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Mercury in Eggs and Feathers of Great Egrets (*Ardea albus*) from the Florida Everglades

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Abstract. Great egret (*Ardea albus*) eggs and nestling feathers were collected for total mercury (THg) and methylmercury (MeHg) analysis from two colonies in the Florida Everglades in 1999 and 2000. THg was present in all eggs at a mean concentration of 0.39 ± 0.19 μg/g fresh weight (n = 33, range = 0.08–0.86 μg/g). Egg-THg levels did not differ significantly between colonies or years. MeHg concentration in eggs was 0.35 ± 0.18 μg/g fresh weight (n = 20, range = 0.05–0.82 μg/g,), and on average represented 85% of the THg found in the egg. Concentration of THg in feathers from egret nestlings, age 11–31 days, ranged from 1.4 to 8.6 μg/g dry weight. Feather-THg levels also did not differ significantly between colonies or years. THg concentrations in feathers, normalized based on bill length, were positively correlated to THg concentrations in eggs from the same clutch. Levels of THg in both eggs and feathers were lower in 1999 and 2000 than values reported for similar samples collected in 1993–95, indicating that MeHg exposure has decreased in the southern Everglades since the mid-1990s. THg levels in eggs and nestling feathers for the period of this study were below levels associated with toxic reproductive effects. Clutch size, fledging success, and brood size observed in this study were consistent for this species in the Everglades. Collectively, these results suggest that MeHg was not adversely affecting the reproductive performance of this population during the study.

Widespread elevated concentrations of mercury were first discovered in freshwater fish from the Florida Everglades in 1989 (Ware *et al.* 1990). Based on these levels, state fish consumption advisories were issued for select species and locations (Florida Department of Health and Rehabilitative Services and Florida Game and Fresh Water Fish Commission, March 6, 1989). Subsequently, elevated concentrations of mercury have also been found in predators like raccoons (Florida Panther Interagency Committee 1991), alligators (Heaton-Jones *et al.* 1997; Jagoe *et al.* 1998), Florida panthers (Roelke and Glass 1992), and wading birds (Sundlof *et al.* 1994).

The Everglades is also threatened by eutrophication, in part, fed by excessive phosphorus loading in runoff from the Everglades Agricultural Area (EAA). To remedy this situation, the Everglades Construction Project (ECP) was initiated with the goal of constructing six stormwater treatment areas (STAs) to reduce phosphorus in EAA farm runoff. These STAs are being built on lands that were formerly cultivated and are to be situated within the EAA, along the southern (downstream) edge (Figure 1).

However, concerns were raised that in reducing downstream eutrophication, the restoration effort could inadvertently worsen the Everglades mercury problem. The basis for these concerns were: (1) an observed inverse relationship between the degree of eutrophication and the degree of mercury bioaccumulation in other areas (Hakanson 1980), and (2) cases in which wetlands have been found to be an important source of methylmercury (MeHg) (St. Louis *et al.* 1994).

With the incorporation of an extensive program to monitor concentrations of total mercury (THg) and MeHg in various abiotic and biotic matrices, the South Florida Water Management District (SFWMD) was issued state and federal permits for construction and operation of the first STA in 1994. The specific goal of this monitoring program was to track spatial and temporal trends in mercury following completion of the ECP to provide assurance that the nutrient cleanup program is not exacerbating the mercury problem.

As part of this long-term program, mercury levels are to be monitored in feathers of free-ranging great egrets (for a review of use of feathers for determining metal levels in birds, see Burger 1993). Use of colonial waterbirds as biomonitors of environmental contaminants offers many advantages (for review, see Kushlan 1993). For instance, their communal nesting facilitates sampling large numbers of eggs, young, and adults. In this particular case, the great egret was selected as the sentinel wading bird species because it is primarily piscivorous, positioned near the top of the aquatic food web and, hence, is highly exposed to bioaccumulative MeHg. It was selected also because baseline data (Frederick *et al.* 1997; Sepulveda *et al.* 1999) were available from which temporal changes could be evaluated. In addition, the great egret was an

