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3910

Evaporation Pond Studies in California's Tulare Basin, 1991-98: Draft Final Report

Division of Environmental Contaminants
Sacramento Fish and Wildlife Office

Introduction

Selenium hazards to fish and wildlife associated with the disposal of agricultural drainage water in evaporation ponds was prominently brought to the attention of ecotoxicologists by the severe episode of selenium poisoning among ducks and other waterbirds that occurred at Kesterson Reservoir in the mid-1980's (Ohlendorf 1989). This immediately raised concerns over the possible impacts that similar evaporation ponds might be having on wildlife in the Tulare Basin, 160 km south of Kesterson. Between 1972 and 1985, 25 evaporation ponds totaling 3,000 ha (7,400 acres) had been constructed in the Tulare Basin (Table 1; Map 1) (Moore et al. 1990; Tanji et al. 1992). Of even greater concern was the fact that another 4,000 to 8,000 ha (10,000-20,000 acres) of new evaporation ponds were in the permit application process (Westcot et al. 1988). Evaporation ponds were viewed as the only feasible drainage water disposal option for many areas of California's San Joaquin Valley, and it was estimated that over a 100-year planning horizon about 67,500 ha (167,000 acres) of ponds would be required if other waste management alternatives were not developed (SJVDIP 1979, Moore et al. 1990). Furthermore, ever since the 1920's, the Salton Sea had already been functioning as an immense 100,000 ha (250,000 acres) evaporation pond in California's Imperial Valley, yet little basis for assessing selenium risks at the Salton Sea had been developed. By 1991, the U.S. Bureau of Reclamation was also proposing a 6,500 ha (16,000 acre) evaporation pond facility to meet the Bureau's drainage service obligations to the San Luis Unit of the Central Valley Project. Thus, in the immediate aftermath of the wildlife catastrophy at Kesterson Reservoir, natural resource managers were faced with an agricultural industry that was on the verge of creating a landscape absolutely awash with seleniferous evaporation ponds similar to Kesterson Reservoir. There was clearly an immediate need for precisely delineating the magnitude of the toxic threat already facing Pacific Flyway populations of waterbirds and for projecting the potential hazards associated with scenarios for the future. Accordingly a strong scientific basis for predictive risk assessment was urgently needed.

These needs were addressed initially by the San Joaquin Valley Drainage Program which funded intensive field research at evaporation ponds in the Tulare Basin by scientists affiliated with the Patuxent Wildlife Research Center. Between 1987 and 1990 a great deal of progress was made characterizing the extent and magnitude of avian selenosis at about 10-15 evaporation ponds included in the initial research efforts (Moore et al. 1990). During this era it was confirmed that the "Kesterson Syndrome" was widespread in the Tulare Basin and that minimum levels of contamination required to cause wildlife toxicity were much lower than initially suspected (Moore et al. 1990; Skorupa and Ohlendorf 1991). It was also established

that the Tulare ponds were supporting about 20 million bird-use days per year in the heart of the Pacific Flyway (Moore et al. 1990), including one of the largest extant breeding populations of the threatened western snowy plover (*Charadrius alexandrinus*) (Page et al. 1991). By the time the San Joaquin Valley Drainage Program's field activities ceased, in 1990, it had been clearly established that the Tulare ponds were in dire need of regulatory control, remediation/mitigation, and further risk characterization.

Thus, in 1991 the Sacramento Fish and Wildlife Office initiated a monitoring and research program at the Tulare ponds. This program was intended to produce the first basic exposure assessments for selenium in birds at pond systems not included in Patuxent's research efforts, to provide a substantive scientific basis for regulatory control and remediation/mitigation efforts at all Tulare ponds, and to continue acquiring the long-term exposure-response data absolutely vital for developing a predictive risk assessment capability. In addition to evaporation ponds, a variety of non-drainwater and mitigation wetlands were also monitored within the Tulare Basin to provide baseline chemistry data and mitigation performance data.

Methods

Contaminant exposure surveys were focused primarily on two species of large shorebirds, American avocets (*Recurvirostra americana*) and black-necked stilts (*Himantopus mexicanus*). Avocets and stilts are closely related phylogenetically (Sibley et al. 1988) and are the only two North American species of birds classified in the family Recurvirostridae. Consequently, the term recurvirostrids is used in this report when referring to both species jointly. Recurvirostrids comprised more than 70% of all breeding birds at evaporation ponds and were common at all evaporation ponds and other types of aquatic habitat within the Tulare Basin. The most reliable and sensitive measure of risk for selenium poisoning of birds is reproductive impairment (Heinz 1996; Skorupa et al. 1996). Consequently, exposure surveys were also focused primarily on selenium contamination of avian eggs. Each breeding season (April-August) ponds were surveyed for recurvirostrid nests and representative samples of randomly selected eggs were collected by hand for chemical analyses. Strategically selected nonrandom eggs were also collected. These were usually fail-to-hatch eggs remaining in nests after all viable eggs had hatched. Comparative studies of foraging behavior at evaporation ponds revealed that avocets and stilts did not differ in their diets (Cooper and Barnum 1993). Therefore, avocet and stilt eggs collected at the same site are interchangable measures of selenium exposure and are lumped for that purpose in this report.

Any egg collected for chemical analysis that contained an intact embryo incubated to about 6-8 days or more was also systematically assessed to determine the status of the embryo. Embryos were assessed for the presence or absence of overt true terata, for confirmation of species identity, and to determine whether the embryo was alive or dead at the time of collection. This "response" data was segregated by species to allow derivation of species-specific response curves.

Nest monitoring, based on standard nestcard protocols (e.g., Klett et al. 1986), was also conducted whenever sufficient staff time was available. Nest monitoring was primarily focused

TABLE 1

EVAPORATION PONDS IN THE SAN JOAQUIN VALLEY[a]

Pond Name [Basin Number][b]	County	First Year Operable	Present Size (acres)[c]	Status[d]
Souza [1]	Merced	---	9	Uncertain[e]
Lindemann [2][f]	Merced	Late 1970's	80	Uncertain
Britz South Dos Palos [3]	Merced	1985	40	Inactive
Sumner Peck [4]	Fresno	1984	100	
Britz Deavenport Five Points [5]	Fresno	1982	30	
Stone Land Company [6]	Kings	1984	210	
Lemoore Naval Air Station (formerly Carlton Duty) [7]	Kings	1983	90	Inactive[g]
Westlake Farms North (#1 & #2) [8]	Kings	1984	260	
Empire Farms (aka Fabry Farms) [28][h]	Kings	1982	7	
Meyers Ranch [9]	Kings	1983	80	Partially Inactive[i]
Barbizon Farms [10]	Kings	1985	100	
Tulare Lake Drainage District North [11]	Kings	1974	290	
Westlake Farms South (#3) [12]	Kings	1984	810	
Jackson & Williams Farms (aka Liberty Farms) [13]	Kings	1981	630	Partially Inactive[j]
Pryse Farms [14]	Tulare	1985	80	
Bowman Farms [15]	Tulare	1981	70	Partially Inactive[k]
Morris Farms [16]	Tulare	1985	40	
Martin Farms [17]	Tulare	1985	17	
Smith Farms [18]	Tulare	1985	8	Inactive
Four - J Corporation [19]	Kings	1985	30	

TABLE 1

EVAPORATION PONDS IN THE SAN JOAQUIN VALLEY (CONT'D)[a]

Pond Name [Basin Number][b]	County	First Year Operable	Present Size (acres)[c]	Status[d]
Nickell [20]	Kings	1985	15	Inactive
Tulare Lake Drainage District Hacienda Ranch [21]	Kings	1978	1,400	
Tulare Lake Drainage District South [22]	Kings & Kern	1978	1,890	
Westfarmers (aka Lost Hills Water District) [23]	Kern	1984	670[l]	
Carmel Ranch (aka Willow Creek) [24]	Kern	1972	170	Partially Inactive[m]
Lost Hills Ranch (aka Latter Day Saints) [25]	Kern	1981	90	
Sam Andrews (aka Rainbow Ranch) [26]	Kern	1983	120	
Chevron Land Company [27]	Kern	1985	60	Never Operated[n]
Total Acreage			7,400	

a Based on Moore et al. (Nov 1989). Includes all 28 known evaporation ponds in the San Joaquin Valley (CCVRWQCB, Nov 1989; Westcot et al., Jul 1988). "---" indicates no data are available.

b Numbers in brackets are evaporation pond "basin numbers" assigned (in order, north to south) by the California Regional Water Quality Control Board - Central Valley Region (Westcot et al., Jul 1988). Empire Farms (aka Fabry Farms) Evaporation Pond was only recently discovered and has been assigned basin number 28 (see footnote h).

c Acreage derived from computerized geographic information system digitized boundaries of evaporation ponds interpreted from baseline aerial photographs taken May 1988 and subsequently updated with more recent photography and through conversations with field research and regulatory personnel. Acreage values for larger ponds ($\geq$30 acres) and "Total Acreage" were rounded off to the nearest 10 acres.

d Unless otherwise noted, ponds are active and information is from pers. comms., Aug 16, 1989 and Aug 7, 1989, A.L. Toto, Water Resource Control Engineer, Calif. Regl. Water Qual. Control Board - Cent. Valley Reg., Sacramento, CA; and pers. comm., Aug 28, 1989, D.W. Westcot, Senior Land

TABLE 1

EVAPORATION PONDS IN THE SAN JOAQUIN VALLEY (CONT'D)[a]

and Water Use Analyst, Calif. Regl. Water Qual. Control Board - Cent. Valley Reg., Sacramento, CA.

[e] According to Norbert Souza (Souza Farms), this pond is not an evaporation basin, but instead functions as a storage reservoir for water from an irrigation canal and runoff from a dairy operation (pers. comm., Oct 26, 1989, N. Souza, Pond Owner, Souza Farms, Gustine, CA). Available water quality data support this assertion (pers. comm., Oct 26, 1989, A.L. Toto, Water Resource Control Engineer, Calif. Regl. Water Qual. Control Board - Cent. Valley Reg., Fresno, CA).

[f] Discussions with George Lindemann (pers. comm., Dec 11, 1989, G. Lindemann, Former Pond Owner, Lindemann Produce, Los Banos, CA) and others reveal that the pond formerly recognized as Lindemann Evaporation Pond may never have operated as an evaporation pond. Rather, two separate ponds (one north and one south of the location of the earlier pond) received and recirculated subsurface agricultural drainage water. These ponds are mapped in figure 4-15 ("Lindemann Evaporation Ponds [2], Merced County, California"). The properties on which these two ponds are located were sold by George Lindemann in 1985.

[g] Previously referred to as Carlton Duty, this pond has not received subsurface agricultural drainage water since November 1987. However, leachate from the perimeter collection system surrounding the Lemoore Naval Air Station sewage ponds currently discharges into the pond (pers. comm., Oct 2, 1989, T.O. Clark, Natural Resource Specialist, Lemoore Naval Air Station, Lemoore, CA).

[h] CCVRWQCB, Nov 1989; pers. comm., Mar 14, 1990, A.L. Toto, Water Resource Control Engineer, Calif. Regl. Water Qual. Control Board - Cent. Valley Reg., Fresno, CA.

[i] Cell C of Meyers Ranch Evaporation Ponds is inactive and trees have been planted within the cell (pers. comm., Aug 13, 1990, A.L. Toto, Water Resource Control Engineer, Calif. Regl. Water Qual. Control Board - Cent. Valley Reg., Fresno, CA).

[j] Pers. comm., Mar 23, 1990, J.P. Skorupa, Research Wildlife Biologist, USFWS-PWRC, Davis, CA.

