Contaminant Levels in Eggs of American White Pelicans, *Pelecanus erythrorhynchos*, from Chase Lake, North Dakota

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Pietz, Pamela J., Marsha A. Sovada, Christine M. Custer, Thomas W. Custer, and Kevin M. Johnson. 2008. Contaminant levels in eggs of American White Pelicans, *Pelecanus erythrorhynchos*, from Chase Lake, North Dakota. Canadian Field-Naturalist 122(4): 312-315.

American White Pelicans (*Pelecanus erythrorhynchos*) are colonial nesters, making them susceptible to site-specific mortality factors. One of the largest known breeding colonies is at Chase Lake National Wildlife Refuge in North Dakota. In 2004, this colony suffered total reproductive failure. In 2005, we collected abandoned eggs from this colony to test for environmental contaminants. Nine eggs were analyzed for 28 organochlorine pesticides, total polychlorinated biphenyls, and 26 inorganic elements. Based on concentrations in this sample of eggs and levels linked to reproductive problems in birds, adult pelicans in the Chase Lake breeding colony are not at known risk from any of the environmental contaminants we measured.

Key Words: American White Pelicans, *Pelecanus erythrorhynchos*, eggs, organic contaminants, metals, Chase Lake National Wildlife Refuge, North Dakota.

American White Pelicans (*Pelecanus erythrorhynchos*, hereafter white pelicans) nest on the ground in colonies, often on remote islands. Because their breeding activities are spatially concentrated, they are vulnerable to site-specific mortality factors. Nearly half of the population breeds in a few colonies in the northern plains. One of the largest known nesting colonies is on Chase Lake National Wildlife Refuge (Sovada et al. 2005). In 2004, this colony suffered total reproductive failure following the mass exodus of breeding adults (Sovada et al. 2008). During the media storm precipitated by this event, numerous possible causes were proposed for the adult departures. Most of the suggestions were easily dismissed by a review of the available facts (Sovada et al. 2008), which suggested Coyote (*Canis latrans*) disturbance and a weather event were responsible. However, the attention provided impetus to examine some possibilities that, although highly unlikely, could not be entirely dismissed. Following the 2005 breeding season (another year in which extreme weather events severely reduced reproductive success [Sovada et al. 2008]), we salvaged eggs from the Chase Lake colony for contaminant testing.

White Pelicans eat mostly fish and other prey taken from shallow waters (Knopf and Evans 2004*). In the past, they have suffered direct effects from agricultural runoff (e.g., toxaphene poisoning [Johnson 1966]) and effects of bioaccumulated organic contaminants (e.g., eggshell thinning from DDT [Anderson et al. 1969; Anderson and Hickey 1972; Knopf and Street 1974]). Restrictions on use of some chemicals have reversed specific contaminant impacts (e.g., Bugden and Evans 1997), but white pelicans, like other piscivorous waterbirds, are still susceptible to a number of environmental contaminants. Several contaminants occur at different levels in male and female white pelicans, presumably because females can excrete organochlorines and some trace elements into their eggs prior to laying (Donaldson and Braune 1999). Thus, we tested contaminant levels in white pelican eggs as a surrogate for exposure levels in adult white pelicans.

Methods

During 11 to 18 August 2005, we collected 10 abandoned eggs, each from a different nest site, on the white pelican breeding colony at Chase Lake National Wildlife Refuge in Stutsman County, North Dakota. The salvaged eggs were laid during May or June 2005. Nine of the eggs were deemed suitable for analysis (one was cracked). In the laboratory, eggs were weighed on an electronic pan balance (0.01 g), measured (length [0.01 mm] and width [0.01 mm, averaged 2 measurements taken at widest point]) with calipers, and the contents emptied into chemically clean glass jars. Egg samples were then frozen (<-30° C) until chemically analyzed.

These nine eggs were analyzed for 28 organochlorine pesticides and total polychlorinated biphenyls (PCBs) by the Geochemical & Environmental Research Group (GERG), Texas A&M University, College Station, Texas. The same eggs were analyzed for 26 trace and other inorganic elements by the Trace Element

Research Laboratory (TERL), Texas A&M University, College Station, Texas.

