The following supplement accompanies the article

Wintering eiders acquire exceptional Se and Cd burdens in the Bering Sea: physiological and oceanographic factors

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Marine Ecology Progress Series 489: 245–261 (2013)

Supplement. Additional details of methods and results

Trace element analyses

In the laboratory, samples (2–5 g wet mass) of liver, kidney, and pectoral muscle were removed from thawed birds and placed into acid-washed glass vials. All non-disposable labware was washed with 5% (v/v) trace element grade HNO_3 (Baker Instra-analyzed) between samples. Samples were frozen to –70°C and freeze-dried. Each dried sample was homogenized and ~0.5 g was placed in a Teflon microwave digestion vessel (CEM Corporation) together with 3 ml of HNO_3. After 15 min at room temperature, 3 ml of 37% H_2O_2 were added and the vessel capped and heated to 180°C in a microwave digester (MDS 2000, CEM Corporation) for 20 min. Each digester run included a standard reference material (SRM) (bovine liver 1577b, NIST) and a duplicate tissue sample spiked with ~50% of the anticipated analyte concentrations. After digestion, samples were cooled and quantitatively transferred to 15-ml trace element grade polypropylene tubes (Elkay no. 2086, Elkay Plastics Corporation), and then brought up to 10 ml with 18 Mohm deionized water. A reagent blank was created by microwaving a 1:1 mixture of HNO_3 and H_2O_2 according to the same protocol.

A 1-ml sample of tissue digest was diluted in 1 ml of internal standard (Ge, Sc, Y, In, Tb, and Bi; SPEX Certiprep) and 4 ml of deionized water in a 15-ml tube. These were then analyzed on an Elan 6100 inductively coupled plasma (ICP) mass spectrometer (PE Sciex, Norwalk, CT). A reagent blank and a set of matrix-matched analytical standards were used to build an external calibration curve, and elemental concentrations in tissue samples were calculated with the manufacturer's software (Elan version 2.3.1, PE Sciex). For quality control, the certified reference material NIST bovine liver (1577b) was used as an SRM for every 10 samples digested. We used spikes as a second, orthogonal measure of analyte recovery. Criteria for accepting results of each run were values within ±10% of nominal element concentrations in the SRM, and 100 ± 10% recovery of spikes. The limit of quantitation for all elements was 0.05 µg g^{-1} dry mass, except for Se (1.00 µg g^{-1}), As (0.5 µg g^{-1}), and V (0.1 µg g^{-1}). For statistical purposes, we assigned a value of one-half the detection limit for concentrations below the quantitation limit.

Converting tissue element concentrations from wet mass to dry mass

When literature values of trace elements in bird tissues were expressed only in terms of fresh mass, we converted values to dry mass. Dry mass percentages can vary with season and especially with lipid content in the liver, e.g. livers of Canada geese (*Branta canadensis*) varied from 36.4% dry mass during pre-laying to 23.4% just after laying, and averaged 30.2% from late December to early April (Raveling 1979). Mean percent dry mass was 31.3% for liver and 25.4% for kidney in 5 seabird species during summer (Elliott & Scheuhammer 1997), 24.5% for liver and 19.8% for kidney in Barrow's goldeneyes (*Bucephala islandica*) in February (Franson et al. 1995), and 32.7% for liver and 23.4% for kidney in captive mallards in February–May (Scanlon 1982). We used 30% for liver and 23% for kidney.

Complement of trace elements in spectacled eider tissues

Concentrations of trace elements in liver, kidney, and muscle of spectacled eiders that were not reported in the main manuscript are reported in Table S3.

Table S1. Concentrations (mean, range) of Se, Cu, and Cd (μg g^{-1} dry mass) in soft tissues of marine bivalves from within the eddy region of high organic matter accumulation in the Bering Sea (Fig. 4), and in other geographic areas

