U.S. Fish and Wildlife Service
Region 6
Environmental Contaminants Program

Chlordane Exposure to Interior Least Terns Nesting Along the Kansas River, Kansas

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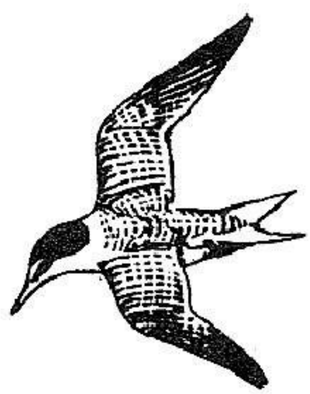

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ABSTRACT

The federally endangered interior least tern (*Sterna antillarum*) has been known to nest on sandbars along the Kansas River, KS since 1996. Documented concentrations of technical chlordane in the past have led to fish consumption advisories. Whole body concentrations in carp (*Cyprinus carpio*) and river carpsuckers (*Carpiodes carpio*) have exceeded recommendations put forth by Eisler (1990) for the protection of avian species in food items. In accordance with the recovery plan for the least tern we investigated exposure levels of chlordane in least tern colonies along the Kansas River. Prey sized cyprinids were collected from six individual sites at five different tern colonies and submitted to the U.S. Fish and Wildlife Service Patuxent Analytical Control Facility (PACF) for a organochlorine scan. Total chlordane levels in the composite fish samples were well below recommended guidelines for protection of avian species. The concentration results of the five composite sample values were used in three risk assessment equations to determine if exposure levels were at a level to cause concern. The results of those equations indicate a low amount of risk when compared to levels suggested by Eisler (1990). Tern nesting success was monitored and compared to other nesting colonies in the midwest. Lastly, five abandoned or addled eggs were collected and analyzed for organochlorine pesticide residues. The contaminant levels screened were comparable to other similar studies completed in the midwest on tern eggs that did not indicate a cause for concern. The above mentioned fish and egg samples were collected 1999 and 2000, levels of organochlorine pesticides in the Kansas River have declined in the last decade due to the banning of chlordane and DDT, 1998 and 1972, respectively (KDHE 2006, KDHE 2007).

KEYWORDS

Least Tern, Chlorinated Hydrocarbons, Contaminants, Eggs, Kansas River, Chlordane, Project ID: 1130-6F42

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LIST OF ACRONMYS AND ABBREVIATIONS

DDT	Dichlorodiphenyltrichloroethane
DL	Detection Limit
KDHE	Kansas Department of Health and Environment
NC	Not Calculated
ND	Not Detected
OR	Optima Reservoir
PPB	Parts Per Billion
PPM	Parts Per Million
QNWR	Quivera National Wildlife Refuge
SPNWR	Salt Plains National Wildlife Refuge
USCOE	United States Corps of Engineers
USFWS	United States Fish and Wildlife Service
WW	Wet Weight

INTRODUCTION

The Kansas River is formed by the confluence of the Smoky Hill and Republican Rivers near Junction City, Kansas, and flows in an easterly direction to its confluence with the Missouri River in north-central Kansas City, Kansas. In 1993, most of the Missouri River System, including the Kansas River, experienced a >100-year flood event (Kolva 1994). Extreme flows observed during this flood widened the channel of the Kansas River, scoured vegetation from existing sand bars, and formed new sand bars.

In the spring of 1996, the Fish and Wildlife Service-Kansas Field Office received its first reports that interior least terns (*Sterna antillarium*) had established several nesting colonies on some of the newly formed sand bars in the Kansas River between Manhattan, KS and Topeka, KS (Busby, et al. 1997). The interior population of least terns was listed as federally endangered in 1985 (50 Federal Register 21,784 - 92).