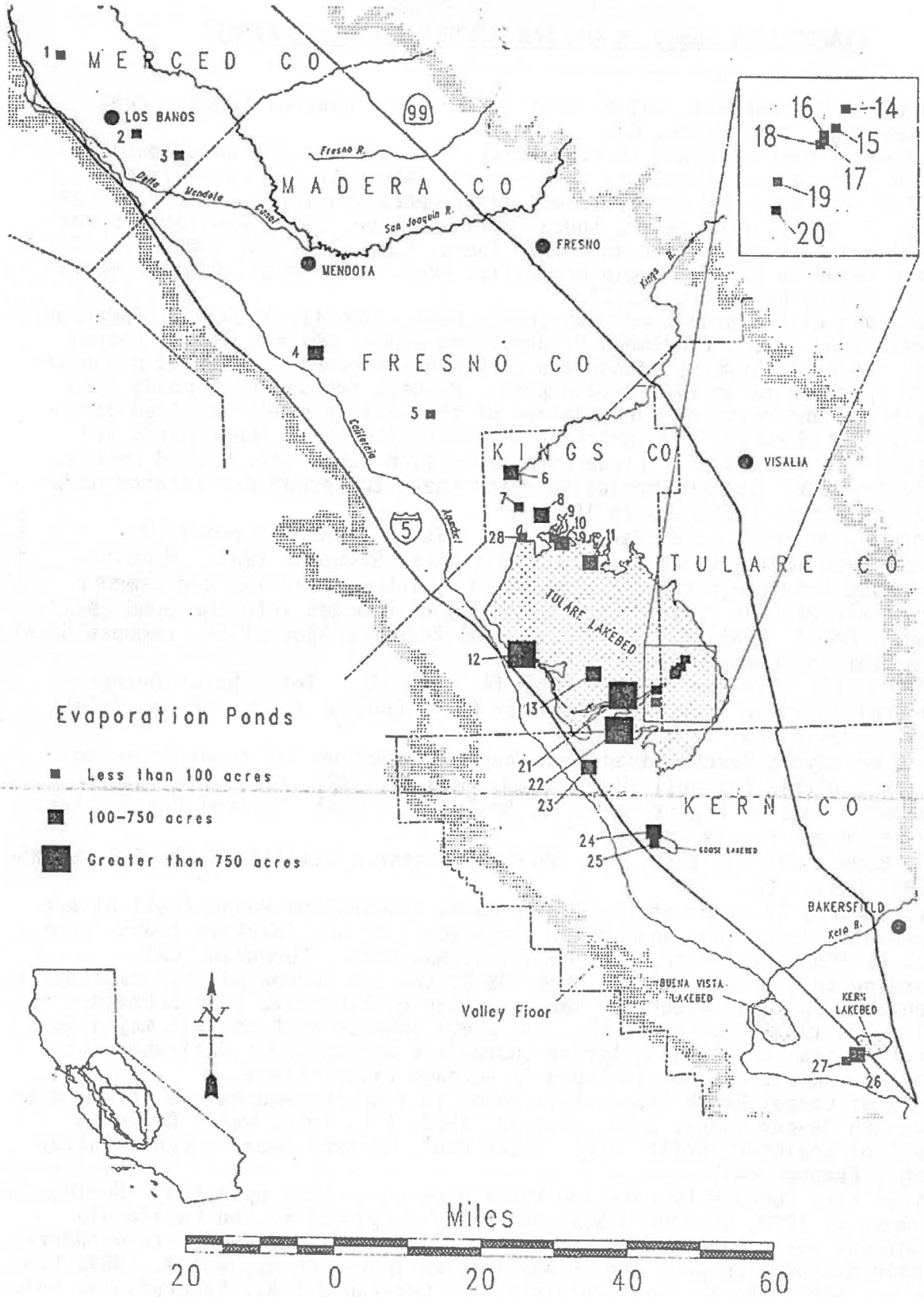
[k] Approximately 15 acres of the Bowman Farms Evaporation Ponds (cell A) are currently operating, another 50 acres (cell B) are inactive (pers. comm., Oct 9, 1989, R. Bowman, Pond Owner, Bowman Farms, Corcoran, CA).

[l] According to Schroeder et al. (Feb 1988), the I-5 borrow pit "...presumably contains only tailwater..," however water quality data (see Schroeder et al., Feb 1988; Westcot et al., Jul 1988) suggest that the pit may also receive shallow ground water or subsurface agricultural drainage water. The borrow pit was not included in acreage calculations.

[m] Cell 6 of Carmel Ranch Evaporation Ponds is inactive and has no northern or eastern levees (pers. comm., Aug 13, 1990, A.L. Toto, Water Resource Control Engineer, Calif. Regl. Water Qual. Control Board - Cent. Valley Reg., Fresno, CA).

[n] Chevron Land Company Evaporation Ponds have never been operated. During the summer of 1989, Chevron U.S.A. submitted a request to the California Regional Water Quality Control Board - Central Valley Region to withdraw their evaporation pond permit application (pers. comm., Oct 2, 1989, L.W. Johns, Agricultural Land Administrator, Chevron U.S.A., Bakersfield, CA).

Evaporation Ponds in the San Joaquin Valley



San Joaquin Valley Drainage Program (July 1990)

MAP 1

on determining the viability of sibling eggs in nests from which random sample eggs had been collected. Nest monitoring was also conducted to document densities of breeding birds, between-pond distributions of birds, overall nesting success, and other basic life-history data required for population impact and mitigation needs/performance assessments. Generally, methodological details for both the selenium exposure surveys and reproductive performance monitoring follow the protocols established by earlier studies in the upper San Joaquin Valley (Ohlendorf et al. 1989; Hothem and Welsh 1994a,b). Finally, all fieldwork was closely coordinated with the work of other agencies that focused on the sampling of water, sediments, and aquatic invertebrates.

Results

Egg Collections:

A total of 902 avocet and stilt eggs were collected and submitted for chemical analyses between 1991 and 1998 (see Appendix 1 for a full inventory of the samples). Forty-nine sites were sampled including 20 evaporation ponds, 5 mitigation wetlands, 5 floodwater storage basins, 4 national wildlife refuges, 2 duck clubs, 2 agroforestry demonstration sites, 2 natural saline sink lakes, 2 roadside ditches, a municipal sewage pond, a dairy pasture, a military base, a university research reserve, an oilfield canal, an oil seep, and a saline sink source stream (Table 2). Of the 902 eggs collected, 465 were stilt eggs and 437 were avocet eggs. Random samples made up 82.8% of the collections and nonrandom samples made up 17.2%. Selenium exposure levels spanned four orders-of-magnitude with individual eggs containing 0.3 to 160 mg/kg selenium on a dry-weight basis (dw). This extremely wide range of exposure levels proved ideal for development of predictive risk assessment capability (see below).

All three national wildlife refuges sampled in California: Kern NWR, Klamath NWR and Pixley NWR exhibited background exposures for egg selenium (respective means of 1.7, 1.6, and 1.1 mg/kg selenium, dw; Table 2). All sampling sites not influenced by agricultural drainage water or petroleum industry activities yielded mean egg concentrations of selenium in the range of 0.5 to 2.5 mg/kg, dw. Such results compare favorably with other estimates of normal background levels of selenium in avian eggs (Skorupa and Ohlendorf 1991). By comparison, mean egg concentrations of selenium at evaporation ponds ranged from 3 to 40 mg/kg, dw. Selenium exposure in recurvirostrid eggs exceeded toxic thresholds (delineated below) for embryo viability in $\geq$ 25% of all random samples at 15 of the 20 evaporation ponds that were sampled. In comparison, 16 of 29 other aquatic habitats exhibited zero exceedance of toxic thresholds. Only 8 non-evaporation pond sites yielded $\geq$ 25% toxic exceedance. Two of those sites were mitigation wetlands located directly adjacent to an evaporation pond, two of the sites were drainage water fed agroforestry plots, two of the sites were in the highly seleniferous (due to overgrazing and excessive erosion of naturally seleniferous soils) Carrizo Plain, one site was a seep associated with highly seleniferous San Joaquin Valley crude oil, and one site was a roadside ditch very near a highly contaminated evaporation pond. Duck clubs and floodwater storage basins within the Tulare Basin that were physically separated from evaporation ponds showed almost no signs of elevated selenium exposure in recurvirostrid eggs. One of the most severe cases of selenium exposure ever recorded for birds was discovered at an agroforestry

TABLE 2. SELENIUM EXPOSURE SURVEYS: RECURVIROSTRID EGGS

Map No. See Map 1	Appendix Code See Appendix 1	Site Name	Site Description	Year	No. Eggs Sampled Random Eggs Only	Geometric Mean Se PPM, dry wgt	No. Eggs @ Risk
4	13	Peck	Evaporation Pond	1992	2	15	2
				1993	8	22	7
5	32	Britz	Evaporation Pond	1991	4	12	4
				1993	1	15	1
				1995	1	9.9	1
				1996	1	4.8	0
				1998	1	9.7	1
6	26	Stone	Evaporation Pond	1991	4	3.3	0
				1992	3	4	1
				1993	11	2.8	0
				1994	1	6.2	1
7	17	Lemoore	Evaporation Pond	1993	8	3.4	1
8	1 & 2	Westlake-North	Evaporation Pond	1993	5	3	0
				1994	5	2.9	0
				1998	1	28	1
9	9	Meyer	Evaporation Pond	1992	2	4.3	1
11	5	Tulare Lake-North	Evaporation Pond	1992	7	3.5	0
				1993	5	3.7	1
				1994	1	3.2	0
				1995	6	3.6	0
				1996	1	2.5	0
				1997	3	3.3	0
12	3	Westlake-South	Evaporation Pond	1991	1	8.8	1
				1992	1	4.2	0
				1993	12	6	7
				1994	2	5.5	0
				1995	8	6	4
				1997	25	4	1
				1998	6	6	2
13	24	Liberty	Evaporation Pond	1991	10	8.3	9
				1995	8	5.1	3
14	11	Pryse	Evaporation Pond	1991	10	7.5	8
				1992	6	4	0

TABLE 2. SELENIUM EXPOSURE SURVEYS: RECURVIROSTRID EGGS

Map No.	Appendix Code	Site Name	Site Description	Year	No. Eggs Sampled	Geometric Mean Se	No. Eggs @ Risk
				1993	12	4.4	1
15	7	Bowman	Evaporation Pond	1992	5	16	5
16	10	Morris	Evaporation Pond	1992	5	11	5
				1993	9	8.9	7
17	8	Martin	Evaporation Pond	1991	2	14	2
				1992	2	17	2
				1993	5	12	5
19	31	Four-J	Evaporation Pond	1991	6	12	6
				1992	3	10	3
				1993	5	6	3
21	6	Tulare Lake-Hacienda	Evaporation Pond	1992	19	8.7	19
				1993	11	7.4	8
				1994	5	16	5
				1995	1	15	1
22	4	Tulare Lake-South	Evaporation Pond	1992	11	8.8	11
				1993	11	10	10
				1994	6	17	6
				1995	17	8.1	14
				1996	4	22	4
				1997	3	19	3
23	12	Lost Hills WD	Evaporation Pond	1991	23	28	23
				1992	13	23	12
				1993	25	41	25
				1994	9	23	9
				1995	7	19	6
				1996	2	13	2
				1998	5	14	4
25	16	Latter Day Saints	Evaporation Pond	1991	3	3.1	0
				1992	10	3.7	0
26	19	Rainbow Ranch	Evaporation Pond	1992	18	11	17
				1993	19	10	17
				1994	1	6.2	1
				1995	4	12	4
				1996	5	20	5

