CONTAMINANTS IN BROWN PELICAN EGGS COLLECTED FROM TEXAS AND MEXICO, 1986

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ABSTRACT--Brown pelican eggs were collected from one nesting colony on the Texas coast and two colonies on the Gulf Coast of Mexico: Pelican Island, Texas; Isla Contoy, Quintana Roo, Mexico; and Laguna del Carmen, Tabasco, Mexico. The objectives of the study were to: 1) compare the concentrations of several organic and trace element contaminants in eggs collected in Texas with those collected in Mexico; 2) compare the concentrations of contaminants in Pelican Island eggs with historic data on these contaminants for Texas brown pelican eggs; and 3) to assess the significance of these contaminants for brown pelicans.

The concentrations of DDT and chlordane compounds were relatively similar between Texas and Mexican colony eggs. Comparison of the present data for Texas eggs with historic data, indicate that DDT and chlordane compounds have all declined. In particular, concentrations of DDT compounds are nearly 10 times less than they were in the mid-1970's. The concentrations of DDT and chlordane compounds are below concentrations likely to cause adverse effects. PCB concentrations in Texas eggs were higher than concentrations in Mexican eggs and may be indicative of the numerous industries and the large population center located on Corpus Christi Bay. Total PCB concentrations in Texas brown pelican eggs have declined since 1970 and are below levels that have been associated with adverse effects. Specific PCB congeners were not determined, however. Other organochlorine compounds were generally below detection limits or at relatively low concentrations.

Most trace elements were below detection limits or detected in less than 50 percent of the samples. Geometric mean concentrations of mercury in Mexican colony eggs were more than twice as high as Texas colony eggs, but were still below levels considered to be biologically harmful. The concentrations of other select trace elements were also below harmful levels.

INTRODUCTION

The brown pelican (Pelecanus occidentalis) was Federally listed in the United States as an endangered species in 1971 (Code of Federal Regulations, Title 50, Part 17). Severe population declines were observed in North America in the 1950's and 1960's (Blus 1970, Schreiber and Risebrough 1972). Population declines and reproductive failure were noted for brown pelicans on the Texas coast concurrently with declines elsewhere in the United States (King et al. 1977). The brown pelican's decline has largely been associated with reproductive failure which is believed to have been caused by exposure to organochlorine pesticides, mainly DDT and its metabolites (Anderson and Hickey 1970; Blus 1970; Blus et al. 1972a; Blus et al 1972b).

The general use of DDT was banned in 1972 and environmental concentrations of DDE (the main DDT metabolite) slowly began to decline in many locations in North America (Grier 1982, Fleming et al. 1983). King et al. (1977) collected brown pelican eggs from Texas nesting colonies in 1970 and 1974 and found that the concentrations of DDE had declined by more than one-third from 1970 to 1974. Despite the decline in DDE residues brown pelican reproduction was poor in 1974. Between 1975 and 1981, King et al. (1985) observed further decreases in the concentration of DDE in Texas brown pelican eggs, improved reproductive success, and an increase in the population.

One of the largest nesting colonies (Pelican Island) on the Texas coast is located in Corpus Christi Bay, which is the largest industrial port on the South Texas Coast. Petrochemical manufacturing and several other industries are located along the bay. Pelican Island is also located adjacent to the Corpus Christi Ship Channel. As a result of the proximity of this colony to an industrialized port, concerns remain regarding the exposure of this colony to various organic and trace element contaminants.

Brown pelicans of the Gulf Coast of Mexico have fared better than those nesting in Texas. However, aerial counts of the Mexican Gulf Coast indicated a possible population decline of 47 percent between 1980 and 1986 (Blankinship 1986). The largest Mexican east coast colony (Isla Contoy) is well isolated from industrial ports and areas of concentrated agriculture. The Laguna del Carmen colony is located about 60 kilometers from the major industrial and port complex of Minatitlan/Coatzacoalcos and is near important farming areas. A survey of colonies along the coast of Texas and Mexico provided the opportunity to collect brown pelican eggs at Pelican Island and two colonies in Mexico.

The objectives of this study were to: 1) compare the concentrations of several organic and trace element contaminants in the Pelican Island eggs with those collected from the Mexican colonies; 2) compare the concentrations of contaminants in Pelican Island eggs with historic contaminant concentration data for Texas brown pelicans; and 3) assess whether concentrations of any contaminants pose a threat to the brown pelicans at Pelican Island or the Mexican colonies.

