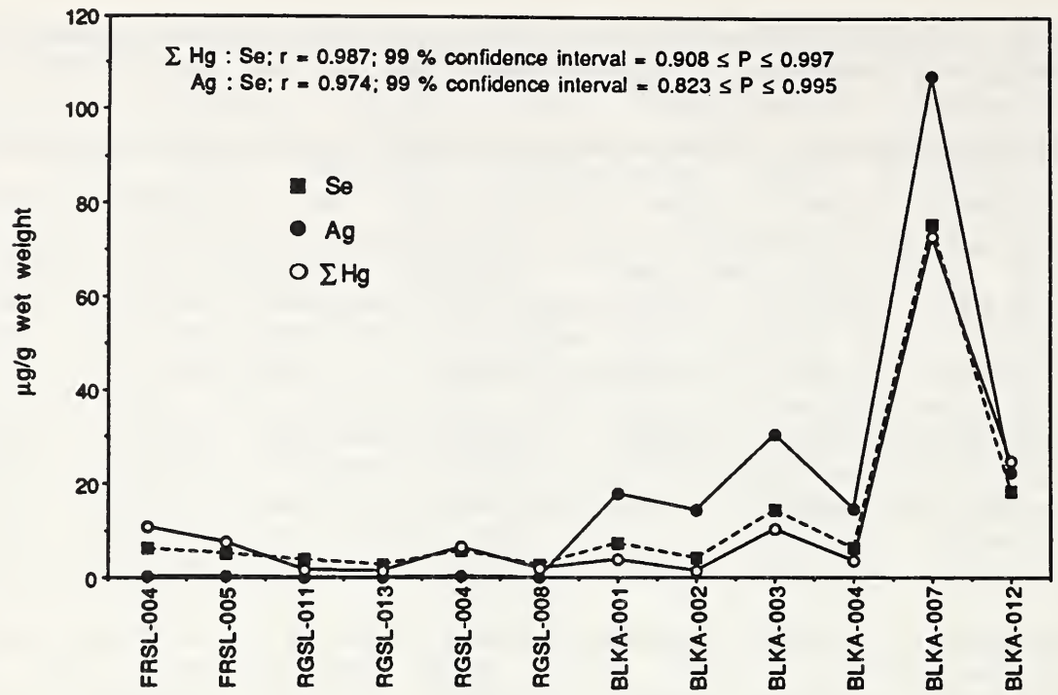


Figure 27. Comparison of Se, Hg, and Ag in *AMMTAP* liver tissue.

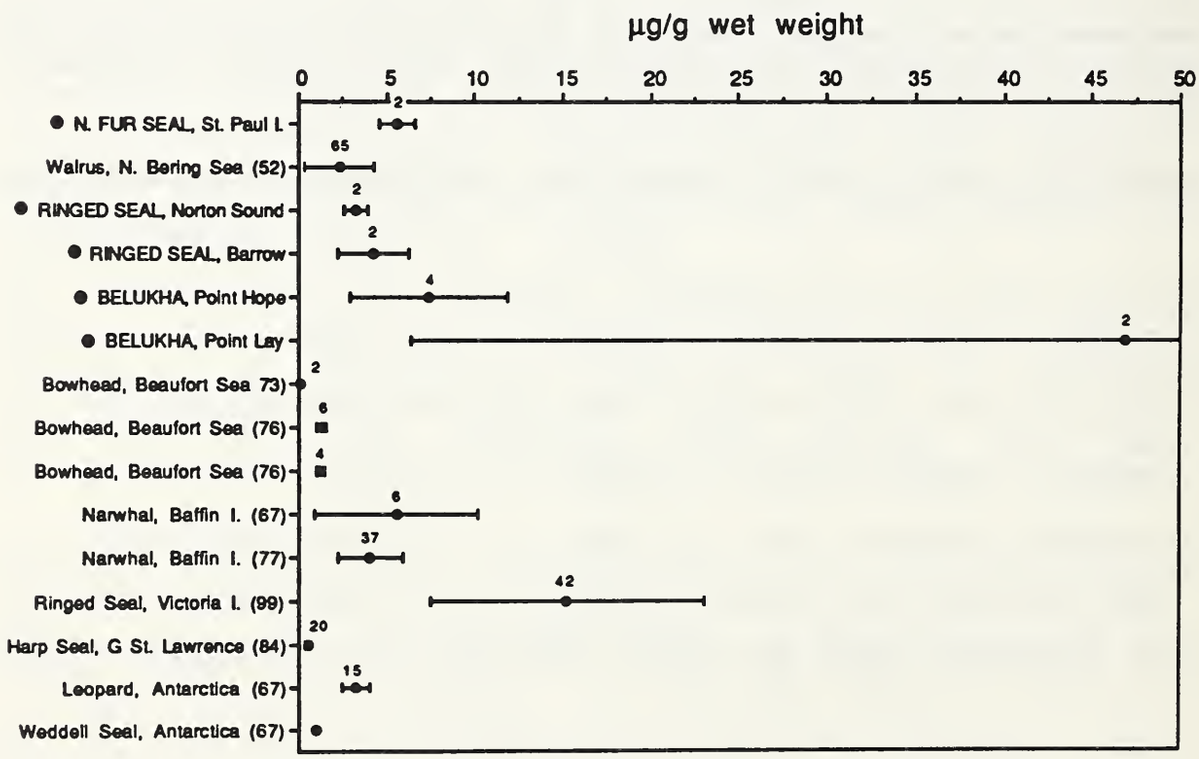


Figure 28. Concentration of selenium reported in liver of marine mammals from the Arctic and Antarctic. Values (mean ± SD, *n* above mean) are listed geographically from the Bering Sea to Eastern Canada. *AMMTAP* samples are indicated by ●.

Vanadium. We could locate no data on vanadium in marine mammals to compare with our results. Liver concentration values were all below 0.5 ppm wet weight ranging from 0.034 to 0.395 ppm (Figure 19). These results are higher than those reported for human liver samples (< 0.02 ppm) [70].

Manganese. Manganese is an essential element in mammals, being a cofactor in several enzymatic reactions, particularly those involved in phosphorylation, cholesterol, and fatty acid synthesis. Organs containing the highest levels of manganese are the liver and kidney. The major route of excretion is gastrointestinal, and it is readily regulated, at least in humans [90].

Based on the limited amount of data in the literature, Thompson indicates that the concentration of manganese in all tissue types in marine mammals tends to be less than 7 ppm wet weight [64]. The liver concentration of this element for the animals that we analyzed ranged from 1.7 to 4.3 ppm wet weight (Figure 16). Values between 1 and 2 ppm wet weight have been reported for liver samples from the Weddell seal in Antarctica [91]. The values for marine mammals in Alaska and the Antarctic are consistent with concentrations found in Bering Sea seabird liver samples [92], and they are somewhat higher than human liver values (0.6 - 2.03 ppm wet weight) [70].

Other Elements. Other elements determined in the *AMMTAP* include some mineral elements such as sodium, magnesium, aluminum, chlorine, potassium, calcium, rubidium, iodine, and cesium as well as transition metals at trace levels such as cobalt, molybdenum, and antimony. Iron was also determined at 0.1 - 1 mg/g levels. Some of these results (Appendices, Tables A.5 - A.8) may have future value for determining the health status of the investigated marine mammals as the data base continues to grow. The elements that were found to be below the detection limit of the applied procedure were: aluminum <0.1 μg/g; scandium <0.5 ng/g; titanium and strontium <2 μg/g; tin <1 μg/g; barium < μg/g; lanthanum, cerium, and samarium <10 ng/g; europium, terbium, hafnium, tantalum, gold, and thorium <1 ng/g; and uranium <0.1 μg/g. These detection limits are for liver tissue; kidney and muscle tissue are lower.

REFERENCES

1 Becker, P.R.; Wise, S.A.; Koster, B.J.; Zeisler, R. *Alaskan Marine Mammal Tissue Archival Project: A Project Description Including Collection Protocols*, NBSIR 88-3750, U.S. Department of Commerce, National Bureau of Standards, Gaithersburg, Maryland, **1988**, 46 pp.

2 Becker, P.R.; Wise, S.A.; Koster, B.J.; Zeisler, R. *Alaska Marine Mammal Tissue Archival Project: Revised Collection Protocol*, NISTIR 4529, U.S. Department of Commerce, National Institute of Standards and Technology, Gaithersburg, Maryland, **1991**, 33 pp.

3 Schantz, M.M; Benner, B.A., Jr., Chesler, S.N.; Koster, B.J.; Hehn, K.E.; Stone, S.F.; Kelly, W.R.; Zeisler, R.; Wise, S.A. *Fresenius J. Anal. Chem.*, **1990**, 338, 501-514.

4 Wise, S.A.; Benner, B.A., Jr.; Christensen, R.G.; Koster, B.J.; Kurz, J.; Schantz, M.M.; Zeisler, R. *Environ Sci. Technol.*, **1991**, 25, 1695-1704.

5 Zeisler, R.; Stone, S.F.; Sanders, R.W. *Anal. Chem.*, **1988**, 60, 2760-2765.

6 Ostapczuk, P.; Valenta, P.; Nürnberg, H.W. *Electoanal. Chem.*, **1986**, 214, 51-64.

7 Ostapczuk, P.; Froning, M.; Stoeppler, M. *Fresenius Z. Anal. Chem.*, **1989**, 334, 661.

8 May, K.; Stoeppler, M. *Fresenius Z. Anal. Chem.*, **1984**, 317, 248-251.

9 May, K.; Stoeppler, M.; Reisinger, *Toxicol. Environ. Chem.*, **1987**, 13, 153-159.

10 Zeisler, R.; Langland, J. K.; Harrison, S. H. *Anal. Chem.*, **1983**, 55, 2431-2434.

11 Parris, R.M.; Chelser, S.N.; Wise, S.A. In: *Progress in Environmenal Specimen Banking*, S.A. Wise, R. Zeisler, and G.M. Goldstein, Eds., Natl. Bur. Stand. Spec. Publ 740, US Government Printing Office, Washington, DC, **1988**, 74-81.

12 Menzie, C.M., *Metabolism of Pesticides*, U.S. Department of the Interior, Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, Special Scientific Report-Wildlife No. 127, Washington, DC, **1969**, 487 p.

13 Menzie, C.M., *Metabolism of Pesticides, an Update*, U.S. Department of the Interior, Fish and Wildlife Service, Special Scientific Report-Wildlife No. 184, Washington, DC, **1974**, 486 p.

14 Meister, R.T., *Farm Chemical Handbook*, 72nd Edition, Meister Publishing Co., Willoughby, Ohio, **1986**.

15 Ballschmiter, K.; Zell, M. Intern. *J. Environ. Anal. Chem.*, **1980**, 8, 15-35

16 Spencer, W.F., *Residue Reviews*, **1975**, 59, 91-117.

17 Mearns, A.J.; Matta, M.B.; Simecek-Beatty, D.; Buchman, M.F.; Shigenaka, G.; Wert, W.A., *PCB and Chlorinated Pesticide Contamination in the U.S. Fish and Shellfish: a Historical Assessment Report.* NOAA Technical Memorandum NOS OMA 39, Seattle, WA, **1988**, 140 p.

18 Aguilar, A., *Can. J. Fish. Aquat. Sci.*, **1984**, 41, 840-844.

19 Aguilar, A., *Marine Mammal Science*, **1987**, 3, 242-262.

20 Jones, D.; Ronald, K.; Lavigne, D.M.; Frank, R.; Holdrinet, M.; Uthe, J.F., *Sci. Total Environ.*, **1976**, 5, 181-195.

21 Holden, A.V., *Mammal Rev.*, **1978**, 8, 53-361.

22 Donkin, P.; Mann, S.V.; Hamilton, E.I., *Sci. Total Environ.*, **1981**, 19, 141-142

23 Helle, E.; Hyvarinen, H.; Pyysalo, H.; Wickstrom, K., *Mar. Poll. Bull.*, **1983**, 14, 256-260.

24 Addison, R.F.; Zinck, M.E.; Smith, T.G., *Environ. Sci. Technol.*, **1986**, 20, 253-256.

25 Addison, R.F.; Brodie, P.F.; Zinck, M.E.; Seargent, D.E., *Environ. Sci. Technol.*, **1984**, 18, 935-937.

26 Pertilla, M.; Stenman, O.; Pyysalo, H.; Wickstrom, K. *Mar. Environ. Res.*, **1986**, 18, 43-59.

27 Muir, D.C.G,; Ford, C.A.; Stewart, R.E.A.; Smith, T.G.; Addison, R.F.; Zinck, M.E.; Béland, P. *Can. Bull. Fish Aquat. Sci.*, **1990**, 224, 165-190.

28 Anas, R.E.; Wilson, A.J., *Pestic. Monit. J.*, **1970**, 3, 198-200.

29 Kurtz, D.A.; Kim, K.C., *Pestic. Monit. J.*, **1976**, 10, 79-83.

30 Kurtz, D.A., *Analysis of northern fur seals for the years 1975-1981 for DDT analogs and PCB mixtures.* Internal Report, Dept. of Entomology, Pensylvania State Univ., University Park, PA, **1984**, 27 p.

31 Kurtz, D.A., *PCB/DDT contamination in northern fur seals: 1984.* Report prepared for Nat. Geogr. Soc., Comm. Res. Explor., Grant No 2921-84, **1987**, 20 p.

32 Calambokidis, J. ; Peard, J. *Chlorinated hydrocarbons in tissues of northern fur seals from St. Paul Island, Alaska*, Final Report, Fur Seal Investigations, 1982, Pat Kozoloff, Ed., NOAA Tech. Memo. NMFS F/NWC-71, NMM Lab., Seattle, WA, **1985**, 75-79.

33 Galster, W.; Burns, J., *Accumulation of pesticides in Alaska marine mammals.* Proceedings from the Alaska Sicence Conference, University of Alaska, Fairbanks, Alaska. Abstract, **1972**, 23, 50.

34 Bowes, G.W.; Jonkel, C.J., *J. Fish. Res. Board Can.*, **1975**, 32, 2111-2123.

35 Muir, D.C.G; Ford, C.A.; Norstrom, R.J.; Simon, M., In Roots, F. and Shearer. R, eds, Proceedings of the Conference of Comite Arctique International on the Global Significance of the Transport and Accumulation of Polychlorinated Hydrocarbons in the Arctic, Plenum Publ., N.Y., **1990**, in press.

36 Thomas, D.J.; Hamilton, M.C., Organochlorine residues in biota of the Baffin Island region. SeaKem Oceanography Ltd., Sidney, B.C. Report prepared for Indian and Northern Affairs Canada, Ottawa, **1988**.

37 Andersson, Ö; Linder, C-E.; Olsson, M.; Reutergårdh, L.; Uvemo, U-B.; Wideqvist, U., *Arch. Environ. Contam. Toxicol.*, **1988**, 17, 755-765.

38 Oehme, M.; Fürst, P.; Krüger, C.; Meemken, H.A.; Groebel, W., *Chemosphere*, **1988**, 17, 1291-1300.

39 Addison, R.F.; Brodie, P.F., *J. Fish. Res. Board Can.*, **1973**, 30, 1733-1736.

40 Holden, A.V., In Ruivo, M., ed., *Marine Pollution and Sea Life*. Fishing News Books, London, **1972**, 262-272.

41 Addison, R.F.; Smith, T.G., *Oikos*, **1974**, 25, 335-337.

42 Clausen, J; Braestrup, L; Berg, O., Bull. Environ. Contam. Toxicol., **1974**, 12, 529-534.

43 Muir, D.C.G.; Norstrom, R.J.; Simon, M., *Environ. Sci. Technol.*, **1988**, 22, 1071-1079.

44 Duinker, J.C.; Hillebrand, M.T.J; Nolting, R.F., Mar. Poll. Bull., 1979, 19, 74-79.

45 Duinker, J.C.; Scurtz, D.E., Petrick, G. *Mar. Poll. Bull.*, **1988**, 19, 19-25.

46 Kannan, N.; Tanabe, S.; Ono, M.; Tatsukawa, R., *Arch. Environ. Contam. Toxicol.*, **1989**, 18, 850-857.

47 Larsen, B.; Riego, J. Intern. J. Environ. Anal. Chem., **1990**, 40, 59-68.

48 Ballschmiter, K., Schafer, W.; Buchert, H. Fresenius Z. Anal. Chem., **1987**, 326, 253-257.

49 Menzie, C.M., *Metabolism of Pesticides, Update III*, U.S. Department of the Interior, Fish and Wildlife Service, Special Scientific Report-Wildlife No. 232, **1980**, 707 p.

50 Gaskin, D.E.; Frank, R.; Holdrinet, M., *Arch. Environ. Contam. Toxicol.*, **1983**, 12, 211-219.

51 Kawano, M.; Matsushita, S.; Inoue, T.; Tanaka, H.; Tatsukawa, R., *Mar. Poll. Bull.*, **1986**, 17, 512-516.

52 Taylor, D.L.; Schliebe, S.; Metsker, H. Mar. Poll. Bull., **1989**, 20, 465-468.

53 National Research Council, Chlordane: Its Effects on Canadian Ecosystems and its Chemistry, Nat. Res. Coun. Can. No. 14094, **1974**, 189 p.