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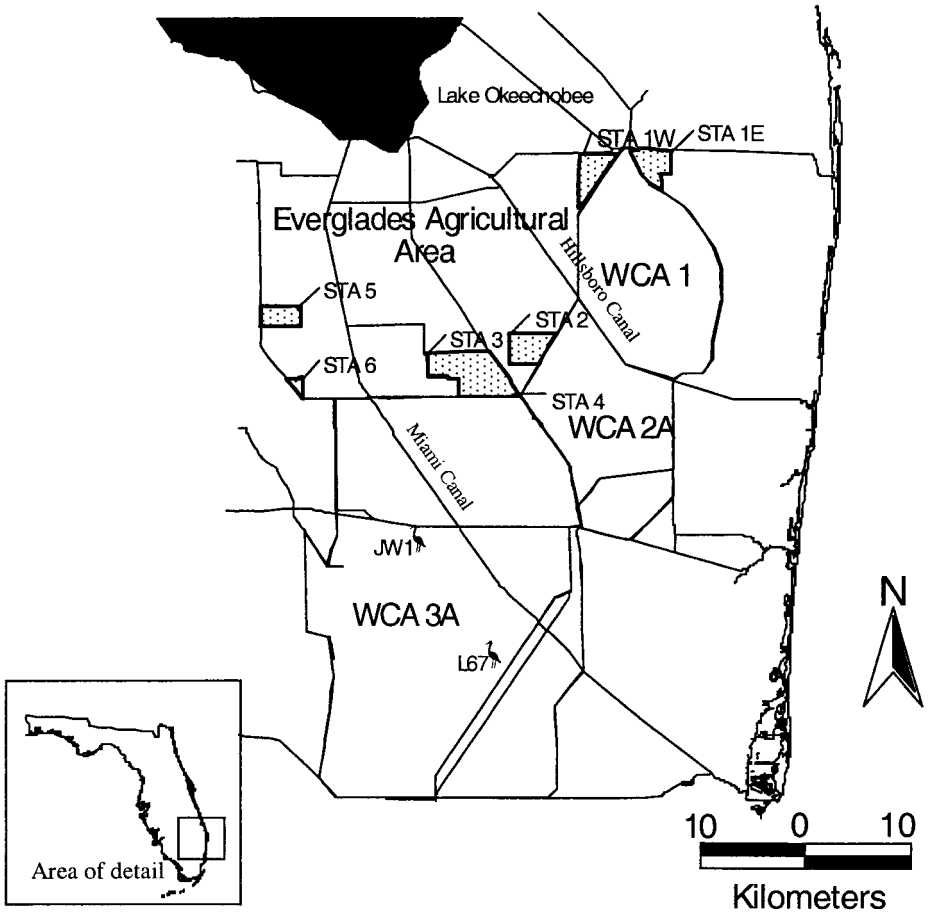

Fig. 1. Map showing locations of egret colonies in relation to water conservation areas (WCA) and stormwater treatment areas (STA)

attractive sentinel species because of the substantial amount of available information on their population biology in the Everglades.

While compliance sampling involved biomonitoring mercury in egret feathers, the program was expanded to include the collection of eggs (for a review of use of eggs to monitor mercury, see Furness 1993) to support an ongoing ecological risk assessment of MeHg (Rumbold 2000).

This paper reports the results of mercury analyses of great egret eggs and feathers collected during the 1999 and 2000 nesting seasons.

Materials and Methods

As of April 2000, only two of the STAs had become fully operational. The prototype STA, the Everglades Nutrient Removal Project (1,545 ha), which had been in operation for about 4 years, was subsumed by STA 1W (2,700 ha) in February 1999. STA 6 (352 ha) began operation in December 1997 (Figure 1).

On 17–18 March 1999 and 16–21 March 2000, great egret eggs were collected from two colonies in the Everglades (Figure 1): JW1 (26° 09′01″ N, 80° 43′15″ W), and L67 (25°57′44.3″N, 80° 34′16.4 W) under appropriate state and federal permits (WX99076, MB007948-0, respectively). At each colony, a single egg was collected from each of 10 nests that contained more than one egg. As eggs were collected, each nest was tagged. Because most eggs had hatched at the time of collection, only three eggs were collected (and nests tagged) from JW1 colony in 2000.