METHODS

During March 1986, Blankenship conducted aerial counts of brown pelicans and located nesting colonies on the Gulf and Caribbean coasts of Mexico. In April 1986, Blankinship visited Mexican colonies to band nestlings. During this banding effort, 14 addled eggs were collected from Pelican Island, 11 eggs were collected from Isla Contoy, Quintana Roo, Mexico; and 3 eggs were collected from a colony at Laguna del Carmen, Tabasco, Mexico (Figure 1).The eggs were wrapped individually in aluminum foil and kept on ice until they could be transferred to a freezer. The eggs remained frozen until they reached the laboratory for chemical analyses. The Pelican Island eggs were collected under Federal and State collecting permits issued to David Blankenship which allow salvage of addled eggs. Permission for the collection of the Mexican brown pelican eggs was provided by Dr. Jose del Rio, with Subdelgado de Ecologia, Secretaria de Desarrollo Urbano Y Ecologia (SEDUE).

All 14 eggs collected from Pelican Island were used for chemical analyses. One of the eggs collected from Isla Contoy was not analyzed, resulting in 13 Mexican eggs analyzed for organics and trace elements. The organic chemical analysis was for 21 organochlorine compounds including a quantification of total polychlorinated biphenyls (Table 1). The organic analyses and quality assurance were conducted by the Patuxent Analytical Control Facility at Laurel, Maryland. Organics were quantified by gass-liquid chromatography. Residues in 10 percent of the samples were confirmed by gas chromatography/mass spectrophotometry. PCBs were determined based on the quantification of PCB 1254. The sample preparation and analytical methods were conducted according to the procedures described by Cromartie et al. (1975). The nominal detection limit for organic contaminants was 0.01 ppm on a wet weight basis.

Egg contents were analyzed for 20 trace elements (Table 1). The trace element analyses and quality assurance also were conducted at the Patuxent Analytical Control Facility. Inductively coupled plasma emission spectroscopy was used to quantify all of the elements according to the methods described by Haseltine et al. (1981) except arsenic, mercury, and selenium. Arsenic and selenium were quantified by hydride generation with atomic absorption spectrophotometry according to the methods described by Krynitsky (1987). Mercury was quantified with cold vapor atomic absorption spectrophotometry as described by (Monk 1961). The nominal detection limits for trace elements are presented in Table 2.

Data Analvsis

Descriptive statistics (geometric mean, maximum, and minimum concentrations) were calculated for select organic compounds and trace elements on the basis of their frequency of detection and/or concern regarding the effects of these contaminants on brown pelicans. Geometric means were determined for those organic compounds and trace elements where more than 50 percent of the samples were above the detection limits. In those cases where geometric means were determined, one-half of the nominal detection limit was used for the samples