54 Helle, E.; Hyvarinen, H.; Pyysalo, H.; Wickstrom, K., *Mar. Poll. Bull.*, **1983**, 14, 256-260.

55 Kramer, W.; Buchert, H.; Reuter. U.; Biscioto, M.; Maul, D.G.; LeGrand, G.; Ballschmiter, K., *Chemosphere*, **1984**, 13, 1255.

56 Kawano, M.; Inoue, T.; Wada, T.; Hidaka, H.; Tatsukawa, R., *Environ. Sci. technol.*, **1988**, 22, 792-797.

57 Albright, L.J; Oloffs, P.C.; Szeto, S.Y., *J. Environ. Sci. Health*, Part B, **1980**, B15, 333.

58 Oloffs, P.C.; Albright, L.J.; Azeto, S.Y., *J. Environ. Sci. Health*, Part B, **1978**, B13, 47.

59 Atlas, E.; Giam, C.S., *Science*, **1981**, 211, 163-165.

60 Bidleman, T.F.; Leonard, R., *Science*, **1982**, 183, 516-518.

61 Oehme, M.; Mano, S., *Fresenius Anal. Chem.*, **1984**, 319, 141-146.

62 Moilianen, R.; Pyysalo, H.; Wickstrom, K.; Linko, R., *Bull. Environ. Contam. Toxicol.*, **1982**, 29, 334-340.

63 Kawano, M.; Inoue, T.; Hidaka, Hl.; Tatsukawa, R., *Chemosphere*, **1984**, 13, 95-100.

64 Thompson, D.R. In: *Heavy Metals in the Marine Environment*. R.W. Furness and P.S. Rainbow, Eds., CRC Press, Inc., Boca Raton, Florida, **1990**, 143-182.

65 Honda, K.; Tatsukawa, R.; Itano, K.; Miyazaki, N.; Fujiyama, T. *Agric. Biol. Chem.*, **1983**, 447, 1219-1228.

66 Martin, J.H.; Elliott, P.D.; Anderlini, V.C.; Girvin, D.; Jacobs, S.A.; Risebrough, R.W.; DeLong, R.L.; Gilmartin, W.G. *Mar. Biol.*, **1976**, 35, 91-104.

67 Wagemann, R.; Muir, D.C.G. *Concentrations of Heavy Metals and Organochlorines in Marine Mammals of Northern Waters: Overview and Evaluation*, Canadian Technical Report of Fisheries and Aquatic Sciences No. 1279, Winnipeg, Manitoba, **1984**, 97.

68 McClurg, T.P. *Mar. Poll. Bull.*, **1984**, 15, 384-389.

69 Wagemann, R.; Stewart, R.E.; Béland, P.; Desjardins, C., *Can. Bull. Fish. Aquat. Sci.*, **1990**, 224, 191-206.

70 Zeisler, R., R.R. Greenberg, and S.F. Stone, In: *The Pilot National Environmental Specimen Bank- Analysis of Human Liver Specimens*, R. Zeisler, S. H. Harrison, and S. A. Wise, Eds., Natl. Bur. Stand. Spec. Publ 656, US Government Printing Office, Washington, DC, **1983**, 81-89.

71 Rusanowski, P.C.; Gardner, L.A.; Jewett, S.C. *Nome Offshore Placer Project: Data Report and Proposed Long-Term Monitoring Plan*, Northern Technical Services, Anchorage, AK, **1986**.

72 Rusanowski, P.C.; Gardner, L.A.; Jewett, S.C. *Nome Offshore Placer Project: Annual Report*. Northern Technical Services, Anchorage, AK, **1987**.

73 Byrne, C.; Balasubramanian, R.; Overton, E.B.; Albert, T.F. *Mar. Poll. Bull.*, **1985**, 16, 497-498.

74 AT, Am Test, Inc., Analysis Report to West Gold, **1988**, 4 p.

75 Johansen, P; Kapel, F.O.; Kraul, I. *Heavy metals and organochlorines in marine mammals from Greenland,* Int. Couc. Explor. Sea ICES C.M., **1980**, E:32.

76 Bratton, G.R.; Flory, W.; Spainhaur, B. In: *Fifth Conference on the Biology of the Bowhead Whale, Balaena mysticetus,* April 1-3, 1990, Anchorage, Alaska, Extended Abstracts, **1990**

77 Wagemann, R.; Snow, N.B.; Lutz, A.; Scott, D.P. *Can J. Fish. Aquat. Sci.*, **1983**, 40 (Suppl.2), 206-214.

78 Mason, C.F.; Reynolds, P. *Mar. Poll. Bull.*, **1988**, 19, 80-81.

79 Goldblatt, C.J.; Anthony, R.G. *J. Environ. Quality*, **1983**, 12, 478-482.

80 Smith, D.R. *Trace Metal Concentrations in Northern Fur Seals (Callorhinus ursinus) from the Pribilof Islands*, Report to NMFS, Juneau, AK, by Creative Educational Consultants, Monterey, California, **1986**.

81 Fujise, Y.; Honda, K.; Tatsukawa, R.; Mishima, S. *Mar. Poll. Bull.*, **1988**, 19, 226-230.

82 Hansen, C.T.; Nielsen, C.O.; Dietz, R.; Hansen, M.M., *Polar Biol.*, **1990**, 10, 529-539.

83 Anas, R.E. *National Marine Fisheries Bull.*, **1974**, 72, 133-137.

84 Wagemann, R.; Stewart, R.E.A.; Lockhart, W.L.; Stewart, B.E.; Povoledo, M. *Mar. Mam. Sci.*, **1988**, 4, 339-355.

85 Smith, T.G.; Armstrong, F.A.J., *Arctic*, **1978**, 31, 75-84.

86 Kari, T.; Kauranen, P. *Bull. Environ. Contam. Toxical.*, **1978**, 19, 273-280.

87 Henriksson, K.; Karppanen, E., *Kvicksilverhalter Hos Insjö-och Haussälar*, In: Nordiskt Symposium Kring Kvicksilverproblematiken. October, **1969**.

88 Dietz, R.; Nielsen, C.O.; Hansen, M.M.; Hansen, C.T. *Sci. Tot. Environ.*, **1990**, 95, 41-51.

89 Honda, K.; Fujise, Y.; Tatsukawa, R.; Itano, K.; Miyazaki, N. *Mar. Environ. Res.*, **1986**, 20, 143-160.

90 Hammond, P.B.; Beliles, R.P. In: *Casareet and Doull's Toxicology: The Basic Science of Poisons*, 2nd edn., J. Doull, C.D. Klaassen, and M.O. Amdur, eds., Macmillan Publishing Co., Inc., New York, **1980**, 409-467.

91 Yamamoto, Y.; Honda, K.; Hidaka, H.; Tatsukawa, R., *Mar. Poll. Bull.*, **1987**, 18, 164-169.

92 Honda, K.; Marcovecchio, J.E.; Kan, S.; Tatsukawa, R.; Ogi, H., *Arch. Environ. Contam. Toxicol.*, **1990**, 19, 704-711.

93 Overton, E.; Byrne, C.; McFall, J.; Antoine, S. Tissue levels of trace organic and heavy metal pollutants in subsistence harvested bowhead whales, *Balaena mysticetus*. In: Third Conference on the Biology of the Bowhead Whale, *Balaena mysticetus*. Extended abstracts and panel., **1985**, 134-143.

94 Hamanaka, T.; Kato, H.; Tjujita, T., *Cadmium and zinc in ribbon seal, Histriophoca fasciata, in the Okhotsk Sea*. Res. Inst. N. Pac. Fish. Spec. Vol., **1982**, 547-561.

95 Burrell, D.C., *Distribution and dynamics of haevy metals in Alaskan shelf environments subject to oil development*. OCSEAP Quarterly Report, Research Unit 162, OCSEAP, NOAA, Boulder, CO, **1977**, 66 p.

96 Galster, W.R., *Accumulation of pesticides in Alaska marine mammals*. Proceedings from the Alaska Science Converence, University of Alaska, Fairbanks, Alaska, **1971**, 23:50, abstract.

97 Lenter, J.W., *Environmental Contaminants and Parasites in Polar Bears*. Final Report. Federal Aid in Wildlife Restoration Project. Nos. W-17-4 and W-117-3. Job 5.5R., **1976**, 22 p.

98 Imperial Oil Limited, *Heavy metals project. Mackenzie delta and estuary*. Beak Consultants, Calgara, Alberta, Canada, **1978**.

99 Smith, T.G.; Armstrong, F.A.J., *Arctic*, **1978**, 31, 75-84.

100 Bligh, E.B.; Armstrong, F.A.J., *Marine mercury pollution in Canada*, Int. Counc. Explor. Sea, ICES C.M. 1971/E34, **1971**.

101 Botta, J.R.; Arsenault, E.; Ryan, H.A., *Bull. Environ. Contam. Toxicol.*, **1983**, 30, 28-32.

102 Born, E.W.; Kraul, I.; Kristensen, T., *Arctic*, **1981**, 34, 255-260.

103 Zar, J.H., *Biostatistical Analysis,* Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 2nd edn., **1984**, 311-314.

APPENDICES

Analytical Data Tables

Table A.1. Concentrations of PCBs and Chlorinated Pesticides in Northern Fur Seal Samples (Concentrations in ng/g, wet weight)[a] - Sheet I

Animal Identification Number	Sampling Site	NIST Identification Number[b]	Percent Nonvolatile Extractables	PCB 8[c]	PCB 18 PCB 15	PCB 28	PCB 44	PCB 52	PCB 66 PCB 95
692-FRSL-004	St. Paul Island	MM1L013	3.1	≤0.04	0.07 ± 0.01	0.42 ± 0.01	≤0.02	1.32 ± 0.01	2.74 ± 0.05
			3.4	≤0.03	0.07 ± 0.01	0.43 ± 0.04	≤0.01	1.35 ± 0.01	2.74 ± 0.02
		MM1K014	5.5	0.19 ± 0.01	0.23 ± 0.01	0.87 ± 0.03	≤0.01	1.17 ± 0.02	1.42 ± 0.02
			5.2	0.18 ± 0.01	0.23 ± 0.01	0.88 ± 0.03	≤0.01	1.22 ± 0.01	1.46 ± 0.04
		MM1M015	2.4	0.08 ± 0.01	0.07 ± 0.01	0.53 ± 0.01	≤0.01	0.83 ± 0.02	1.20 ± 0.02
			2.6	0.09 ± 0.01	0.06 ± 0.01	0.55 ± 0.01	≤0.01	0.85 ± 0.06	1.25 ± 0.04
		MM1B016	87.6	1.79 ± 0.01	0.89 ± 0.03	11.03 ± 0.34	2.80 ± 0.11	21.47 ± 0.24	29.65 ± 0.22
			86.2	1.79 ± 0.01	0.88 ± 0.01	12.10 ± 0.12	2.90 ± 0.07	22.13 ± 0.19	29.80 ± 0.02
692-FRSL-005	St. Paul Island	MM1L017	3.9	≤0.19	≤0.15	0.74 ± 0.01	≤0.07	1.01 ± 0.01	5.31 ± 0.28
			3.1	≤0.14	≤0.10	0.77 ± 0.01	≤0.05	1.00 ± 0.01	5.13 ± 0.17
		MM1K018	4.6	≤0.15	0.35 ± 0.01	2.34 ± 0.03	≤0.05	1.79 ± 0.03	7.71 ± 0.28
			4.9	≤0.11	0.34 ± 0.01	2.34 ± 0.05	≤0.04	1.70 ± 0.05	7.85 ± 0.21
		MM1M019	2.9	≤0.12	≤0.10	0.71 ± 0.02	≤0.04	0.53 ± 0.01	3.09 ± 0.07
			3.2	≤0.11	≤0.08	0.72 ± 0.02	≤0.04	0.54 ± 0.02	3.11 ± 0.03
		MM1B020	87.6	≤4.2	≤3.1	13.67 ± 0.10	≤1.65	12.74 ± 0.24	108.4 ± 3.1
			86.8	≤2.5	≤1.9	13.23 ± 0.36	≤1.08	12.30 ± 0.07	112.8 ± 1.6

[a] Results are averages for analysis of two subsamples, each analyzed in triplicate by GC-ECD; uncertainties are one standard deviation of a single measurement.
[b] In the NIST Identification Number the letters L, K, M, and B indicate the sample type, i.e., L = Liver; K = Kidney; M = Muscle; and B = Blubber.
[c] PCBs are numbered according to reference (Ballschmiter, K and Zell, M (1980), Fresenuis Z Anal. Chem., 302:20-31). PCB congener listed first is the major component; additional congeners listed may be present as minor components.
[d] n.d. = results were less than the detection limit; results were probaby low due to volatility losses during sample preparation.

Table A.1. Concentrations of PCBs and Chlorinated Pesticides in Northern Fur Seal Samples (Concentrations in ng/g, wet weight)[a] - Sheet II

Sample Identification Number	NIST Identification Number[b]	PCB 101 PCB 90[c]	PCB 105	PCB 118	PCB 138 PCB 163 PCB 164	PCB 153	PCB 170 PCB 190	PCB 180	PCB 187 PCB 159 PCB 182
692-FRSL-004	MM1L013	0.36 ± 0.01	0.50 ± 0.02	1.41 ± 0.02	4.12 ± 0.11	5.74 ± 0.11	0.38 ± 0.02	1.07 ± 0.01	≤0.15
		0.37 ± 0.01	0.51 ± 0.04	1.47 ± 0.02	4.43 ± 0.07	5.69 ± 0.13	0.40 ± 0.02	1.08 ± 0.02	≤0.11
	MM1K014	0.76 ± 0.02	0.58 ± 0.02	0.92 ± 0.05	3.55 ± 0.05	5.20 ± 0.10	0.63 ± 0.03	1.33 ± 0.03	≤0.07
		0.79 ± 0.02	0.59 ± 0.02	0.96 ± 0.01	3.61 ± 0.08	5.14 ± 0.10	0.65 ± 0.01	1.37 ± 0.06	≤0.06
	MM1M015	0.35 ± 0.01	0.40 ± 0.01	0.81 ± 0.02	3.17 ± 0.09	4.72 ± 0.20	0.40 ± 0.01	1.03 ± 0.01	≤0.09
		0.34 ± 0.01	0.44 ± 0.02	0.85 ± 0.05	3.24 ± 0.02	4.59 ± 0.27	0.41 ± 0.01	1.09 ± 0.03	≤0.06
	MM1B016	7.75 ± 0.15	15.60 ± 0.47	32.4 ± 1.3	17.58 ± 0.75	122.8 ± 4.8	11.93 ± 0.23	1.49 ± 0.02	≤0.24
		7.87 ± 0.11	14.57 ± 0.01	29.5 ± 0.4	17.48 ± 0.86	114.8 ± 1.5	12.12 ± 0.12	1.55 ± 0.03	≤0.24
692-FRSL-005	MM1L017	0.91 ± 0.07	1.30 ± 0.04	6.62 ± 0.19	10.65 ± 0.17	15.47 ± 0.36	1.40 ± 0.05	3.69 ± 0.12	≤0.26
		0.94 ± 0.02	1.35 ± 0.05	6.82 ± 0.13	10.87 ± 0.26	16.21 ± 0.98	1.46 ± 0.11	3.62 ± 0.08	≤0.25
	MM1K018	2.93 ± 0.08	3.87 ± 0.11	9.08 ± 0.04	20.29 ± 0.78	30.92 ± 0.61	1.79 ± 0.10	5.86 ± 0.08	≤0.21
		3.01 ± 0.05	3.94 ± 0.02	8.93 ± 0.09	20.51 ± 0.35	30.74 ± 0.22	1.73 ± 0.06	5.89 ± 0.11	≤0.19
	MM1M019	0.83 ± 0.07	1.26 ± 0.06	1.34 ± 0.04	7.07 ± 0.07	11.87 ± 0.91	0.84 ± 0.01	2.27 ± 0.04	≤0.15
		0.83 ± 0.05	1.27 ± 0.04	1.30 ± 0.09	7.16 ± 0.09	12.90 ± 0.62	0.86 ± 0.03	2.30 ± 0.06	≤0.19
	MM1B020	8.33 ± 0.19	18.19 ± 0.02	97.50 ± 0.73	90.78 ± 1.74	189.22 ± 7.47	12.12 ± 0.22	32.38 ± 1.14	≤4.7
		8.55 ± 0.18	18.24 ± 0.18	93.49 ± 5.72	92.49 ± 1.01	191.86 ± 1.85	11.72 ± 0.35	32.76 ± 1.10	≤13.4

[a] Results are averages for analysis of two subsamples, each analyzed in triplicate by GC-ECD; uncertainties are one standard deviation of a single measurement.
[b] In the NIST Identification Number the letters L, K, M, and B indicate the sample type, i.e., L = Liver; K = Kidney; M = Muscle; and B = Blubber.
[c] PCBs are numbered according to reference (Ballschmiter, K and Zell, M (1980), Fresenuis Z Anal. Chem., 302:20-31]. PCB congener listed first is the major component; additional congeners listed may be present as minor components.
[d] n.d. = results were less than the detection limit; results were probably low due to volatility losses during sample preparation.