TABLE 2. SELENIUM EXPOSURE SURVEYS: RECURVIROSTRID EGGS

Map No.	Appendix Code	Site Name	Site Description	Year	No. Eggs Sampled	Geometric Mean Se	No. Eggs @ Risk
				1997	2	22	2
28	29	Fabry	Evaporation Pond	1992	3	49	3
				1993	5	9	4
				1994	1	26	1
				1995	2	2.7	0
N/A	35	Westlake-Sect 3	Mitigation Site	1993	7	5.2	3
				1994	11	6	4
				1995	4	5.3	0
				1997	25	2.7	0
N/A	40	Westlake-Sect 16	Mitigation Site	1994	11	3.6	0
				1995	22	3.5	1
				1996	14	3.3	1
N/A	44	Westlake-Sect 23	Mitigation Site	1995	7	3.1	0
27	45	Chevron	Mitigation Site	1995	2	3.6	0
				1996	2	14	2
N/A	46	Tulare Lake Comp	Mitigation Site	1995	7	4.1	0
				1996	8	3.6	0
				1997	4	2.8	0
				1998	2	5.3	0
N/A	22	Kern NWR	Nat'l Wildl. Refuge	1993	4	1.7	0
N/A	25	Pixley NWR	Nat'l Wildl. Refuge	1993	7	1.1	0
N/A	204	Lower Klamath	Nat'l Wildl. Refuge	1995	3	1.6	0
N/A	202	Mahala Slough	Nat'l Wildl. Refuge	1991	2	4.1	0
N/A	33	Hacienda-East	Floodwater Basin	1995	17	2.1	1
				1997	2	12	2
N/A	34	Hacienda-Mid	Floodwater Basin	1993	10	1.8	0
				1995	3	3.4	0
N/A	28	South Wilbur	Floodwater Basin	1991	9	14	7
				1992	4	3.1	0
				1994	2	19	2

TABLE 2. SELENIUM EXPOSURE SURVEYS: RECURVIROSTRID EGGS

Map No.	Appendix Code	Site Name	Site Description	Year	No. Eggs Sampled	Geometric Mean Se	No. Eggs @ Risk
				1995	9	4.9	3
				1997	4	9.3	4
N/A	36	Alpaugh ID	Floodwater Basin	1993	5	1.9	0
N/A	42	Widgeon Club	Duck Club	1992	8	1.9	0
N/A	43	Garces Farms	Duck Club	1992	8	2.5	1
N/A	48	Redrock Ranch	Agroforestry Demo	1996	14	45	14
N/A	49	Mendota	Agroforestry Demo	1996	Only nonrandoms	N/A	N/A
				1998	1	31	1
N/A	23	Corcoran	Sewage Pond	1991	4	1.8	0
N/A	27	Eight-Ball	Dairy Pasture	1991	6	1.6	0
				1992	2	1.5	0
N/A	37	Sunset Lake	Military Base	1993	1	1	0
N/A	50	Dairy Avenue	Roadside Ditch	1996	2	3.9	0
				1997	1	3.8	0
N/A	51	Old River Road	Roadside Ditch	1998	1	10	1
N/A	52	Soda Lake Island	Natural Saline Sink	1998	5	15	5
N/A	53	McKittrick Seep	Oil Seep	1998	1	24	1
N/A	59	Tulare Lake	Floodwater Basin	1997	1	3.6	0
N/A	64	Soda Lake Tributary	Natural Source Tributary	1996	2	12	2
				1997	3	24	3
N/A	201	B&B Wetlands	Univ. Research Reserve	1992	4	1.8	0
N/A	38	Barter Petroleum	Oilfield Canal	1993	2	5.4	1
N/A	203	Honey Lake	Natural Saline Sink	1992	2	0.5	0

demonstration site in 1996. Avian selenium exposure at mitigation wetlands was slightly (1.5X) to moderately (3-5X) elevated above normal baseline values in all five cases examined. In some cases the mitigation wetlands did not meet performance goals stipulated by the California Regional Water Quality Control Board.

Embryo and Sibling Egg Assessments:

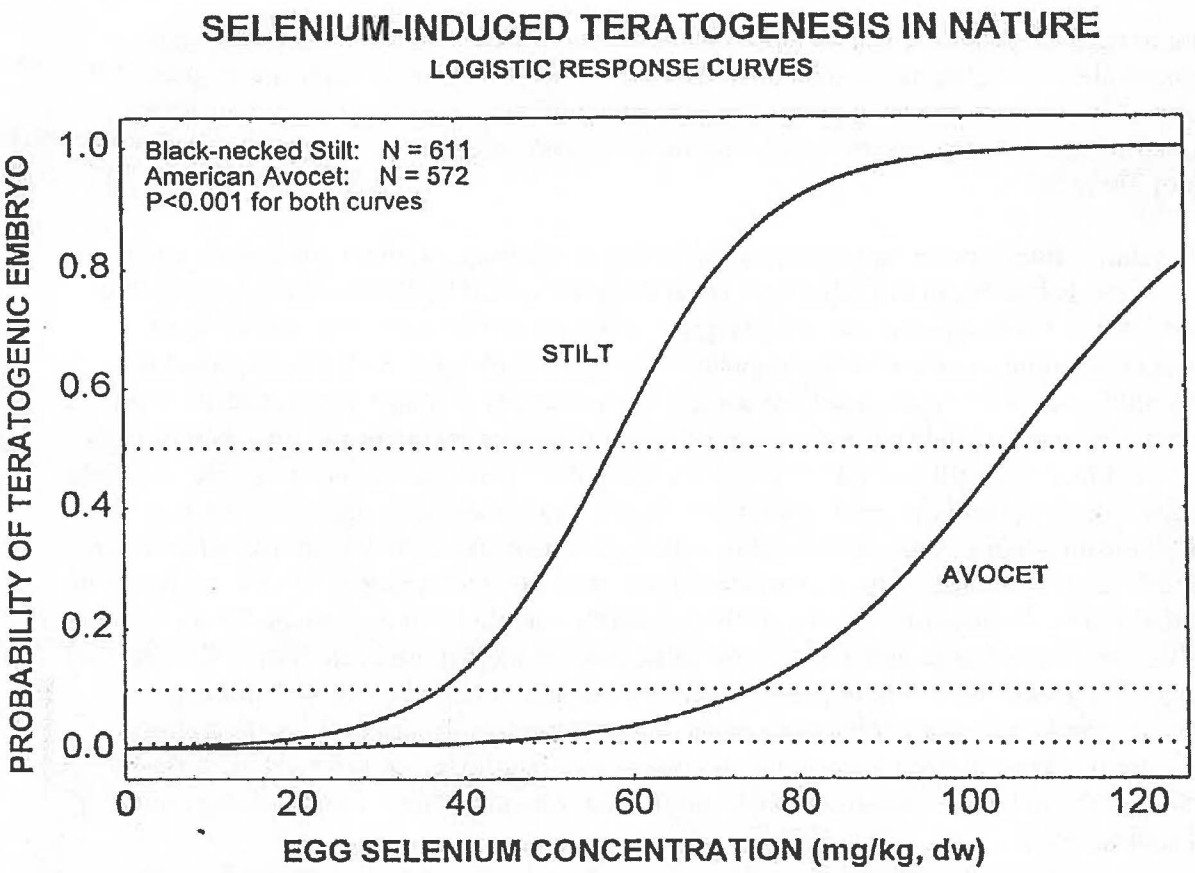
A total of 455 (50.5%) of the randomly collected recurvirostrid eggs contained assessable embryos (see "logistic egg" column of Appendix 1). The typical suite of eye, bill, and limb deformities associated with the Kesterson Syndrome was documented at 5 evaporation ponds and 1 agroforestry demonstration site. Selenium-induced embryonic deformites were documented at one or more sampling sites every year of the study. The 455 assessable embryos examined during this study added substantially to the cumulative database available for developing predictive risk assessment capabilities (see below).

A total of 186 recurvirostrid nests, from which random eggs were sampled, were monitored to full term allowing the determination of viability of sibling eggs. Egg viability is a substantively more sensitive response variable than embryonic deformities; and the cumulative set of data for full-term sibling eggs, now provides an extremely precise estimate of the embryotoxicity threshold for black-necked stilts, a good model species for risk assessment (see below).

Developing Predictive Risk Assessment Capability:

The overt teratogenic status of any fresh stilt or avocet embryo incubated to at least 6-8 days of age, such as the presence or absence of eyes, is unambiguous. Consequently, teratogenic response is a very precise variable for examining species' relative sensitivity to selenium exposure. Sufficient field data have now been collected for stilts and avocets to delineate species-specific teratogenic response curves (Figure 1). Surprisingly, even though stilts and avocets are each other's closest phylogenetic relatives (Sibley et al., 1988), their response coefficients for selenium (coefficient b_1 in Figure 1) are significantly different ($Z=2.70$, $p<0.01$; Afifi and Clark, 1996). Based on predicted 50%-effect concentrations (EC_{50}'s, see Figure 1), stilt embryos are about twice as sensitive as avocets to *in ovo* selenium exposure. Stilts, therefore, are the more sensitive model species for further examination of threshold points.

Although embryo teratogenesis is a precise response variable, it is also relatively insensitive because teratogenesis is a severe response. Subtle disruptions of embryonic physiology and development are likely to cause inviability of stilt eggs at exposure levels less severe than those required for selenium-induced overt teratogenesis. Analysis of egg viability (hatchability) should therefore provide a sensitive estimate of the exposure threshold for reproductive toxicity. By examining the clutchwise incidence of inviable stilt eggs as a function of selenium concentrations measured in sibling sample eggs, it was determined that the threshold exposure for impaired hatchability occurred between 4 and 9 mg/kg selenium in the egg (Ohlendorf et al., 1993). Enough additional data has been accumulated by this study since 1993 to re-examine that threshold region by single mg/kg increments. These additional data produce an estimate of the stilt embryotoxicity threshold that is narrowed down to the region between 6 and 7 mg/kg



GENERAL LOGISTIC MODEL : $Y=EXP(b_0+b_1X)/(1+EXP(b_0+b_1X))$

MODEL COEFFICIENTS:

MODEL	b_0	(S.E.)	b_1	(S.E.)
STILT	-6.125	(0.575)	0.1061	(0.0115)
AVOCET	-7.479	(1.179)	0.0710	(0.0144)

PREDICTED EFFECT CONCENTRATIONS (mg/kg, dw) :

	STILT	AVOCET
EC_{01}	14	41
EC_{10}	37	74
EC_{50}	58	105

FIGURE 1. Logistic response curves for selenium-induced teratogenesis among black-necked stilt and American avocet populations exposed to agricultural drainage water.

selenium in eggs (Figure 2). Thus, the upper boundary of safe exposure levels for stilt eggs (embryos) is about 6 mg/kg, or roughly 3-4 times the normal background exposure of about 1.5-2.0 mg/kg. This toxic threshold standard, or "stilt standard" was used to quantify how many recurvirostrid eggs in the exposure surveys contained @ risk selenium concentrations (see last column of Table 2).

A strong relationship between the mean concentration of selenium in impounded water and in stilt eggs at the Tulare Basin sampling sites (r^2=0.81) is described by the equation, Log[egg Se, mg/kg]=0.44 + 0.434 Log[water Se, g/L] (Figure 3). Based on that regression equation, the average concentration of selenium in a population sample of stilt eggs would be expected to exceed 6 mg/kg when the mean selenium content of impounded drainage water exceeds 6 g/L. If the *average* exposure of embryos is 6 mg/kg selenium when water contains 6 g/L, then roughly 50% of individual eggs still exceed the toxic risk threshold. Thus, the zero-exceedance threshold point must be associated with water containing <6 g/L total recoverable selenium. During the 1987-89 Patuxent studies, eggs of stilts were collected at two sites with waterborne selenium in the 3-6 g/L range (Skorupa et al., unpublished data). At a site that averaged 3.8 g/L selenium in impounded water, the selenium content of five randomly sampled stilt eggs ranged from 2.2 to 5.6 mg/kg (zero exceedance, and a maximum value close to the 6 mg/kg safe limit). At a site that averaged 4.7 g/L selenium in impounded water, two of eight randomly sampled stilt eggs contained >6 mg/kg selenium (25% exceedance rate). Consequently, the reproductive effects threshold for black-necked stilts nesting at drainage evaporation facilities in the Tulare Basin appears to be about 4 g/L selenium in impounded water (about 10 times normal background for natural saline sinks).