Collected whole eggs were immediately placed in individually labeled plastic bags and put into egg cartons. Eggs were transported to the laboratory in a clean cooler where they were weighed and measured with calipers. Eggs were then opened and their contents transferred to labeled jars, where they were homogenized using a Polytron®. Homogenates were subsampled for archiving and frozen pending shipment to the analytical laboratory.

Nests were revisited 21–40 days later, at which time between 10 and 20 growing scapular feathers were collected from a single nestling from each nest previously sampled for eggs (*i.e.*, nest mate). In 2000, feathers were also collected at JW1 (where only three eggs had been collected) from chicks from untagged nests. Feathers were placed into individually labeled plastic bags and stored dry until shipment to the analytical laboratory. At the time of feather collection, nestling weight and bill length (*i.e.*, base of bill to the tip of maxilla) were measured using a spring scale and plastic ruler, respectively. At this time, the number of nest occupants was also recorded.

THg and MeHg concentrations in eggs, and THg concentrations in feathers were determined by the Florida Department of Environmental Protection (FDEP) Chemistry Laboratory in Tallahassee. For MeHg determination in egg tissue, 0.5 g of the tissue was dissolved in 10 ml of a solution of 25% KOH in methanol. This step served to extract the MeHg in the sample. A small aliquot (typically 100–200 μl) of this extract was added to 50 ml of deionized water. The resulting aqueous sample was analyzed using a combination of chemical derivatization (by the addition of sodium tetraethyl borate, which converts MeHg to

volatile methylethylmercury), followed by concentration (Tekmar 3000 purge and trap concentrator), gas chromatographic separation (Hewlett Packard HP 5890 GC), pyrolysis (at 700°C to convert the methylethylmercury to Hg°), and atomic fluorescence detection (Tekran Model 2500 mercury detector).

For THg determination in feathers, multiple feathers from one individual were cut into smaller pieces, and the entire sample homogenized by dissolving it in a mixture of concentrated acids comprised of a 5:2 ratio of trace metal–grade sulfuric acid to trace metal–grade nitric acid. An aliquot of this homogenate was then digested and analyzed using a modified version of EPA Method 245.6 (US EPA 1991). For THg determination in egg tissue, 0.25 g of the tissue was heated in a mixture of sulfuric and nitric acids to dissolve the protein, then digested and analyzed using the same modified version of EPA Method 245.6 (US EPA 1991). The mercury in the sample was first oxidized to Hg^{2+}, using a combination of potassium permanganate and potassium persulfate. Hydroxylamine hydrochloride was added to reduce excess oxidizing reagents. The mercuric ions in solution were then reduced to atomic mercury using stannous chloride and purged into an atomic absorption spectrometer (Varian SpectraAA 400 with SPS5 autosampler, Mulgrove, Victoria, Australia) using UHP-grade nitrogen.

Quality control samples included method blanks, lab-fortified blanks, matrix spikes, lab duplicates, and blind matrix duplicates. No anomalies were reported in QC samples. Recoveries in lab fortified blanks averaged 103% (n = 8); recoveries from matrix spikes averaged 98.8% (n = 14). Relative percent difference was less than 5.3% for laboratory duplicates (n = 10) and less than 25.5% in blind field duplicates (n = 3). Each sample was large enough for the laboratory to determine the concentration above the limit of detection, which was between 0.005 and 0.008 μg MeHg/g wet weight in eggs and between 0.08 and 0.2 μg THg/g wet weight in eggs and between 0.025 and 0.31 μg THg/g dry weight in feathers.