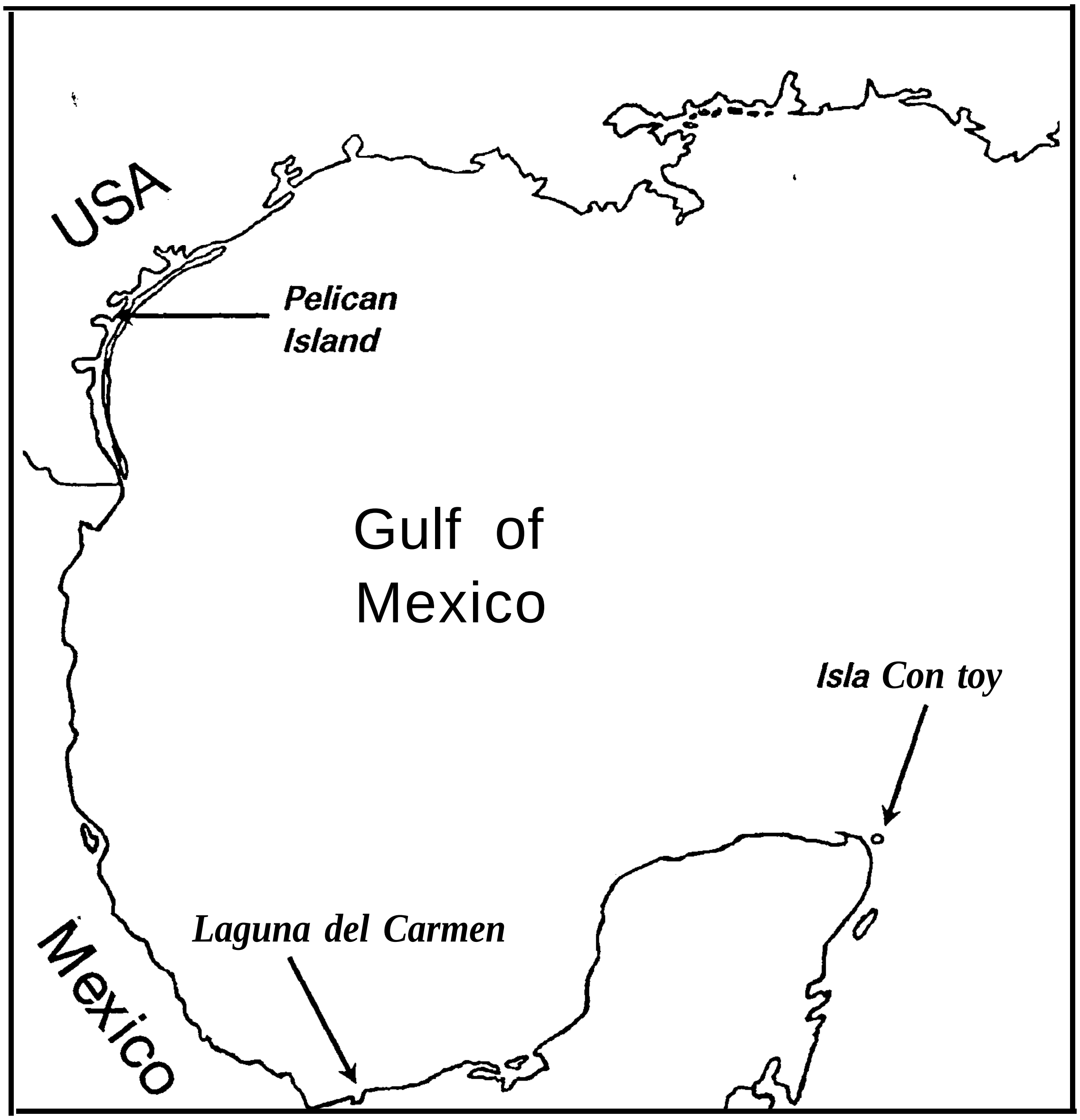

Figure 1. Location of Texas and Mexican brown pelican colonies where eggs were collected, 1986.

Table 1. Organochlorine and trace element analytes for brown pelican egg contents collected from Texas and Mexico, 1986.

ORGANOCHLORINES	TRACE ELEMENTS
Oxychlordane	Aluminum
cis-chlordane	Arsenic
trans-chlordane	Barium
cis-nonachlor	Beryllium
trans-nonachlor	Boron
Heptachlor Epoxide	Cadmium
o',p' - DDT	Chromium
o',p' - DDD	Copper
o',p' - DDE	Iron
p',p' - DDT	Lead
p',p' - DDD	Magnesium
p',p' - DDE	Manganese
Endrin	Mercury
Dieldrin	Molybdenum
Lindane	Nickel
alpha-BHC	Selenium
beta-BHC	Strontium
Hexachlorobenzene	Tin
Mirex	Vanadium
Toxaphene	Zinc
PCBs	

Table 2. Nominal detection limits of analytical methods used in the analysis of brown pelican egg contents collected from Texas and Mexico, 1986.

TRACE ELEMENTS	DETECTION LIMITS (ppm wet weight)
Aluminum	1.0
Arsenic	0.1
Barium	0.1
Beryllium	0.10
Boron	1.0
Cadmium	0.1
Chromium	1.1
Copper	0.1
Iron	1.0
Lead	0.2
Magnesium	4.8
Manganese	1.0
Mercury	0.05
Moybdenum	0.19
Nickel	0.44
Selenium	0.1
Strontium	0.1
Tin	1.0
Vanadium	0.1
Zinc	1.0

that were below the detection limit. Despite the relatively low concentrations for most contaminants, the data are presented in parts per million (ppm) to facilitate comparison with historic data which is usually presented as ppm.

Although all the chlordane isomers (cis-chlordane, trans-chlordane, *cis*-nonachlor, and *trans*-nonachlor) were quantified, the descriptive statistics are presented as the geometric mean, maximum, and minimum of the sum of these isomers (trans-chlordane was detected above the detection limit in fewer than 50 percent of the Pelican Island eggs and is not included as part of the sum for that location). Chlordane is frequently reported as a, sum of these isomers and was done so in this report for comparitive purposes.