Table A.1. Concentrations of PCBs and Chlorinated Pesticides in Northern Fur Seal Samples (Concentrations in ng/g, wet weight)[a] - Sheet III

Sample Identification Number	NIST Identification Number[b]	PCB 195[c]	Hexachloro-benzene	Lindane (γ-HCH)	Heptachlor epoxide	*cis*-Chlordane	*trans*-Nonachlor	Dieldrin
692-FRSL-004	MM1L013	≤0.01	n.d.[d]	0.98 ± 0.02	1.13 ± 0.04	0.16 ± 0.01	5.85 ± 0.19	0.97 ± 0.01
		≤0.01	n.d.	0.96 ± 0.01	1.10 ± 0.05	0.15 ± 0.01	5.90 ± 0.08	0.92 ± 0.01
	MM1K014	≤0.01	n.d.	1.39 ± 0.01	1.99 ± 0.05	0.25 ± 0.01	8.19 ± 0.20	1.09 ± 0.01
			n.d.	1.37 ± 0.03	1.89 ± 0.04	0.25 ± 0.01	9.05 ± 0.66	1.16 ± 0.08
	MM1M015	≤0.01	n.d.	1.02 ± 0.02	2.22 ± 0.07	0.19 ± 0.01	8.77 ± 0.20	0.71 ± 0.01
			n.d.	0.99 ± 0.02	2.39 ± 0.06	0.18 ± 0.02	8.78 ± 0.31	0.75 ± 0.02
	MM1B016	3.10 ± 0.35	n.d.	25.93 ± 0.47	34.58 ± 0.30	4.25 ± 0.05	296.0 ± 11.1	25.86 ± 0.14
		1.99 ± 1.13	n.d.	25.82 ± 0.59	33.97 ± 0.92	4.24 ± 0.04	310.6 ± 3.6	26.64 ± 0.64
692-FRSL-005	MM1L017	≤0.05	n.d.	0.40 ± 0.02	2.43 ± 0.05	≤0.01	6.82 ± 0.13	0.28 ± 0.01
		≤0.05	n.d.	0.40 ± 0.01	2.43 ± 0.08	≤0.01	6.86 ± 0.19	0.29 ± 0.01
	MM1K018	≤0.04	n.d.	1.91 ± 0.02	4.35 ± 0.24	≤0.02	32.84 ± 0.79	0.74 ± 0.01
		≤0.03	n.d.	1.82 ± 0.01	4.26 ± 0.06	≤0.02	32.37 ± 0.72	0.80 ± 0.01
	MM1M019	≤0.03	n.d.	0.46 ± 0.01	1.73 ± 0.05	≤0.01	10.97 ± 0.09	0.27 ± 0.01
		≤0.04	n.d.	0.47 ± 0.01	1.83 ± 0.12	≤0.01	11.54 ± 0.18	0.28 ± 0.01
	MM1B020	≤0.88	n.d.	2.66 ± 0.09	14.86 ± 0.40	≤0.08	62.82 ± 0.29	1.18 ± 0.01
		≤2.31	n.d.	2.88 ± 0.08	14.47 ± 0.27	≤0.07	66.71 ± 2.21	1.15 ± 0.05

[a] Results are averages for the analysis of two subsamples, each analyzed in triplicate by GC-ECD; uncertainties are 1 standard deviation of a single measurement.
[b] In the NIST Identification Number the letters L, K, M, and B indicate the sample type i.e., L = Liver; K = Kidney; M = Muscle; and B = Blubber.
[c] PCBs are numbered according to reference [Ballschmiter, K and Zell, M (1980), Fresenuis Z Anal. Chem., 302:20-31]. PCB congener listed first is the major component; additional congeners listed may be present as minor components.
[d] n.d. = results were less than the detection limit; results were probably low due to volatility losses during sample preparation.

Table A.1. Concentrations of PCBs and Chlorinated Pesticides in Northern Fur Seal Samples (Concentrations in ng/g, wet weight)[a] - Sheet IV

Sample Identification Number	NIST Identification Number[b]	2,4'-DDE	4,4'-DDE	2,4'-DDD	4,4'-DDD	2,4'-DDT	4,4'-DDT
692-FRSL-004	MM1L013	≤0.03	36.62 ± 0.30	1.22 ± 0.02	3.46 ± 0.11	≤1	2.79 ± 0.05
		≤0.03	36.67 ± 0.44	1.16 ± 0.02	3.52 ± 0.01	≤1	2.69 ± 0.04
	MM1K014	≤0.01	34.93 ± 1.57	≤0.02	2.95 ± 0.02	≤1	1.72 ± 0.18
		≤0.02	33.84 ± 0.15	≤0.03	3.07 ± 0.14	≤1	1.63 ± 0.09
	MM1M015	≤0.01	35.18 ± 1.38	≤0.03	2.94 ± 0.08	≤1	1.73 ± 0.06
		≤0.02	36.73 ± 0.47	≤0.01	2.90 ± 0.05	≤1	1.78 ± 0.07
	MM1B016	1.13 ± 0.08	1317 ± 51	11.76 ± 0.01	116.1 ± 3.8	≤1	34.50 ± 2.25
		1.12 ± 0.10	1349 ± 4	12.23 ± 0.47	120.3 ± 0.4	≤1	33.80 ± 1.55
692-FRSL-005	MM1L017	≤0.18	84.59 ± 4.35	0.91 ± 0.02	4.09 ± 0.18	≤1	3.40 ± 0.05
		≤0.13	85.52 ± 3.42	0.94 ± 0.03	4.32 ± 0.06	≤1	3.23 ± 0.01
	MM1K018	≤0.14	191.6 ± 0.84	0.46 ± 0.02	9.32 ± 0.42	≤1	7.29 ± 0.33
		≤0.1	182.5 ± 5.63	0.49 ± 0.03	8.96 ± 0.01	≤1	7.10 ± 0.16
	MM1M019	≤0.11	71.65 ± 1.76	0.15 ± 0.01	3.19 ± 0.05	≤1	2.93 ± 0.09
		≤0.04	72.30 ± 5.69	0.14 ± 0.01	3.32 ± 0.07	≤1	2.82 ± 0.02
	MM1B020	≤4.03	1057 ± 40	0.39 ± 0.02	19.37 ± 0.91	≤1	16.48 ± 0.72
		≤2.41	1052 ± 37	0.40 ± 0.01	18.67 ± 1.16	≤1	16.43 ± 0.46

[a] Results are averages for analysis of two subsamples, each analyzed in triplicate by GC-ECD; uncertainties are one standard deviation of a single measurement.

[b] In the NIST Identification Number the letters L, K, M, and B indicates the sample type, i.e., L = Liver; K = Kidney; M = Muscle; and B = Blubber.

Table A.2. Concentration of PCBs and Chlorinated Pesticides in Ringed Seal Tissue Samples (Concentration ng/g wet weight)[a] - Sheet I

Animal Identification Number	Sampling Site	NIST Identification Number[b]	Percent Nonvolatile Extractables	PCB 8[c]	PCB 18 PCB 15	PCB 28	PCB 44	PCB 52	PCB 66 PCB 95
692-RGSL-004	Barrow	MM2L030	2.7	2.5 ± 0.1	≤0.2	2.1 ± 0.1	≤0.2	0.7 ± 0.1	2.9 ± 0.1
			3.2	2.7 ± 0.1	≤0.1	2.2 ± 0.1	≤0.2	0.8 ± 0.1	2.8 ± 0.1
		MM2K031	2.7	1.2 ± 0.1	≤0.2	0.5 ± 0.1	0.3 ± 0.1	0.5	2.0 ± 0.1
			3.1	1.4 ± 0.1	≤0.1	0.4 ± 0.1	0.4 ± 0.1	0.5	2.0 ± 0.1
		MM2B032	89.4	0.4 ± 0.1	≤0.2	6.3 ± 0.1	0.5 ± 0.1	3.9 ± 0.1	14 ± 1
			88.5	0.5 ± 0.1	≤0.1	6.4 ± 0.1	0.4 ± 0.1	4.1 ± 0.1	12 ± 1
692-RGSL-008	Barrow	MM2L042	3.9	2.0 ± 0.1	≤0.2	1.6 ± 0.2	1.0 ± 0.1	0.9 ± 0.1	3.2 ± 0.1
			3.5	2.1 ± 0.1	≤0.1	1.5 ± 0.1	1.1 ± 0.1	1.0 ± 0.1	3.1 ± 0.1
		MM2K043	3.9	1.1 ± 0.1	≤0.1	5.3 ± 0.1	1.0 ± 0.1	0.8 ± 0.1	2.8 ± 0.1
			3.4	1.1 ± 0.1	≤0.1	5.1 ± 0.2	1.0 ± 0.1	0.7 ± 0.1	2.7 ± 0.1
		MM2B044	93.0	42 ± 2	≤2	14 ± 1	10 ± 0.4	12 ± 1	36 ± 1
			94.0	43 ± 1	≤1	16 ± 1	9 ± 1	13 ± 0.3	39 ± 1
692-RGSL-011	Nome	MM3L054	3.4	≤5	≤2	≤2	≤2	1.2 ± 0.1	≤2
			3.4	≤5	≤2	≤2	≤2	1.2 ± 0.1	≤2
		MM3B056	88.3	41 ± 1	33 ± 1	15 ± 1	≤4	23 ± 2	≤3
			87.0	49 ± 1	40 ± 2	11 ± 2	≤3	29 ± 1	≤3
692-RGSL-013	Nome	MM3L060	3.4	≤3	≤3	≤2	≤3	≤3	≤2
			3.2	≤2	≤3	≤1	≤2	≤3	≤2
		MM3B062	87.3	≤6	≤5	13 ± 1	≤3	24 ± 1	7.8 ± 0.2
			86.5	≤4	≤4	13 ± 1	≤3	24 ± 1	8.0 ± 0.1

[a] Results are averages for the analysis of two subamples, each analyzed in triplicate by GC-ECD; uncertainties are one standard deviation a single measurement.
[b] In the NIST Identification Number, the letters L, K, and B indicate the sample type, i.e., L = Liver; K = Kidney; and B = Blubber.
[c] PCBs are numbered according to reference [Ballschmiter, K and Zell, M (1980) Fresenius Z Anal. Chem., 302:20-31]. PCB congener listed first is the major component; additional congeners listed may be present as minor components.

Table A.2. Concentration of PCBs and Chlorinated Pesticides in Ringed Seal Tissue Samples (Concentrations ng/g wet weight)[a] - Sheet II

Animal Identification Number	NIST Identification Number[b]	PCB 101[c] PCB 90	PCB 105	PCB 118	PCB 138 PCB 163 PCB 164	PCB 153	PCB 170 PCB 190	PCB 180	PCB 187 PCB 159 PCB 182
692-RGSL-004	MM2L030	4.8 ± 0.1	0.6 ± 0.1	2.5 ± 0.1	3.7 ± 0.1	5.0 ± 0.2	0.42 ± 0.02	1.2 ± 0.1	0.9 ± 0.1
		4.6 ± 0.1	0.4 ± 0.1	2.3 ± 0.1	3.8 ± 0.2	4.9 ± 0.1	0.43 ± 0.02	1.1 ± 0.2	1.0 ± 0.1
	MM2K031	0.8 ± 0.1	0.14 ± 0.01	1.0 ± 0.1	1.1 ± 0.1	1.5 ± 0.1	0.11 ± 0.01	0.5 ± 0.1	0.32 ± 0.01
		0.7 ± 0.1	0.13 ± 0.02	0.9 ± 0.1	1.2 ± 0.2	1.3 ± 0.1	0.13 ± 0.01	0.5 ± 0.1	0.33 ± 0.02
	MM2B032	165 ± 1	35 ± 1	88 ± 1	131 ± 3	176 ± 4	12 ± 1	37 ± 1	15 ± 0.3
		162 ± 2	33 ± 2	86 ± 2	134 ± 3	180 ± 3	11 ± 1	36 ± 1	14 ± 1
692-RGSL-008	MM2L042	0.8 ± 0.1	≤0.4	1.1 ± 0.1	2.4 ± 0.1	3.0 ± 0.1	0.3 ± 0.1	0.8 ± 0.1	0.5 ± 0.01
		0.7 ± 0.2	≤0.3	1.1 ± 0.1	2.1 ± 0.2	3.1 ± 0.2	0.2 ± 0.1	0.7 ± 0.1	0.4 ± 0.03
	MM2K043	1.6 ± 0.1	≤0.2	0.5 ± 0.03	1.1 ± 0.1	1.6 ± 0.1	0.12 ± 0.01	0.5 ± 0.2	0.2 ± 0.1
		1.7 ± 0.1	≤0.2	0.4 ± 0.02	1.1 ± 0.1	1.5 ± 0.1	0.13 ± 0.01	0.4 ± 0.1	0.1 ± 0.1
	MM2B044	203 ± 4	12 ± 1	53 ± 1	90 ± 2	172 ± 2	4.4 ± 0.1	21 ± 1	10 ± 1
		207 ± 4	11 ± 2	55 ± 1	93 ± 2	170 ± 1	4.2 ± 0.2	20 ± 1	11 ± 1
692-RGSL-011	MM3L054	2.3 ± 0.2	≤2	≤2	2.5 ± 0.1	3.3 ± 0.1	≤2	≤2	≤1
		1.9 ± 0.1	≤2	≤2	2.4 ± 0.1	3.5 ± 0.1	≤1	≤2	≤2
	MM3B056	59 ± 1	10 ± 1	39 ± 1	60 ± 2	99 ± 2	≤3	14 ± 1	14 ± 1
		63 ± 1	12 ± 1	41 ± 1	64 ± 2	87 ± 2	≤4	14 ± 1	16 ± 1
692-RGSL-013	MM3L060	1.7 ± 0.1	≤2	1.2 ± 0.1	1.9 ± 0.1	2.8 ± 0.1	≤2	≤2	≤2
		1.8 ± 0.1	≤2	1.1 ± 0.1	2.0 ± 0.1	2.7 ± 0.1	≤2	≤2	≤2
	MM3B062	65 ± 1	20 ± 2	40 ± 1	62 ± 2	103 ± 6	≤4	14 ± 1	12 ± 1
		70 ± 2	20 ± 1	42 ± 2	70 ± 1	107 ± 5	≤4	13 ± 1	14 ± 1

[a] Results are averages for the analysis of two subsamples, each analyzed in triplicate by GC-ECD; uncertainties are 1 standard deviation of a single measurement.
[b] In the NIST Identification Number the letters L, K, and B indicated the sample type, i.e., : = Liver; K = Kidney; and B = Blubber.
[c] PCBs are numbered according to reference [Ballschmiter, K and Zell, M (1980) Fresenius Z Anal. Chem., 302:20-31]. PCB congener listed first is the major component; additional congeners listed may be present as minor components.