The teratogenic response curve for stilts in the Tulare Basin (Figure 1) is almost identical to the curve for Kesterson Reservoir (Figure 4). This suggests that the combined data from Kesterson and the Tulare Basin now provide precise and accurate predictive risk assessment capability. This risk assessment capability has recently been applied to data from the Salton Sea using exposure data for stilts to generate response (i.e., risk) predictions. The field verified incidence of 13% impaired stilt nests matched the prediction of 11.9% very closely (Bennett 1997; Skorupa, In Press). The Redrock agroforestry demonstration site provided another chance to test the utility of developed predictive risk assessment tools. Based on exposure data for stilts, it was predicted that 50.4% of exposed embryos at the Redrock site would be deformed. Field surveys documented a deformity rate of 56.7% (Skorupa 1998). Other independent validations of the risk assessment capability developed, in substantive part, from data generated by the Tulare Evaporation Pond Studies of 1991-1998 have confirmed the westwide applicability of these assessment capabilities to wetlands receiving agricultural drainage water (Skorupa 1998).

Resource Management Applications

Throughout the course of the Tulare Basin Evaporation Pond Studies, monitoring and research data have been applied in the regulatory and resource management arenas. A summary of some of that activity is provided below:

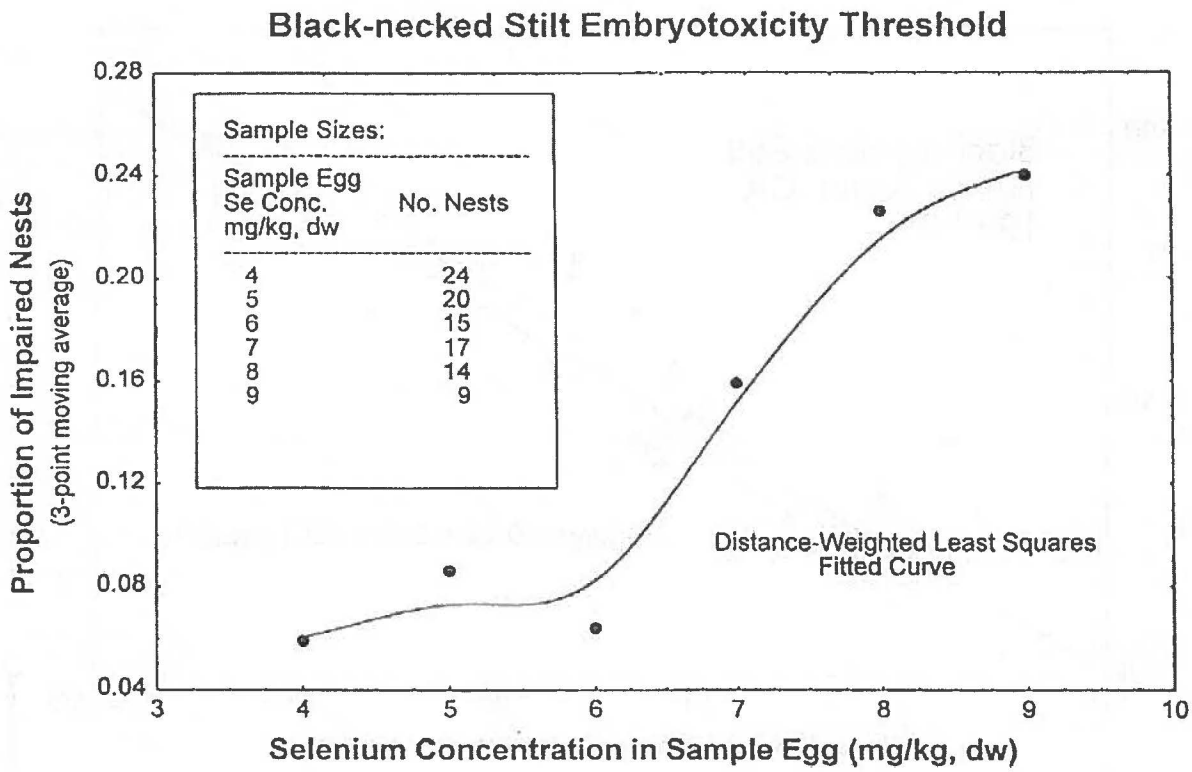


FIGURE 2. Response threshold for selenium-induced inviability of black-necked stilt eggs among populations exposed to agricultural drainage water.

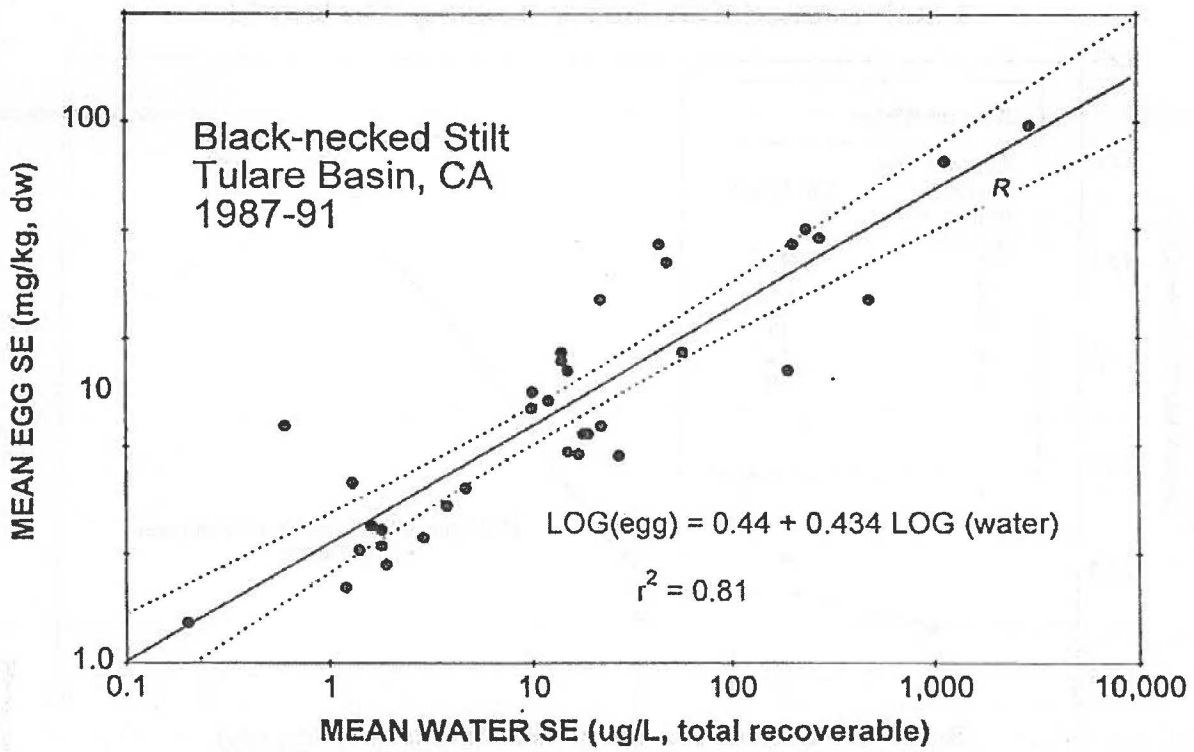


FIGURE 3. Regression relationship for mean selenium ~~concentrations in black-necked stilt eggs as a~~ function of mean selenium concentrations in impounded drainage water at study sites in the Tulare Basin, California. A data point for Red Rock Ranch Agroforestry Demonstration site is plotted as the letter "R".

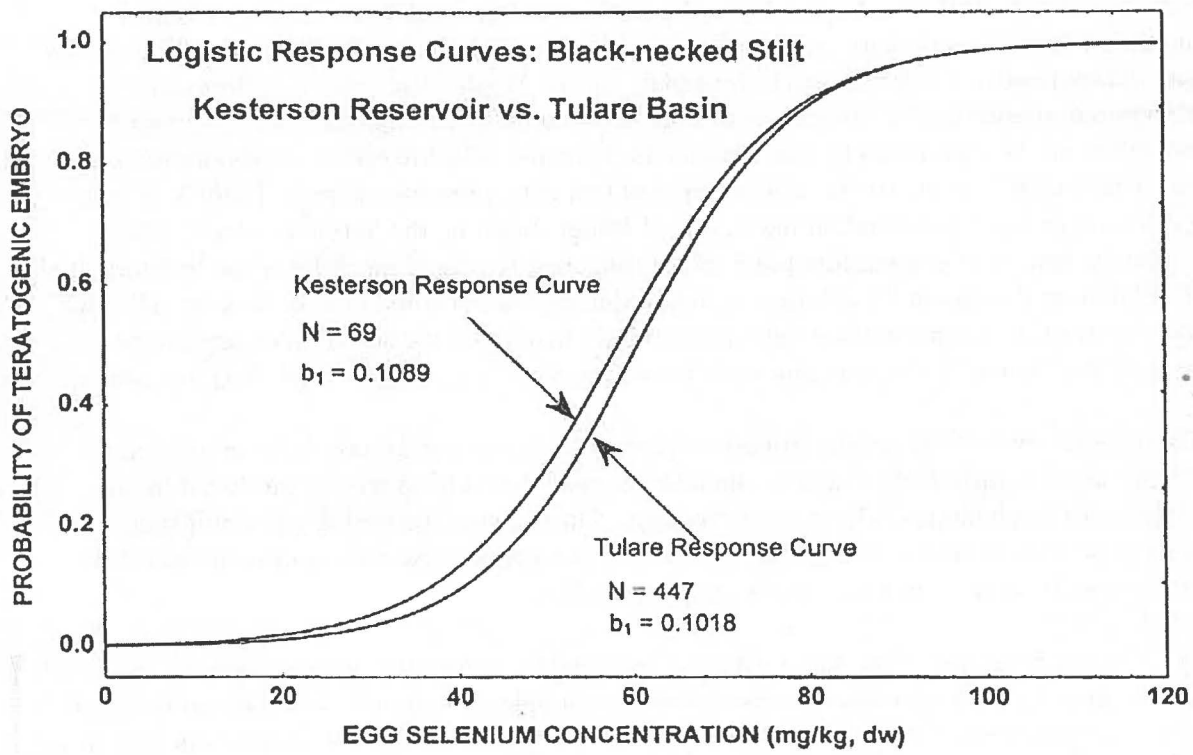


FIGURE 4. Comparison of teratogenesis response curves ~~generated from black-necked stilt data at~~ Kesterson Reservoir versus Tulare Basin Evaporation Ponds. The selenium response logistic regression coefficients, b1, are are not significantly different.

(1) Between March 1991 and August 1993, the California Regional Water Quality Control conducted a series of workshops and hearings to prepare a Cumulative Assessment of the effects of evaporation ponds on wildlife and to formulate formal Waste Discharge Requirements for each evaporation pond in the Tulare Basin. The final Cumulative Impacts report was based almost solely on data produced by the Sacramento Fish and Wildlife Office's evaporation pond studies (CH2M HILL et al. 1993). An example of that data, presented here as Table 3, is taken from a comment letter submitted to the Regional Water Board by the Service in May, 1993. Note how the results of evaporation pond monitoring clearly placed the risks posed by individual ponds relative to Kesterson Reservoir, a standard that regulators could clearly understand. The availability of clear and persuasive field data strongly facilitated the adoption of regulatory controls by the State of California that went beyond federal (e.g., Clean Water Act) protections.

(2) Throughout 1991-1998, results from the evaporation pond studies have been employed to objectively and quantitatively evaluate annual biological monitoring reports produced by the U.S. Bureau of Reclamation's Kesterson Program. The focus of the biological monitoring program at Kesterson was re-directed in 1994 as a direct result of Service comments based-on and backed-up by data from the evaporation pond studies.

(3) In 1992, the Food and Drug Administration convened hearings to consider the environmental impacts of proposals for increased levels of selenium supplementation of domestic animal diets. The entire Department of Interior testimony package was based on the risk assessment data then available from the evaporation pond studies.

(4) In the fall of 1993, Service testimony before the New Mexico Water Commission regarding water quality criteria for selenium was substantively built around results from the Sacramento Fish and Wildlife Office's evaporation pond studies. The State of New Mexico praised the Service for its strong scientific presentation, and ultimately adopted the 2 ug/L criterion for wildlife habitats advocated by the Service.

(5) In the summer of 1994, the U.S. Attorney's office sought expert testimony from the Service on potential for selenium hazards to fish and wildlife that might be associated with discharge of agricultural drainage water to the San Francisco Bay. A large part of the federal government's courtroom arguments regarding risk assessment were provided by Sacramento Field Office scientists and based on data from the evaporation pond studies.