	Se	Cu	Cd	Source[a]
Nuculana radiata				
North-central Bering Sea	2.4, 1.9–2.8	5.4, 4.2–6.4	6.4, 5.3–7.8	Present study
Macoma balthica				
Western coast, Norway	2.9			1
Gulf of Finland		45	0.7–2.1	2, 3
Gdansk Bay, Poland		7–33	0.2–0.7	2
Southern Baltic Sea		59	0.6	2
Wadden Sea, Netherlands	3.4, 2.2–4.9			1
Looe Estuary, UK		300, 96–615	0.7, 0.2–0.9	4
Chesapeake Bay, USA		26, 9–48	0.4, 0.2–0.6	5
Fraser River Estuary, Canada		132, 49–314		6
San Francisco Bay, USA	3.4, 1.1–5.8	15–517	0.1–0.5	7, 8, 9
Mya arenaria				
Gdansk Bay, Poland		2–48	1.0–5.1	2
Black Sea, Russia		50–150		2
Orwell estuary, UK		26, 16–31	0.14, 0.13–0.15	10
Frobisher Bay, Canada			1.2	11
Chesapeake Bay, USA		15, 14–16	0.3, 0.2–0.4	5
Puget Sound, USA	2.3, 1.9–2.6	13, 10–16	0.7, 0.6–0.9	12
Potamocorbula amurensis				
San Francisco Bay, USA	8.7–12.5	26, 13–43	3.9, 1.4–10.0	9, 13
Rangia cuneata				
Chesapeake Bay, USA		10, 1–21	0.7, 0.2–1.4	5
Serripes groenlandicus				
Greenland	0.5		1.1	14
Pechora Sea, Russia			2.7	11
Clinocardium ciliatum				
Pechora Sea, Russia			1.8	11
Ruditapes philippinarum				
6 coastal sites, China		11, 6–31	1.8, 0.4–5.0 except one site 0.5–8.5	15
Chlamys islandica				
Greenland	0.9		4.7	14

Cerastoderma edule				
Looe Estuary, UK		10, 5–27	0.8, 0.5–1.0	4
Mercenaria mercenaria				
Puget Sound, USA	3.6, 2.8–4.8	7, 5–9	2.0, 0.9–3.1	12
Musculus discors				
Greenland	1.2		1.3, 0.7–1.9	14
Perna viridis				
6 coastal sites, China		12, 6–25 except one site 0–68	2.2, 0–2.7 except one site 1.6–8.3	15
Mytilus edulis				
Greenland	1.1–5.6	9, 7–11	0.4–2.3	16, 17, 18
Barents Sea, Russia		9	2.0	19
Iceland		10, 9–18	0.6, 0.3–1.9	20
West coast, Norway	4.1			1
Trondheimsfjorden, Norway		24, 5–88	2.4, <1–5	21
White Sea, Russia		4–5	4.9–5.1	22
North Sea, Germany		11–14	0.5–0.9	19
Wadden Sea, Netherlands	3.7, 2.4–5.5			1
Looe Estuary, UK		10, 4–14	1.8, 0.8–2.6	4
Orwell and Stour estuaries, UK		11, 2–21	1.8, 1.0–2.9	10
Shannon, Ireland		7		19
6 coastal sites, China		12, 1–29 except one site 4–54	3.3, 1.2–5.3 except one site 2.4–13.7	15
Mytilus trossulus				
9 sites, Kuril Islands, Russia		7.5, 6.8–9.0	11.9, 3.5–34.0	23
Crenomytilus grayanus				
3 sites, Kuril Islands, Russia		5.5, 5.1–5.9	50, 37–66	23

[a]References: (1) Goede et al. (1993), (2) Szefer (1986), (3) Jankovski & Simm (1999), (4) Bryan & Hummerstone (1977), (5) Di Giulio & Scanlon (1985), (6) McGreer (1982), (7) Johns et al. (1988), (8) Cain & Luoma (1986), (9) Brown & Luoma (1995), (10) Wright & Mason (1999), (11) AMAP (1998), (12) US Fish and Wildlife Service (1994), (13) Linville et al. (2002), (14) Dietz et al. (1996), (15) Pan & Wang (2012), (16) Dietz et al. (2000), (17) Riget & Dietz (2000), (18) Riget et al. (1996), (19) Zauke et al. (2003), (20) Ólafsson (1986), (21) Lande (1977), (22) Millward et al. (1999), (23) Kavun et al. (2002)

Table S2. Mean (±1 SE) Se concentrations in sediments from the north-central Bering Sea and other geographic areas

Location	Se (µg g^{-1} dry mass)	Source[a]
North-central Bering Sea		1
Within steady eddy	0.49 ± 0.05	
Outside steady eddy	0.37 ± 0.02	
Padilla and Fidalgo Bays, Puget Sound, USA	0.31 ± 0.01	2
Suisun and San Pablo Bays, USA	0.27 ± 0.02	3
Nearshore surface sediments, Japan		4
Suruga Bay	0.68 ± 0.03	
Off Shikoku Island	1.13 ± 0.04	
Outer Macquarie estuary, Australia	0.85 ± 0.12	5
Lower St. Lawrence estuary	0.75	6