Table A.2. Concentration of PCBs and Chlorinated Pesticides in Ringed Seal Tissue Samples (Concentrations ng/g wet weight)[a] - Sheet III

Animal Identification Number	NIST Identification Number[b]	PCB 195[c]	Hexa-chloro-benzene	Lindane (γ-HCH)	Heptachlor epoxide	*cis*-Chlordane	*trans*-Nonachlor	Dieldrin	2,4'-DDE	4,4'-DDE
692-RGSL-004	MM2L030	≤0.1	0.7 ± 0.1[d]	1.0 ± 0.1	2.6 ± 0.2	≤0.1	1.4 ± 0.2	0.9 ± 0.1	≤1	10.1 ± 0.2
		≤0.1	0.8 ± 0.1[d]	0.9 ± 0.1	2.4 ± 0.1	≤0.1	1.2 ± 0.1	1.0 ± 0.1	≤1	9.9 ± 0.2
	MM2K031	≤0.1	0.3 ± 0.01[d]	≤0.2	0.3 ± 0.1	≤0.1	0.6 ± 0.1	≤0.3	≤1	2.8 ± 0.1
		≤0.1	0.4 ± 0.1[d]	≤0.1	0.2 ± 0.1	≤0.1	0.5 ± 0.1	≤0.2	≤1	2.9 ± 0.1
	MM2B032	1.5 ± 0.1	2.1 ± 0.2[d]	2.4 ± 0.2	46 ± 1	3.4 ± 0.1	116 ± 3	0.6 ± 0.1	5.1 ± 0.1	27.2 ± 0.2
		1.6 ± 0.1	2.1 ± 0.1[d]	2.2 ± 0.2	44 ± 2	3.4 ± 0.1	115 ± 3	0.5 ± 0.1	5.0 ± 0.1	27.3 ± 0.3
692-RGSL-008	MM2L042	≤0.1	4.5 ± 0.1[d]	0.3	2.8 ± 0.1	≤0.2	0.8 ± 0.1	3.1 ± 0.1	≤0.1	6.6 ± 0.2
		≤0.1	4.2 ± 0.2[d]	0.3	2.7 ± 0.1	≤0.1	0.7 ± 0.1	3.1 ± 0.1	≤0.1	6.3 ± 0.2
	MM2K043	≤0.1	7.3 ± 0.1[d]	≤0.1	0.3 ± 0.1	≤0.1	0.2 ± 0.1	0.2 ± 0.1	≤0.1	6.7 ± 0.2
		≤0.1	7.1 ± 0.2[d]	≤0.1	0.3 ± 0.1	≤0.1	0.1 ± 0.1	0.1 ± 0.1	≤0.1	6.8 ± 0.1
	MM2B044	≤0.2	56 ± 1[d]	21 ± 1	35 ± 1	0.7 ± 0.1	43 ± 2	25 ± 1	24 ± 1	345 ± 6
		≤0.2	55 ± 1[d]	21 ± 1	33 ± 2	0.6 ± 0.2	42 ± 1	23 ± 2	24 ± 1	355 ± 6
692-RGSL-011	MM3L054	≤3	9.5 ± 0.1	5.2 ± 0.3	1.4 ± 0.1	≤1	1.8 ± 0.1	≤1	≤5	6.5 ± 0.1
		≤5	9.6 ± 0.1	5.4 ± 0.2	1.3 ± 0.1	≤1	1.9 ± 0.1	≤1	≤5	5.3 ± 0.1
	MM3B056	≤3	117 ± 2	234 ± 3	65 ± 2	30 ± 2	273 ± 3	22 ± 2	≤2	170 ± 3
		≤5	131 ± 2	238 ± 2	65 ± 3	33 ± 1	276 ± 2	25 ± 2	≤2	176 ± 2
692-RGSL-013	MM3L060	≤5	5.0 ± 0.1	2.6 ± 0.2	2.5 ± 0.1	1.6 ± 0.1	1.7 ± 0.1	≤1	≤3	3.7 ± 0.1
		≤5	4.6 ± 0.1	2.7 ± 0.3	2.5 ± 0.1	1.6 ± 0.1	1.8 ± 0.1	≤1	≤3	3.8 ± 0.1
	MM3B062	≤5	151 ± 4	630 ± 3	606 ± 4	101 ± 2	1210 ± 8	125 ± 4	3.0 ± 0.2	233 ± 2
		≤5	158 ± 6	636 ± 3	600 ± 3	104 ± 1	1220 ± 4	119 ± 3	2.7 ± 0.2	248 ± 5

[a] Results are averages for the analysis of two subsamples, each analyzed in triplicate by GC-ECD; uncertainties are 1 standard deviation of single measurement.
[b] In the NIST Identification Number the letters L, K, and B indicate the sample type, i.e., L = Liver; K = Kidney; and B = Blubber.
[c] PCBs are numbered according to reference [Ballschmiter, K and Zell, M (1980) Fresenius Z Anal. Chem., 302:20-31]. PCB congener listed first is the major component; additional congeners listed may be present as minor components.
[d] Results may be low due to volatility losses during sample preparation.

Table A.2. Concentration of PCBs and Chlorinated Pesticides in Ringed Seal Tissue Samples (Concentrations ng/g wet weight)[a] - Sheet IV

Animal Identification Number	NIST Identification Number[b]	2,4'-DDD	4,4'-DDD	2,4'-DDT	4,4'-DDT
692-RGSL-004	MM2L030	≤0.2	1.5 ± 0.1	≤0.2	≤0.3
		≤0.1	1.3 ± 0.2	≤0.2	≤0.2
	MM2K031	≤0.2	0.4 ± 0.1	≤0.2	≤0.2
		≤0.1	0.5 ± 0.1	≤0.1	≤0.2
	MM2B032	≤1	0.7 ± 0.1	1.1 ± 0.1	0.7 ± 0.1
		≤1	0.7 ± 0.1	1.1 ± 0.1	0.8 ± 0.1
692-RGSL-008	MM2L042	≤0.1	0.3 ± 0.1	0.21 ± 0.02	0.2 ± 0.1
		≤0.1	0.2 ± 0.1	0.21 ± 0.02	0.2 ± 0.1
	MM2K043	≤0.1	0.12 ± 0.02	0.31 ± 0.02	0.2 ± 0.1
		≤0.1	0.11 ± 0.02	0.33 ± 0.03	0.1 ± 0.1
	MM2B044	≤0.5	0.6 ± 0.1	1.3 ± 0.1	1.8 ± 0.2
		≤0.4	0.5 ± 0.1	1.1 ± 0.2	1.7 ± 0.1
692-RGSL-011	MM3L054	≤1	≤1	2.8 ± 0.1	1.6 ± 0.1
		≤1	≤1	2.6 ± 0.1	1.5 ± 0.1
	MM3B056	≤1	≤1	109 ± 2	51 ± 2
		≤1	≤1	106 ± 2	54 ± 2
692-RGSL-013	MM3L060	≤1	≤1	≤1	1.4 ± 0.1
		≤1	≤1	≤1	1.3 ± 0.1
	MM3B062	≤1	106 ± 3	521 ± 3	557 ± 3
		≤1	102 ± 3	525 ± 2	553 ± 3

[a] Results are averages for the analysis of two subsamples, each analyzed in triplicate by GC-ECD; uncertainties are one standard deviation of a single measurement.
[b] In the NIST Identification Number the letters L, K, and B indicate the sample type, i.e., Liver = Liver; K = Kidney; and B = Blubber.

Table A.3. Concentrations of PCBs and Chlorinated Pesticides in Belukha Whale Blubber Samples (Concentrations in ng/g, wet weight)[a] - Sheet I

Animal Identification Number	Sampling Site	NIST Identification Number	Percent Nonvolatile Extractables	PCB 8[b]	PCB 18 PCB 15	PCB 28	PCB 44	PCB 52	PCB 66 PCB 95
692-BLKA-001	Point	MM3B071	84.3	46 ± 1	11 ± 1	86 ± 4	30 ± 1	163 ± 6	84 ± 1
	Hope		85.7	55 ± 1	11 ± 1	83 ± 4	31 ± 1	174 ± 7	89 ± 1
692-BLKA-002	Point	MM3B074	84.9	39 ± 1	≤6	136 ± 8	54 ± 1	167 ± 5	104 ± 2
	Hope		83.7	42 ± 1	≤7	163 ± 9	53 ± 1	171 ± 4	101 ± 2
692-BLKA-007	Point	MM4B133	83.6	59 ± 2	≤5	85 ± 1	48 ± 3	234 ± 11	132 ± 10
	Lay		81.1	48 ± 2	≤4	80 ± 5	44 ± 2	225 ± 11	122 ± 8
692-BLKA-012	Point	MM4B148	85.3	≤6	≤4	≤8	27 ± 2	89 ± 2	22 ± 2
	Lay		84.0	≤7	≤6	≤8	32 ± 2	93 ± 2	23 ± 2

[a] Results are averages for the analysis of two subsamples, each analyzed in triplicate by GC-ECD; uncertainties are one standard deviation of a single measurement.
[b] PCBs are numbered according to reference [Ballschmiter, K. and Zell, M. (1980) Fresenius Z Anal. Chem., 302:20-31]. PCB congener listed first is the major component; additional congeners listed may be present as minor components.

Table A.3. Concentrations of PCBs and Chlorinated Pesticides in Belukha Whale Blubber Samples (Concentrations in ng/g, wet weight)[a] - Sheet II

Animal Identification Number	NIST Identification Number	PCB 101[b] PCB 90	PCB 105	PCB 118	PCB 138 PCB 163 PCB 164	PCB 153	PCB 170 PCB 190	PCB 180	PCB 187 PCB 159 PCB 182
692-BLKA-001	MM3B071	184 ± 2 193 ± 3	37 ± 2 30 ± 1	94 ± 2 105 ± 2	235 ± 3 224 ± 2	340 ± 3 351 ± 3	15 ± 1 14 ± 1	69 ± 1 60 ± 1	69 ± 3 77 ± 2
692-BLKA-002	MM3B074	342 ± 3 328 ± 4	55 ± 1 59 ± 1	160 ± 4 166 ± 4	266 ± 11 250 ± 12	420 ± 15 403 ± 11	13 ± 1 13 ± 1	58 ± 1 54 ± 2	70 ± 1 61 ± 2
692-BLKA-007	MM4B133	434 ± 4 443 ± 5	102 ± 4 106 ± 3	321 ± 10 346 ± 12	585 ± 6 579 ± 11	832 ± 14 818 ± 12	43 ± 1 42 ± 1	163 ± 2 166 ± 1	164 ± 2 149 ± 2
692-BLKA-012	MM4B148	199 ± 3 195 ± 2	59 ± 1 71 ± 5	121 ± 4 122 ± 3	258 ± 16 231 ± 9	360 ± 9 376 ± 7	18 ± 2 17 ± 2	66 ± 4 60 ± 3	70 ± 1 73 ± 2

[a] Results are averages for the analysis of two subsamples, each analyzed in triplicate by GC-ECD; uncertainties are one standard deviation of a single measurement

[b] PCBs are numbered according to reference [Ballschmiter, K. and Zell, M. (1980) Fresenius Z Anal. Chem., 302:20-31]. PCB congener listed first is the major component; additional congeners listed may be present as minor components.

Table A.3. Concentrations of PCBs and Chlorinated Pesticides in Belukha Whale Blubber Samples (Concentrations in ng/g, wet weight)[a] - Sheet III

Animal Identification Number	NIST Identification Number	PCB 195[b]	Hexachloro-benzene	Lindane (γ-HCH)	Heptachlor epoxide	*cis*-Chlordane	*trans*-Nonachlor	Dieldrin
692-BLKA-001	MM3B071	≤5	654 ± 7	≤3	≤5	13 ± 1	44 ± 4	20 ± 1
		≤5	683 ± 7	≤3	≤5	13 ± 1	49 ± 5	21 ± 1
692-BLKA-002	MM3B074	≤5	235 ± 4	11 ± 1	15 ± 1	15 ± 1	86 ± 4	28 ± 1
		≤5	273 ± 4	12 ± 2	17 ± 1	14 ± 1	98 ± 9	29 ± 1
692-BLKA-007	MM4B133	≤5	264 ± 10	351 ± 6	230 ± 5	42 ± 2	1290 ± 10	340 ± 8
		≤5	241 ± 10	361 ± 5	239 ± 4	40 ± 1	1309 ± 9	353 ± 5
692-BLKA-012	MM4B148	≤5	116 ± 9	1089 ± 7	119 ± 4	35 ± 1	594 ± 5	352 ± 2
		≤5	121 ± 9	1100 ± 6	115 ± 3	34 ± 1	606 ± 7	347 ± 3

[a] Results are averages for the analysis of two subsamples, each analyzed in triplicate by GC-ECD; uncertainties are one standard deviation of a single measurement.
[b] PCBs are numbered according to reference [Ballschmiter, K. and Zell, M. (1980) Fresenius Z Anal. Chem., 302:20-31]. PCB congener listed first is the major component; additional congeners listed may be present as minor components.

Table A.3. Concentrations of PCBs and Chlorinated Pesticides in Belukha Whale Blubber Samples (Concentrations in ng/g, wet weight)[a] - Sheet IV

Animal Identification Number	NIST Identification Number	2,4'-DDE	4,4'-DDE	2,4'-DDD	4,4'-DDD	2,4'-DDT	4,4'-DDT
692-BLKA-001	MM3B071	20 ± 1	1028 ± 21	≤3	≤3	163 ± 8	414 ± 3
		21 ± 1	1097 ± 21	≤3	≤3	155 ± 3	421 ± 4
692-BLKA-002	MM3B074	60 ± 1	1182 ± 10	45 ± 1	56 ± 3	262 ± 8	321 ± 7
		63 ± 1	1231 ± 13	41 ± 3	52 ± 2	274 ± 7	303 ± 10
692-BLKA-007	MM4B133	65 ± 2	2896 ± 36	40 ± 2	11 ± 3	103 ± 2	695 ± 5
		63 ± 2	2935 ± 26	40 ± 3	16 ± 2	106 ± 5	702 ± 3
692-BLKA-012	MM4B148	17 ± 1	750 ± 7	46 ± 2	191 ± 5	136 ± 3	269 ± 2
		18 ± 1	763 ± 6	51 ± 3	200 ± 4	148 ± 6	264 ± 3

[a] Results are averages for the analysis of two subsamples, each analyzed in triplicate by GC-ECD; uncertainties are one standard deviation of a single measurement.

[b] PCBs are numbered according to reference [Ballschmiter, K. and Zell, M. (1980) Fresenius Z Anal. Chem., 302:20-31]. PCB congener listed first is the major component; additional congeners listed may be present as minor components.

Table A.4. Concentrations of PCBs and Chlorinated Pesticides in Marine Mammal Blubber Samples (Concentrations in ng/g, wet weight)[a] - Sheet I

Animal Identification Number	Sampling Site	NIST Identification Number	PCB 8[b]	PCB 18 PCB 15	PCB 28	PCB 44	PCB 52	PCB 66 PCB 95	PCB 101 PCB 90	PCB 105	PCB 118	PCB 138 PCB 163 PCB 164	PCB 153
692-RGSL-004	Barrow	MM2B032	0.5 ± 0.1	≤1	6.3 ± 0.1	0.5 ± 0.1	3.9 ± 0.1	13 ± 1	163 ± 2	35 ± 1	179 ± 5	35 ± 1	133 ± 2
692-RGSL-008	Barrow	MM2B044	42 ± 1	≤2	15 ± 1	10 ± 1	13 ± 1	38 ± 1	205 ± 7	14 ± 1	170 ± 3	14 ± 1	92 ± 3
692-RGSL-011	Nome	MM3B056	44 ± 5	36 ± 4	13 ± 2	≤4	26 ± 3	≤3	61 ± 2	11 ± 1	94 ± 5	11 ± 1	61 ± 3
692-RGSL-013	Nome	MM3B062	≤6	≤5	13 ± 1	≤3	24 ± 1	7.9 ± 0.2	67 ± 4	20 ± 2	105 ± 6	20 ± 2	65 ± 4
692-FRSL-004	St. Paul Island	MM1B016	1.8 ± 0.1	0.9 ± 0.1	12 ± 1	2.8 ± 0.1	22 ± 1	30 ± 1	7.8 ± 0.2	15 ± 1	120 ± 6	15 ± 1	18 ± 1
692-FRSL-005	St. Paul Island	MM1B020	≤3	≤3	14 ± 1	≤2	13 ± 1	111 ± 4	8.5 ± 0.9	19 ± 1	191 ± 6	19 ± 1	92 ± 2
692-BLKA-001	Pt. Hope	MM3B071	51 ± 5	11 ± 1	84 ± 5	31 ± 2	169 ± 8	86 ± 3	189 ± 5	32 ± 4	346 ± 6	346 ± 6	229 ± 6
692-BLKA-002	Pt. Hope	MM3B074	42 ± 2	≤7	151 ± 16	54 ± 1	170 ± 4	102 ± 3	335 ± 8	57 ± 3	411 ± 17	411 ± 17	259 ± 14
692-BLKA-007	Pt. Lay	MM4B133	54 ± 6	≤5	82 ± 6	46 ± 3	230 ± 13	128 ± 10	439 ± 6	104 ± 4	826 ± 17	826 ± 17	583 ± 11
692-BLKA-012	Pt. Lay	MM4B148	≤7	≤6	≤8	30 ± 4	92 ± 3	23 ± 2	197 ± 3	65 ± 7	122 ± 4	241 ± 20	369 ± 11

[a] Mean Concentrations from triplicate analyses of two subsamples (See Tables A.1. - A.3.); uncertainties are one standard deviation of a single measurement.

[b] PCBs are numbered according to reference [Ballschmiter, K. and Zell, M. (1980) Fresenius Z Anal. Chem., 302:20-31]. PCB congener listed first is the major component; additional congeners listed may be present as minor components.

