ENVIRONMENTAL CONTAMINANTS IN TISSUES OF FOUR EIDER SPECIES FROM ALASKA AND ARCTIC RUSSIA

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Precipitous declines in spectacled (*Somateria fischeri*) and Steller's eider (*Polysticta stelleri*) populations compelled the US Fish and Wildlife Service to list both species as threatened under the Endangered Species Act.

Liver and kidney tissues were collected from 115 eider carcasses including 51 common eiders (*Somateria mollissima*), 37 king eiders (*Somateria spectabilis*), 18 spectacled eiders and 9 Steller's eiders.

Organochlorine residues were at or near the lower limits of analytical detection (<0.05 ppm dry weight) and well below toxic thresholds found in other birds.

High concentrations of cadmium, copper, lead and selenium were found in eider tissues relative to other species. Interestingly, all four elements were highest in spectacled eiders, the species in most rapid decline.

With the exception of lead, adverse physiological responses to these contaminants have not been documented in eiders, but many of these concentrations are known to be toxic in other waterfowl. Thus contaminant impacts cannot be ruled out as a factor in the decline of some eider species.

Figure 1: A male common eider (*Somateria mollissima*).
Photo provided by the US FWS.

Figure 2: A male king eider (*Somateria spectabilis*).
Photo provided by Lynne Dickson.

INTRODUCTION

Precipitous declines in spectacled and Steller's eider populations compelled the US Fish and Wildlife Service to list both species as threatened under the Endangered Species Act (58 FR 27480; 62 FR 31757). These declines are largely unexplained and have raised concerns about organochlorine and elemental contamination in eider habitats of the Bering Sea and Arctic Ocean. Organochlorine pesticides and polychlorinated biphenyls (PCBs) are well known for their deleterious effects in fish and wildlife and have been found in measurable quantities in polar ice caps (Gregor *et al.* 1995) and tissues from high latitude animals (Galster and Burns 1972; Szaro *et al.* 1979; Barrett *et al.* 1996; Estes *et al.* 1997). Sea ducks are known to accumulate high concentrations of nonessential metals such as cadmium (Di Giulio and Scanlon 1984) and other potentially harmful elements (Lande 1977; Nicholson and Osborn 1983; Karlog *et al.* 1983; Norheim 1987). Recent studies in Alaska (Quakenbush and Snyder-Conn 1993; Cochrane and Trust 1996) have reported eider tissues with relatively low concentrations of toxic elements such as arsenic and mercury and high concentrations of other elements including copper and selenium.

Objectives:

to determine contaminant concentrations in liver and kidney tissues of four eider species,
to compare eider tissue residue values to literature values for related species, and
to identify potential contaminants of concern for eiders.

MATERIALS AND METHODS

A total of 115 eiders were collected between 1991 and 1995 (Table 1). Common eiders were collected from the Aleutian Islands and king eiders were found dead or dying near Barrow, Alaska; (Figure 3). Eider tissues from Russia's Indigirka River Delta were donated by Russian biologists and all other tissues were extracted from carcasses that were opportunistically recovered by US agency field personnel and other cooperators. It should be noted that while recovered carcasses were not randomly collected, they did provide relatively low-cost, low-impact and useful data on these threatened species.

At Alaskan field sites, whole carcasses were wrapped in plastic, frozen and shipped to Anchorage, where they were thawed and liver and kidney tissues were collected. Tissue collection was performed using acid/acetone-washed dissection tools and sterile stainless-steel scalpel blades. Tissues were placed into acid-washed glass jars and frozen.

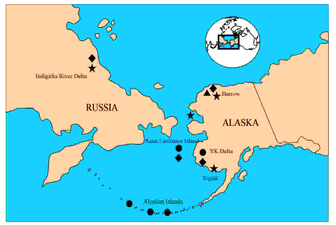

Figure 3: Eider carcass recovery locations in Alaska and arctic Russia. Species collected are indicated as common eider (●), king eider (▲), spectacled eider (◆) and Steller's eider (★).