Unless otherwise noted, concentrations are reported in μg/g on a fresh- and dry-weight basis for egg and feather samples, respectively. To correct for moisture loss and weight reduction after eggs were laid, linear dimensions and an empirically derived weight coefficient (K_w = 0.537) were used to adjust egg concentrations to fresh wet-weight basis ($W = K_w \times \text{length} \times \text{breadth}^2$; Hoyt 1979). The assumptions of normality and equal variances were tested by the Kolmorogov-Smirnov and Levene median tests, respectively. Having met these requirements, egg concentrations were compared using a two-way analysis of variance (ANOVA). Where appropriate (*i.e.*, nonzero homogeneous slopes), analysis of covariance (ANCOVA; SAS GLM procedure) was used to evaluate differences in feather-THg concentrations, with bill size as a covariate. For comparison to baseline data (Frederick *et al.* 1997), feather-THg concentrations were expressed as least square means (LSM) for a bird with a bill length of 7.1 cm. In cases where ANCOVA was inappropriate but bill sizes were similar, the nonparametric Rank Sum Test was used to assess differences. Correlation among variables was determined using Spearman rank order correlation. All statistical tests, other than ANCOVA, were performed using the statistical software program SigmaStat™ (Jandel Corporation, San Rafael, CA).

Results

Tissue Concentrations

All eggs had detectable concentrations of THg that ranged from 0.08 to 0.86 μg/g fresh weight (FW). The highest concentration occurred in a freshly laid egg collected in 1999 from an L67 nest where the remaining two eggs (clutch size = 3) hatched and produced nestlings. Egg-THg concentrations (Table 1) did not differ significantly between colonies or between years (two-way ANOVA; df = 1, 29; $F = 0.444$, p = 0.51 and df = 1, 29; $F = 0.005$; p = 0.94, respectively). Interaction between colony and year was also not significant (df = 1, 29; $F = 2.035$, p = 0.16). Combined eggs from both colonies collected during the 2-year study had a grand mean THg concentration of 0.39 ±0.19 μg/g FW (n = 33). Concentration of MeHg in eggs collected in 1999 (MeHg was determined only in 1999 eggs) ranged from 0.05 to 0.82 μg/g FW (n = 20, mean = 0.35 ± 0.18), and on average represented 84.9 ± 7.5% of the THg found in the egg.

THg in feathers from egret nestlings (estimated age 11–31 days, based on bill length) ranged from 1.4 to 8.6 μg/g dry weight (DW), with arithmetic mean concentrations for colonies ranging from 3.2 to 4.4 μg/g DW (Table 1). Generally, feather-THg concentration increased with bill length (*i.e.*, age surrogate; Figure 2). This relationship was significant in both years for nestlings at the JW1 colony (1999: df = 1, 8; $F = 22.9$, p = 0.001; 2000: df = 1, 8; $F = 8.14$; p = 0.02), but was not significant in either year for nestlings at the L67 colony (1999: df = 1, 8; $F < 0.001$, $p > 0.9$; 2000: df = 1, 8; $F = 1.7$; p = 0.23; Figure 2). Feather-THg concentration did not differ between years in nestlings at JW1 (ANCOVA; df = 1, 17; $F = 1.93$, p = 0.18) or L67 (rank sum test; n = 10, 10; $T = 129.5$; p = 0.07). Comparison of median feather-THg concentrations at the two colonies, which was a valid test because bill length was similar between colonies and years (two-way ANOVA, colony × year; df = 1, 36; $F = 1.33$; p = 0.24), found no significant difference (rank sum test; n = 20, 20; $T = 373$; p = 0.32).

When the two colonies were combined, a significant positive correlation ($r_s = 0.46$, n = 23, p = 0.03) was detected between THg levels in eggs and normalized THg concentration in feathers (*i.e.*, ratio of feather-THg concentration to bill length) from nest mates (Figure 3).

Biological Survey Data

During the initial nest visit (*i.e.*, at the time of egg collection), the mean number of eggs per nest was 2.6 ± 0.5 (mode = 3; n = 20) in 1999 and 2.8 ± 0.4 (mode = 3; n = 13) in 2000.