Least terns are the smallest of the North American terns; adult length of 21-24 cm and a wingspan of about 51cm (Whitman 1988). Their diet predominantly consists of numerous species of small, shallow-bodied fishes which occur either in shallow water, or the upper portion of the water column. Least terns will also consume shrimp and terrestrial and aquatic invertebrates as available. Least terns capture their prey by hovering over likely foraging habitats, then plunging into the water. Least terns lay 2-3 eggs in a shallow scrape on open beaches, islands or sandbars (Thompson, et al. 1997). Prior to 1996, the only known least tern nesting colonies in Kansas were at the Cimarron River in Meade County, Quivira National Wildlife Refuge (QNWR) in Stafford County, and at the Jeffery Energy Center in Pottawatomie County, Kansas.

The Fish and Wildlife Service-Kansas Field Office was concerned about the presence of an endangered fish-eating bird using this particular portion of the Kansas River as a nesting colony site existed due to potential chlordane exposure. Although Arruda et al. (1987) sampled fish species and sizes not used by least terns, they did show that chlordane had accumulated in fish tissues from the Kansas River to elevated concentrations. Mean chlordane concentrations below Manhattan (0.12 mg/kg) were higher than at Topeka (0.08 mg/kg), and only slightly less than mean concentrations below Lawrence (0.13 mg/kg). Chlordane concentrations in Kansas City were an order of magnitude higher still (1.4 mg/kg). Effects of chlordane poisoning in birds include reduced activity and feeding rates, loss of voluntary muscle control and abnormal behaviors, convulsions, tetany, and ultimately death. In the event that chlordane could be shown to have accumulated in more appropriate fish species and sizes, the nesting habitats along the Kansas River could be considered as an attractive nuisance for the interior least tern.

Arruda et al. (1987) documented concentrations of technical chlordane in edible tissues of common carp from the Kansas River below Manhattan, through Topeka and Lawrence, KS, to its confluence with the Missouri River. Concentrations of chlordane were attributed to transport from areas of land application by movement of water or contaminated soils, and are directly related to the proximity to sewage treatment plants and tributaries draining urban areas along this corridor. Chlordane concentrations in fish were sufficiently elevated to compel the Kansas Department of Health and Environment (KDHE) to establish fish consumption guidelines from Lawrence to the Missouri River.

The National Academy of Sciences and National Academy of Engineering (1973) have determined that concentrations in prey items greater than 0.10 mg/kg total cyclodienes (including total chlordane, aldrin, dieldrin, endrin, heptachlor, and endosulfan) be considered detrimental. This concentration was also recommended by Eisler (1990) as a no observable effect level (NOEL), but only for total chlordane.

Several studies have shown the presence of organochlorine compounds residues in least terns in Kansas and other portions of the mid-western United States. Allen (1992) collected four flooded or abandoned least tern eggs from QNWR and analyzed them for total chlorinated hydrocarbon residues. Three eggs had reportable p,p=-DDE residues chlorinated hydrocarbon (0.07 - 0.09 mg/kg). Allen and Blackford (1993, 1997) analyzed least tern eggs from QNWR and other sites in Nebraska, North Dakota, South Dakota, and Montana. Their results showed reportable concentrations of total chlordane compounds, and total cyclodiene concentrations equal to or exceeding the recommended NOEL. We assume that these compounds are accumulated at sites within the migratory range of interior least terns including the nesting sites.

Technical chlordane is a mixture of approximately 45 (Eisler 1990) chlorinated cyclodiene compounds. Chlordane was first used in the United States as a broad-spectrum insecticide in 1948. Between 1948 and 1983, annual use of chlordane in the United States was estimated to be in excess of 3.6 million pounds (EPA 2001a). After 1983, the use of chlordane was restricted to subterranean termite control (ATSDR 1994). In 1988, the U.S. Environmental Protection Agency cancelled all registered uses of chlordane over concerns of cancer risk in humans, persistence in the environment, and hazards to wildlife (EPA 2001b).