RESULTS AND DISCUSSION

Organochlorines

Concentrations of six organochlorine compounds were below the detection limit in brown pelican eggs: mirex, dieldrin, endrin, alpha BHC, beta BHC, and lindane. Four compounds (HCB, oxychlordane, trans-chlordane, and toxaphene) were found above the detection limit in less than 50 percent of the samples. Several chlordane isomers (cis-chlordane, cis-nonachlor, and trans-nonachlor), DDT and two metabolites (DDD; and DDE), heptachlor epoxide, and total PCB's were above detection limits in more than 50 percent of the samples at all locations. Table 3 presents the minimum, maximum and geometric mean concentrations of the most frequently detected compounds.

DDT and Metabolites

The most persistent metabolite, DDE, was found in all the Mexican colony eggs and in 12 of the Pelican Island eggs. The geometric mean concentrations of DDE were similar for the Texas and Mexican colonies (0.16 ppm and 0.14 ppm, wet weight basis, respectively). The highest DDE concentration (0.93 ppm, wet weight) was in an egg from the Laguna del Carmen colony. Other than this one sample, the ranges were similar. The geometric means for DDD (Texas colony=0.028 ppm, Mexican colonies=0.036 ppm) and DDT (Texas colony=0.017, Mexican colonies=0.030) were relatively low. The highest concentration of DDD and DDT was in the same egg with the highest DDE concentration from the Laguna del Carmen colony. Streams that flow into Laguna del Carmen flow through nearby agricultural lands and DDE, DDT, and other organochlorines have been detected in sediments and oysters from this bay (Botello et al. 1994). Other than this one egg, the ranges of DDD and DDT for the colonies were much the same.

Comparison of DDE, DDD, and DDT concentrations from the present study with those reported from 1975 to 1981 for Texas brown pelican eggs (King et al. 1985) (Table 4) reveals that declines have occurred for all three compounds. The geometric mean concentrations of all three compounds in 1986 were approximately one-tenth of that reported in 1975. King et al. (1985) noted that DDE concentrations in Texas brown pelican eggs had declined somewhat between 1970 (King et al. 1977) and 1975, but the decline was much slower than had been observed elsewhere. Despite a great deal of between-year variability in concentrations, it appears that these compounds have steadily declined and the greatest declines have occurred between 1981 and 1986.

A number of studies examined the levels of DDE in brown pelican eggs associated with reduced reproductive success. King et al. (1985) reported that the concentrations observed between 1975 to 1981 were no longer adversely affecting Texas brown pelicans and that reproductive success had improved. Blus et al. (1974) found that unsuccessful nests in South Carolina were generally associated with DDE concentrations that exceeded 2.5 ppm in eggs. And Blus et al. (1982) later reported that DDE residues exceeding 3.0 ppm in eggs were associated with impaired reproductive success and DDE residues

Table 3. Geometric mean, minimum, and maximum concentrations (presented as ppm on a wet weight basis) of organochlorine compounds in brown pelican eggs collected from Texas and Mexico, 1986.

Organochlorine Compound	Texas Colony (Pelican Island) N=14	Mexican Colonies N=13
DDE	0.16[1] 0.06-0.56[2] 12[3]	0.14 0.03-0.93 13
DDD	0.028 0.019-0.068 12	0.036 0.013-0.10 13
DDT	0.017 0.017-0.047 10	0.030 0.019-0.10 13
Chlordane	0.052 0.027-0.175 --	0.052 0.039-0.103 --
Heptachlor Epoxide	0.010 0.009-0.031 8	0.017 0.015-0.031 12
PCBs	0.51 0.04-2.70 14	0.17 0.05-2.90 13

1 Geometric mean value (-- indicates that the geometric mean was not determined because 50 percent or more of the samples were below the detection limit).

2 The minimum (above the detection limit) and maximum values

3 The number of samples that exceeded the detection limit for each compound.

Table 4. Geometric mean concentrations (ppm on a wet weight basis) of organic contaminants in brown pelican eggs collected at Pelican Island in 1986 and in eggs collected from various Texas brown pelican colonies between 1975 and 1981