When nests were revisited 29–40 days later in 1999, to collect feathers from nestlings, all but three nests were found to be active. Of these three, which were all located at the JW1 colony, one nest could not be relocated (could not find tag or nest, may or may not have failed); one nest was found empty, and one was completely missing (*i.e.*, tag was located, but nest was missing). This represents an 85% nesting success, *i.e.*, probability that a nest would produce at least one 14–21-day-old chick. The 17 remaining active nests produced a total of 33 nestlings age 14–21 days, or 1.94 nestling per active nest (mode = 2). This includes four nests found to have replaced the collected egg (or clutch was incomplete at time of sampling; eggs are typically laid over 2–3-day period).

In 2000, when nests were revisited 21–36 days later to collect feathers from nestlings, 3 of the 13 nests had failed; one nest was completely missing, one nest was found empty, and one contained a new clutch of eggs. The 10 remaining active nests contained a total of 19 nestlings (mode = 2 chicks per

Table 1. Mean concentrations (±1 SD, n in parenthesis) of total mercury in eggs and nestling feathers of great egrets from two Everglades colonies: 1999–2000

	JW1 colony		L67 colony	
Tissue	1999	2000	1999	2000
Eggs (μg/g FW)	0.38 (± 0.22, n = 10)	0.49 (± 0.23, n = 3)	0.44 (± 0.20, n = 10)	0.34 (± 0.12, n = 10)
Scapular feathers (μg/g DW)	3.8 (± 1.97, n = 10)	3.4 (± 1.88, n = 10)	4.4 (± 1.19, n = 10)	3.2 (± 1.36, n = 10)
LSM feather-THg (μg/g) for chick with 7.1-cm bill	6.8 (± 0.7, n = 10)	6.9 (± 1.3, n = 10)	NS[a]	NS

[a] Regression did not differ significantly from zero.

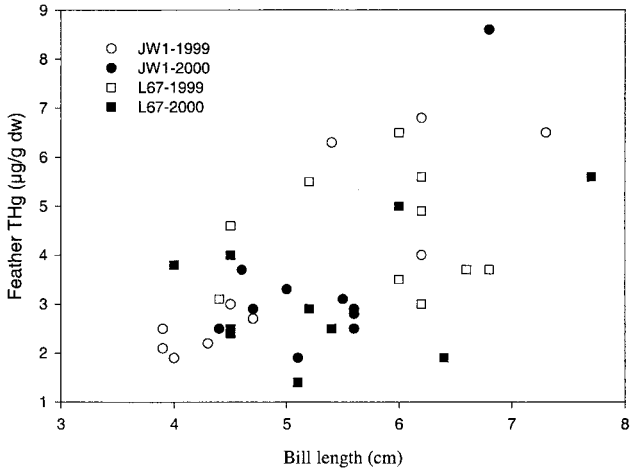

Fig. 2. Concentration of THg (μg/g) in growing scapular feathers of great egret nestlings in relation to bill length (cm)

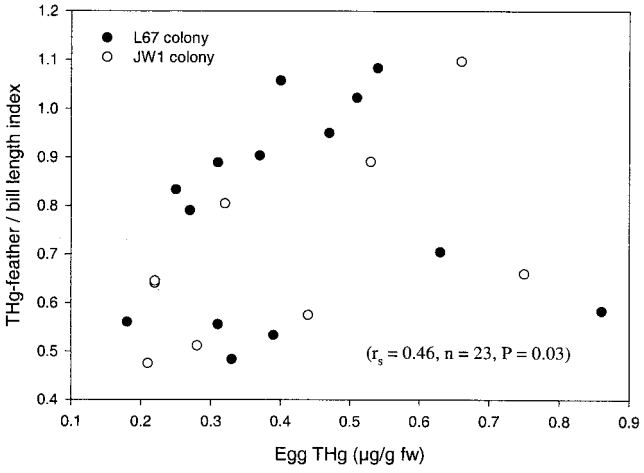

Fig. 3. Correlation between THg concentration in great egret eggs and nestling feathers from the same nest.

nest). This would represent a 79% nesting success, *i.e.*, probability that a nest would produce at least one 14–21-day-old chick, had all nests contained a chick older than 14 days. However, three of the nests contained chicks less than 2 weeks old and, thus, should not be used to estimate nesting success or fledgling success.