Our study was initiated to determine the amount of chlordane to which least tern chicks on the Kansas River are exposed, develop an estimate of chlordane dose, and measure and estimate accumulated body burdens. Our results are used to determine the suitability of the Kansas River sites for use by terns as nesting colonies. These measurements and estimates are compared to the scientific literature to determine the potential for adverse health effects to tern chicks produced at these colonies. In addition where available, observed nesting success at the various colonies is compared to expected rates.

METHODS AND MATERIALS

Estimates of Tern Productivity

Monitoring of the least tern nesting colonies and was conducted by researchers from Baker University, Baldwin City, Kansas. Colonies were accessed either by boat or from the river bank on a weekly basis. At each of the four colonies, Jeffery Energy Center Intake, Belvue, Belvue Annex, and Perry West, (Figure1), adult least terns were observed and enumerated, and nest locations were approximated. An attempt was then made to find each nest, and if found, the number of eggs and/or chicks was recorded. Adult terns were trapped in a radio-controlled spring-trap, and pre-fledge tern chicks were captured by hand. All adult terns and the larger pre-fledge chicks were banded with Fish and Wildlife Service leg bands.

Productivity monitoring began in 1999. However, high flows into the Kansas River below Milford and Tuttle Creek Reservoirs during the spring of 1999 flooded all of the nesting colonies, and there was not a successful nest in the study area. Colony monitoring continued in 2000, when three of the previously known colonies, and a new downstream nest near Lecompton, KS, were monitored.

Forage Fish Collection and Analysis

We collected fish from foraging habitats frequently used by least terns. These areas were determined by visual observation of tern foraging behavior. We collected composite fish samples from six foraging sites at each of the four active colonies; three upstream, and three downstream of each colony. Fish collections in 2000 were categorized into three periods, Early (June 20th-July15th), Mid (July 16th-August 10th) and Late (August 11th –September 5th). Sample sites included shallow water areas along the bank, or back-water areas where schools of small fish can be easily observed and captured by adult terns. Fish were collected using a minnow seine. After each seine haul, individual fish >5 cm were discarded, as they were not representative of tern chick food items (Whitman1988). The remaining fish were identified to species and enumerated. A single composite sample was collected consisting of the numerous species proportional to their presence at the site. We did not attempt to determine the species of fish upon which the terns may have been foraging. Rather, we simply collected whatever species of fish may have been present at these sites, and selected individuals of an appropriate size. By sampling fish based on their relative presence at sample sites rather than targeting a certain species, we attempted to negate variable accumulation rates observed in philopatric cyprinid species (Hebert and Haffner 1991, Mandenjian et al. 1994) and develop an estimate of mean contaminant exposure. One method to improve upon this estimate would be to use ligature devices and collect food items actually captured by adult terns and fed to the chicks. However, this type of intrusive sampling was not warranted during this study.

We also collected a set of fish samples from several unoccupied islands and sandbars throughout the upper Kansas River. These samples were collected to evaluate any future use of these locations by least terns. As these samples are not yet associated with a nesting colony, they are referred to as the "River Wide" samples.

All samples were collected in pre-cleaned glass jars, placed on ice in the field, and stored at -20C in the lab. Fish samples were submitted for organochlorine scan (Table 1) at the U.S. Fish and Wildlife Service Patuxent Analytical Control Facility (PACF) located in Laurel, Maryland, USA. Residue analyses employed the Soxhlet extraction technique described by Cromartie et al. (1975) and were quantified using a gas-liquid chromatograph equipped with a 63Ni electron capture detector. Residues in 10% of the samples were confirmed by gas chromatography/mass spectrometry, Quality Assurance and Quality Control procedures, including the use of procedural blanks, duplicate and spike samples, were conducted and approved according to protocols established by PACF.