Table 1. Collection locations of different eider species. The Indigirka River is located in Russia, whereas all other locations are in Alaska.

Location	Common	King	Spectacled	Steller's
Indigirka	0	0	3	2
Barrow	0	37	1	5
Kotzebue	0	0	0	1
St Lawrence Island	1	0	4	0
Yukon-Kuskokwim Delta	3	0	10	0
Togiak	0	0	0	1
Aleutian Islands	47	0	0	0
Total	**51**	**37**	**18**	**9**

The eiders from the Indigirka River Delta were dissected in Russia, where tissues were removed, placed into chemically clean glass jars, frozen and shipped Anchorage. Frozen samples were then shipped to one of the US Fish & Wildlife Service's contract laboratories for analysis.

Tissues from 37 common eiders, two Steller's eiders and three spectacled eiders underwent organochlorine analysis whereas those from all 115 eiders underwent elemental analysis. All of the 22+ organochlorine residues were determined by gel or gas chromatography. Most of the 19 elemental residues were determined using inductively coupled plasma emission spectroscopy; whereas arsenic and selenium residues were determined using graphite furnace atomic absorption spectrometry analysis and mercury residues were determined using cold vapor atomic absorption analysis. All analytical results are expressed in parts per million (ppm) on a dry-weight basis, unless otherwise specified.

Quality assurance measures were applied to 10% of the samples and compared to criteria set forth by Quakenbush and Snyder-Conn (1993) and K. Mueller (USFWS, personal communication). Medians were calculated for all elements discussed herein except lead. Residue values were analyzed using SigmaStat Statistical Software package (Jandel Scientific Software, San Rafael, CA). Comparison of spectacled eider values to those of the other species were performed using the Kruskal-Wallis ANOVA, comparisons between sexes were performed using the Wilcoxon rank sums and all other comparisons were qualitative.

RESULTS & DISCUSSION

Organochlorine Residues

Alpha-, *beta*-, *gamma*- and *delta*-BHCs; *alpha*- and *gamma*-chlordanes; *cis*- and *trans*-nonachlors; endrin; mirex; *o,p*-DDD, DDE and DDT; *p,p*-DDD and DDT; and toxaphene were not detected in any tissues.
Other residues (HCB, PCBs, dieldrin, heptachlor epoxide, oxychlordane and *p,p*-DDE) were detected in less than 50% of the samples and were within an order of magnitude of the detection limit (0.03 - 1.24 ppm).

Elemental Residues

Most elemental residues were found at levels that were either biologically essential or below concentrations believed to cause harmful effects in birds.
Cadmium, copper, lead, mercury and selenium are discussed below, though lead and mercury are not graphically depicted.

CADMIUM residues in eiders (Figure 4):

Overall, livers (20 ppm) < kidneys (84 ppm)
Male livers (23 ppm) > female livers (15 ppm), p=<0.001
Spectacled eiders exhibited the highest concentrations with some individuals as high as 180 ppm (liver) and 350 ppm (kidney).
Spectacled eiders with the highest concentrations came from the Indigirka and Yukon-Kuskokwim River Deltas.
Spectacled eider kidney values were up to four times greater than the other eider species.

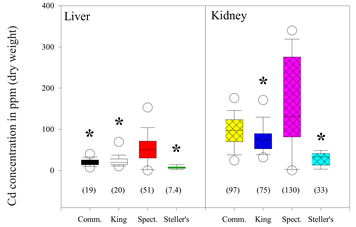

Figure 4: Cadmium concentrations in eider tissues from Alaska and arctic Russia. Median values are shown in parentheses. The asterisk ( ) denotes a significant (p<0.05) difference from spectacled eider concentrations.