Year	DDE	DDD	DDT	Chlordane[4]	PCBs
1975 (18)[1]	1.7[2] (18)[3]	0.3 (18)	0.1-0.2 (4)	0.2 (16)	4.0 (18)
1976 (9)	0.9 (9)	0.1 (8)	0.1-0.2 (2)	0.1 (1)	0.8 (9)
1977 (2)	2.3 (2)	0.7 (2)	0.8 (1)	ND	2.8 (2)
1978 (4)	2.2 (4)	0.2 (4)	0.1 (1)	0.2 (4)	3.5 (4)
1979 (9)	0.9 (9)	0.1-0.4 (2)	0.1 (1)	0.1-0.2 (2)	1.4 (9)
1980 (4)	1.4 (4)	0.1 (3)	0.1 (1)	0.1 (1)	1.8 (4)
1981 (57)	1.3 (57)	0.2 (48)	0.2 (2)	0.1-0.5 (15)	1.1 (56)
1986 (14)	0.16 (12)	0.028 (12)	0.017 (10)	0.052 (--)	0.51 (14)

The number of samples analyzed during the given year.

2 The geometric mean or the range (if fewer than 50 percent of the samples were below the detection limit) reported by King et al. (1985) (ND indicates that the geometric mean was not determined).

3 The number of samples above the detection limit.

4 The geometric mean of four summed chlordane isomers: cis-chlordane, trans-chlordane, cis-nonachlor, and trans-nonachlor.

exceeding 4.0 ppm were associated with complete reproductive failure. All the DDE concentrations from the present study were well below these effect levels. Even the highest concentration observed in an egg from a Mexican colony (0.93 ppm) was substantially below these levels.

Chlordane Isomers

Technical chlordane is a complex mixture of isomers, most prominent among them are cis-chlordane, trans-chlordane, heptachlor, cis-nonachlor, and trans-nonachlor (EPA 1980). Heptachlor (which rapidly metabolizes to heptachlor epoxide) and oxychlordane are minor constituents of technical chlordane.

Cis-chlordane, trans-chlordane, cis-nonachlor, and trans-nonachlor were found above the detection limit in all the eggs from Mexican colonies. Heptachlor epoxide was detected in all but one egg from Mexican colonies. Oxychlordane was detected in just 5 eggs from Mexican colonies. These isomers were not detected as frequently in Texas colony eggs. Cis-nonachlor was detected in 12 samples; trans-nonachlor and cis-chlordane were detected in 11 samples; heptachlor epoxide was detected in eight samples; and trans-chlordane and oxychlordane were detected in just one sample each. Despite the relatively high frequency of detection, the concentration of the individual isomers was low. Because of this, and for comparative purposes, the descriptive statistics presented in Table 3 are for the sum of all chlordane isomers except heptachlor epoxide. Heptachlor epoxide is presented separately because it's presence is potentially related to the use of heptachlor as a pesticide.

The geometric means for the sum of chlordane isomers was the same for eggs from the Texas colony and Mexican colonies (0.052 ppm). The highest concentration was from a Texas egg (0.175 ppm), which was slightly higher than the highest concentration in a Mexican egg (0.103 ppm). The similarity of the geometric means suggests that the exposure of Pelican Island and the two Mexican colony brown pelicans is very similar. One difference is of note: all the Mexican eggs contained trans-chlordane while only one Texas egg contained this isomer. The trans-chlordane isomer has been found to be relatively unstable compared to other chlordane isomers (Kawano et al. 1988). This may reflect more recent exposure of brown pelican prey to chlordane in the vicinity of the two Mexican colonies. The use of chlordane in the United States was significantly restricted in 1983 (Eisler 1990).

Comparison of the concentrations of total chlordane in Pelican Island eggs from this study with the concentrations reported for Texas eggs between 1975 and 1981 suggest that total chlordane has declined somewhat but not to the extent that DDE has declined. The highest concentrations of total chlordane for 1986 are within the range of concentrations reported for all years except 1977 when chlordane isomers were not detected. This could reflect the more recent (1983) restriction on the use of chlordane as compared to the 1972 ban on the use of DDT.

Chlordane has received attention in recent years due to the presence of elevated levels in certain regions of the United States (Arruda et al. 1987, Kansas Department of Health and Environment 1987, Arruda et al. 1988). These elevated levels of chlordane compounds have usually been associated with riverine habitats downstream of major urban areas (Kansas Department of Health and Environment 1987). This situation has been attributed to the use of chlordane for subterranean termite control in urban areas.

King et al. (1985) suggest that the concentrations in eggs between 1975 and 1981 were not biologically significant. It is assumed that the same holds true for the concentrations observed in the present study.