Table A.4. Concentrations of PCBs and Chlorinated Pesticides in Marine Mammal Blubber Samples (Concentrations in ng/g, wet weight)[a] - Sheet II

Animal Identification Number	NIST Identification Number	PCB 170 PCB 190[b]	PCB 180	PCB 187 PCB 159 PCB 182	PCB 195	Hexachloro-benzene	Lindane (γ-HCH)	Heptachlor epoxide	*cis*-Chlordane	*trans*-nonachlor	Dieldrin
692-RGSL-004	MM2B032	12 ± 1	36 ± 1	15 ± 1	1.6 ± 0.1	2.2 ± 0.1[c]	2.4 ± 0.1	46 ± 1	3.4 ± 0.1	116 ± 2	0.6 ± 0.1
692-RGSL-008	MM2B044	4.3 ± 0.1	20 ± 1	11 ± 1	≤0.2	56 ± 1[c]	21 ± 1	34 ± 1	0.7 ± 0.1	44 ± 1	26 ± 1
692-RGSL-011	MM3B056	≤4	14 ± 1	15 ± 1	≤5	125 ± 8	236 ± 3	65 ± 3	31 ± 3	275 ± 3	24 ± 2
692-RGSL-013	MM3B062	≤4	14 ± 1	14 ± 1	≤5	156 ± 7	633 ± 4	603 ± 4	103 ± 3	1215 ± 8	122 ± 5
692-FRSL-004	MM1B016	12 ± 1	1.5 ± 0.1	≤1	≤1	n.d.[c]	26 ± 1	34 ± 1	4.3 ± 0.1	302 ± 14	26 ± 1
692-FRSL-005	MM1B020	12 ± 1	33 ± 1	≤3	≤2	n.d.[c]	2.8 ± 0.2	15 ± 1	≤1	65 ± 3	1.2 ± 0.1
692-BLKA-001	MM3B071	14 ± 1	64 ± 3	72 ± 4	≤5	669 ± 15	≤3	≤5	13 ± 1	47 ± 5	20 ± 1
692-BLKA-002	MM3B074	13 ± 1	55 ± 3	66 ± 4	≤5	257 ± 11	12 ± 1	16 ± 2	15 ± 1	92 ± 9	29 ± 1
692-BLKA-007	MM4B133	43 ± 1	164 ± 2	156 ± 9	≤5	253 ± 14	355 ± 7	235 ± 6	41 ± 2	1299 ± 12	348 ± 9
692-BLKA-012	MM4B148	18 ± 2	63 ± 3	71 ± 3	≤5	118 ± 10	1095 ± 8	117 ± 4	35 ± 2	599 ± 8	350 ± 4

[a] Mean Concentrations from triplicate analyses of two subsamples (See Tables A.1. - A.3); uncertainties are one standard deviation of a single measurement.
[b] PCBs are numbered according to reference [Ballschmiter, K. and Zell, M. (1980) Fresenius Z Anal. Chem., 302:20-31]. PCB congener listed first is the major component; additional congeners listed may be present as minor components.
[c] Results may be low due to volatility losses during sample preparation. n.d. = results were less than the detection limit.

Table A.4. Concentrations of PCBs and Chlorinated Pesticides in Marine Mammal Blubber Samples (Concentrations in ng/g, wet weight)[a] - Sheet III

Animal Identification Number	NIST Identification Number	2,4'-DDE	4,4'-DDE	2,4'-DDD	4,4'-DDD	2,4'-DDT	4,4'-DDT
692-RGSL-004	MM2B032	5.0 ± 0.1	27 ± 1	≤1	0.8 ± 0.1	1.1 ± 0.1	0.7 ± 0.1
692-RGSL-008	MM2B044	24 ± 1	350 ± 12	≤0.5	0.6 ± 0.1	1.4 ± 0.1	1.8 ± 0.1
692-RGSL-011	MM3B056	≤3	173 ± 4	≤1	≤1	107 ± 3	52 ± 3
692-RGSL-013	MM3B062	2.8 ± 0.3	240 ± 9	≤1	104 ± 3	524 ± 3	555 ± 4
692-FRSL-004	MM1B016	1.1 ± 0.1	1330 ± 47	12.1 ± 0.5	118 ± 4	≤1	35 ± 2
692-FRSL-005	MM1B020	≤3	1050 ± 42	0.4 ± 0.1	19 ± 1	≤1	17 ± 1
692-BLKA-001	MM3B071	20 ± 1	1062 ± 33	≤3	≤3	159 ± 7	417 ± 5
692-BLKA-002	MM3B074	61 ± 2	1214 ± 21	43 ± 3	54 ± 3	268 ± 7	312 ± 13
692-BLKA-007	MM4B133	64 ± 2	2912 ± 38	40 ± 3	13 ± 4	105 ± 6	699 ± 5
692-BLKA-012	MM4B148	17 ± 1	757 ± 8	48 ± 4	196 ± 6	142 ± 8	267 ± 4

[a] Mean Concentrations from triplicate analyses of two subsamples (See Tables A.1. - A.3.); uncertainties are one standard deviation of a single measurement.

Table A.5. Concentrations of Inorganic Constituents in Northern Fur Seal Samples[a] (Concentrations in mg/kg, wet weight) - Sheet I

Animal Identification Number	Sampling Site	NIST Identification Number[b]	Na	Mg	Al	Cl	K	Ca	Sc
692-FRSL-004	St. Paul Island	MM1L013	760.4 ± 6.0	194 ± 4.5	0.533 ± 0.081	1016 ± 13	3316 ± 50	38.3 ± 4.4	≤0.00012
		MM1K014	1305.4 ± 9.8	189 ± 5.4	1.599 ± 0.085	1578 ± 18	2610 ± 49	38.1 ± 4.4	≤0.00011
		MM1M015	505.4 ± 3.7	231 ± 3.9	0.313 ± 0.041	538.9 ± 8.0	3350 ± 33	31.5 ± 3.7	0.000143 ± 0.000007
692-FRSL-005	St. Paul Island	MM1L017	699.8 ± 5.5	213 ± 4.4	0.522 ± 0.042	891 ± 12	3155 ± 59	30.6 ± 3.8	≤0.00013 ≤0.00015
		MM1K018	1382.3 ± 10.2	168.4 ± 4.2	0.780 ± 0.053	1697 ± 16	2464 ± 33	53.1 ± 4.0	≤0.00009 ≤0.00008
		MM1M019	479.4 ± 3.6	272 ± 4.5	0.712 ± 0.049	470.0 ± 6.0	3615 ± 38	22.1 ± 2.5	0.000087 ± 0.000006 0.000055 ± 0.000006

[a] All elements determined by instrumental neutron activation analysis (INAA) except as noted; the uncertainties associated with the INAA results are due to counting statistics, including propagated uncertainties of the standards.
[b] In the NIST Identification Number, the letters L, K, and M, indicate the sample type, i.e., L = Liver; K = Kidney; and M = Muscle.
[c] Samples analyzed by voltammetry

Table A.5. Concentrations of Inorganic Constituents in Northern Fur Seal Samples[a] (Concentrations in mg/kg, wet weight) - Sheet II

Animal Identification Number	NIST Identification Number[b]	V	Cr	Mn	Fe	Co	Ni	Cu
692-FRSL-004	MM1L013	0.0843 ± 0.0062	0.0251 ± 0.0044	4.179 ± 0.045	171.8 ± 1.0	0.01884 ± 0.00016 0.0158 ± 0.0011[c]	0.04242 ± 0.00029[c]	56.34 ± 0.82 53.91 ± 1.18[c]
	MM1K014	≤0.013	0.0390 ± 0.0036	1.157 ± 0.022	74.00 ± 0.49	0.02501 ± 0.00017		7.06 ± 0.52
	MM1M015	≤0.0073	0.0621 ± 0.0030	0.1630 ± 0.0058	75.12 ± 0.48	0.005094 ± 0.000068		2.20 ± 0.45
692-FRSL-005	MM1L017	0.1088 ± 0.0044	0.0551 ± 0.0050 0.0525 ± 0.0057	3.185 ± 0.036	118.8 ± 0.8 109.3 ± 0.8	0.01624 ± 0.00016 0.01523 ± 0.00019 0.0150 ± 0.0021[c]	0.0777 ± 0.0022[c]	17.03 ± 0.49 14.87 ± 0.80[c]
	MM1K018	≤0.008	0.0106 ± 0.0032 0.0136 ± 0.0032	1.260 ± 0.015	51.70 ± 0.37 52.52 ± 0.39	0.01733 ± 0.00014 0.01784 ± 0.00016		8.71 ± 0.35
	MM1M019	≤0.0073	0.0386 ± 0.0030 0.0229 ± 0.0026	0.1857 ± 0.0063	70.58 ± 0.45 72.19 ± 0.46	0.003641 ± 0.000057 0.003313 ± 0.000058		2.07 ± 0.30

[a] All elements determined by instrumental neutron activation analysis (INAA) except as noted; the uncertainties associated with the INAA results are due to counting statistics, including propagated uncertainties of the standards.
[b] In the NIST Identification Number, the letters L, K, and M indicate the sample type, i.e., L = Liver; K = Kidney; M = Muscle.
[c] Samples analyzed by voltammetry

Table A.5. Concentrations of Inorganic Constituents in Northern Fur Seal Samples[a] (Concentrations in mg/kg, wet weight) - Sheet III

Animal Identification Number	NIST Identification Number[b]	Zn	As	Se	Rb	Sr	Mo	Ag	Cd
692-FRSL-004	MM1L013	56.53 ± 0.42 61.6 ± 2.9[c]	≤0.092	6.289 ± 0.052	1.874 ± 0.047	≤0.89	0.38 ± 0.10	0.1721 ± 0.0023	18.51 ± 0.29 16.85 ± 0.18[c]
	MM1K014	63.28 ± 0.47	0.164 ± 0.021	3.856 ± 0.032	1.368 ± 0.033	≤0.78	≤0.40	≤0.0044	66.66 ± 0.79
	MM1M015	35.00 ± 0.26	0.174 ± 0.012	3.109 ± 0.026	1.518 ± 0.028	≤0.54	≤0.25	≤0.0030	≤0.26
692-FRSL-005	MM1L017	57.89 ± 0.43 53.03 ± 0.40 52.5 ± 1.2[c]	0.187 ± 0.020 0.239 ± 0.024	5.450 ± 0.045 4.987 ± 0.042	1.759 ± 0.049 1.598 ± 0.045	≤0.96 ≤1.1	0.65 ± 0.11 0.46 ± 0.10	0.3815 ± 0.0037 0.3472 ± 0.0039	8.01 ± 0.19 7.50 ± 0.18 6.14 ± 0.18[c]
	MM1K018	37.18 ± 0.28 37.75 ± 0.28	0.503 ± 0.023 0.479 ± 0.025	3.066 ± 0.026 3.085 ± 0.026	1.038 ± 0.030 1.094 ± 0.029	≤0.66 ≤0.72	≤0.29 ≤0.38	0.0129 ± 0.0011 0.0126 ± 0.0013	29.02 ± 0.39 29.02 ± 0.39
	MM1M019	33.43 ± 0.25 34.04 ± 0.25	0.311 ± 0.014	2.147 ± 0.018 2.195 ± 0.018	1.408 ± 0.028 1.410 ± 0.029	≤0.53 ≤0.56	≤0.28	≤0.0029 ≤0.0031	≤0.39

[a] All elements determined by instrumental neutron activation analysis (INAA) except as noted; the uncertainties associated with the INAA results are due to counting statistics, including propagated uncertainties of the standards.
[b] In the NIST Identification Number, the letters L, K, and M indicate the sample type, i.e., L = Liver; K = Kidney; M = Muscle.
[c] Samples analyzed by voltammetry

Table A.5. Concentrations of Inorganic Constituents in Northern Fur Seal Samples[a] (Concentrations in mg/kg, wet weight) - Sheet IV

Animal Identification Number	NIST Identification Number[b]	Sb	I	Cs	La	Ce	Sm	Eu	Tb
692-FRSL-004	MM1L013	0.00105 ± 0.00027	0.447 ± 0.071	0.01691 ± 0.00048	≤0.0085	≤0.014	≤0.0024	≤0.00076	≤0.015
	MM1K014	≤0.00069	≤0.32	0.02474 ± 0.00050	≤0.011	≤0.0095	≤0.0019	≤0.00072	≤0.019
	MM1M015	≤0.00048	≤0.20	0.04045 ± 0.00046	≤0.0070	≤0.0073	≤0.0012	≤0.00049	≤0.014
692-FRSL-005	MM1L017	0.00375 ± 0.00033 0.00304 ± 0.00037	1.74 ± 0.12	0.02880 ± 0.00053 0.02218 ± 0.00067	≤0.0092 ≤0.0086	≤0.015 ≤0.017	≤0.0023 ≤0.0023	≤0.00079 ≤0.00099	≤0.017 ≤0.016
	MM1K018	≤0.00054 0.00115 ± 0.00021	≤0.16	0.02312 ± 0.00044 0.02229 ± 0.00048	≤0.012 ≤0.011	≤0.0091 ≤0.010	≤0.0017 ≤0.0017	≤0.00059 ≤0.00067	≤0.021 ≤0.020
	MM1M019	0.00060 ± 0.00016 0.00043 ± 0.00012	≤0.21	0.04321 ± 0.00045 0.04266 ± 0.00047	≤0.0070	≤0.0070 ≤0.0075	≤0.0013	≤0.00046 ≤0.00049	≤0.014

[a] All elements determined by instrumental neutron activation analysis (INAA) except as noted; the uncertainties associated with the INAA results are due to counting statistics, including propagated uncertainties of the standards.
[b] In the NIST Identification Number, the letters L, K, and M indicate the sample type, i.e., L = Liver; K = Kidney; M = Muscle.
[c] Samples analyzed by voltammetry

Table A.5. Concentrations of Inorganic Constituents in Northern Fur Seal Samples[a] (Concentrations in mg/kg, wet weight) - Sheet V

Animal Identification Number	NIST Identification Number[b]	Hf	Ta	Au	Hg	Methyl-HG	Pb	U
692-FRSL-004	MM1L013	≤0.0011	≤0.0015	≤0.00033	10.84 ± 0.71[d]		0.02204 ± 0.00018[e]	≤0.070
	MM1K014	≤0.00094	≤0.00098	≤0.00038				≤0.073
	MM1M015	≤0.00068	≤0.00074	≤0.00023				≤0.045
692-FRSL-005	MM1L017	≤0.00096	≤0.0017	≤0.00035	7.65 ± 0.12[d]	0.94[c]	0.0467 ± 0.0034[e]	≤0.071
		≤0.0014	≤0.0020	≤0.00033				≤0.070
	MM1K018	≤0.00083	≤0.00092	≤0.00041				≤0.075
		≤0.00090	≤0.0010	≤0.00039				≤0.073
	MM1M019	≤0.00067	≤0.00071	≤0.00024				≤0.047
		≤0.00070	≤0.00074					

[a] All elements determined by instrumental neutron activation analysis (INAA) except as noted; the uncertainties associated with the INAA results are due to counting statistics, including propagated uncertainties of the standards.
[b] In the NIST Identification Number, the letters L, K, and M indicate the sample type, i.e., L = Liver; K = Kidney; M = Muscle.
[c] Samples analyzed by voltammetry.
[d] Samples analyzed by CVAAS.
[e] Determined using ion-exchange chromatography and CVAAS.