Comparisons with literature values:

Elevated concentration: > 33 ppm in vertebrate livers and kidneys (Eisler 1985a)
Sublethal threshold: > 130 ppm in avian livers and > 330 ppm in kidneys (Furness 1996)
Common concentrations in seabird tissues: 17 - 120 ppm (Furness 1996)
78% of the spectacled eiders had elevated liver concentrations (Eisler 1985a) as compared to < 10% of the other eider species.
Nearly all (89%) eiders had elevated kidney concentrations (Eisler 1985a).
Spectacled eider livers were more than twice those of common eiders from Norway (Lande 1977; Norheim 1987) and Denmark (Karlog *et al.* 1983).
Kidney lesions were found in fulmars (*Fulmarus glacialis*), Manx shearwaters (*Puffinus puffinus*) and Atlantic puffin (*Fratercula arctica*) with concentrations similar to our spectacled eiders (Nicholson and Osborn 1983).
Our values were less than or similar to those in oldsquaw (*Clangula hyemalis*), herring gulls (*Larus argentatus*), Arctic terns (*Sterna paradisaea*), and long-tailed jaegers (*Stercorarius longicaudus*) from northeastern Siberia (Kim *et al.* 1996) and similar to concentrations in pelagic seabirds from the North Pacific (Honda *et al.* 1990) and white-winged scoters (*Melanitta fusca*) collected during a die-off from unknown causes in Southeast Alaska (Henny *et al.* 1995).

COPPER residues in eiders (Figure 5):

Overall, livers (310 ppm) > kidneys (46 ppm)
Spectacled eiders exhibited the highest levels with some individuals as high as 3,700 ppm (liver) and 200 ppm (kidney).
Male livers (480 ppm) > female livers (80 ppm), p=<0.001
41% of the common and 56% of the spectacled eiders had liver concentrations over 500 ppm as compared to < 5% of the other eider species.
12% of the common and 28% of the spectacled eiders had liver concentrations over 1,000 ppm as compared to 0% of the other eider species.

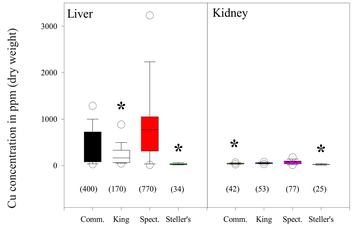

Figure 5: Copper concentrations in eider tissues from Alaska and arctic Russia. Median values are shown in parentheses. The asterisk ( ) denotes a significant (p<0.05) difference from spectacled eider concentrations.

Comparisons with literature values:

Toxicological data for copper in wild fowl is scarce.
Our highest median concentrations were similar to pochard (*Aythya ferina*) from England (Parslow *et al.* 1982), common eiders from Norway (Norheim 1987) and a king eider from northeastern Siberia (Kim et al. 1996).
Our highest individual liver residues were similar to mute swans (*Cygnus olor*) from Denmark (Elvestad *et al.* 1982) and New York (Molnar 1983) and one common eider from Svalbard (Norheim and Borch-Iohnsen 1990).

LEAD background concentrations are extremely low and exposure to lead is often attributed to the ingestion of spent shot (Pain 1996) or contaminated sediments. Only a few eiders had elevated concentrations thus median values were meaningless.

Four spectacled and one common eider had concentrations high enough to be diagnosed with lead poisoning (Franson *et al.* 1995).
One Steller's eider exhibited elevated tissue residues (liver: 26 ppm; kidney: 93 ppm), suggesting that lead may have contributed to its death.
Three common and one spectacled eider exhibited low liver concentrations and inconsistently high kidney concentrations.
Because the common eiders were killed with a shotgun, it is conceivable that these inconsistencies were caused by direct contamination from lead shot rather than by ingestion of lead prior to collection.