Figure 1. Active Tern Colony Locations in 2000 on the Kansas River

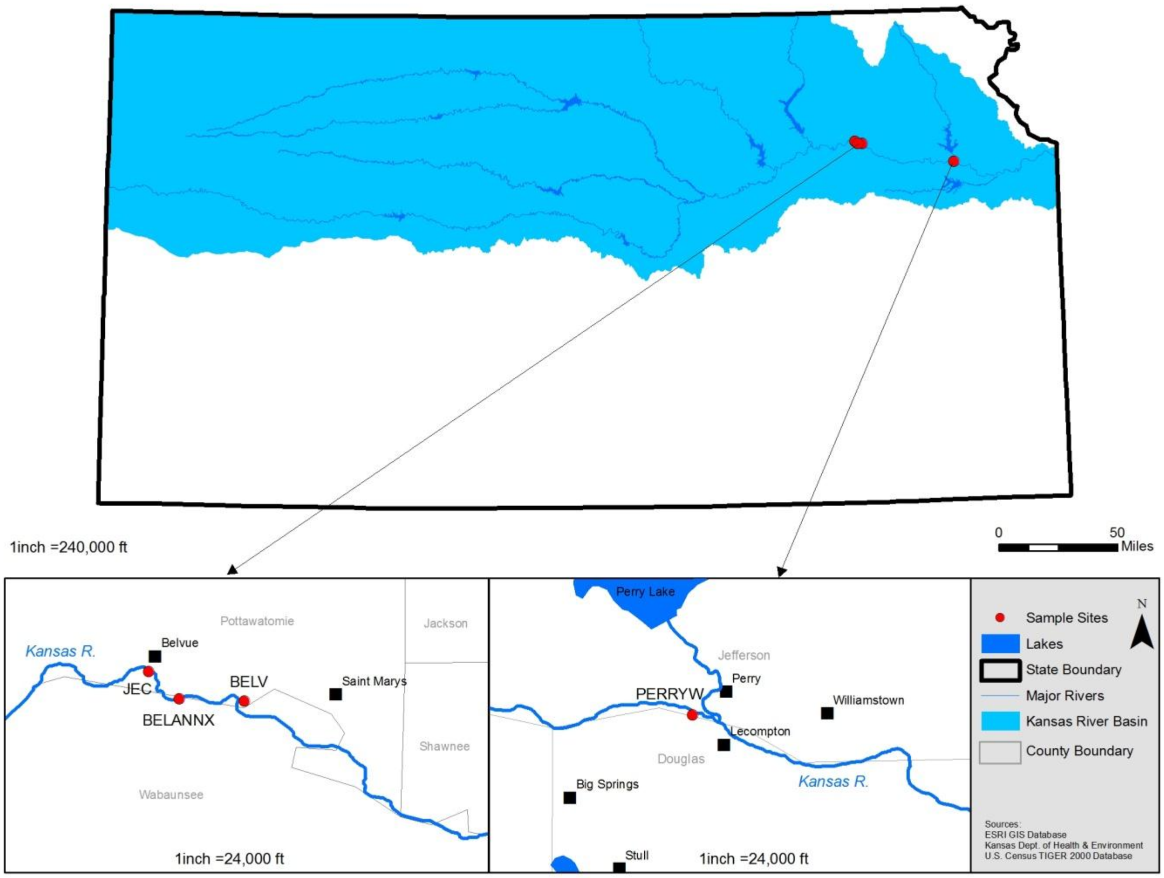

Table 1.
Organic compounds analyzed in fish (cyprinids) samples collected from five foraging sites near active least tern nesting colonies along the Kansas River, Kansas.

PCB total	dieldrin	mirex	p,p'-DDD
alpha BHC	endrin	o,p'-DDD	p,p'-DDE
alpha chlordane	gamma BHC	o,p'-DDE	p,p'-DDT
beta BHC	gamma chlordane	o,p'-DDT	toxaphene
cis-nonachlor	heptachlor epoxide	oxychlordane	trans-nonachlor

KDHE and EPA also conduct both routine and sporadic fish sampling programs along the Kansas River (Steve Wharton, EPA, pers. comm.). Information contained in these databases was used to determine long-term trends in chlordane concentrations in Kansas River fish.