Eggs were analyzed for the following organochlorine contaminants: aldrin; α-, β-, γ- and δ-benzene hexachloride (BHC); α- and γ-chlordane; chlorpyrifos; *cis*-nonachlor; *trans*-nonachlor; dieldrin; endosulfan II; endrin; heptachlor; heptachlor epoxide (HE); hexachlorobenzene (HCB); mirex; oxychlordane; 1,1-dichloro-2-(*o*-chlorophenyl)-2-(*p*-chlorophenyl)ethane [*o,p*'DDD]; 1,1-dichloro-2,2-bis(*p*-chlorophenyl) ethene [*o,p*'-DDE]; 1,1,1-trichloro-2,2-bis(*p*-chlorophenyl) ethane [*o,p*'-DDT]; *p, p*'-DDD; *p, p*'-DDE; *p,p*'-DDT; pentachloro-anisole; toxaphene; and 1,2,3,4- and 1,2,4,5-tetrachlorobenzene. Average levels of detection were 0.0008 µg/g wet weight for all organics except total PCBs and toxaphene, which had detection limits of 0.016 µg/g wet weight. For the above organic chemicals, tissues were homogenized and extracted with Na_2SO_4 and methylene chloride, and then purified by silica/alumina column chromatography and high performance liquid chromatography (MacLeod et al. 1985; Wade et al. 1988, Brooks et al. 1989). Quantitative analyses were performed by capillary gas chromatography with an electron capture detector for pesticides and PCBs.

Analyses were conducted for 21 inorganic elements, with detection limits (in µg/g dry weight) given parenthetically as follows: aluminum (5), arsenic (0.1), boron (1), barium (0.1), beryllium (0.05), cadmium (0.01), chromium (0.5), cobalt (0.5), copper (0.5), iron (1), magnesium (1), manganese (0.2), mercury (0.002), molybdenum (1), nickel (0.5), lead (0.05), selenium (0.1), strontium (0.05), titanium (0.5), vanadium (1), and zinc (0.5). Also analyzed were calcium (2), potassium (24), sodium (191), phosphorus (5), and sulfur (10).

For the inorganic analyses, tissue samples were homogenized and wet digested in the presence of nitric acid. Inductively coupled argon plasma spectrophotometry was used for all elements, except for arsenic, cadmium, lead, mercury, and selenium. Arsenic, cadmium, lead, and selenium were analyzed by inductively coupled plasma-mass spectroscopy and mercury by trapping on a gold column followed by atomic absorption.

For quality control purposes, each laboratory ran one blank, duplicate, and spike with the samples. Certified reference material was also used by each laboratory and one sample was confirmed by gas chromatography mass spectrometry. Concentrations were not corrected for percent recovery. The blanks, duplicates, and spikes met the respective GERG and TERL quality assurance standards. Concentrations of inorganic elements are reported on a dry weight basis. Organic contaminant concentrations were adjusted to account for moisture lost during incubation (Stickel et al. 1973) and after the nests were abandoned. The moisture correction factor for each egg was the total egg weight divided by the egg volume. Egg volume was estimated by the equation from Hoyt (1979): Volume = $0.51{*}LB^2$, where L is egg length and B is egg width (maximum diameter). All organic contaminant concentrations are expressed on a wet weight basis in tables and text. Average moisture and lipid content of the eggs are provided as percentages.

Results

Three organic chemicals, chlorpyrifos, δ-BHC, and toxaphene, were not detected in our sample of white pelican eggs. Aldrin, α- and β-BHC, and γ-chlordane were each detected in <50% of samples (Table 1) and had maximum concentrations of ≤0.002 µg/g wet weight. Of the remaining 23 organic chemicals all had geometric mean concentrations <0.01 µg/g wet weight except for total PCBs (0.35 µg/g), *p,p*'DDD (<0.02 µg/g), *p,p*'DDE (0.08 µg/g), and dieldrin (0.01 µg/g) (Table 1). Moisture and lipid content of the eggs averaged 79.0% and 4.4%, respectively.

Aluminum, boron, beryllium, cadmium, chromium, cobalt, molybdenum, nickel, titanium, and vanadium were not detected in our sample of white pelican eggs. Lead was detected in only 1 egg, which contained <0.06 µg/g dry weight (Table 2). All of the remaining 15 elements were detected in all eggs (Table 2). Arsenic, mercury and selenium, which are of special interest because they can cause physiological problems in birds, had geometric mean concentrations of 0.28, 0.69, and 2.06 µg/g dry weight, respectively.

Discussion

Neither organic nor inorganic chemicals in white pelican eggs from the Chase Lake National Wildlife Refuge were at concentrations considered to be problematic for the health of the birds. For three organic chemicals that have been linked to reproductive problems, levels of concern reported for wild bird eggs are >10 µg/g wet weight for PCBs (Hoffman et al. 1996; Custer et al. 2003), >3 µg/g wet weight for *p,p*'DDE (Blus et al. 1974), and >9 µg/g wet weight for dieldrin (Peakall 1996). Geometric mean concentrations for these three contaminants in our samples were much lower: <0.5 µg/g for PCBs, <0.1 µg/g for *p,p*'DDE, and <0.1 for dieldrin. Compared to other locations, concentrations of *p,p*'DDE at Chase Lake National Wildlife Refuge were lower than concentrations previously documented in white pelicans in California and Nevada (Boellstorff et al. 1985; Wiemeyer et al. 2005). Dieldrin and PCB concentrations were similar among these three studies and were low. Of the trace elements, arsenic, lead, mercury, and selenium can be problematic in wild birds, but they were at low concentrations in our sample of white pelican eggs. Only one egg had detectable concentrations of lead. Levels of concern in eggs for the other three elements are >3 µg/g dry weight for arsenic (Seiler et al. 2003*), >2 µg/g dry weight for mercury (Thompson 1996) and >12 µg/g dry weight

TABLE 1. Concentrations of organic contaminants in eggs (n = 9) of American White Pelicans nesting at Chase Lake National Wildlife Refuge, North Dakota, in 2005.