(6) In the spring of 1995, data from the Tulare Basin evaporation pond studies were employed to develop mitigation protocols stipulating site-specific methods for calulating mitigation habitat requirements for active evaporation ponds. Table 4 is a summary table from the Alternative Habitat Protocol. These mitigation protocols currently serve as the scientific basis for settlement agreements between the Service and most current evaporation pond operators. The settlement agreements have been endorsed by the California State Water Board, and in 1996 resulted in the creation of about 2,000-3,000 acres of mitigation wetlands. In 1997, these mitigation efforts were recognized with the awarding of a Governor's Award for Economic and Environmental Leadership to Westlake Farms, Inc., the first farming operation in the Tulare Basin to adopt the Service mitigation protocols.

TABLE 3

Table II. Percent of species means for egg selenium in the reproductive effects zone (*** or ****) for San Joaquin Valley evaporation ponds and comparison sites (1983-1992)

Site	Years Sampled	No. Spp. Means	% Spp. Means in Reproductive Effects Zone
EVAPORATION POND SYSTEMS			
Rainbow (RWQCB #26)	2	7	100%
Peck (RWQCB #4)	3	6	100%
Morris (RWQCB #16)	3	5	100%
Bowman (RWQCB #15)	2	5	100%
Britz-D. (RWQCB #5)	1	2	100%
Fabry (RWQCB #28)	1	1	100%
Westfarmer (RWQCB #23)	5	18	89%
TLDD-H (RWQCB #21)	3	9	89%
TLDD-S (RWQCB #22)	4	33	85%
Westlake-S (RWQCB #12)	4	5	80%
Kesterson Reservoir	3	28	79%
Martin (RWQCB #17)	4	7	71%
Pryse (RWQCB #14)	4	13	54%
Four-J (RWQCB #19)	2	4	50%
Liberty (RWQCB #13)	2	6	33%
Lost Hills (RWQCB #25)	4	5	20%
Westlake-N (RWQCB #8)	4	13	8%
Meyer (RWQCB #9)	1	3	0%
Carlton (RWQCB #7)	1	1	0%
Stone (RWQCB #6)	2	4	0%
Carmel (RWQCB #24)	1	4	0%
TLDD-N (RWQCB #21)	3	22	0%
NONDRAINWATER COMPARISON SITES			
South Wilbur	1	5	40%
Volta Wildlife Area	3	23	0%
Mendota Wildlife Area	3	9	0%
Corcoran Sewage Ponds	2	6	0%
Frey Duck Club	1	3	0%
Garces Duck Club	1	3	0%
Kern NWR	2	2	0%
Wigeon Duck Club	1	2	0%
Eight-Ball Pasture	1	2	0%
San Luis NWR	1	1	0%
Pixley NWR	1	1	0%
Semitropic Canal	1	1	0%

obligations. **TABLE 4** lternative habitat

Summary Table for Alternative Habitat Obligations

BASIN	K	DS	EH	BX	AX	AH SOLUTION
BRITZ-DAVENPORT	3.87	2.6	25	8.0	1.25	26 acres
MEYER	2.0	2.6	59	<1.5	1.25	0 acres
RAINBOW RANCH	2.0	2.6	100	5.0	1.25	89 acres
STONE LAND CO.	2.0	2.6	210	1.5	1.25	0 acres
TLDD-HACIENDA	2.0	2.6	1,026	4.1	1.25	570 acres
TLDD-NORTH	2.0	2.6	301	1.75	1.25	0 acres
TLDD-SOUTH	2.0	2.6	1,832	5.5	1.25	1,967 acres
WESTFARMERS	2.0	2.6	542	14.5	1.25	2,389 acres
WESTLAKE-NORTH	2.0	2.6	260	1.3	1.25	0 acres
WESTLAKE-SOUTH	3.87	2.6	740	3.0	1.25	57 acres
PRYSE FARMS	3.87	2.6	30	2.6	1.25	0 acres
BOWMAN FARMS	3.87	2.6	7	7.8	1.25	7 acres
MORRIS & SONS	3.87	2.6	10	4.75	1.25	4 acres
MARTIN RANCH	3.87	2.6	4	5.0	1.25	2 acres
4J-CORPORATION	3.87	2.6	13	4.15	1.25	4 acres
TOTALS			5,159			5,115 acres

For the full alternative habitat protocol see the "Products" appendices attached to this summary report.

(7) In the fall of 1995, Service testimony regarding aquatic selenium hazards was presented before the Colorado Water Commission. Substantive portions of the testimony were based on data from the evaporation pond studies.

(8) Also in the Fall of 1995, the Service responded to a request from U.S. EPA for guidance on the adequacy of current national water quality criteria for selenium. A substantive core of the Service's response is based on the predictive risk assessment capability developed from evaporation pond studies. In large part due to the Service's response package, and the formal outside reviews of that package solicited by U.S. EPA, a meeting was convened in May, 1997, to initiate revision of current national water quality criteria for selenium. U.S. EPA plans to convene a technical workshop in November, 1997. Results from evaporation pond studies will play a key role in Service testimony at the EPA workshop.

(9) In the spring of 1996, the California State Water Board held hearings to consider the adequacy of adopted Waste Discharge Requirements for evaporations ponds. With a strong set of monitoring and research data from evaporation pond studies in hand, the Service was able to effectly demonstrate the inadequacies of current Waste Discharge Requirements for protecting and compensating wildlife populations. This resulted in the State Water Board remanding the discharge permits to the Regional Water Board for re-evaluation and re-issuance.

(10) In the winter of 1997, the Central Valley Regional Water Board of California will be re-evaluating and re-issuing Waste Discharge Requirements for evaporation ponds in the Tulare Basin. The long-term continuing ability of the Service to collect monitoring and research data at the evaporation ponds insures the incorporation of much stronger protections for Pacific Flyway waterfowl and shorebird populations.

Finally, the strongest measure of the direct resource managment impacts attributable to the Sacramento Fish and Wildlife Office's Tulare Basin Evaporation Pond studies is the radically altered trajectory of evaporation pond construction in the San Joaquin Valley. Prior to 1991, knowledgable observers projected that there would be an increase from 7,400 to 30,000 acres of evaporation ponds between 1991 and 1998. As a direct result of data generated by the evaporation pond studies, and the strong position that data has put the Service in with regard to advocacy for regulatory controls, the total acreage of evaporation ponds will have actually declined between 1991 and 1998 (from 7,400 acres to < 5,000 acres), and the extent of clean wetlands will have increased by several thousand acres via the mitigation protocol settlements entered into by the Service and pond operators. A more hidden management impact of the evaporation pond studies, is the incentive they have provided to the agricultural community for development of environmentally superior alternatives to standard evaporation ponds for the disposal of agricultural subsurface drainage water.

Products List to Date

(1) Bobker, G. 1993. *Death in the Ponds: Selenium-induced Waterbird Deaths and Deformities at Agricultural Evaporation Ponds*. Briefing Paper, The Bay Institute of San Francisco, Sausalito, CA. **(Appendix 2)**

(2) Ohlendorf, H.M., J.P. Skorupa, M.K. Saiki, and D.A. Barnum. 1993. Food-chain transfer of trace elements to wildlife. Pp. 596-603 in R.G. Allen and C.M.U. Neale (eds.), *Management of Irrigation and Drainage Systems: Integrated Perspectives*. Am. Soc. Civil Engineers, New York, NY. **(Appendix 3)**

(3) Skorupa, J.P. 1994. Impacts of selenium on the biological systems of the Salton Sea. In: *Proceedings of the Salton Sea Symposium*, January 13, 1994, Indian Wells, California. Salton Sea Authority, Imperial, CA. 15 pp. **(Appendix 4)**

(4) Skorupa, J.P., and S.E. Schwarzbach. 1995a. *Compensation Habitat Protocol, USFWS, For Drainwater Evaporation Basins*. Sacramento Fish and Wildlife Office, U.S. Fish and Wildlife Service, Sacramento, CA. January, 1995, 26 pp. **(Appendix 5)**

(5) Skorupa, J.P., and S.E. Schwarzbach. 1995b. *Alternative Habitat Protocol, USFWS, For Drainwater Evaporation Basins*. Sacramento Fish and Wildlife Office, U.S. Fish and Wildlife Service, Sacramento, CA. March, 1995, 11 pp. **(Appendix 6)**

(6) Skorupa, J.P. 1996. Drainage ponds and demonstration wetlands. In: Proceedings of the 1996 North American Water and Environment Congress (CD ROM). Am. Soc. Civil Engineers, New York, NY. 6 pp. **(Appendix 7)**

(7) Skorupa, J.P., S.P. Mormon, and J.S. Sefchick-Edwards. 1996. *Guidelines for Interpreting Selenium Exposures of Biota Associated with Nonmarine Aquatic Habitats*. Report to the National Irrigation Water Quality Program. Sacramento Fish and Wildlife Office, U.S. Fish and Wildlife Service, Sacramento, CA. 74 pp. **(Appendix 8)**

(8) Robinson, J.A., L.W. Oring, J.P. Skorupa, and R. Boettcher. 1997. American Avocet *(Recurvirostra americana)*. In: *The Birds of North America*, No. 275 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C. **(Appendix 9)**

(9) Skorupa, J.P. *In Press*. Selenium poisoning of fish and wildlife in nature: Lessons from twelve real-world examples. Pp. 315-354 in W.T. Frankenberger and R.A. Engberg (eds.), *Environmental Chemistry of Selenium*. Dekker, New York, NY. **(Appendix 10)**

(10) Robinson, J.A. J.M. Reed, J.P. Skorupa, and L.W. Oring. *In Press*. Black-necked Stilt (*Himantopus mexicanus*). In: *The Birds of North America*, No. ___ (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C. **(Appendix 11)**