Discussion

Status and Trends

Use of avian eggs or feathers as biomonitors relies on two, often implicit, basic assumptions: (1) that tissue concentration is a function of amount in the environment, and (2) that the collected sample is representative of the population in a consistent manner. The validity of each of these assumptions should be examined for proper interpretation and use of the data.

MeHg is deposited to avian eggs in proportion to exposure (Tejning 1967), and accumulates preferentially in albumen (*i.e.*, egg white proteins; Vermeer *et al.* 1973; Fossi *et al.* 1984). As reported here, other studies have found that MeHg is the predominant form of mercury in eggs (Fimreite 1974; DesGranges *et al.* 1998). Because albumen-mercury has been strongly linked to dietary MeHg (Walsh 1990), levels in eggs appear to reflect adult exposure over a comparatively short period of time (Fossi *et al.* 1984; Furness 1993; Sanpera *et al.* 2000). Therefore, depending on the timing of the bird's arrival on the breeding grounds, mercury concentrations in eggs closely reflect local contamination.

In the present study, THg concentrations in the egret eggs (grand mean = 0.39 ± 0.19 μg/g; max = 0.86 μg/g) were higher than egret eggs collected during the mid-1990s from other areas of south Florida (Rodgers 1997; D. Day, USGS, personal communication). However, concentrations have declined, albeit slightly, in comparison to egret eggs collected from this same area in 1993 (WCA3A, mean = 0.46 μg/g, max = 1.16 μg/g, n = 43; D. Day, USGS, personal communication).

Several studies have found feather-THg concentration and body burden to increase with age of chicks (Becker *et al.* 1993; Sepulveda *et al.* 1999). When this situation exists, concentrations are often normalized based on age or some validated age surrogate. However, similar to what is reported here, several

studies report levels to be independent (Thompson *et al.* 1991; Goutner and Furness 1997) or even negatively correlated with age (Goutner and Furness 1997). In the present study, the absence of a relationship between feather-THg concentration and bill length at the L67 colony may be explained by the small sample size ($n = 10$) or limited range of ages. However, increasing the sample size by pooling data collected in 1999 from an independent concurrent study at this same colony (P. Frederick, personal communication, total $n = 20$) improved the correlation only slightly ($p > 0.05$). The absence of an age-concentration relationship might also be related to the average age of the sampled nestlings. Because of the dynamic nature of their physiology at this young age (*e.g.*, rates of growth, feeding, depuration), even minor differences in age distribution would greatly influence where in the uptake curve the nestlings were located. Alternatively, Monteiro and Furness (1995) maintain that contradictions in age-related differences can be reconciled simply based on level of exposure. They argue that in more heavily contaminated environments, elevated MeHg exposure to the chick overcomes the natural "growth dilution" leading to increases in mercury concentration with age. If this is the case in the present study, then both body burden and feather-THg concentration in chicks at JW1 colony, which showed a significant regression between feather-THg concentration and bill size, will likely continue to increase as chicks age. Alternatively, feather-THg concentration may actually decrease in chicks at the L67 colony, which had a regression that did not differ significantly from zero, even though their body burden may increase. The difference in exposure conditions between the two colonies was therefore greater than what is suggested by the raw data for young chicks (Table 1). Equally important, standardized feather-THg concentrations at JW1 (*i.e.*, LSM for a chick with 7.1 cm bill length) was over three times lower than LSM values reported for this same colony in 1994 and 1995 (21.1 μg/g and 14.5 μg/g, respectively; Frederick *et al.* 1997).

As previously stated, depending on the timing of the bird's arrival on the breeding grounds, mercury concentrations in eggs closely reflect local contamination. However, mercury concentrations in nestling feathers are believed to reflect an even smaller area that is defined by the limited parental foraging distance from the nest (for review, see Monteiro and Furness 1995). Hughes *et al.* (1997) collected samples from osprey nests in the Great Lakes and found no correlation in THg levels between chick feathers and eggs from the same clutch. Because they found THg patterns in chick feathers to be more similar to those found in local fish, they concluded that chick feathers were better indicators of local contaminant conditions than eggs. In the present study, concentrations of THg in nestling feathers were weakly correlated to levels in the egg ($r_s = 0.46$). A better correlation might have been achieved had we selected first-laid eggs and removed the variation in egg-THg concentration known to be associated with laying order (Becker 1992). Still, the relationship would not have been straightforward because of the small sample size and the necessary adjustment for nestling age. Nevertheless, the observed correlation does suggest that some of the same factors controlling exposure of the adult female (*e.g.*, location, prey size or species), and thus the amount of mercury she deposited to the egg, may also govern exposure of the chick.