Analyte	Geometric mean (µg/g wet wt.)	95% confidence interval	Range[b]
Aldrin	—[a]		7ND–0.00169
α-BHC	—		8ND–0.000677
β-BHC	—		6ND–0.00164
γ-BHC	0.0009	0.0005–0.002	3ND–0.00344
α-chlordane	0.003	0.002–0.005	1ND–0.00697
γ-chlordane	—		5ND–0.00305
o,p'-DDD	0.002	0.001–0.003	1ND–0.00515
o,p'-DDE	0.001	0.0006–0.001	2ND–0.00193
o,p'-DDT	0.001	0.0008–0.002	1ND–0.00269
o,p'-DDD	0.015	0.011–0.019	0.00858–0.0306
o,p'-DDE	0.080	0.051–0.123	0.0293–0.215
o,p'-DDT	0.004	0.003–0.007	0.00174–0.012
Dieldrin	0.013	0.009–0.019	0.00528–0.0343
Endosulfan II	0.001	0.0006–0.002	4ND–0.00410
Endrin	0.002	0.001–0.003	0.000979–0.01009
HCB	0.001	0.0006–0.001	2ND–0.00305
Heptachlor	0.001	0.0007–0.002	2ND–0.00544
Heptachlor epoxide	0.003	0.002–0.003	0.00164–0.00385
Mirex	0.002	0.0007–0.003	3ND–0.00559
cis-nonachlor	0.003	0.001–0.005	1ND–0.00773
trans-nonachlor	0.006	0.005–0.009	0.00308–0.0139
Oxychlordane	0.003	0.003–0.005	0.00182–0.00694
PCBs (total)	0.354	0.298–0.419	0.243–0.496
Pentachloro-anisole	0.002	0.001–0.002	0.00101–0.00299
1,2,3,4-tetrachlorobenzene	0.001	0.0006–0.002	3ND–0.00511
1,2,4,5-tetrachlorobenzene	0.001	0.0006–0.002	3ND–0.00394

[a] Geometric mean not calculated because <50% of samples with detectable concentrations.
[b] The number before 'ND' is the number of samples that had undetected values.

TABLE 2. Element concentrations in eggs (n = 9) of American White Pelicans nesting at Chase Lake National Wildlife Refuge, North Dakota, in 2005.

Analyte	Geometric mean (µg/g, dry wt.)	95% confidence interval	Range
Arsenic	0.282	0.238–0.334	0.16–0.384
Barium	0.693	0.474–1.01	0.229–1.75
Calcium	6621	5007–8754	2940–10900
Copper	7.19	6.41–8.07	5.74–9.67
Iron	77.5	57.5–104	27.6–124
Lead	—[a]		8ND[b]–0.058
Magnesium	633.7	572–702	539–837
Manganese	0.709	0.527–0.953	0.344–1.73
Mercury	0.685	0.55–0.85	0.457–1.19
Phosphorus	4595	3839–5500	2530–6080
Potassium	6051	5347–6847	3780–7150
Selenium	2.06	1.79–2.37	1.53–3.26
Sodium	9401	8510–10384	6780–11000
Strontium	8.64	6.06–12.3	3.61–15.5
Sulfur	6787	6518–7068	6180–7680
Zinc	37.7	35.8–39.8	33.1–41.5

[a] Geometric mean not calculated because <50% of samples with detectable concentrations.
[b] The number before 'ND' is the number of samples that had undetected values.

for selenium (Heinz 1996). None of the concentrations in our sample of white pelican eggs approached these levels of concern. Concentrations of mercury in pelican eggs at Chase Lake NWR were 2–4 times lower than in Nevada and California from areas with known mercury contamination (Wiemeyer et al. 2007). Based on concentrations of organic and inorganic contaminants in this sample of eggs, adult white pelicans in this breeding colony are not at risk from any of the environmental contaminants measured.

Acknowledgments

Funding for chemical analyses was provided by the Environmental Contaminants Program of the U.S. Fish and Wildlife Service. We thank Michael Erickson and Paulette Scherr, U.S. Fish and Wildlife Service, for logistic support; Paul Dummer for sample processing and statistical analysis; and Kevin Kenow, Mark Sherfy, A. J. Erskine, and two anonymous reviewers for helpful comments on the manuscript.

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Received 5 October 2008
Accepted 5 June 2009