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Appendix 1

Site	Year	Species	Nest	Egg	Type	Day	Month	Stage	Condition	Fate	Sib1	Sib2	Sib3	Sib4	Sib5	Sib6	Sib7	Logistic-Egg	Logistic-Clutch	Lab	Catalog	Moisture	Selenium
1	94	2	1	1	1	9	6	5	6	26	91	91	92							2	1080084	77	2.4
1	94	3	1	1	1	9	6	2	7	27	91	91	91	91	91	69				2	1080084	73.7	2.1
1	94	3	2	1	1	9	6		7	27	54	54	68	68	68				1	2	1080084	75.2	4.6
1	94	3	3	1	1	9	6		7	27	54	54	68	68	68				1	2	1080084	71.4	2.6
1	94	3	4	1	1	9	6	16	1	21								0		2	1080084	74.9	3.5
2	93	2	1	1	1	20	5	7	3	23										3	1080063	75.5	3.5
2	93	2	2	1	1	20	5	17	1	21								0		3	1080063	73.8	3.3
2	93	2	3	1	1	20	5	12	1	21								0		3	1080063	73.7	3.5
2	93	2	4	1	1	20	5	4	3	23										3	1080063	74	2.4
2	93	3	1	1	1	20	5	6	3	23										3	1080063	73.8	2.4
2	98	2	5	1	1	2	6	17	1	21								0		6			28
3	91	3	1	1	1	27	6	1	7	27	69	69	92							3	1080007	73.8	8.8
3	92	2	17	1	2	4	6	18	6	36	53	53	54							3	8510010	74	5.5
3	92	3	1	1	1	28	4	12	1	21	62	62	62					0		3	8510010	73.7	4.2
3	93	2	21	1	1	12	5	10	1	21	61	61	61					0		3	1080063	72.3	3.5
3	93	2	29	1	1	26	5	11	1	21	54	54	54					0	0	3	1080063	75.4	4.4
3	93	2	31	1	1	8	6	11	1	21	37	53	53	54				0	1	3	1080063	74.9	7
3	93	2	102	1	1	12	5	10	1	21	54	54	54					0	0	3	1080063	73.7	4
3	93	2	106	1	1	25	5	14	1	21	54	54	54					0	0	3	1080063	74.4	4.1
3	93	3	27	1	2	19	5	19	5	35	62	54	54							3	1080063	73	8.1
3	93	3	33	1	1	11	5	13	1	21	61	61	61					0		3	1080063	73.9	8.3
3	93	3	41	1	1	11	5	13	1	21	51	53	53					0	0	3	1080068	74.1	8.7
3	93	3	109	1	1	11	5	13	1	21	51	53	53	53				0	0	3	1080068	72.7	8.6
3	93	3	161	1	1	12	5	14	1	21	61	61	61					0		3	1080063	72	7.5
3	93	3	233	1	1	1	6	16	1	21	51	51	53					0	0	3	1080063	70.5	4.1
3	93	3	277	1	1	8	6	13	1	21	51	53	54					0	0	3	1080063	69.4	6.2
3	93	3	334	1	1	22	6	16	1	21	54	54	54					0	0	3	1080063	72.9	10
3	94	3	1	1	1	1	6	0	7	27										2	1080084	73.4	5.6
3	94	3	2	1	1	1	6	6	6	26										2	1080084	68.2	5.5
3	95	2	2	1	2	19	6		7	47										4	1080090	75.2	3.5
3	95	2	5	1	1	19	6	20	1	21	27	54	54					0	0	4	1080090	72.8	5.4
3	95	3	172	1	1	19	6	20	1	21	91	91	91					0		4	1080101	74.6	7.6
3	95	3	188	1	1	19	6	12	1	21	54	54	54					0	0	4	1080101	75	6.4
3	95	3	192	1	1	19	6		7	27	54	54	54						1	4	1080101	72.3	5.8
3	95	3	244	1	1	19	6	18	1	21	62	54	54	54				0	0	4	1080090	72.7	5
3	95	3	286	1	1	19	6		7	27	69	69	69							4	1080090	74.9	4.6
3	95	3	288	1	1	19	6	12	1	21								0		4	1080090	72.2	6.6
3	95	3	289	1	1	19	6	6	7	27	54	54	54						0	4	1080101	76	7.5
3	97	2	2	1	1	9	6	20	1	21								0		3	1080154	74.5	4.8
3	97	2	5	1	1	9	6	9	1	21								0		3	1080154	74.4	5.4
3	97	2	6	1	1	9	6	6	3	23										3	1080154	74	5.6
3	97	2	13	1	1	26	6	18	1	21								0		3	1080154	74.5	4.3
3	97	2	301	1	1	15	5	0	7	27										3	1080154	75.2	5.1
3	97	3	17	1	1	11	5	0	7	27										3	1080145	74.6	3.3
3	97	3	18	1	1	11	5	0	7	27										3	1080145	74.7	2.4
3	97	3	19	1	1	11	5	0	7	27										3	1080145	74	2.7
3	97	3	23	1	1	9	5	0	7	27										3	1080145	73.8	3.3
3	97	3	42	1	1	15	5	1	7	27										3	1080145	75.9	5
3	97	3	301	1	1	20	5	0	7	27										3	1080145	74.8	3.6
3	97	3	305	2	2	9	6		7	37										3	1080145	72.3	3
3	97	3	305	3	2	9	6	18	5	35										3	1080145	73.2	2.9
3	97	3	316	1	1	9	6	8	1	21								0		3	1080145	73.5	3.2
3	97	3	318	1	1	30	5	0	7	27										3	1080145	75.8	4.5
3	97	3	319	1	1	30	5	0	7	27										3	1080145	73.6	3.8
3	97	3	322	1	1	4	6	3	3	23										3	1080145	75.1	4.1
3	97	3	325	1	1	4	6	0	7	27										3	1080145	72.8	7.4
3	97	3	326	1	1	1	6	7	3	23										3	1080145	74.9	5.3
3	97	3	328	1	1	4	6	0	7	27										3	1080145	74.5	3.4

Appendix 1

Site	Year	Species	Nest	Egg	Type	Day	Month	Stage	Condition	Fate	Sib1	Sib2	Sib3	Sib4	Sib5	Sib6	Sib7	Logistic-Egg	Logistic-Clutch	Lab	Catalog	Moisture	Selenium
3	97	3	339	1	1	8	6	0	7	27										3	1080145	75.4	3
3	97	3	343	1	1	4	6	1	7	27										3	1080145	72.5	3.5
3	97	3	349	1	1	26	6	15	1	21								0		3	1080145	74	4.9
3	97	3	395	1	1	26	6	6	3	23										3	1080145	73	3.1
3	97	3	396	1	1	26	6	11	1	21								0		3	1080145	72.9	4.5
3	97	3	400	1	1	26	6	6	3	23										3	1080145	74.2	4.1
3	97	3	453	1	1	26	6	7	3	23										3	1080145	73.6	4.2
3	98	3	1	1	1	4	6	12	1	21								0		6			5.7
3	98	3	2	1	1	4	6	13	1	21								0		6			5.3
3	98	3	3	1	1	4	6	20	1	21								0		6			4.9
3	98	3	4	1	1	4	6	12	1	21								0		6			6.2
3	98	3	18	1	1	4	6	16	1	21								0		6			5.9
3	98	3	25	1	1	4	6	16	1	21								0		6			9
4	92	2	3	1	1	12	5	14	1	21	54	54	54					0	0	3	8510010	74.4	11
4	92	2	17	1	1	12	5	14	1	21	53	53	53					0	0	3	8510010	72.3	12
4	92	2	31	1	1	5	20	16	1	21	54	54	35					0	1	3	8510010	75.5	33
4	92	2	31	2	2	5	28	16	5	35	21	54	54							3	8510010	74.9	53
4	92	2	87	1	2	9	6	6	6	36	53	53	54							3	8510010	71.6	9.3
4	92	2	200	1	1	19	5	14	1	21	51	53	53					0	0	3	8510010	73.1	10
4	92	2	236	1	1	9	6	16	1	21	54	54	54					0	0	3	8510010	74.1	15
4	92	2	280	1	2	2	7	22	6	36	53	53	37							3	8510010	74.2	24
4	92	3	1	1	1	12	5	19	1	21	18	53	53					0		3	8510010	73.7	7.9
4	92	3	3	1	1	29	5	16	1	21								0		3	8510010	78.6	6.7
4	92	3	37	1	1	12	5	17	1	21	18	54	53					0		3	8510010	74.5	10
4	92	3	63	1	1	12	5	19	1	21	53	53	36					0	1	3	8510010	70.5	6.1
4	92	3	206	1	1	19	5	19	1	21	54	54	68					0	1	3	8510010	75.4	8.6
4	92	3	223	1	2	29	5	21	5	35	54	54	54							3	8510010	71.5	11
4	92	3	345	1	2	18	6	17	4	34	54	54	54							3	8510010	72.2	17
4	92	3	400	1	1	11	6	15	1	21	54	54	54					0	0	3	8510010	73.2	11
4	92	3	621	1	2	14	7	16	5	35	54	54	93	93	93					3	8510010	71.1	19
4	92	3	695	1	2	14	7	14	5	35	53	54	54							3	8510010	72	13
4	92	3	897	1	2	7	7	21	4	34	53	53	92							3	8510010	72.6	12
4	93	2	119	1	1	2	6	13	1	21	53	53	53					0	0	3	1080067	73.7	9.3
4	93	2	125	1	1	10	6	16	1	21	54	54	54					0	0	3	1080067	76	9.4
4	93	3	35	1	2	26	5	20	4	34	54	54	34							3	1080063	73.5	12
4	93	3	103	1	2	17	6	11	5	35	0	18	54							3	1080063	71	13
4	93	3	137	1	1	26	5	15	1	21	53	53	53					0	0	3	1080063	71.1	4.7
4	93	3	197	1	2	23	6	13	6	76	77	74	76	74	93					3	1080063	71.8	10
4	93	3	214	1	1	23	6	11	1	21	54	54	54					0	0	3	1080063	74.4	11
4	93	3	281	1	2	23	6	22	4	34	51	53	53							3	1080063	74.5	12
4	93	3	290	1	1	16	6	17	1	21	34	44	44					0	1	3	1080063	72.7	14
4	93	3	310	1	1	6	7	11	1	21	61	61	61					0		3	1080063	73.4	16
4	93	3	365	1	2	17	6	16	5	35	53	92								3	1080063	71.9	13
4	93	3	367	1	1	10	6	15	1	21	53	53	54					0	0	3	1080068	74.7	11
4	93	3	385	1	1	10	6	13	1	21	53	53	54					0	0	3	1080063	76.9	7.7
4	93	3	388	1	1	1	7	4	6	26	69	69	69							3	1080068	72.6	11
4	93	3	405	1	2	23	6	19	5	45	61	61	61							3	1080063	72.8	13
4	93	3	631	1	2	7	7	20	2	32	32	53	53	37						3	1080063	74.8	14
4	93	3	631	2	2	7	7	17	2	32	32	53	53	37						3	1080063	76	10
4	93	3	835	1	2	14	7	21	5	35	54	53	51							3	1080063	72.7	6.7
4	93	3	861	1	1	15	7	20	1	21	54	54	54					0	0	3	1080063	75.8	15
4	93	3	879	1	2	21	7	18	5	35	53	53	53							3	1080063	71.9	15
4	93	3	1068	1	1	21	7	15	1	21	61	61	61					0		3	1080063	73.3	12
4	94	3	1	1	1	4	6	0	7	27										2	1080084	73.1	23
4	94	3	2	1	1	4	6	0	7	27	91	91	92							2	1080084	73.1	16
4	94	3	3	1	1	4	6	6	4	24								0		2	1080084	73.2	12
4	94	3	4	1	1	4	6	3	7	27										2	1080084	73.9	22
4	94	3	5	1	1	4	6	4	7	27										2	1080084	74.7	16