RESULTS

We used three equations to evaluate the possible impacts of least tern chick exposure to chlordane in the nesting colonies. Some of the variables used in the equations below were assumed to be constants for the purpose of this study, although their true nature as variables is acknowledged. Site-specific data could be substituted into the equations to yield a more accurate estimate of risk. The body weight of each individual fish consumed by least tern chicks was approximated at 1.2 g. This assumption was based on the most common size of the most predominant species of fish, sand shiner (*Notropis straminus*), captured during collections at the colonies. The Assimilation Constant was held at 1.0, which is known to be high and does not consider depuration over time. The length of time between hatching and fledging varied from 19-22 days and averaged 21 days (R. Boyd, Baker Univ., pers com.). We assumed equivalent toxicity and no interactive effects between the five compounds which comprise Total Chlordane. This assumption will likely over-state the potential for adverse impacts as the relative toxicities of these compounds are known to be non-equivalent. The remaining variables were either directly measured or are based on values available in published literature. It should be noted that due to the small concentration values, the units are in µg/kg as opposed to mg/kg.

<u>Estimate of Total Chlordane Exposure/Accumulation</u>

We used Equation 1 to estimate the total amount of chlordane (µg /kg wet weight [ww]) least tern chicks are exposed to at each colony. We used a value of 9.5 fish/day as the mean consumption rate during the entire chick-rearing period (Thompson1997).

Equation 1: ([x] µg/kg)*(0.0012 kg/fish)*(9.5 fish/day)*(1/1)*(21day/1) = X µg Chlordane

Where
([x] µg /kg) = Mean measured chlordane concentration in fish
(0.0012 kg/fish) = Individual fish weight
(9.5 fish/day)= Fish consumption rate (mean)
(1/1)= Assimilation Constant
(21 day/1) = Number of days hatch to fledge

Jeffery Energy Center Intake:	(4.11µg)*(.0012kg)*(9.5)*(1/1)*(21/1) = 0.98µg/kg
Belvue:	(3.79µg)*(.0012kg)*(9.5)*(1/1)*(21/1) = 0.91µg/kg
Belvue Annex:	(3.39µg)*(.0012kg)*(9.5)*(1/1)*(21/1) = 0.81µg/kg
Perry West:	(5.26µg)*(.0012kg)*(9.5)*(1/1)*(21/1) = 1.26µg/kg
River Wide:	(4.77µg)*(.0012kg)*(9.5)*(1/1)*(21/1) = 1.14µg/kg

<u>Estimate of Chlordane Dose</u>

We used Equation 2 to estimate daily dose of chlordane (µg/kg-d ww). We used the body weight of the chick and the daily consumption rate which correspond to the measured chlordane concentration for each of the three time periods when fish were collected. We then compared the variation in dose during these three time periods when chicks were present in the colony. Finally, we calculated mean values for these three variables to compare dose between the four colonies. Fish consumption rate and chick body weight information can be found in Thompson (1997).

Equation 2: ([x]µg/kg)*(0.0012 kg/fish)* (#fish/day)*(1/1) / chick body weight kg =
X µg /kg-d

Where ([x] µg /kg) = Mean measured chlordane concentration in fish
(0.0012 kg/fish) = Individual fish weight
(X fish/day)= Fish consumption rate (hatch, mid and fledge)
(1/1)= Assimilation Constant
(1/W_{chick}-kg) Chick body weight (hatch, mid and fledge)