In the Everglades, location and spatial coverage by foraging egrets is highly variable due to differences in the patterns and timing of water flows and draw downs (Bancroft *et al.* 1994). For instance, systematic reconnaissance flights over the Everglades in 1999 found large numbers of wading birds moving among the WCAs in February and March (Nelson and Theriot 1999), just prior to egg laying. For such birds, MeHg exposure to the adult female, and subsequently for the egg, would be integrated over this large spatial scale. After arriving and establishing nest territories, birds would likely feed in the area surrounding the colony. While feeding young, great egrets forage typically within 9 km of their colonies (Bancroft *et al.* 1990, 1994). As the "normal" dry season progresses, birds forage in drying pools near the colony taking advantage of the concentrated prey to meet the energetic requirements of the growing young. Thus, the spatial scale over which exposure to the nestling is integrated could be relatively small compared to that of the egg. However, if the water recedes and areas dry out, birds may need to fly farther from the colony to find prey and can become concentrated in fewer foraging sites. Thus, depending on the timing of the draw down and the speed at which the water recedes, birds from the same colony could well be foraging in different areas and over different spatial scales in different years.

Where a contaminant is spatial highly variable, as in the present case, differences in spatial scale over which exposure is integrated will likely also influence the rate of any temporal change. If, as argued above, nestling feathers reflect exposure over a smaller region of the potential exposure distribution (*i.e.*, relative to the adult female and egg), it could explain the difference in the rate of temporal change in tissue levels (*i.e.*, egg versus nestling). As previously discussed, levels of THg in both eggs and feathers declined from previous years; however, the magnitude of decline was greater in nestling feathers. Because nesting colonies were located near known mercury "hot spots" (*i.e.*, where levels in fish were almost two times higher than the basin-wide average), the decline in feather-THg may represent a decrease in exposure maximums.

Use of avian eggs or feathers to biomonitor differences across space or time also relies on the assumption that the diets of the birds are constants across the same space-and time-scales. A change in diet will likely alter mercury exposure and burdens, if mercury levels vary among prey species. As a consequence, some authors argue that it is preferable to select species with narrow and inflexible diets, rather than generalist feeders (Monteiro and Furness 1995). A great egret's diet consists of invertebrates, such as crayfish, various fish species, and amphibians, and differs from year to year (Frederick and Collopy 1988; Frederick *et al.* 1997). For example, Frederick *et al.* (1997) reported that the proportion of warmouth (*Lepomis gulosus*) in regurgitum from chicks varied from 0.0% to 79% (*i.e.*, % of total biomass) during the period from 1993 to 1996. Warmouth in the Everglades have been found to have high THg concentrations relative to other fish species of similar size (SFWMD, unpublished, T. Lange, FFWCC, personal communication). Therefore, the proportion of warmouth in the egret's diet may have extra significance in their exposure to mercury. Great egrets have been also called the true habitat generalists (Ogden 1999). Changes in foraging habitat, possibly due to changes in hydrology, could easily lead to a diet shift (*e.g.*, variation in fish species among habitats, larger size fish concentrated in low water years). Such a diet shift exaggerating

small differences in THg levels in the local environment, in space and time, could account for the differences in feather-THg levels between colonies (*e.g.*, arithmetic means and slope of regression between feather-THg concentration and bill size). Therefore, trend analysis of egg- or feather-THg concentrations should be evaluated cautiously and, where possible, should include an assessment of THg concentrations in their prey. Results from fish collections by the FGFWFC, now known as the Florida Fish and Wildlife Conservation Commission, also show a decrease in THg concentrations in fish collected at several Everglades sites over the last few years (Lange *et al.* 1999). Collectively, these results suggest that there has been a decline in levels of MeHg and possibly THg in these areas.