As indicated above, the detection of heptachlor epoxide may indicate exposure either to technical chlordane or heptachlor. Blus et al. (1985) state that if the ratio of heptachlor epoxide to oxychlordane is approximately 1:1, exposure to technical chlordane is indicated. Using the few samples where oxychlordane was detected, the ratio was approximately 1:1. Thus the heptachlor epoxide detected in brown pelican eggs is assumed to be a result of exposure to technical chlordane. The geometric means and ranges were very similar between the Texas colony and the Mexican colonies. Henny et al. (1983) found that concentrations as low as 1.5 ppm wet weight could reduce productivity of American kestrels. In a study of Canada geese, Blus et al. (1984) found that 10 ppm heptachlor epoxide in eggs was associated with lower reproductive success. The concentrations of heptachlor epoxide observed in this study were substantially lower than those where adverse effects have been observed.

Total PCBs

PCBs were the only organic contaminant detected in all Texas and Mexican eggs. Although the highest concentration was detected in a Mexican colony egg (2.9 ppm wet weight in an egg from Isla Contoy), the geometric mean was greater for the Texas eggs (0.51 ppm compared to 0.17 ppm). Four of the Pelican Island eggs were greater than 1.0 ppm, where as only one egg from Mexican colonies exceeded 1.0 ppm. This difference likely reflects the concentration of industrial facilities and a major urban area on Corpus Christi Bay.

In general, PCB concentrations appear to be steadily declining in brown pelican eggs. King et al. (1985) noted an eight-fold decrease in PCB concentrations from 1970 to 1981 (from 9.36 ppm in 1970 to 1.1 ppm in 1981, over an 11 year period). A similar eight-fold decrease in geometric mean PCB concnetrations was observed from 1975 to 1986 (from 4.0 ppm in 1975 to 0.51 ppm in 1986). The maximum concentration has also declined but not as substantially (2.9 ppm in 1986 versus 7.3 ppm in 1975) as the mean levels. The concentrations detected in this study are below levels generally associated with adverse effects (Eisler 1986).

It should be noted, however, that recent assessments of deformities in fish eating birds of the Great Lakes region suggest that PCBs and/or other halogenated hydrocarbons (such as polychlorinated dibenzodioxins and polychlorinated dibenzofurans) may be responsible (Geisey et al. 1994). These deformities are associated with concentrations much lower than previously considered harmful. The significance of these findings for brown pelicans cannot be determined, because these assessments are based on specific PCB congener analysis (in contrast to the total PCB analysis used in the present study). Deformities such as those described for Great Lakes fish-eating birds have not been observed in Texas brown pelicans, however.

Trace Elements

Fifteen of 20 trace elements were above the detection limits in brown pelican eggs. Beryllium, manganese, molybdenum, tin, and vanadium were not found above detection limits. A number of trace elements (arsenic, aluminum, boron, barium, chromium, nickel, and lead) had six or fewer samples that were above detection limits. Copper, mercury, iron, magnesium, strontium, and zinc were detected above detection limits in all samples. Table 5 presents the median, geometric mean, minimum concentrations, and maximum concentrations for selected trace elements in brown pelican eggs.

Arsenic

Arsenic was detected in only one Texas egg and three Mexican eggs. The arsenic concentrations in the all three Mexican eggs exceeded that found in the one Texas egg (a range of 0.26 to 1.70 ppm dry weight for the Mexican eggs versus 0.09 for the one Texas egg). Background concentrations of arsenic in birds and other biota is generally considered to be less than 1 ppm fresh weight (this value would be higher on a dry weight basis), however, marine organisms may have much higher concentrations (Eisler 1988). King et al. (1985) reported arsenic concentrations ranging from 0.3 to 1.3 ppm in Texas brown pelican eggs collected from 1975 to 1978. For the present study it would appear, since most concentrations were below detection, that arsenic is at relatively low levels in Texas and Mexican brown pelican eggs. The few Mexican eggs with concentrations above detection limits are still likely to represent background levels.

Cadmium

Cadmium was detected in only three eggs from Pelican Island and five from the two Mexican colonies. Except for the one Pelican Island egg which contained cadmium concentrations of 2.6 ppm, the concentrations in Texas and Mexican eggs were similar. Their is a paucity of studies examining the significance of cadmium in brown pelican eggs and avian eggs in general. Cadmium has been considered more of a problem for birds when consumed in the diet (Eisler 1985). Based on the fact that concentrations were below the detection limit in most eggs, it is assumed that cadmium does not pose a problem for brown pelicans at these Texas or Mexican colonies.