MERCURY residues in eiders:

Overall, livers (1.7 ppm) > kidneys (0.96 ppm)
The highest median liver concentration was 2.9 ppm (Steller's eider)

Comparisons with literature values:

Seabird tissues naturally contain higher concentrations of mercury relative to other birds and therefore, may be more resistant to mercury's deleterious effects (Thompson, 1996).
The median liver residues for each of the eider species were below the elevated concentrations (> 4 ppm) suggested by Eisler (1987).
22% of the Steller's eiders had elevated liver concentrations as compared to < 6% of the other eider species.
None of the eiders exhibited elevated kidney residues.

SELENIUM residues in eiders (Figure 6):

Overall, liver (18 ppm) kidney (13 ppm) concentrations
Spectacled eider tissues had the highest concentrations with some individuals as high as 400 ppm (liver) and 230 ppm (kidney).
Eiders with the highest liver concentrations came from the Indigirka River Delta.

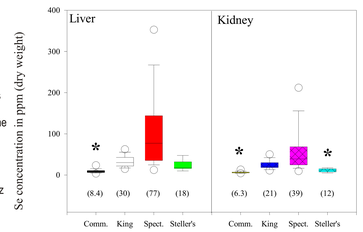

Figure 6: Selenium concentrations in eider tissues from Alaska and arctic Russia. Median values are shown in parentheses. The asterisk ( ) denotes a significant (p<0.05) difference from spectacled eider concentrations.

Comparisons with literature values:

Reproductive effects: > 10 ppm in livers (Heinz 1996)
Lethal threshold: > 67 ppm in livers (Heinz 1996)
Selenium concentrations are higher in marine birds than other species (Ohlendorf *et al.* 1986).
78% of the spectacled eiders had liver concentrations associated with reproductive effects (Heinz 1996) as compared to < 20% of the other eider species.
61% of the spectacled eiders had liver concentrations associated with lethality (Heinz 1996) as compared to < 0% of the other eider species.

Common eider tissue concentrations were lower than those found in greater scaup (*Aythya marila*) and surf scoters from San Francisco Bay and the Pacific northwest (Ohlendorf *et al.* 1986; Ohlendorf 1987; Henny *et al.* 1991).
Spectacled eider tissue concentrations were similar to Leach's storm petrels (*Oceanodroma leucorhoa*) from Canada (Elliott *et al.* 1992) but twice that of sea birds from other polar regions (Norheim 1987).
Steller's eider tissue concentrations were similar to or less than those found in common eiders from Denmark (Norheim 1987), oystercatchers (*Haematopus ostralegus*), herring gulls and great skua (*Catharacta skua*) from the United Kingdom (Hutton 1981).

Figure 7: A male spectacled eider (*Somateria fischeri*).
Photo provided by Greg Balogh.

Figure 8: A male Steller's eider (*Polysticta stelleri*).
Photo provided by the USFWS.

CONCLUSIONS

Organochlorine residues are not elevated in eiders and thus pose a minimal threat.

The following elements are elevated and therefore warrant concern:
- Cadmium is elevated in spectacled eiders and potentially elevated in common and king eiders.
- Copper is elevated in individual spectacled eiders, but not enough data is available from wild birds to estimate toxicity.
- Lead is elevated in individual spectacled eiders but may be effectively dealt with using resource management tools.
- Selenium is elevated in spectacled eiders at concentrations known to impair reproduction or cause death in other species.

Important considerations:
- Collected carcasses were not randomly selected from their respective eider populations.
- With the exception of lead, point sources of contaminants are unlikely due to the remoteness of eider ranges.
- Recent geologic activity in Arctic regions such as Alaska may cause background concentrations of some elements to be high. Thus, high concentrations of some metals (e.g. cadmium) in eider tissues may be normal.
- Mercury was not elevated, thus potential antagonistic effects with selenium are probably not occurring.

Several questions remain to be answered:
- Do these residues represent background concentrations for Alaskan and Russian eiders?
- What physiological effects, if any, might these elevated concentrations cause?
- Are eiders more tolerant to these elements than other species?
- Are these high levels due to anthropogenic sources?

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LITERATURE CITED

Available upon request.

Converted from fresh weights using 70% moisture content