The factor or factors producing this decline in THg concentrations in Everglades fishes and egrets are as yet unknown. Given the small acreage of STAs in operation during this period, it is highly improbable that the ECP was a significant factor in the observed decline. More likely it resulted from a reduction in net methylation rates within the system or decrease in THg loading rate. With regard to the latter, a 65% decline in THg emissions in south Florida air sources has been reported over the last decade (T. Atkeson, FDEP, personal comm.). While there is cause for optimism, it remains to be seen whether decreasing mercury concentrations will continue as a long-term trend.

Toxicological Significance

Although egg concentration is thought to be the best predictor of MeHg risk to avian reproduction (Wolfe *et al.* 1998), embryonic sensitivity differs among species. Mallards (*Anas platyrhynchos*) dosed with MeHg over three generations produced fewer ducklings from eggs with mean THg concentrations ranging from 0.79 to 0.86 μg/g (Heinz 1979). Yet herring gulls (*Larus argentatus*) apparently suffered no ill effects despite having egg-THg concentrations of up to 16 μg/g (Vermeer *et al.* 1973). While a critical egg concentration has not yet been determined for wading birds, Thompson (1996) has proposed generic benchmarks. Based on a literature review, he concluded that adverse effects were unlikely to occur in birds at egg-THg concentrations less than 0.5 μg/g, but that toxic effects were probable at concentrations greater than 2.0 μg/g. While the mean egg-THg concentration in the present study was lower than Thompson's no-effect benchmark, 27% of the eggs had concentrations greater than 0.5 μg/g (maximum concentration was 0.86 μg/g). Establishing a benchmark for critical feather-THg concentration is difficult because of observed or suspected interspecies differences in mercury sensitivity, particularly between piscivores and nonpiscivores and between freshwater birds and seabirds. This is further complicated because, unlike MeHg in eggs, MeHg bonded to keratin and sequestered in feathers no longer represents a risk to the bird. Feather-THg concentration is used only as an indicator of MeHg level and possible risk in targeted organs. However, Bouton *et al.* (1999) and Spalding *et al.* (2000) recently reported results of a controlled dosing study of great egrets that combined feather analysis with toxicological observations. They dosed great egret juveniles with MeHg-containing gelatin capsules at 0.5 mg Hg/kg food (n = 5) and found subtle behavioral changes and statistically significant differences in blood chemistry, liver, biochemistry and weight index (Bouton *et al.* 1999; Frederick *et al.* 1979; Spalding *et al.* 2000). At 5 weeks, chicks in this dose group had 19 μg/g THg in feathers and showed a significant decline in packed cell volume (Spalding *et al.* 2000). Several recent studies report Florida waterbirds having feather-THg concentrations approaching or exceeding this values (Beyer *et al.* 1997; Frederick *et al.* 1997; Sepulveda *et al.* 1999). However, neither the arithmetic mean nor the calculated LSM (feather-THg concentrations were predicted to be 8.87 ± 1.1 and 8.9 ± 2.9 μg/g in 5-week-old chicks at JW1 colony in 1999 and 2000, respectively) in the present survey approached these values. If we use the value reported by Spalding *et al.* (2000) as a lowest observed adverse effects benchmark, then the nestlings in the present study do not appear to be at an elevated risk of toxic effects from environmental exposure to MeHg in their diet.

Because nests were visited and sampled at different stages of development, the number of eggs found in these nests likely underestimated clutch size, *i.e.*, unfinished clutch or partial clutch loss by predation. Still, observed values were consistent with clutch sizes and hatching success reported in other studies of great egrets in south Florida (for review, see Frederick 1994). Equally important, nesting success observed at these two colonies, compared favorably with other studies of great egrets in Florida (for review, see Frederick 1994). Brood size was also consistent for this species in other areas. Thus, there was no evidence to suggest that MeHg adversely affected egret breeding performance during the monitoring period.

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