<u>EARLY (June20-July15)</u>

Jeffery Energy Center Intake: (3.49µg)* (0.0012kg)*(7.2)*(1/1)/6.9 = 0.0044 µg /kg-d
Belvue: (3.92µg) *(0.0012kg)*(7.2)*(1/1)/6.9 = 0.0049 µg /kg-d
Belvue Annex: (4.21µg) *(0.0012kg)*(7.2)*(1/1)/6.9 = 0.0053 µg /kg-d
Perry West: (2.50µg) *(0.0012kg)*(7.2)*(1/1)/6.9 = 0.0031 µg /kg-d
River Wide: (4.33µg) *(0.0012kg)*(7.2)*(1/1)/6.9 = 0.0054 µg /kg-d

<u>MID (July16-August10th)</u>

Jeffery Energy Center Intake: (5.20µg)* (0.0012kg)*(9.5)*(1/1)/23.5 = 0.0025 µg /kg-d
Belvue: (4.12µg) *(0.0012kg)*(9.5)*(1/1)/23.5 = 0.0020 µg /kg-d
Belvue Annex: (2.86µg) *(0.0012kg)*(9.5)*(1/1)/23.5 = 0.0014 µg /kg-d
Perry West: NA
River Wide: (3.45µg) *(0.0012kg)*(9.5)*(1/1)/23.5 = 0.0017 µg /kg-d

<u>LATE (August 11th-September 5th)</u>

Jeffery Energy Center Intake: (3.32µg)* (0.0012kg)*(7.2)*(1/1)/40.0 = 0.0012 µg /kg-d
Belvue: (3.03µg) *(0.0012kg)*(7.2)*(1/1)/40.0 = 0.0011 µg /kg-d
Belvue Annex: (2.29µg) *(0.0012kg)*(7.2)*(1/1)/40.0 = 0.0008 µg /kg-d
Perry West: (6.18µg) *(0.0012kg)*(7.2)*(1/1)/40.0 = 0.0022 µg /kg-d
River Wide: (4.75µg) *(0.0012kg)*(7.2)*(1/1)/40.0 = 0.0017 µg /kg-d

<u>MEAN</u>

Jeffery Energy Center Intake: (4.11µg) *(0.0012kg)*(9.5)*(1/1)/23.5 = 0.0020 µg /kg-d
Belvue: (3.79µg) *(0.0012kg)*(9.5)*(1/1)/23.5 = 0.0018 µg /kg-d
Belvue Annex: (3.39µg) *(0.0012kg)*(9.5)*(1/1)/23.5 = 0.0016 µg /kg-d
Perry West: (5.26µg) *(0.0012kg)*(9.5)*(1/1)/23.5 = 0.0026 µg /kg-d
River Wide: (4.77µg) *(0.0012kg)*(9.5)*(1/1)/23.5 = 0.0023 µg /kg-d

Estimate of Chlordane Body Burden

We used Equation 3 to estimate whole body burden (µg/kg ww) in least tern chicks at the time of fledging. Biomagnification factors used were consistent with numbers used for organochlorine compounds in tissues and eggs of fish-eating birds including the herring gull and brown pelican (Hoffman et al. 2003).

Equation 3: ([x] µg /kg)*BMF = X µg /kg

Where	([x] µg /kg) = Mean measured chlordane concentration in fish
	BMF = Biomagnification Factor

CARCASS

Jeffery Energy Center Intake:	(4.11µg)*(5) = 20.50 µg /kg
Belvue:	(3.79µg)*(5) = 18.94 µg /kg
Belvue Annex:	(3.39µg)*(5) = 16.97 µg /kg
Perry West:	(5.26µg)*(5) = 18.40 µg /kg
River Wide:	(4.77µg)*(5) = 23.85 µg /kg

EGG

Jeffery Energy Center Intake:	(4.11µg)*(45) = 184.73 µg /kg
Belvue:	(3.79µg)*(45) = 170.45 µg /kg
Belvue Annex:	(3.39µg)*(45) = 152.75 µg /kg
Perry West:	(5.26µg)*(45) = 165.63 µg /kg
River Wide:	(4.77µg)*(45) = 214.65 µg /kg