[a]References: (1) present study, (2) US Fish and Wildlife Service (1994), (3) Meseck & Cutter (2012), (4) Takematsu et al. (1993), (5) Peters et al. (1999), (6) Takayanagi & Belzile (1988)

Table S3. *Somateria fischeri*. Arithmetic and geometric means (µg g^{-1} dry mass, ±SE) and ranges of trace elements in liver, kidney, and pectoral muscle of 26 male and 12 female adult spectacled eiders in March 2001 in the north-central Bering Sea. Levels of Ti were mostly below detection limits

		Male			Female		
		Arithmetic mean ± SE	Geometric mean	Range	Arithmetic mean ± SE	Geometric mean	Range
As	Liver	3.5 ± 0.2	3.4	1.5–5.3	2.9 ± 0.4	2.7	1.3–5.0
	Kidney	3.7 ± 0.2	3.6	2.1–6.5	3.6 ± 0.3	3.4	2.2–5.5
	Muscle	2.3 ± 0.1	2.3	1.4–3.7	2.0 ± 0.2	1.9	1.0–3.1
Ba	Liver	0.039 ± 0.007	0.034	0.025–0.198	0.034 ± 0.004	0.033	0.025–0.067
	Kidney	0.101 ± 0.034	0.059	0.025–0.852	0.178 ± 0.110	0.070	0.025–1.378
	Muscle	0.046 ± 0.012	0.033	0.025–0.268	0.032 ± 0.003	0.031	0.025–0.062
Co	Liver	0.287 ± 0.027	0.264	0.157–0.662	0.273 ± 0.043	0.249	0.152–0.704
	Kidney	0.307 ± 0.029	0.283	0.122–0.813	0.282 ± 0.025	0.270	0.159–0.501
	Muscle	0.069 ± 0.006	0.063	0.035–0.135	0.054 ± 0.005	0.052	0.031–0.088
Cr	Liver	34.73 ± 4.05	25.85	2.57–79.80	28.38 ± 5.75	20.90	4.90–66.21
	Kidney	9.63 ± 2.33	6.26	2.21–43.57	9.41 ± 2.26	6.96	1.96–26.47
	Muscle	15.79 ± 2.64	11.00	2.41–45.14	6.32 ± 0.970*	5.48	2.18–11.85
Fe	Liver	884 ± 59	837	434–1572	840 ± 118	760	385–1653
	Kidney	581 ± 38	557	316–1199	519 ± 39	502	297–695
	Muscle	366 ± 24	349	231–582	295 ± 12*	292	208–346
Mg	Liver	535 ± 14	530	344–639	507 ± 23	501	373–623
	Kidney	648 ± 25	639	505–1133	654 ± 24	650	527–825
	Muscle	741 ± 15	738	595–876	770 ± 15	769	681–879
Mn	Liver	129.99 ± 5.08	127.54	83.60–197.68	138.12 ± 10.86	133.46	76.22–222.72
	Kidney	131.28 ± 4.04	129.40	60.89–159.93	137.68 ± 5.34	136.41	96.57–156.22
	Muscle	41.28 ± 1.29	40.85	32.79–61.54	43.49 ± 1.50	43.21	36.04–53.28
Mo	Liver	2.48 ± 0.14	2.38	1.53–3.94	2.13 ± 0.18	2.05	1.59–3.34
	Kidney	2.79 ± 0.12	2.70	0.84–3.89	2.89 ± 0.12	2.86	2.34–3.62
	Muscle	0.09 ± 0.01	0.09	0.06–0.22	0.09 ± 0.01	0.08	0.06–0.22
Ni	Liver	37.08 ± 7.44	7.44	0.28–144.04	32.49 ± 10.03	22.56	7.32–132.88
	Kidney	0.62 ± 0.07	0.07	0.23–1.65	0.46 ± 0.09	0.54	0.15–1.13
	Muscle	0.55 ± 0.08	0.09	0.17–1.27	0.25 ± 0.04*	0.43	0.10–0.49
V	Liver	0.37 ± 0.02	0.36	0.23–0.56	0.30 ± 0.02*	0.29	0.13–0.38
	Kidney	0.56 ± 0.03	0.55	0.27–0.88	0.54 ± 0.04	0.52	0.41–0.91
	Muscle	0.25 ± 0.01	0.24	0.15–0.40	0.22 ± 0.01	0.22	0.14–0.30

*Significantly different from males, *t*-test, $p < 0.05$

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