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Site	Year	Species	Nest	Egg	Type	Day	Month	Stage	Condition	Fate	Sib1	Sib2	Sib3	Sib4	Sib5	Sib6	Sib7	Logistic-Egg	Logistic-Clutch	Lab	Catalog	Moisture	Selenium
4	94	3	6	1	1	4	6	9	1	21								0		2	1080084	73.4	17
4	95	2	1	1	2	2	6		7	47										4	1080090	72.9	3.1
4	95	2	34	1	1	2	6	20	1	21								0		4	1080090	72.5	7.1
4	95	2	203	1	1	2	6		7	27										4	1080090	74.8	12
4	95	3	1	1	1	16	5	0	7	27	91	91	92							4	1080090	71.5	5
4	95	3	1.1	1	2	10	6	3	7	47										4	1080090	73.1	10
4	95	3	1.2	1	2	2	6		7	47										4	1080090	73.3	4.8
4	95	3	2	1	1	16	5	0	7	27	91	92								4	1080090	73.6	7.3
4	95	3	2.1	1	2	2	6		7	47										4	1080090	73.8	8.9
4	95	3	3	1	1	16	5	2	7	27	92									4	1080090	72.2	5.5
4	95	3	3.1	1	2	2	6		7	47										4	1080090	69.9	12
4	95	3	4	1	1	16	5	0	7	27	92									4	1080090	74.5	7.8
4	95	3	4.1	1	2	2	6		7	47										4	1080090	72.5	12
4	95	3	5	1	1	16	5	1	7	27	91	91	92							4	1080090	73.1	6.1
4	95	3	6	1	2	2	6		7	47										4	1080090	74.1	13
4	95	3	28	1	1	2	6		7	27										4	1080090	74.5	10
4	95	3	31	1	1	2	6	25	1	21								0		4	1080090	75.4	4.9
4	95	3	51	1	1	2	6		7	27										4	1080090	73.2	9.8
4	95	3	54	1	1	2	6	12	1	21								0		4	1080090	74.4	8.6
4	95	3	62	1	1	2	6	9	1	21								0		4	1080090	72.2	9.7
4	95	3	70	1	1	2	6	9	1	21								0		4	1080090	74.4	9.4
4	95	3	200	1	1	2	6	6	1	21								0		4	1080090	74.1	11
4	95	3	201	1	1	2	6	3	3	23										4	1080090	72.2	7.5
4	95	3	204	1	1	2	6		7	27										4	1080090	74.1	11
4	95	3	205	1	1	2	6	3	3	23										4	1080090	73.5	9.6
4	96	3	1	1	1	5	6	2	7	27										7	1080124	72.8	21
4	96	3	2	1	1	5	6	2	7	27										7	1080124	69.5	19
4	96	3	3	1	1	5	6	3	7	27										7	1080124	74.2	24
4	96	3	4	1	1	5	6	3	7	27										7	1080124	75	23
4	97	2	15	1	2	27	6		7	37										3	1080134	71.5	19
4	97	2	32	1	1	27	6		7	27										3	1080134	72.3	17
4	97	3	1	1	1	30	5	1	7	27										3	1080134	73.3	20
4	97	3	1	2	2	30	5			475										3	1080134	86.6	46
4	97	3	4	1	1	30	5	0	7	27										3	1080134	74.1	20
4	97	3	126	1	2	27	6	1	6	36										3	1080134	72.7	20
4	97	3	208	1	2	27	6	1	6	36										3	1080134	74.2	14
5	92	2	3	1	1	30	5	14	1	21	61	61	61	61				0		3	8510010	73.9	3.9
5	92	2	5	1	1	25	5	14	1	21	61	61	61					0		3	8510010	74.4	4.6
5	92	2	157	1	1	26	6	10	1	21	66	61	61					0		3	8510010	75.5	3.8
5	92	2	197	1	1	26	6	11	1	21	62	62	62					0		3	8510010	75.4	3.6
5	92	2	203	1	1	17	7	18	1	21	54	54	54					0	0	3	8510010	74.9	4.4
5	92	3	3	1	1	30	5	16	1	21	54	54	54					0	0	3	8510010	74.2	1.8
5	92	3	117	1	1	3	7	8	3	23	62	62	62							3	8510010	74.1	3.2
5	93	2	5	1	1	21	6	17	1	21	63	63	63					0		3	1080063	73.9	3.3
5	93	2	6	1	1	7	6	9	3	23	61	61	61							3	1080063	72.3	2.4
5	93	2	12	1	1	19	7	13	1	21	54	54	54					0	0	3	1080063	73.1	3.2
5	93	3	13	1	1	31	5	8	1	21	53	53	53					0	0	3	1080063	73.7	3.2
5	93	3	24	1	1	19	7	19	1	21	53	54	54					0		3	1080063	75	8.1
5	94	2	1	1	1	6	6	2	7	27	91	91	92							2	1080084	73.1	3.2
5	95	2	18	1	1	2	6	9	1	21								0		4	1080090	73.3	4
5	95	2	27	1	1	2	6	9	1	21								0		4	1080090	73.8	4.1
5	95	2	31	1	1	2	6	6	1	21								0		4	1080090	74.2	3
5	95	2	33	1	1	2	6	9	1	21								0		4	1080090	73.8	3.5
5	95	2	42	1	1	2	6	6	1	21								0		4	1080090	74.1	3.7
5	95	3	3	1	1	2	6	9	1	21								0		4	1080090	72.6	3.6
5	96	2	2	1	1	15	5	17	1	21								0		7	1080124	71.8	2.5
5	97	2	1	1	1	30	5	0	7	27										3	1080134	74.3	3.8
5	97	2	19	1	1	30	5	12	1	21								0		3	1080134	72.6	3.4

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Site	Year	Species	Nest	Egg	Type	Day	Month	Stage	Condition	Fate	Sib1	Sib2	Sib3	Sib4	Sib5	Sib6	Sib7	Logistic-Egg	Logistic-Clutch	Lab	Catalog	Moisture	Selenium
5	97	2	53	1	1	12	6	19	1	21								0		3	1080134	74.4	2.9
6	92	2	5	1	1	18	5	16	1	21	54	54	54					0	0	3	8510010	73.8	6.2
6	92	2	34	1	1	26	5	16	1	21	51	51	51					0	0	3	8510010	74.9	9.8
6	92	2	39	1	1	18	5	15	1	21	54	54	54					0	0	3	8510010	73.7	6.7
6	92	2	42	1	1	26	5	12	1	21	37	51	53					0	1	3	8510010	73.5	8.2
6	92	2	42	2	2	8	6	4	7	37	21	51	53							3	8510010	70.7	9.2
6	92	2	43	1	1	25	5	13	1	21	61	61	61					0		3	8510010	73.2	9.9
6	92	2	117	1	1	8	6	12	1	21	61	61	61					0		3	8510010	74.4	7.5
6	92	2	126	1	1	8	6	15	1	21	63	63	63					0		3	8510010	74.5	6.5
6	92	2	133	1	1	8	6	13	1	21	53	54	54					0	0	3	8510010	73.7	9.6
6	92	2	149	1	1	15	6	20	1	21	66	54	37					0	1	3	8510010	74.4	15
6	92	2	199	1	2	3	7	17	4	664	62	54	54							3	8510010	66.6	10
6	92	2	226	1	1	15	6	11	1	21	61	61	61					0		3	8510010	73.4	9.1
6	92	3	1	1	1	11	5	16	1	21	54	54	54					0	0	3	8510010	74.5	9.2
6	92	3	9	1	1	18	5	16	1	21	51	54	54					0		3	8510010	72.3	7.8
6	92	3	29	1	2	25	5	21	4	34	34	34	34							3	8510010	71.2	9.9
6	92	3	41	1	1	11	5	16	1	21	53	54	36					0	1	3	8510010	73.8	7.5
6	92	3	67	1	2	25	5	22	5	35	53	53	51							3	8510010	71.8	7
6	92	3	96	1	1	20	5	19	1	21	54	54	54					0	0	3	8510010	74	8.2
6	92	3	123	1	1	18	5	6	6	26	667	667	667							3	8510010	72.2	9.7
6	92	3	168	1	1	8	6	16	1	21	53	54	54					0	0	3	8510010	71.5	11
6	92	3	170	1	2	18	6	20	6	36	53	37	34							3	8510010	72.3	14
6	92	3	246	1	1	15	6	14	1	21	53	54	54					0	0	3	8510010	74.1	11
6	92	3	278	1	1	15	6	13	1	21	61	61	61					0		3	8510010	73.8	8.9
6	92	3	331	1	1	25	5	15	1	21	54	54	54					0	0	3	8510010	73.9	7.4
6	93	2	6	1	1	21	5	3	3	23	61	61	61							3	1080063	72.2	9.8
6	93	2	10	1	1	21	5	5	3	23	61	61	61							3	1080063	72.4	4.6
6	93	2	12	1	1	21	5	3	3	23	54	54	54						0	3	1080063	74.5	4
6	93	2	48	1	1	4	6	12	1	21	91	91	91					0		3	1080063	73.6	6.5
6	93	2	144	1	1	2	7	17	1	21	51	51	53					0	0	3	1080063	73.7	2.1
6	93	3	16	1	1	21	5	16	1	21	54	54	54					0	0	3	1080063	73.8	6.8
6	93	3	23	1	1	24	6	15	1	21	54	54	54					0	0	3	1080068	73.7	12
6	93	3	73	1	1	22	7	16	1	21	54	54	54					0	0	3	1080063	74.9	22
6	93	3	106	1	2	1	7	14	1	4103	61	92								3	1080063	73.1	11
6	93	3	136	1	1	11	6	11	1	21	61	61	61					0		3	1080063	73.9	10
6	93	3	220	1	1	25	6	15	1	21	63	63	63					0		3	1080068	73.9	11
6	93	3	350	1	1	24	6	14	1	21	54	53	54					0	0	3	1080063	74	7.6
6	94	3	1	1	1	21	6	5	1	21	91	91	91					0		2	1080084	74.7	10
6	94	3	2	1	1	21	6	0	7	27	91	91	91					0		2	1080084	74.3	15
6	94	3	3	1	1	21	6	7	4	24	91	91	91					0		2	1080084	72.6	17
6	94	3	4	1	1	21	6	7	4	24	91	91	91					0		2	1080084	73.8	18
6	94	3	5	1	1	21	6	3	1	21	91	91	91					0		2	1080084	73.7	20
6	95	2	400	1	1	29	6	3	7	27										4	1080090	75.6	15
6	95	2	401	1	2	29	6		7	47	47									4	1080090	73.9	9.2
6	95	2	401	2	2	29	6		7	47	47									4	1080090	74.1	9.6
7	92	2	1	1	1	2	6	1	7	27										2	1080016	75	9.9
7	92	2	2	1	1	2	6	20	1	21	91	91	91					0		2	1080016	85.9	15
7	92	2	3	1	1	2	6	8	1	21	91	91	91					0		2	1080016	72.8	28
7	92	3	1	2	2	2	6		6	36	35	36	92							2	1080016	72.1	7.4
7	92	3	1	3	2	2	6		6	36	35	36	92							2	1080016	72.6	12
7	92	3	2	1	1	2	6	1	7	27	91	91	91							2	1080016	71.8	21
7	92	3	3	1	1	2	6	15	1	21	91	91	91					0		2	1080016	73.1	11
8	91	2	1	1	1	28	5	13	1	21								0		3	1080007	69.6	21
8	91	3	1	1	1	28	5	4	3	23										3	1080007	74.1	9.1
8	92	2	101	1	1	24	6	19	1	21	91	91	91					0		2	1080016	75.8	31
8	92	3	1	1	1	2	6	5	3	23	91	91								2	1080016	74.1	9
8	93	2	3	1	1	19	5	17	1	21								0		3	1080063	73.4	14
8	93	2	4	1	1	19	5	2	3	23										3	1080063	74	6.8