Table A.6. Concentrations of Inorganic Constituents in Ringed Seal Samples[a] (Concentrations in mg/kg, wet weight) - Sheet I

Animal Identification Number	Sampling Site	NIST Identification Number[b]	Na	Mg	Al	Cl	K	Ca
692-RGSL-004	Barrow	MM2L030	841.6 ± 5.0	231.4 ± 8.3	≤0.07	1047.1 ± 6.0	3114 ± 61	42.1 ± 2.8
			821.5 ± 5.0	201.8 ± 8.2	≤0.07	1032.0 ± 6.0	2947 ± 67	≤8.7
		MM2K031	1912 ± 11	124.9 ± 9.1	≤0.10	2584 ± 14	1196 ± 44	47.1 ± 5.1
			1922 ± 11	157.7 ± 8.9	≤0.11	2555 ± 14	2166 ± 78	53.1 ± 4.5
692-RGSL-008	Barrow	MM2L042	833.4 ± 5.0	223.7 ± 8.1	≤0.07	933.0 ± 5.5	3110 ± 60	41.3 ± 3.0
			816.3 ± 5.0	250.2 ± 9.2	≤0.07	907.9 ± 5.6	3131 ± 71	44.8 ± 3.2
		MM2K043	2120 ± 11	169 ± 10	≤0.12	2939 ± 15	1930 ± 74	≤12
			2095 ± 11	173 ± 12	≤0.12	2893 ± 15	1852 ± 62	≤13
692-RGSL-011	Nome	MM3L054	869.9 ± 6.9	220.1 ± 4.7	0.877 ± 0.094	810 ± 7	2568 ± 85	30.06 ± 2.76
			880.1 ± 6.9	230.0 ± 4.4	0.742 ± 0.058	828 ± 7	2761 ± 85	30.89 ± 4.14
692-RGSL-013	Nome	MM3L060	880.2 ± 7.0	191.7 ± 4.5	0.977 ± 0.059	1108 ± 8	2559 ± 91	31.25 ± 2.79
			878.0 ± 7.0	174.7 ± 4.5	0.605 ± 0.064	1100 ± 8	2663 ± 70	31.25 ± 2.79

[a] All elements determined by instrumental neutron activation analysis (INAA) except as noted; the uncertainties associated with the INAA results are due to counting statistics, including propagated uncertainties of the standards.
[b] In the NIST Identification Number, the letters L and K indicate the sample type, i.e., L = Liver and K = Kidney.
[c] Samples analyzed by voltammetry

Table A.6. Concentrations of Inorganic Constituents in Ringed Seal Samples[a] (Concentrations in mg/kg, wet weight) - Sheet II

Animal Identification Number	NIST Identification Number[a]	Sc	Ti	V	Cr	Mn	Fe	Co
692-RGSL-004	MM2L030	≤0.000058	≤1.3	0.1999 ± 0.0043	0.0131 ± 0.0030	3.732 ± 0.037	729.3 ± 9.5	0.01841 ± 0.00021
		≤0.000097	≤1.3	0.1959 ± 0.0038	≤0.011	3.659 ± 0.037	721.9 ± 6.7	0.01776 ± 0.00034
								0.0221 ± 0.0020[c]
	MM2K031	≤0.000031	≤2.1	≤0.077	0.0141 ± 0.0020	1.337 ± 0.027	123.6 ± 1.6	0.02070 ± 0.00019
		≤0.000053	≤1.9	≤0.082	0.0108 ± 0.0030	1.032 ± 0.020	121.1 ± 1.2	0.02067 ± 0.00023
692-RGSL-008	MM2L042	0.000084 ± 0.000018	≤1.3	0.4042 ± 0.0053	0.0228 ± 0.0026	3.849 ± 0.038	889 ± 12	0.03377 ± 0.00031
		≤0.000040	≤1.3	0.3859 ± 0.0053	0.0336 ± 0.0019	3.675 ± 0.037	884 ± 12	0.03350 ± 0.00030
								0.0472 ± 0.0023[c]
	MM2K043	≤0.000034	≤2.5	0.0729 ± 0.0044	0.0192 ± 0.0022	1.021 ± 0.024	115.2 ± 1.5	0.05571 ± 0.00047
		≤0.000041	≤1.6	0.0565 ± 0.0037	0.0178 ± 0.0024	0.702 ± 0.021	114.5 ± 1.1	0.05511 ± 0.00048
692-RGSL-011	MM3L054	0.000196 ± 0.000044		0.3803 ± 0.0072	0.0855 ± 0.0074	4.222 ± 0.039	573 ± 5	0.04479 ± 0.00066
		0.000323 ± 0.000050		0.3949 ± 0.0074	0.0527 ± 0.0074	4.278 ± 0.041	582 ± 5	0.04611 ± 0.00069
								0.0458 ± 0.0022[c]
692-RGSL-013	MM3L060	0.000206 ± 0.000045		0.1258 ± 0.0050	0.0815 ± 0.0078	2.865 ± 0.036	314 ± 3	0.02388 ± 0.00050
		0.000123 ± 0.000033		0.1242 ± 0.0056	0.0918 ± 0.0073	3.024 ± 0.033	315 ± 3	0.02352 ± 0.00050
								0.0430 ± 0.0011[c]

[a] All elements determined by instrumental neutron activation analysis (INAA) except as noted; the uncertainties associated with the INAA results are due to counting statistics, including propagated uncertainties of the standards.
In the NIST Identification Number, the letters L and K indicate the sample type, i.e., L = Liver; K = Kidney.
[c] Samples analyzed by voltammetry

Table A.6. Concentrations of Inorganic Constituents in Ringed Seal Samples[a] (Concentrations in mg/kg, wet weight) - Sheet III

Animal Identification Number	NIST Identification Number[b]	Ni	Cu	Zn	As	Se	Rb	Sr	Mo
692-RGSL-004	MM2L030		11.21 ± 0.37	38.06 ± 0.49	0.263 ± 0.012	5.712 ± 0.075	2.418 ± 0.053	≤0.31	0.253 ± 0.061
			10.92 ± 0.35	37.61 ± 0.49	0.300 ± 0.022	5.628 ± 0.053	2.267 ± 0.051	≤0.56	0.244 ± 0.073
		0.05085 ± 0.00057[c]	9.452 ± 0.029[c]	37.9 ± 2.0[c]					
	MM2K031		≤0.85	26.29 ± 0.34	0.175 ± 0.016	3.941 ± 0.052	1.222 ± 0.024	≤0.18	≤0.30
			3.90 ± 0.36	26.08 ± 0.34	0.200 ± 0.018	3.888 ± 0.051	1.181 ± 0.032	≤0.30	≤0.30
692-RGSL-008	MM2L042		6.40 ± 0.31	36.98 ± 0.48	0.584 ± 0.015	2.818 ± 0.037	3.515 ± 0.062	≤0.27	0.519 ± 0.067
			6.54 ± 0.32	36.73 ± 0.48	0.634 ± 0.021	2.798 ± 0.037	3.523 ± 0.050	≤0.23	0.524 ± 0.073
		0.0315 ± 0.0015[c]	6.296 ± 0.029[c]	37.0 ± 2.0[c]					
	MM2K043		7.66 ± 0.46	26.61 ± 0.35	0.444 ± 0.020	3.205 ± 0.042	1.718 ± 0.032	≤0.20	≤0.33
			3.34 ± 0.26	26.06 ± 0.34	0.428 ± 0.024	3.092 ± 0.041	1.720 ± 0.028	≤0.27	≤0.32
692-RGSL-011	MM3L054		8.00 ± 0.55	32.35 ± 0.28	2.46 ± 0.03	3.707 ± 0.036	1.613 ± 0.058	≤1.3	0.403 ± 0.080
			7.72 ± 0.44	33.01 ± 0.28	2.37 ± 0.03	3.767 ± 0.036	1.663 ± 0.066	≤1.4	≤0.31
		0.01768 ± 0.00025[c]	7.69 ± 0.17[c]	33.37 ± 0.55[c]					
692-RGSL-013	MM3L060		7.95 ± 0.45	27.61 ± 0.24	2.15 ± 0.03	2.730 ± 0.028	2.254 ± 0.056	≤1.3	0.416 ± 0.086
			8.82 ± 0.47	27.77 ± 0.24	2.06 ± 0.03	2.736 ± 0.027	2.235 ± 0.056	≤1.2	0.299 ± 0.078
		0.0385 ± 0.0025[c]	7.98 ± 0.17[c]	26.39 ± 0.89[c]					

[a] All elements determined by instrumental neutron activation analysis (INAA) except as noted; the uncertainties associated with the INAA results are due to counting statistics, including propagated uncertainties of the standards.
[b] In the NIST Identification Number, the letters L and K indicate the sample type, i.e., L = Liver; K = Kidney.
[c] Samples analyzed by voltammetry

Table A.6. Concentrations of Inorganic Constituents in Ringed Seal Samples[a] (Concentrations in mg/kg, wet weight) - Sheet IV

Animal Identificaiton Number	NIST Identification Number[b]	Ag	Cd	Sn	Sb	I	Cs	Ba	La
692-RGSL-004	MM2L030	0.1644 ± 0.0031	2.77 ± 0.12	≤0.53	0.00662 ± 0.00034	0.953 ± 0.067	0.03080 ± 0.00067	≤1.2	≤0.0083
		0.1656 ± 0.0047	2.55 ± 0.14	≤1.1	0.00664 ± 0.00052	0.690 ± 0.061	0.0306 ± 0.0010	≤0.78	≤0.0071
			2.425 ± 0.017[c]						
	MM2K031	0.00222 ± 0.00060	6.76 ± 0.16	≤0.32	0.003041 ± 0.00018	≤0.18	0.02888 ± 0.00051	≤0.60	≤0.011
		≤0.0025	6.61 ± 0.16	≤0.58	0.003290 ± 0.00032	≤0.17	0.02812 ± 0.00063	≤0.84	≤0.0093
692-RGSL-008	MM2L042	0.0474 ± 0.0016	2.14 ± 0.12	≤0.45	0.005565 ± 0.00027	0.667 ± 0.056	0.02346 ± 0.00054	≤1.1	≤0.0079
		0.0472 ± 0.0015	2.13 ± 0.12	≤0.47	0.005133 ± 0.00021	0.747 ± 0.070	0.02375 ± 0.00050	≤0.25	≤0.0070
			2.180 ± 0.061[c]						
	MM2K043	0.00224 ± 0.00066	3.37 ± 0.15	0.82 ± 0.15	0.00191 ± 0.00016	≤0.22	0.02412 ± 0.00045	≤0.70	≤0.012
		≤0.0023	3.80 ± 0.16	≤0.60	0.002527 ± 0.00023	≤0.16	0.02402 ± 0.00056	≤0.32	≤0.0097
692-RGSL-011	MM3L054	0.0734 ± 0.0030	1.72 ± 0.15		0.0129 ± 0.0011	7.64 ± 0.72	0.0464 ± 0.0013		≤0.0074
		0.0753 ± 0.0033	1.94 ± 0.20		0.0110 ± 0.0012	9.38 ± 0.85	0.0491 ± 0.0012		≤0.011
			1.840 ± 0.022[c]						
692-RGSL-013	MM3L060	0.0935 ± 0.0039	1.95 ± 0.18		0.0061 ± 0.0011	6.03 ± 0.81	0.0470 ± 0.0013		≤0.0072
		0.0898 ± 0.0031	1.74 ± 0.17		0.00575 ± 0.00078	6.72 ± 0.73	0.0442 ± 0.0011		≤0.0070
			1.992 ± 0.039[c]						

[a] All elements determined by instrumental neutron activation analysis (INAA) except as noted; the uncertainties associated with the INAA results are due to counting statistics, including propagated uncertainties of the standards.
[b] In the NIST Identification Number, the letters L and K indicate the sample type, i.e., L = Liver; K = Kidney.
[c] Samples analyzed by voltammetry

Table A.6. Concentrations of Inorganic Constituents in Ringed Seal Samples[a] (Concentrations in mg/kg, wet weight) - Sheet V

Animal Identification Number	NIST Identification Number[b]	Ce	Sm	Eu	Tb	Hf	Ta	Au	Hg	Methyl-Hg	Pb
692-RGSL-004	MM2L030	≤0.0057 ≤0.0096	≤0.0012 ≤0.0019	≤0.00038 ≤0.00077	≤0.00031 ≤0.00064	≤0.00052 ≤0.00084	≤0.00047 ≤0.00093	≤0.0003 ≤0.0003	6.35 ± 0.11[d]	0.28[e]	0.0287 ± 0.0014[c]
	MM2K031	≤0.0034 ≤0.0059	≤0.0012 ≤0.0014	≤0.00020 ≤0.00035	≤0.00019 ≤0.00034	≤0.00029 ≤0.00049	≤0.00020 ≤0.00035	≤0.0004 ≤0.0004			
692-RGSL-008	MM2L042	0.0050 ± 0.0018 ≤0.0037	≤0.0013 ≤0.0018	≤0.00034 ≤0.00033	≤0.00026 ≤0.00027	≤0.00046 ≤0.00034	≤0.00042 ≤0.00040	≤0.0003 ≤0.0003	1.95 ± 0.29[d]	0.17[e]	0.0312 ± 0.0012[c]
	MM2K043	≤0.0038 ≤0.0050	≤0.0013 ≤0.0015	≤0.00022 ≤0.00032	≤0.00021 ≤0.00035	≤0.00032 ≤0.00041	≤0.00024 ≤0.00036	≤0.0004 ≤0.0004			
692-RGSL-011	MM2L054	≤0.016 ≤0.017	≤0.00091 ≤0.00099	≤0.00097 ≤0.0010	≤0.0014 ≤0.0015	≤0.0011 ≤0.0011	≤0.00083 ≤0.00088	≤0.00030 ≤0.00041	1.627 ± 0.83[d]	0.70[e]	0.0287 ± 0.0033[c]
692-RGSL-013	MM2L060	≤0.017 ≤0.016	≤0.0010 ≤0.00095	≤0.00086 ≤0.00081	≤0.0012 ≤0.0011	≤0.0011 ≤0.0010	≤0.00064 ≤0.00067	≤0.00028 ≤0.00028	1.423 ± 0.028[d]	0.49[e]	0.02372 ± 0.00011[c]

[a] All elements determined by instrumental neutron activation analysis (INAA) except as noted; the uncertainties associated with the INAA results are due to counting statistics, including propagated uncertainties of the standards.
[b] In the NIST Identification Number, the letters L and K indicate the sample type, i.e., L = Liver; K = Kidney.
[c] Samples analyzed by voltammetry.
[d] Samples analyzed by CVAAS.
[e] Determined using ion-exchange chromatography and CVAAS.

Table A.6. Concentrations of Inorganic Constituents in Ringed Seal Samples[a] (Concentrations in mg/kg, wet weight) - Sheet VI

Animal Identification Number	NIST Identification Number[b]	Th	U
692-RGSL-004	MM2L030	≤0.00078	≤0.054
		≤0.0012	≤0.060
	MM2K031	≤0.00047	≤0.063
		≤0.00078	≤0.060
692-RGSL-008	MM2L042	≤0.00069	≤0.052
		≤0.00045	≤0.057
	MM2K043	≤0.00052	≤0.069
		≤0.00060	≤0.065
692-RGSL-011	MM2L054		≤0.085
			≤0.099
692-RGSL-013	MM2L060		≤0.092
			≤0.086

[a] All elements determined by instrumental neutron activation analysis (INAA) except as noted; the uncertainties associated with the INAA results are due to counting statistics, including propagated uncertainties of the standards.
[b] In the NIST Identification Number, the letters L and K indicate the sample type, i.e., L = Liver; K = Kidney.
[c] Samples analyzed by voltammetry

Table A.7. Concentrations of Inorganic Constituents in Belukha Whale Liver Samples[a] (Concentrations in mg/kg, wet weight) - Sheet I

Animal Identification Number	Sampling Site	NIST Identification Number	Na	Mg	Al	Cl	K	Ca	Sc	V
692-BLKA-001	Point Hope	MM3L069	1333 ± 15	220 ± 5	0.485 ± 0.080	1535 ± 14	2268 ± 111	21.18 ± 4.32	0.000302 ± 0.000077	0.0499 ± 0.0054
			1346 ± 14	218 ± 23	0.517 ± 0.089	1577 ± 15	2362 ± 50	29.41 ± 4.79	0.000336 ± 0.000050	0.0480 ± 0.0064
692-BLKA-002	Point Hope	MM3L072	1215 ± 10	151 ± 5	0.421 ± 0.062	1390 ± 10	2531 ± 82	23.94 ± 2.49	≤0.00013	0.0888 ± 0.0040
			1199 ± 9	162 ± 5	0.534 ± 0.057	1394 ± 10	2576 ± 95	29.43 ± 3.74	≤0.00014	0.0955 ± 0.0052
692-BLKA-003	Point Hope	MM3L075							≤0.00018	
			1049 ± 8	78.5 ± 3.1	0.440 ± 0.056	1496 ± 11	2704 ± 114	26.92 ± 3.65	≤0.00018	0.0948 ± 0.0056
692-BLKA-004	Point Hope	MM3L077	951 ± 9	113 ± 5	0.596 ± 0.086	1383 ± 13	2338 ± 89	31.39 ± 3.69	≤0.00034	0.0390 ± 0.0061
			970 ± 10	111 ± 18	0.557 ± 0.085	1386 ± 13	2207 ± 48	30.24 ± 3.75	0.000502 ± 0.000074	0.0286 ± 0.0057
692-BLKA-007	Point Lay	MM4L131	1138 ± 13	166 ± 27	≤1.16	1464 ± 14	2513 ± 107	29.93 ± 6.36	≤0.0009	0.2945 ± 0.0225
			1144 ± 12	154 ± 18	0.439 ± 0.066	1508 ± 14	2372 ± 52	27.37 ± 4.03	0.00211 ± 0.00179	0.2629 ± 0.0099
692-BLKA-012	Point Lay	MM4L146	1530 ± 18	168 ± 22	0.333 ± 0.097	1796 ± 16	2407 ± 119	33.11 ± 3.36	≤0.0004	0.0919 ± 0.0076
			1459 ± 16	176 ± 7	0.557 ± 0.085	1755 ± 16	2016 ± 50	48.79 ± 5.81	0.000526 ± 0.000083	0.0877 ± 0.0068

[a] All elements determined by instrumental neutron activation analysis (INAA) except as noted; the uncertainties associated with the INAA results are due to counting statistics including propagated uncertainties of the standards.
[b] Samples analyzed by voltammetry.