Copper

The concentrations of copper in the Texas and Mexican brown pelican eggs were very similar. The geometric mean copper concentrations for Texas and Mexican eggs were 1.40 and 1.50 ppm, respectively. The range of concentrations were also quite similar (0.96 to 2.80 ppm for Texas eggs and 1.0 to 2.60 ppm for Mexican eggs).

Table 5. Geometric mean, minimum, and maximum concentrations of trace elements (presented as ppm on a wet weight basis) in brown pelican eggs collected from Texas and Mexico, 1986.

Trace Element	Texas Colony (Pelican Island) N=14	Mexican Colonies N=13
Arsenic	--[1] 0.094[2] 1[3]	-- 0.26-1.70 3
Cadmium	-- 0.11-2.60 3	-- 0.11-0.27 5
Copper	1.40 0.96-2.80 14	1.50 1.0-2.60 13
Mercury	0.12 0.06-0.27 14	0.29 0.12-0.81 13
Selenium	0.23 0.15-0.46 13	0.23 0.24-0.55 10
Zinc	7.4 6.3-9.4 14	6.3 5.1-7.6 13

1 The geometric mean value (-- indicates that the geometric mean was not determined because 50 percent or more of samples were below detection).

2 The minimum (above the detection limit) and maximum value).

3 The number or samples that exceeded the detection limit for each trace element.

Concentrations of copper in brown pelican eggs have not been reported in the literature for comparison. King et al. (1983) did report the copper concentrations in the eggs of royal terns collected from Pelican Island, Texas. The mean copper concentration in these eggs was 1.11 ppm wet weight and the maximum concentration was 2.2 ppm. The mean and maximum copper concentrations in royal tern eggs from Sundown Island, Texas were 1.27 and 2.2 ppm (King et al. 1983). King et al. (1983) considered these concentrations as representative of background concentrations. It appears that the copper concentrations observed in Texas and Mexican brown pelican eggs also represent background levels.

Mercury

The geometric mean concentrations for mercury in Texas and Mexican eggs was 0.12 and 0.29 ppm wet weight, respectively. And the maximum mercury concentrations for Texas and Mexican eggs was 0.27 and 0.81 ppm, respectively. The geometric mean and maximum concentrations for Mexican eggs were more than twice that for Texas eggs. Although the concentrations for both Mexican colonies were generally higher than the Texas eggs, the highest concentrations were in the eggs from Isla Contoy.

King et al. (1985) found that mercury geometric mean concentrations in Texas brown pelican eggs from 1975 to 1978 were 0.16, 0.11, 0.04, and 0.28 ppm (wet weight). And the highest concentrations detected by King et al. (1985) from 1975 to 1978 were 0.54, 0.46, 0.05, and 0.60 ppm. The geometric mean concentrations for mercury in the present study are similar to those from 1975 to 1978. And the maximum mercury concentrations in the Pelican Island eggs were lower than those observed by King et al. (1985) in all but one year.

Mercury concentrations in animals are frequently of concern because mercury can bioconcentrate in organisms and biomagnify through food chains, potentially impacting those at higher trophic levels (Eisler 1987). Mercury does occur naturally, but it has no known biological function. The mercury concentrations in eggs which have been associated with adverse affects vary depending on the species studied (Eisler 1987). Effects have been observed in controlled studies of mallards when mercury concentrations in the eggs were as low as 0.79 to 0.86 ppm wet weight. Effects were observed in ring-necked pheasants with mercury concentrations ranging form 0.9 to 3.1 ppm (Spann et al. 1972). However, concentrations ranging from 2 to 16 ppm in herring gull eggs did not affect hatching or fledging success (Vermeer et al. 1973). All but one of brown pelican egg from the present study were below the lower effect concentrations and the geometric mean concentrations were much lower. Therefore, the mercury concentrations in the Texas and Mexican brown pelicans should be considered below levels of concern.

Selenium

The geometric mean concentrations of selenium was the same for both Texas and Mexican brown pelican eggs at 0.23 ppm. The ranges were also very similar with the Texas eggs ranging from 0.15 to 0.46 ppm and the Mexican eggs ranging from 0.24 to 0.55 ppm. This suggests that the brown pelicans from these three colonies are exposed to similar levels of selenium in their diet.