TERN PRODUCTIVITY

Least tern productivity data collected at the four active colonies is presented in Table 2 (R. Boyd, Baker Univ., written communication). These data were compared to literature values which also consider natural mortality to evaluate overall nesting success at the colonies. These data were then screened to remove from consideration eggs and nests lost to flooding, predation, or other forms of external mortality. Only eggs that actually hatched were included in the risk assessment of chlordane exposure at the active colonies. The "Screened" column includes only nests where at least one egg hatched, and the resulting productivity metrics from these nests. The "% Change" column indicates the results of removing failed nests from the data set for each metric.

Table 2: Total and screened least tern nesting success at the Kansas River, 2000.

Year	**Total 2000**	***Screened 2000***	***% Change***	**QNWR* 1980-87**	**SPNWR*[H] 1986-87**	**OR*[I] 1986-87**
Total Nests (x̄)	23 (NC)	*12*	*-48%*	359 (44.9)	148 (74)	72 (36)
Egg Productivity						
Total Eggs (x̄)	58 (NC**)	*30 (NC)*	*-48%*	806 (100.8)	299 (149.5)	181 (90.5)
Eggs/Nest	2.52	*2.50*	*-1%*	1.95 - 2.58	1.96 - 2.17	2.28 - 2.7
Hatching Rate						
Total Hatch (x̄)	30 (NC)	*24*	*-20%*	182 (22.8)	60 (30)	108 (54)
Hatch/Eggs	51.7%	*80.0%*	*55%*	10% - 57%	12% - 38%	59% - 60%
Hatch/Nest	1.3	*2.0*	*53%*	0.21 - 1.36	0.24 - 0.83	1.38 - 1.60
Fledging Rate						
Total Fledged(x̄)	15 (NC)	*15*	*0%*	68 (8.5)	NC	56 (28)
Fledge/Hatch	50%	*63%*	*25%*	0% - 70%	NC	50% - 59.1%
Fledge/Egg	25.9%	*50.0%*	*93%*	0% - 24%	NC	30% - 36%
Fledge/ Nest	0.65	*1.25*	*92%*	0 - 0.95	NC	1.00 - 1.07

* Data from Boyd 1987
** NC - Not Calculated
[H] SPNWR-Salt Plains National Wildlife Refuge, Oklahoma
[I] OR-Optima Reservoir, Oklahoma

As would be expected, hatching and fledging success metrics increase dramatically with the removal of unhatched eggs and non-fledging chicks, respectively, from the data set. Other studies have reported egg production at 2-3 (Thompson et al. 1997), and from 1-4 (Whitman 1988) eggs per nest. With the exception of the Fledging Rate metrics at Optima Reservoir, least tern productivity measured at colonies in the Kansas River compare favorably to least tern colonies elsewhere in the Central United States.

In 1999 and 2001 there was zero success due to the flooding of colonies from water releases from upstream reservoirs. The success level in 1997 and 1998 is unknown due to limited monitoring.

Mean concentrations of Total Chlordane in fish are presented in Table 3. These results have been segregated by sample site and represent the mean concentration throughout the least tern breeding season. Mean concentration values were also calculated by season, and for sampling locations relative to each colony for use in the risk assessment calculations. Concentrations of other chlorinated hydrocarbon compounds detected in these samples are presented in Table 4.

River-wide mean chlordane fish concentrations were found to be 0.0048 mg/kg wet weight. This is below the NOEL of 0.1-0.3 mg/kg diet for birds (Eislers1990). Additionally, even the highest concentration measured (0.0053 mg/kg wet weight) at the Perry West site was below the NOEL.

Table 3: Mean chlordane concentrations* mg/kg wet weight, measured in composite fish samples collected from the Kansas River, Kansas, 2000.