Table A.7. Concentrations of Inorganic Constituents in Belukha Whale Liver Samples[a] (Concentrations in mg/kg, wet weight) - Sheet II

Animal Identification Number	NIST Identification Number	Cr	Mn	Fe	Co	Ni	Cu	Zn
692-BLKA-001	MM3L069	≤0.023	3.03 ± 0.21	387 ± 10	0.0078 ± 0.0013		10.27 ± 0.63	32.33 ± 0.35
		1.670 ± 0.022	3.336 ± 0.051	387 ± 10	0.0114 ± 0.0011		13.73 ± 0.70	32.15 ± 0.35
						0.02431 ± 0.00046[b]	12.12 ± 0.29[b]	32.18 ± 0.24[b]
692-BLKA-002	MM3L072	0.066 ± 0.010	3.327 ± 0.035	363 ± 3	0.01175 ± 0.00067		14.52 ± 0.45	38.53 ± 0.32
		0.107 ± 0.012	3.387 ± 0.035	362 ± 3	0.01107 ± 0.00070		14.27 ± 0.50	38.53 ± 0.32
					0.01042 ± 0.00057[b]	0.0521 ± 0.0025[b]	13.842 ± 0.075[b]	39.2 ± 1.0[b]
692-BLKA-003	MM3L075	≤0.030		627 ± 6	0.0178 ± 0.0011			30.30 ± 0.27
		0.045 ± 0.012	3.093 ± 0.039	618 ± 6	0.0178 ± 0.0010		13.15 ± 0.53	30.19 ± 0.27
					0.0317 ± 0.0014[b]	0.04178 ± 0.00028[b]	12.17 ± 0.17[b]	32.8 ± 1.7[b]
692-BLKA-004	MM3L077	0.0643 ± 0.0011	2.865 ± 0.036	591 ± 15	0.0101 ± 0.0013		13.05 ± 0.76	22.72 ± 0.25
		0.225 ± 0.033	2.147 ± 0.044	584 ± 15	0.0114 ± 0.0011		11.68 ± 0.66	22.52 ± 0.24
						0.0197 ± 0.0026[b]	12.48 ± 0.47[b]	21.7 ± 0.71[b]
692-BLKA-007	MM4L131	0.088 ± 0.017	1.92 ± 0.18	769 ± 20	0.0153 ± 0.0033		41.21 ± 5.33	23.83 ± 0.29
		≤0.054	1.847 ± 0.042	792 ± 20	0.0143 ± 0.0032		40.14 ± 1.05	24.27 ± 0.31
						0.0142 ± 0.0011[b]	33.4 ± 1.0[b]	23.2 ± 0.10[b]
692-BLKA-012	MM4L146	≤0.025	1.804 ± 0.047	556 ± 14	0.0070 ± 0.0015		14.88 ± 0.77	20.67 ± 0.24
		≤0.025	1.509 ± 0.039	568 ± 14	0.0093 ± 0.0014		16.67 ± 0.88	21.14 ± 0.24
						0.01433 ± 0.00065[b]	14.59 ± 0.57[b]	19.79 ± 0.19[b]

[a] All elements determined by instrumental neutron activation analysis (INAA) except as noted; the uncertainties associated with the INAA results are due to counting statistics including propagated uncertainties of the standards.
[b] Samples analyzed by voltammetry.

Table A.7. Concentrations of Inorganic Constituents in Belukha Whale Liver Samples (Concentrations in mg/kg, wet weight) - Sheet III

Animal Identification Number	NIST Identification Number	As	Se	Br	Rb	Sr	Mo	Ag	Cd
692-BLKA-001	MM3L069	0.215 ± 0.014	7.245 ± 0.083	24.17 ± 0.68		≤3.4	≤0.27	17.68 ± 0.12	1.42 ± 0.14
		0.244 ± 0.012	7.162 ± 0.081	24.54 ± 0.72		≤3.4	≤0.35	17.58 ± 0.12	1.83 ± 0.18
									1.62 ± 0.073[b]
692-BLKA-002	MM3L072	0.132 ± 0.015	3.993 ± 0.040		1.152 ± 0.070	≤2.5	0.606 ± 0.087	14.365 ± 0.085	0.33 ± 0.11
		0.194 ± 0.020	3.988 ± 0.040		1.197 ± 0.072	≤2.5	0.416 ± 0.090	14.363 ± 0.095	0.58 ± 0.15
									1.112 ± 0.012[b]
692-BLKA-003	MM3L003	0.294 ± 0.024	14.27 ± 0.13		1.458 ± 0.104	≤3.7	≤0.28	30.53 ± 0.18	1.97 ± 0.18
		0.209 ± 0.021	14.23 ± 0.13		1.579 ± 0.101	3.98 ± 0.84	0.275 ± 0.084	30.49 ± 0.18	1.71 ± 0.18
									2.448 ± 0.017[b]
692-BLKA-004	MM3L077	0.183 ± 0.013	6.260 ± 0.072	24.92 ± 0.73		≤2.2	≤0.23	14.25 ± 0.09	≤0.91
		0.170 ± 0.010	6.227 ± 0.071	26.32 ± 0.75		≤2.2	≤0.27	14.92 ± 0.09	≤0.59
									0.896 ± 0.037[b]
692-BLKA-007	MM4L131	0.205 ± 0.019	74.38 ± 0.82	22.99 ± 0.69		≤8.7	≤0.64	105.55 ± 0.68	3.51 ± 0.25
		0.198 ± 0.015	76.64 ± 0.84	23.25 ± 0.74		≤8.9	≤0.42	109.21 ± 0.71	3.69 ± 0.24
									3.49 ± 0.20[b]
692-BLKA-012	MM4L146	0.180 ± 0.015	18.06 ± 0.20	40.33 ± 1.00		≤5.2	≤0.22	22.21 ± 0.15	3.60 ± 0.19
		0.176 ± 0.015	18.50 ± 0.21	30.82 ± 0.84		≤3.38	≤0.34	22.67 ± 0.15	3.70 ± 0.22
									3.36 ± 0.19[b]

[a] All elements determined by instrumental neutron activation analysis (INAA) except as noted; the uncertainties associated with the INAA results are due to counting statistics including propagated uncertainties of the standards.
[b] Samples analyzed by voltammetry.

Table A.7. Concentrations of Inorganic Constituents in Belukha Whale Liver Samples[a] (Concentrations in mg/kg, wet weight) - Sheet IV

Animal Identification Number	NIST Identification Number	Sb	I	Cs	La	Ce	Sm	Eu	Tb
692-BLKA-001	MM3L069	0.0123 ± 0.0013	5.97 ± 0.87	0.0454 ± 0.0019	≤0.0038	≤0.031	≤0.0012	≤0.0006	≤0.0088
		0.0107 ± 0.0018	4.69 ± 1.07	0.0465 ± 0.0023	≤0.0050	≤0.031	≤0.0014	≤0.0006	≤0.0089
692-BLKA-002	MM3L072	0.0092 ± 0.0024	4.46 ± 0.75	0.0315 ± 0.0015	≤0.0072	0.0114 ± 0.0055	≤0.0010	≤0.0013	≤0.0016
		≤0.0065	5.16 ± 0.62	0.0306 ± 0.0015	≤0.0070	≤0.0175	≤0.0011	≤0.0013	≤0.0017
692-BLKA-003	MM3L075	≤0.0095		0.0390 ± 0.0019	≤0.0076	≤0.022	≤0.0011	≤0.0019	≤0.0023
		≤0.0098	5.30 ± 0.76	0.0364 ± 0.0018	≤0.0087	≤0.022	≤0.0011	≤0.0019	≤0.0023
692-BLKA-004	MM3L077	0.00301 ± 0.00085	6.37 ± 0.98	0.0219 ± 0.0021	≤0.0030	≤0.028	≤0.0010	≤0.0005	≤0.0089
		0.00192 ± 0.00069	4.79 ± 0.85	0.0194 ± 0.0022	≤0.0037	≤0.028	≤0.0011	≤0.0005	≤0.0088
692-BLKA-007	MM4L131	0.0654 ± 0.00530	4.87 ± 1.14	0.0273 ± 0.0035	0.0466 ± 0.0034	0.089 ± 0.022	≤0.0029	≤0.0017	≤0.20
		0.0371 ± 0.0065	5.33 ± 1.49	0.0382 ± 0.0039	0.0431 ± 0.0032	≤0.067	≤0.0017	≤0.0018	≤0.20
692-BLKA-012	MM4L146	0.0043 ± 0.0027	≤4.6	0.0337 ± 0.0019	0.0182 ± 0.0020	≤0.035	≤0.0013	≤0.00064	≤0.0097
		≤0.0047	6.43 ± 1.07	0.0369 ± 0.0024	0.0175 ± 0.0027	≤0.036	≤0.0014	≤0.00067	≤0.0098

[a] All elements determined by instrumental neutron activation analysis except as noted; the uncertainties associated with the INAA results are due to counting statistics including propagated uncertainties of the standards.
[b] Samples analyzed by voltammetry

Table A.7. Concentrations of Inorganic Constituents in Belukha Whale Liver Samples[a] (Concentrations in mg/kg, wet weight) - Sheet V

Animal Identification Number	NIST Identification Number	Hf	Ta	Au	Hg	Methyl-Hg	Pb	U
692-BLKA-001	MM3L069	≤0.0069	≤0.0049	≤0.00023				≤0.11
		≤0.0054	≤0.0049	0.0017 ± 0.00013				≤0.13
					3.803 ± 0.073[c]	0.361 ± 0.049[d]	0.0439 ± 0.0032[b]	
692-BLKA-002	MM2L072	≤0.0022	≤0.0030	0.00235 ± 0.00013				≤0.090
		≤0.0023	≤0.0030	0.00340 ± 0.00015				≤0.095
					1.397 ± 0.012[c]	0.41[d]	0.11847 ± 0.00025[b]	
692-BLKA-003	MM3L075	≤0.0034	≤0.0045	0.00288 ± 0.00018				≤0.10
		≤0.0035	≤0.0048	0.00275 ± 0.00019				≤0.10
					18 ± 0.36[c]	0.75[d]	0.0460 ± 0.0090[b]	
692-BLKA-004	MM3L077	≤0.0052	≤0.0046	≤0.00021				≤0.09
		≤0.0051	≤0.0047	≤0.00023				≤0.10
					3.52 ± 0.37[c]	0.37[d]	0.07332 ± 0.00026[b]	
692-BLKA-007	MM4L131	≤0.0015	≤0.0014	≤0.00040				≤0.26
		≤0.0015	≤0.0015	≤0.00032				≤0.16
					72.9 ± 4.6[c]	2.15 ± 0.43[d]	0.0651 ± 0.0015[b]	
692-BLKA-012	MM4L146	≤0.0061	≤0.0057	≤0.00023				≤0.12
		≤0.0061	≤0.0052	≤0.00028				≤0.13
					24.64 ± 0.24[c]	0.688 ± 0.017[d]	0.0430 ± 0.00024[b]	

[a] All elements determined by instrumental neutron activation analysis (INAA) except as noted; the uncertainties associated with the INAA results are due to counting statistics including propagated uncertainties of the standards.
[b] Samples analyzed by voltammetry.
[c] Samples analyzed by CVAAS.
[d] Determined using ion-exchange chromatography and CVAAS.

Table A.8. Concentrations of Inorganic Constituents in Marine Mammal Livers[a] (Concentrations in mg/kg, wet weight) - Sheet I

Animal Identification Number	Sampling Site	NIST Identification Number	Na	Mg	Al	Cl	K	Ca
692-FRSL-004	St. Paul Island	MM1L013	760.4 ± 6.0	194 ± 4.5	0.533 ± 0.081	1016 ± 13	3316 ± 50	38.3 ± 4.4
692-FRSL-005	St. Paul Island	MM1L017	699.8 ± 5.5	213 ± 4.4	0.522 ± 0.042	891 ± 12	3155 ± 59	30.6 ± 3.8
692-RGSL-004	Barrow	MM2L030	831.6 ± 5.0	216.6 ± 8.2	≤0.07	1039.6 ± 6.0	3031 ± 64	42.1 ± 2.8
692-RGSL-008	Barrow	MM2L042	824.8 ± 5.0	237.0 ± 8.7	≤0.07	920.4 ± 5.6	3121 ± 66	43.1 ± 3.1
692-RGSL-011	Nome	MM3L054	875.0 ± 6.9	225.1 ± 4.6	0.810 ± 0.078	819 ± 7	2664 ± 85	30.48 ± 3.52
692-RGSL-013	Nome	MM3L060	879.1 ± 7.0	183.2 ± 4.5	0.791 ± 0.062	1104 ± 8	2611 ± 81	31.25 ± 2.79
692-BLKA-001	Point Hope	MM3L069	1340 ± 14	219 ± 17	0.501 ± 0.085	1556 ± 15	2315 ± 86	25.30 ± 4.56
692-BLKA-002	Point Hope	MM3L072	1207 ± 10	156.5 ± 5	0.478 ± 0.060	1392 ± 10	2554 ± 89	26.68 ± 3.18
692-BLKA-003	Point Hope	MM3L075	1049 ± 8	78.5 ± 3.1	0.440 ± 0.056	1496 ± 11	2704 ± 114	26.92 ± 3.65
692-BLKA-004	Point Hope	MM3L077	960.5 ± 10	112 ± 13	0.576 ± 0.086	1384 ± 13	2272 ± 72	30.82 ± 3.72
692-BLKA-007	Point Lay	MM4L131	1141 ± 12	160 ± 23	0.439 ± 0.066	1486 ± 14	2442 ± 84	28.65 ± 5.32
692-BLKA-012	Point Lay	MM4L146	1494 ± 17	172 ± 16	0.445 ± 0.091	1776 ± 16	2212 ± 91	40.95 ± 4.74

[a] Data is reported as the average of duplicate INAA analysis, if duplicate analyses were performed (See Tables A.5 - A.7.). The uncertainity (S.D.) was determined using $\frac{\sqrt{(n_1)^2 + (n_2)^2}}{2}$ where n_1 and n_2 are the S.D. for each sample. For results determined by INAA and voltammetry, only INAA results are reported.

[b] Element determined by voltammetry.

Table A.8. Concentrations of Inorganic Constituents in Marine Mammal Livers[a] (Concentrations in mg/kg, wet weight) - Sheet II

Animal Identification Number	NIST Identification Number	Sc	Ti	V	Cr	Mn	Fe	Co
692-FRSL-004	MM1L013	≤0.00012		0.0843 ± 0.0062	0.0251 ± 0.0044	4.179 ± 0.045	171.8 ± 1.0	0.01884 ± 0.00016
692-FRSL-005	MM1L017	≤0.00014		0.1088 ± 0.0044	0.0538 ± 0.0054	3.185 ± 0.036	114.1 ± 0.8	0.01574 ± 0.00018
692-RGSL-004	MM2L030	≤0.000078	≤1.3	0.1979 ± 0.0041	0.0131 ± 0.0030	3.696 ± 0.037	725.6 ± 8.2	0.01808 ± 0.00028
692-RGSL-008	MM2L042	0.000084 ± 0.000018	≤1.3	0.3951 ± 0.0053	0.0282 ± 0.0023	3.762 ± 0.038	886 ± 12	0.03364 ± 0.00031
692-RGSL-011	MM3L054	0.000260 ± 0.000047		0.3876 ± 0.0073	0.0691 ± 0.0074	4.250 ± 0.040	578 ± 5	0.04545 ± 0.00067
692-RGSL-013	MM3L060	0.000164 ± 0.000039		0.1250 ± 0.0053	0.0866 ± 0.0076	2.944 ± 0.034	314 ± 3	0.02370 ± 0.00050
692-BLKA-001	MM3L069	0.000319 ± 0.000061		0.04900 ± 0.0059	0.167 ± 0.022	3.183 ± 0.153	387 ± 10	0.0096 ± 0.0012
692-BLKA-002	MM3L072	≤0.00013		0.0922 ± 0.0046	0.086 ± 0.011	3.357 ± 0.035	362 ± 3	0.01141 ± 0.00068
692-BLKA-003	MM3L075	≤0.00018		0.0948 ± 0.0056	0.045 ± 0.012	3.093 ± 0.039	622 ± 6	0.0178 ± 0.0011
692-BLKA-004	MM3L077	0.000502 ± 0.000074		0.0338 ± 0.0059	0.1446 ± 0.023	2.506 ± 0.040	588 ± 15	0.0107 ± 0.0012
692-BLKA-007	MM4L131	0.00211 ± 0.000179		0.2787 ± 0.0174	0.088 ± 0.017	1.884 ± 0.131	781 ± 20	0.0148 ± 0.0032
692-BLKA-012	MM4L146	0.000526 ± 0.000083		0.0898 ± 0.0072	≤0.025	1.656 ± 0.043	562 ± 14	0.0081 ± 0.0014

[a] Data is reported as the average of duplicate INAA analysis, if duplicate analyses were performed (See Tables A.5.-A.7.). The uncertainity (S.D.) was determined using $\frac{\sqrt{(n_1)^2 + (n_2)^2}}{2}$ where n^1 and n^2 are the S.D. for each sample. For results determined by INAA and voltammetry, only INAA results reported.