King et al. (1985) examined selenium concentration in Texas brown pelicans from 1975 to 1978. They found geometric mean concentrations in those years of 0.45, 0.50, 0.43, and 0.21. The geometric mean selenium concentrations in Pelican Island brown pelican eggs were lower than all but the mean from 1978. Ohlendorf et al. (1986) studied a site contaminanted with selenium and another that was uncontaminated and found that concentrations of selenium in bird eggs from the uncontaminated site were less than 0.87 to 1.16 ppm (on a wet weight basis converted from dry weight). Heinz et al. (1989) found that impaired reproduction for mallards was associated with selenium concentrations in eggs ranging between 3.4 to 11 ppm wet weight. The selenium concentrations observed in the present study were all within the range of concentrations found at uncontaminated areas, below potential effect levels, and generally lower than concentrations observed in Texas brown pelicans between 1975 and 1978.

Zinc

The geometric mean concentration of zinc in Texas and Mexican brown pelican eggs was 7.4 and 6.3 ppm, respectively. The range of zinc concentrations in Pelican Island eggs was 6.3 to 9.4 ppm and the range in Mexican colony eggs was 5.1 to 7.6 ppm. Zinc concentrations in the Pelican Island eggs were slightly higher than that of the Mexican colony eggs.

King et al. (1985) found zinc concentrations in Texas brown pelicans that were similar to those from this study. The geometric mean for zinc concentrations for 1976, 1977, and 1978 was 8.82, 4.93, and 6.90 ppm, respectively. The range for zinc concentrations over the three year period was 4.20 to 10.40 ppm. King et al. (1985) considered these concentrations to be indicative of background levels with no effect on reproduction or survival. All the concentrations observed in the present study were within this range and thus would also be considered representative of background levels.

CONCLUSIONS AND RECOMMENDATIONS

Of the organochlorines, DDT and its metabolites (DDE and DDD), several chlordane isomers, and PCBs were the most frequently detected compounds in brown pelican eggs. The concentrations of DDT and chlordane compounds were relatively similar between the Texas and Mexican colony eggs. When the present data for the Texas eggs are compared to historic data, it is clear that the concentrations of the DDT and chlordane compounds have all declined. The concentrations of the DDT compounds are approximately 10 times less than they were in the mid-1970's. The regulations which restricted the use of DDT in 1972 and chlordane in 1983 have had a measurable effect'in the reduction of residue concentrations in brown pelicans in Texas. The concentrations of the organochlorine compounds in eggs from Texas and Mexico were below levels considered to be harmful.

The geometric mean concentration of PCBs for Texas eggs was nearly three times as high as the geometric mean for Mexican eggs. This is probably indicative of the numerous industries and the large population center that are located on Corpus Christi Bay. PCBs have consistently been detected in Texas brown pelican eggs since collections were first made in 1970. Since that time, PCB concentrations have steadily declined. The concentrations of total PCBs detected in this study are below levels that have been associated with adverse effects. Recent studies in the Great Lakes region, which quantified individual PCB congeners, have linked deformities in young fish-eating birds with much lower concentrations of halogenated hydrocarbons than previously considered harmful. The significance of these assessments for the brown pelican cannot be determined because of differences in chemical analysis, however, deformities such as those observed in Great Lakes birds have not been observed in brown pelicans.

Five of 20 trace elements were below detection limits in all brown pelican eggs. Seven trace elements were dectected in eight or fewer samples. Six trace elements were selected for the determination of descriptive statistics. The geometric mean, minimum, and maximum concentrations for eggs collected at the Texas colony was similar to those from the Mexican colonies for all trace elements except mercury. Geometric mean concentrations of mercury in Mexican eggs were more than twice as high in the Texas colony eggs. Despite this difference, the mercury concentrations from all locations were generally below levels considered to be harmful. The concentrations of the other select trace elements also were below levels considered to be harmful.

None of the contaminants examined in this study appear to be of immediate concern for brown pelicans based on concentrations in eggs. Because of recent assessments which suggest that PCBs may be responsible for deformities in fish-eating birds, the National Audubon Society warden that patrols Pelican Island should be alerted to watch for deformites in brown pelican young. A more detailed study of PCB congeners in brown pelicans would not be necessary unless deformites are observed. No other specific management recommendations relative to these contaminants are warrented.

The greatest concern for brown pelicans at Pelican Island is the threat of exposure to petroleum hydrocarbons that could result from an accidental spill of petroleum products in the Corpus Christi Ship Channel. The same concern was noted by King et al. (1985). Because Pelican Island is adjacent to the ship channel and the brown pelican is gregarious during the nesting season, large numbers of pelcians could be oiled if a spill occured nearby. Oil spill contingency plans have identified Pelican Island as a sensitive area for brown pelicans.

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