Site	Total Chlordane
Jeffrey Energy Center Intake	0.0041
Belvue	0.0038
Belvue Annex	0.0034
Perry West	0.0053
River-Wide	0.0048

*Detection Level = 0.0002 mg/kg
** mg/kg wet weight

Table 4: Organochlorine compound residues mg/kg wet weight, measured in composite fish samples from the Kansas River, Kansas, 2000.

Sample Number	Total PCBs*	o,p-DDD**	p,p=-DDE**	p,p=-DDT**
10	0.121	nd	nd	nd
20	nd***	nd	0.011	nd
30	0.12	nd	nd	nd
33	nd	0.0256	nd	0.031

* DL=0.001 mg/kg wet weight
** DL=0.0002 mg/kg wet weight
*** nd-Not Detected

We were not able to collect abandoned or addled eggs during the summer of 2000. However, five abandoned or addled eggs were collected from the Jeffrey Energy Center Intake colony during 1999. These eggs were analyzed for organochlorine compound pesticide residues (Table 5). All but one egg were below detection levels for Total Chlordane; and all eggs had detectable levels of Dieldrin, Heptachlor Eposice and p-p+-DDE.

Table 5: Total chlordane concentrations* measured in mg/kg wet weight in abandoned or addled eggs collected from the Jeffrey Energy Center, 1999.

Sample Number	Total Chlordane
JECLT1	<0.01
JECLT2	<0.01
JECLT3	0.48
JECLT4	<0.01
JECLT5	<0.01

*Detection Level = 0.01 mg/kg

Table 6: Organochlorine compounds concentrations* measured in mg/kg wet weight in least tern eggs collected from the Jeffery Energy Center, Kansas, 1999.

Sample Number	Dieldrin	Heptachlor Epoxide	p-p=-DDE
JECLT1	0.06	0.03	2.45
JECLT2	0.16	0.04	2.85
JECLT3	1.28	0.36	1.22
JECLT4	0.13	0.05	0.93
JECLT5	0.02	0.03	0.68

*Detection Level = 0.01 mg/kg

Charbonneau (1993), collected thirteen addled eggs from Mississippi County, Missouri and analyzed for 22. Levels for DDE ranged from 2.5-3.1 PPM and dieldrin levels ranged from 0.11-0.60 mg/kg. She concluded those levels were not problematic. Blus et al (1977) measured organochlorine compounds (DDE, Dieldrin, PCB's, DDT and DDD) in brown pelican eggs and found a geometric mean of 1.77 mg/kg and concluded those levels were not correlated to reproductive success. Switzer et al (1973) and Fox (1976) suggest DDE concentrations in common terns must exceed 4.0 mg/kg to affect reproductive success. The eggs we collected from the Jeffery energy Center, KS had lower concentrations of organochlorine compounds than reported by the above researchers. However our sample size (n=5), was not sufficient to provide an overall picture of the effects of organochlorine compounds on reproduction of least terns nesting on the Kansas River.

MANAGEMENT RECOMENDATIONS

The results of our investigation indicate levels of organochlorine compounds found in 2000 along the Kansas River, KS were not problematic for least tern chicks. Our results are supported by previous researchers. Allen and Blackford (1992; 1993; 1997) and Charbonneau (1993) found organochlorine compounds levels were likely not significant enough to adversely affect least terns in the Midwest. Total chlordane levels found in this study were significantly lower than levels known to have detrimental effects on terns, and from that perspective the Kansas River should be considered suitable habitat for interior least tern.

The implementation of best management practices to maintain sandbar habitat on the Kansas River is not anticipated to create a contaminated attractive nuisance for least terns.

During flood years, displaced breeding terns have been documented to nest on a fly ash depository at Jefferies Energy Center located six miles north of the Kansas River in Pottawatomie, KS (USACOE 2006). The potential for exposure to metals possibly present in the fly ash at this site has not been evaluated for nesting least terns. Future investigations concerning exposure to nesting terns from contaminants on the fly ash could prove beneficial.

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