[b] Element determined by voltammetry

Table A.8. Concentrations of Inorganic Constituents in Marine Mammal Livers[a] (Concentrations in mg/kg, wet weight) - Sheet III

Animal Identification Number	NIST Identification Number	Ni	Cu	Zn	As	Se	Br	Rb	Sr
692-FRSL-004	MM1L013	0.04242 ± 0.00029[b]	56.34 ± 0.82	56.53 ± 0.42	≤0.092	6.289 ± 0.052		1.874 ± 0.047	≤0.89
692-FRSL-005	MM1L017	0.0777 ± 0.0022[b]	17.03 ± 0.49	55.46 ± 0.42	0.213 ± 0.022	5.218 ± 0.044		1.678 ± 0.047	≤1.0
692-RGSL-004	MM2L030	0.05085 ± 0.00057[b]	11.06 ± 0.36	37.84 ± 0.49	0.282 ± 0.018	5.670 ± 0.065		2.342 ± 0.052	≤0.44
692-RGSL-008	MM2L042	0.0315 ± 0.0015[b]	6.47 ± 0.32	36.86 ± 0.48	0.609 ± 0.018	2.808 ± 0.037		3.519 ± 0.056	≤0.25
692-RGSL-011	MM3L054	0.01768 ± 0.00025[b]	7.86 ± 0.50	32.68 ± 0.28	2.42 ± 0.03	3.737 ± 0.036		1.638 ± 0.062	≤1.4
692-RGSL-013	MM3L060	0.03850 ± 0.00251[b]	8.38 ± 0.46	27.69 ± 0.24	2.11 ± 0.03	2.733 ± 0.028		2.244 ± 0.056	≤1.2
692-BLKA-001	MM3L069	0.02431 ± 0.00046[b]	12.00 ± 0.66	32.24 ± 0.35	0.230 ± 0.013	7.204 ± 0.082	24.36 ± 0.70		≤3.4
692-BLKA-002	MM3L072	0.0521 ± 0.0025[b]	14.40 ± 0.48	38.53 ± 0.32	0.163 ± 0.018	3.991 ± 0.040		1.174 ± 0.071	≤2.5
692-BLKA-003	MM3L075	0.04178 ± 0.00028[b]	13.15 ± 0.53	30.24 ± 0.27	0.252 ± 0.022	14.25 ± 0.13		1.518 ± 0.102	3.98 ± 0.84
692-BLKA-004	MM3L077	0.0197 ± 0.0026[b]	12.36 ± 0.71	22.62 ± 0.24	0.176 ± 0.012	6.24 ± 0.07	25.62 ± 0.74		≤2.2
692-BLKA-007	MM4L131	0.0142 ± 0.0011[b]	40.68 ± 3.84	24.05 ± 0.30	0.202 ± 0.017	75.51 ± 0.83	23.12 ± 0.72		≤8.8
692-BLKA-012	MM4L146	0.01433 ± 0.00065[b]	15.78 ± 0.83	20.91 ± 0.24	0.178 ± 0.015	18.28 ± 0.20	35.58 ± 0.92		≤4.5

[a] Data is reported as the average of duplicate INAA analysis, if duplicate analyses were performed (See Tables A.5-A.7.). The uncertainity (S.D.) was determined using $\frac{\sqrt{(n_1)^2 + (n_2)^2}}{2}$ where n_1 and n_2 are S.D. for each sample. For results determined by INAA and voltammetry, only INAA results reported.

[b] Element determined by voltammetry.

Table A.8. Concentrations of Inorganic Constituents in Marine Mammal Livers[a] (Concentrations in mg/kg, wet weight) - Sheet V

Animal Identification Number	NIST Identification Number	Ba	La	Ce	Sm	Eu	Tb	Hf	Ta	Au
692-FRSL-004	MM1L013		≤0.0085	≤0.014	≤0.0024	≤0.00076	≤0.015	≤0.0011	≤0.0015	≤0.00033
692-FRSL-005	MM1L017		≤0.0089	≤0.016	≤0.0023	≤0.00089	≤0.016	≤0.0012	≤0.0018	≤0.00034
692-RGSL-004	MM2L030	≤0.99	≤0.0077	≤0.0076	≤0.0016	≤0.00058	≤0.00048	≤0.00068	≤0.00070	≤0.0003
692-RGSL-008	MM2L042	≤0.68	≤0.0074	0.0050 ± 0.0018	≤0.0016	≤0.00034	≤0.00026	≤0.00040	≤0.00041	≤0.0003
692-RGSL-011	MM3L054		≤0.0091	≤0.017	≤0.00095	≤0.00098	≤0.0014	≤0.0011	≤0.00086	≤0.00036
692-RGSL-013	MM3L060		≤0.0071	≤0.016	≤0.00095	≤0.00084	≤0.0012	≤0.0011	≤0.00066	≤0.00028
692-BLKA-001	MM3L069		≤0.0044	≤0.031	≤0.0013	≤0.0006	≤0.0088	≤0.0062	≤0.0049	0.0017 ± 0.00013
692-BLKA-002	MM3L072		≤0.0071	0.0114 ± 0.0055	≤0.0011	≤0.0013	≤0.0016	≤0.0022	≤0.0030	0.00288 ± 0.00014
692-BLKA-003	MM3L075		≤0.0082	≤0.022	≤0.0011	≤0.0019	≤0.0023	≤0.0034	≤0.0046	0.00282 ± 0.00018
692-BLKA-004	MM3L077		≤0.0034	≤0.028	≤0.0011	≤0.0005	≤0.0088	≤0.0052	≤0.0046	≤0.00022
692-BLKA-007	MM4L131		0.0448 ± 0.0033	0.089 ± 0.022	≤0.0023	≤0.0018	≤0.020	≤0.0015	≤0.0014	≤0.00036
692-BLKA-012	MM4L146		0.0178 ± 0.0024	≤0.036	≤0.0014	≤0.00066	≤0.0098	≤0.0061	≤0.0054	≤0.00026

[a] Data is reported as the average of duplicate INAA analysis, if duplicate analyses were performed (See Tables A.5.-A.7.). The uncertainity (S.D.) was determined using $\sqrt{\frac{(n_1)^2 + (n_2)^2}{2}}$ where n_1 and n_2 are the S.D. for each sample. For results determined by INAA and voltammetry, only INAA results reported.

[b] Element determined by voltammetry.

Table A.8. Concentrations of Inorganic Constituents in Marine Mammal Livers[a] (Concentrations in mg/kg, wet weight) - Sheet IV

Animal Identification Number	NIST Identification Number	Mo	Ag	Cd	Sn	Sb	I	Cs
692-FRSL-004	MM1L013	0.380 ± 0.10	0.1721 ± 0.0023	18.51 ± 0.29		0.00105 ± 0.00027	0.447 ± 0.071	0.01691 ± 0.00048
692-FRSL-005	MM1L017	0.56 ± 0.11	0.3644 ± 0.0038	7.76 ± 0.18		0.00340 ± 0.00035	1.74 ± 0.12	0.02549 ± 0.00060
692-RGSL-004	MM2L030	0.248 ± 0.067	0.1650 ± 0.0040	2.66 ± 0.13	≤0.82	0.00663 ± 0.00044	0.822 ± 0.064	0.03070 ± 0.00085
692-RGSL-008	MM2L042	0.522 ± 0.070	0.0473 ± 0.0016	2.14 ± 0.12	≤0.46	0.005349 ± 0.00024	0.707 ± 0.063	0.02361 ± 0.00052
692-RGSL-011	MM3L054	0.403 ± 0.080	0.0744 ± 0.0032	1.83 ± 0.18		0.01197 ± 0.00113	8.51 ± 0.79	0.0478 ± 0.0012
692-RGSL-013	MM3L060	0.358 ± 0.082	0.0916 ± 0.0035	1.84 ± 0.18		0.00592 ± 0.00093	6.38 ± 0.77	0.0456 ± 0.0012
692-BLKA-001	MM3L069	≤0.31	17.63 ± 0.12	1.62 ± 0.16		0.0115 ± 0.0016	5.33 ± 0.98	0.0460 ± 0.0021
692-BLKA-002	MM3L072	0.511 ± 0.088	14.364 ± 0.090	0.46 ± 0.13		0.0092 ± 0.0024	4.81 ± 0.69	0.03105 ± 0.0015
692-BLKA-003	MM3L075	0.275 ± 0.084	30.52 ± 0.18	1.84 ± 0.18		≤0.0097	5.30 ± 0.76	0.0377 ± 0.0018
692-BLKA-004	MM3L077	≤0.25	14.58 ± 0.09	≤0.75		0.00246 ± 0.00077	5.58 ± 0.92	0.02065 ± 0.0022
692-BLKA-007	MM4L131	≤0.53	107.38 ± 0.70	3.60 ± 0.24		0.0513 ± 0.0059	5.10 ± 1.33	0.0328 ± 0.0037
692-BLKA-012	MM4L146	≤0.28	22.44 ± 0.15	3.65 ± 0.21		0.0043 ± 0.0027	6.43 ± 1.07	0.0353 ± 0.0022

[a] Data is reported as the average of duplicate INAA analysis, if duplicate analyses were performed (See Tables A.5.-A.7.). The uncertainity (S.D.) was determined using $\frac{\sqrt{(n_1)^2 + (n_2)^2}}{2}$ where n_1 and n_2 are the S.D. for each sample. For results determined by INAA and voltammetry, only INAA results reported.

[b] Element determined by voltammetry.

Table A.8. Concentrations of Inorganic Constituents in Marine Mammal Livers[a] (Concentrations in mg/kg, wet weight) - Sheet VI

Animal Identification Number	NIST Identification Number	Hg	Methyl-Hg	Pb	Th	U
692-FRSL-004	MM1L013	10.84 ± 0.71[c]	0.28[d]	0.02204 ± 0.00018[b]		≤0.070
692-FRSL-005	MM1L017	7.65 ± 0.12[c]	0.94[d]	0.0467 ± 0.0034[b]		≤0.071
692-RGSL-004	MM2L030	6.35 ± 0.11[c]		0.0287 ± 0.0014[b]	≤0.00099	≤0.057
692-RGSL-008	MM2L042	1.95 ± 0.29[c]	0.17[d]	0.0312 ± 0.0012[b]	≤0.00057	≤0.054
692-RGSL-011	MM3L054	1.627 ± 0.083[c]	0.70[d]	0.0287 ± 0.0033[b]		≤0.092
692-RGSL-013	MM3L060	1.423 ± 0.028[c]	0.49[d]	0.02372 ± 0.00011[b]		≤0.089
692-BLKA-001	MM3L069	3.803 ± 0.073[c]	0.361 ± 0.049[d]	0.0439 ± 0.0032[b]		≤0.12
692-BLKA-002	MM3L072	1.397 ± 0.012[c]	0.41[d]	0.11847 ± 0.00025[b]		≤0.092
692-BLKA-003	MM3L075	10.18 ± 0.36[c]	0.75[d]	0.0460 ± 0.0090[b]		≤0.10
692-BLKA-004	MM3L077	3.52 ± 0.37[c]	0.37[d]	0.07332 ± 0.00026[b]		≤0.10
692-BLKA-007	MM4L131	72.9 ± 4.6[c]	2.15 ± 0.43[d]	0.0651 ± 0.0015[b]		≤0.21
692-BLKA-012	MM4L146	24.64 ± 0.24[c]	0.688 ± 0.017[d]	0.00430 ± 0.00024[b]		≤0.12

[a] Data is reported as the average of duplicate INAA analysis, if duplicate analyses were performed (See Tables A.5.-A.7.). The uncertainity (S.D.) was determined using $\sqrt{\frac{(n_1)^2 + (n_2)^2}{2}}$ where n_1 and n_2 are the S.D. for each sample. For results determined by INAA and voltammetry, only INAA results reported.
[b] Element determined by voltammetry.
[c] Element determined by CVAAS.
[d] Determined using ion-exchange chromatography and CVAAS.

Table A.9. Concentrations of Selected Elements in Marine Mammal Livers as Determined by DPASV and CVAAS (Concentrations in mg/kg, wet weight)

Animal Identification Number	Sampling Site	NIST Identification Number	Co	Ni	Cu	Zn	Cd	Hg	Methyl-Hg	Pb
692-FRSL-004	St. Paul Is.	MM1L013 B005	0.0158 ± 0.0011	0.04242 ± 0.00029	53.91 ± 1.18	61.6 ± 2.9	16.85 ± 0.18	10.84 ± 0.71		0.02204 ± 0.00018
692-FRSL-005	St. Paul Is.	MM1L017 B005	0.0150 ± 0.0021	0.0777 ± 0.0022	14.87 ± 0.80	52.5 ± 1.2	6.14 ± 0.18	7.65 ± 0.12	0.94	0.0467 ± 0.0034
692-RGSL-004	Barrow	MM1L030 B005	0.0221 ± 0.0020	0.05085 ± 0.00057	9.452 ± 0.029	37.9 ± 2.0	2.425 ± 0.017	6.35 ± 0.11	0.28	0.0287 ± 0.0014
692-RGSL-008	Barrow	MM1L042 B005	0.0472 ± 0.0023	0.0315 ± 0.0015	6.296 ± 0.029	37.0 ± 2.0	2.180 ± 0.061	1.95 ± 0.29	0.17	0.0312 ± 0.0012
692-RGSL-011	Nome	MM3L054 B011	0.0458 ± 0.0022	0.01760 ± 0.00025	7.69 ± 0.17	33.37 ± 0.55	1.840 ± 0.022	1.627 ± 0.083	0.70	0.0287 ± 0.0033
692-RGSL-013	Nome	MM3L060 B011	0.0430 ± 0.0011	0.0385 ± 0.0025	7.98 ± 0.17	26.39 ± 0.89	1.992 ± 0.039	1.423 ± 0.028	0.49	0.02372 ± 0.00011
692-BLKA-001	Pt. Hope	MM3L069 B005		0.02431 ± 0.00046	12.12 ± 0.29	32.18 ± 0.24	1.62 ± 0.073	3.803 ± 0.073	0.361 ± 0.049	0.0439 ± 0.0032
692-BLKA-002	Pt. Hope	MM3L072 B005	0.01042 ± 0.00057	0.0521 ± 0.0025	13.842 ± 0.075	39.2 ± 1.0	1.112 ± 0.012	1.397 ± 0.012	0.41	0.11847 ± 0.00025
692-BLKA-003	Pt. Hope	MM3L075 B005	0.0317 ± 0.0014	0.04178 ± 0.00028	12.17 ± 0.17	32.8 ± 1.7	2.448 ± 0.017	10.18 ± 0.36	0.75	0.0460 ± 0.0090
692-BLKA-004	Pt. Hope	MM3L077 B005		0.0197 ± 0.0026	12.48 ± 0.47	21.7 ± 0.71	0.896 ± 0.037	3.52 ± 0.37	0.37	0.07332 ± 0.00026
692-BLKA-007	Pt. Lay	MM4L131 B005		0.0142 ± 0.0011	33.4 ± 1.0	23.2 ± 0.10	3.49 ± 0.20	72.9 ± 4.6	2.15 ± 0.43	0.0651 ± 0.0015
692-BLKA-012	Pt. Lay	MM4L146 B005		0.01433 ± 0.00065	14.59 ± 0.57	19.79 ± 0.19	3.36 ± 0.19	24.64 ± 0.24	0.688 ± 0.017	0.0430 ± 0.00024

Table A.10. Percent Water in Marine Mammal Tissue Specimens

Animal Identification Number	Sampling Site	NIST Identification Number	Percent Water[a]
692-FRSL-004	St. Paul Island	MM1L013 B005	70.54
		MM1K014 B005	75.50
		MM1M015 B005	74.51
		MM1B016 B005	25.64
692-FRSL-005	St. Paul Island	MM1L017 B005	69.28
		MM1K018 B005	73.57
		MM1M019 B005	73.49
		MM1B020 B005	15.85
692-RGSL-004	Barrow	MM1L030 B005	71.27
		MM1K031 B005	78.14
692-RGSL-008	Barrow	MM1L042 B005	70.85
		MM1K043 B005	77.44
692-RGSL-011	Nome	MM3L054 B011	72.42
692-RGSL-013	Nome	MM3L060 B011	72.10
692-BLKA-001	Point Hope	MM3L069 B005	75.62
692-BLKA-002	Point Hope	MM3L072 B005	75.06
692-BLKA-003	Point Hope	MM3L075 B005	71.96
692-BLKA-004	Point Hope	MM3L077 B005	73.72
692-BLKA-007	Point Lay	MM4L131 B005	74.68
692-BLKA-012	Point Lay	MM4L146 B005	75.84

[a] Water loss determined by freeze drying.

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In 1987, the Alaska Marine Mammal Tissue Archival Project (AMMTAP) was established as part of the National Biomonitoring Specimen Bank (NBSB) program at the National Institute of Standards and Technology (NIST). The purpose of the AMMTAP was to establish a representative collection of Alaska marine mammal tissues for future contaminant analyses and documentation of long-term trends in environmental quality. Since 1987, specimens have been collected from 65 animals (seven species) from six different sites. This report contains the current sample inventory and the results of the analysis of selected samples for the measurement of inorganic and organic compounds.

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Arctic; Chlorinated Pesticides; Marine Mammals; Polychlorinated Biphenyls (PCBs); Specimen Banking; Trace Elements

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