Appendix 1

Site	Year	Species	Nest	Egg	Type	Day	Month	Stage	Condition	Fate	Sib1	Sib2	Sib3	Sib4	Sib5	Sib6	Sib7	Logistic-Egg	Logistic-Clutch	Lab	Catalog	Moisture	Selenium
8	93	2	5	1	1	19	5	8	1	21								0		3	1080063	73.7	19
8	93	2	6	1	1	19	5	16	1	21								0		3	1080063	71.3	13
8	93	2	7	1	1	19	5	6	7	27										3	1080063	73.7	11
9	92	2	1	1	1	11	5	0	7	27	91	91	91							2	1080016	73.6	2.7
9	92	3	1	1	1	13	5	0	7	27	92									2	1080016	74	6.8
10	92	2	1	1	1	2	6	21	1	21	91	91	91					0		2	1080016	77.9	6.9
10	92	2	2	1	1	2	6	16	1	21	91	91	91					0		2	1080016	76.3	18
10	92	2	3	1	1	2	6	15	1	21	91	91	91					0		2	1080016	70.4	10
10	92	2	4	1	1	2	6	11	1	21	91	91	91					0		2	1080016		9.7
10	92	2	101	1	1	24	6	6	3	23	91	91	91							2	1080016	75.6	11
10	93	2	1	1	1	19	5	6	7	27										3	1080063	76.7	9.4
10	93	2	2	1	1	19	5	6	1	21								0		3	1080063	73.7	12
10	93	2	3	1	1	19	5	21	1	21								0		3	1080063	75.8	19
10	93	2	4	1	1	19	5	23	1	21								0		3	1080063	71.2	11
10	93	2	5	1	2	19	5	22	4	44										3	1080063	62.6	17
10	93	3	1	1	1	19	5	18	4	24								0		3	1080063	75.1	4.1
10	93	3	2	1	1	19	5	21	1	21								0		3	1080063	73.2	12
10	93	3	3	1	1	19	5	14	1	21								0		3	1080063	74.5	5.1
10	93	3	4	1	1	19	5	16	1	21								0		3	1080063	72.9	7
10	93	3	6	1	1	19	5	11	1	21								0		3	1080063	73.2	8.7
11	91	2	1	1	1	28	5	16	1	21	53	53	53					0	0	3	8510007	73.5	10
11	91	2	2	1	1	28	5	13	1	21	54	54	54					0	0	3	8510007	71.4	7.9
11	91	2	3	1	1	28	5	15	1	21	53	53	54					0	0	3	8510007	71.1	8
11	91	2	4	1	1	28	5	13	1	21	51	51	37					0	1	3	8510007	68.2	8.6
11	91	2	6	1	1	28	5	4	6	26	47	47	47							3	8510007	72.1	7.2
11	91	3	1	1	1	28	5	14	1	21	62	62	62					0		3	8510007	73.4	5.5
11	91	3	5	1	1	28	5	17	1	21	54	54	54					0	0	3	8510007	74.1	8
11	91	3	7	1	1	28	5	12	1	21	44	44	44					0		3	8510007	72	3.8
11	91	3	9	1	1	28	5	21	1	21	53	53	53					0	0	3	8510007	74.3	14
11	91	3	21	1	1	28	5	20	1	21	53	53	53					0	0	3	8510007	75	6.4
11	92	2	4	1	1	20	5	13	1	21	53	53	54					0	0	3	8510010	72.7	3.6
11	92	2	15	1	2	13	5	7	6	36	37	54	54							3	8510010	69	4.2
11	92	2	31	1	1	29	4	15	1	21	51	53	53					0	0	3	8510010	74.3	4.9
11	92	2	34	1	1	13	5	17	1	21	54	54	54					0	0	3	8510010	75.2	2.8
11	92	2	37	1	2	11	6	15	4	34	54	54	54	54						3	8510010	69.6	4.3
11	92	3	33	1	2	23	4	4	3	4303	37	53	54							3	8510010	72.2	3.1
11	92	3	43	1	2	27	5	22	4	34	37	54	54							3	8510010	65.4	2.9
11	92	3	79	1	1	23	4	15	1	21	53	53	53					0	0	3	8510010	72.8	4.1
11	92	3	89	1	2	21	5	17	4	34	34	34	34							3	8510010	69.7	2.9
11	92	3	112	1	1	29	4	10	1	21	62	62	62					0		3	8510010	74	4.6
11	92	3	140	1	1	20	5	20	1	21	53	54	54					0	0	3	8510010	76.6	4.6
11	93	2	2	1	1	28	6	11	1	21	54	54	54					0	0	3	1080063	72.4	5.1
11	93	2	23	1	1	26	4	12	1	21	54	54	54					0	0	3	1080063	72.3	3.7
11	93	2	31	1	1	5	5	12	1	21	54	54	54	54				0	0	3	1080063	72.2	3.4
11	93	2	39	1	1	14	6	1	7	27	54	54	54						0	3	1080063	71.6	2.9
11	93	2	41	1	1	28	6	2	7	27	54	54	67						0	3	1080063	71.5	4.1
11	93	3	75	1	1	26	4		7	27	54	54	54						1	3	1080068	70.9	3.3
11	93	3	103	1	1	26	4	19	1	21	51	53	53					0	0	3	1080063	70.4	4.1
11	93	3	155	1	1	5	5	21	1	21	53	53	54					0	0	3	1080063	74	4.8
11	93	3	171	1	1	24	5	15	1	21	51	51	51					0	0	3	1080063	74.4	4.4
11	93	3	179	1	1	24	5	17	1	21	54	54	51					0	0	3	1080068	73.7	4
11	93	3	183	1	1	7	6	18	1	21	54	54	54					0	0	3	1080063	75	12
11	93	3	185	1	1	31	5	14	1	21	54	54	54					0	0	3	1080063	73.2	4.4
12	91	2	7	1	1	17	5	13	1	21	53	54	54					0	0	3	8510007	72.6	40
12	91	2	9	1	1	17	5	12	1	21	54	54	54					0	0	3	8510007	75.2	47
12	91	2	11	1	1	17	5	11	1	21	61	61	61					0		3	8510007	73.2	29
12	91	2	15	1	1	10	5	13	1	21	61	61	61					0		3	8510007	74.2	15
12	91	2	37	1	1	17	5	14	2	22	35	35	35					1	1	3	8510007	72.5	55

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Site	Year	Species	Nest	Egg	Type	Day	Month	Stage	Condition	Fate	Sib1	Sib2	Sib3	Sib4	Sib5	Sib6	Sib7	Logistic-Egg	Logistic-Clutch	Lab	Catalog	Moisture	Selenium
12	91	2	37	2	2	27	5	18	5	35	22	35	35							3	8510007	71.2	66
12	91	2	37	3	2	27	5	18	5	35	22	35	35							3	8510007	71.2	66
12	91	2	37	4	2	27	5	18	5	35	22	35	35							3	8510007	71.7	63
12	91	2	43	1	1	27	5	19	1	21	62	53	53					0	0	3	8510007	75.3	65
12	91	2	49	1	1	17	5	10	1	21	62	62	62					0		3	8510007	73.7	21
12	91	2	57	1	1	27	5	14	1	21	61	61	61					0		3	8510007	74.4	43
12	91	2	59	1	1	27	5	14	1	21	53	53	54					0	0	3	8510009	79.1	43
12	91	2	81	1	1	27	5	13	1	21	61	61	61					0		3	8510007	73.3	47
12	91	2	89	1	1	27	5	12	1	21	61	61	61					0		3	8510009	72.6	44
12	91	2	123	1	1	1	6	10	1	21	61	61	61					0		3	8510009	73.1	23
12	91	2	125	1	1	1	6	12	1	21	61	61	61					0		3	8510009	72.5	44
12	91	2	137	1	1	1	6	10	1	21	54	54	54					0	0	3	8510009	73.6	37
12	91	2	139	1	1	1	6	11	1	21	61	61	61					0		3	8510009	74.1	27
12	91	2	143	1	1	27	5	17	1	21	54	54	54					0	0	3	8510007	75	45
12	91	2	149	1	1	7	6	17	1	21	51	51	53					0	0	3	8510009	74	22
12	91	2	167	1	1	22	6	8	1	21	61	61	61					0		3	8510009	71	23
12	91	3	1	1	1	10	5	14	1	21	54	41	41					0	0	3	8510007	73.6	45
12	91	3	43	1	1	17	5	14	1	21	54	54	54					0	0	3	8510007	74.5	27
12	91	3	45	1	1	17	5	17	1	21	61	61	61					0		3	8510007	72.8	33
12	91	3	49	1	1	17	5	16	1	21	61	61	61					0		3	8510007	73.8	18
12	91	3	63	1	1	17	5	15	1	21	61	61	61					0		3	8510007	74.6	26
12	92	2	5	1	1	23	4	12	1	21	62	62	62					0		3	8510010	74.8	29
12	92	2	27	1	2	15	5	18	4	34	18	53	53							3	8510010	72.7	53
12	92	2	37	1	1	4	5	16	1	21	53	53	53					0	0	3	8510010	73.5	42
12	92	2	71	1	1	23	4	12	1	21	666	54	36					0	1	3	8510010	72.4	19
12	92	2	85	1	1	1	5	13	1	21	54	54	54					0	0	3	8510010	73	34
12	92	2	87	1	2	8	5	16	4	664	54	54	54							3	8510010	67.3	29
12	92	2	121	1	1	21	5	9	1	21	66	54	54					0	0	3	8510010	73	20
12	92	2	157	1	1	7	6	12	1	21	51	53	53					0	0	3	8510010	72	5.2
12	92	2	159	1	1	31	5	6	3	23	63	63	63							3	8510010	74.2	29
12	92	2	165	1	1	7	6	13	1	21	51	54	34					0	1	3	8510010	73	22
12	92	2	169	1	2	9	7	4	6	36	54	51	51							3	8510010	70.2	40
12	92	2	175	1	1	13	7	15	4	24	51	36						0	1	3	8510010	75.3	41
12	92	3	41	1	1	4	5	16	1	21	51	53	54					0	0	3	8510010	74	26
12	92	3	49	1	1	24	4	19	1	21	44	44	92					0		3	8510010	65.5	36
12	92	3	49	2	2	8	5	22	4	44	21	44	92							3	8510010	66.6	34
12	92	3	121	1	1	18	6	15	1	21	51	53	54					0	0	3	8510010	75.2	23
12	92	3	163	1	1	18	6	13	1	21	74	666	66					0		3	8510010	71.7	9.1
12	92	3	163	2	2	7	7	19	4	74	21	666	66							3	8510010	73	14
12	93	2	1	1	1	12	5	13	1	21	35	35	35					0	1	3	1080067	71.9	46
12	93	2	1	2	2	27	5	16	5	35	21	35	35							3	1080063	71.1	47
12	93	2	1	3	2	27	5	16	5	35	21	35	35							3	1080063	71.3	55
12	93	2	1	4	2	27	5	16	5	35	21	35	35							3	1080063	68.2	65
12	93	2	5	1	1	6	5	13	1	21	53	53	53					0	0	3	1080067	73	17
12	93	2	7	1	2	27	5	18	5	35	18	54	0							3	1080063	78	56
12	93	2	9	1	1	20	5	13	1	21	37	35	51					0	1	3	1080067	72.2	20
12	93	2	9	2	2	3	6	16	5	35	21	37	51							3	1080063	71.7	68
12	93	2	10	1	1	10	6	4	6	26	51	54	37						1	3	1080063	72	160
12	93	2	12	1	1	3	6	12	2	22	53	53	35	36				1	1	3	1080067	74.4	70
12	93	2	12	2	2	18	6	18	5	35	22	53	53	36						3	1080063	72	86
12	93	2	14	1	1	27	5	6	5	25	61	61	61					1		3	1080067	75.5	44
12	93	2	15	1	1	3	6	15	1	21	54	54	54					0	0	3	1080067	74	42
12	93	2	16	1	1	27	5	15	1	21	51	51	53					0	0	3	1080067	73.6	56
12	93	2	18	1	1	27	5	14	2	22	35	36	36					1	1	3	1080067	72.8	59
12	93	2	18	2	2	10	6	18	5	35										3	1080063	76.3	56
12	93	2	22	1	2	24	6	20	5	35	53	53	53							3	1080063	72.6	54
12	93	2	24	1	2	24	6	18	5	35	35	35	53							3	1080063	71.2	74
12	93	2	24	2	2	24	6	17	5	35	35	35	53							3	1080063	73.1	69

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Site	Year	Species	Nest	Egg	Type	Day	Month	Stage	Condition	Fate	Sib1	Sib2	Sib3	Sib4	Sib5	Sib6	Sib7	Logistic-Egg	Logistic-Clutch	Lab	Catalog	Moisture	Selenium
12	93	2	24	3	2	24	6	18	5	35	35	35	53							3	1080063	69.2	66
12	93	2	26	1	1	3	6	7	3	23	51	35	35						1	3	1080067	73.9	49
12	93	2	26	2	2	24	6	18	5	35	35	23	51							3	1080063	73.8	67
12	93	2	26	3	2	24	6	18	5	35	35	23	51							3	1080063	74	68
12	93	2	27	1	1	10	6	15	1	21	54	53	53					0	0	3	1080067	74	39
12	93	2	29	1	2	1	7	9	5	35	54	36	37							3	1080063	72.1	62
12	93	2	30	1	1	3	6	16	2	22	61	61	61					1		3	1080067	73.5	44
12	93	2	32	1	1	3	6	6	3	23	35	36	53						1	3	1080063	74.8	81
12	93	2	32	2	2	24	6	18	5	35	23	36	53							3	1080063	70.3	60
12	93	2	33	1	1	17	6	18	5	25	35	36	37					1	1	3	1080067	78.1	77
12	93	2	33	2	2	30	6	17	5	35	23	36	53							3	1080063	73.4	72
12	93	2	35	1	1	1	7	15	1	21	54	54	54					0	0	3	1080063	72.6	18
12	93	2	37	1	1	1	7	14	5	25	54	54	54					1	1	3	1080067	72.7	14
12	93	2	39	1	1	1	7	13	1	21	54	54	54					0	0	3	1080067	72.5	37
12	93	2	40	1	1	10	6	11	1	21	35	35	35					0	1	3	1080067	74.1	49
12	93	2	40	2	2	1	7	17	5	35	35	35	21							3	1080063	70.1	59
12	93	2	40	3	2	1	7	16	5	35	35	35	21							3	1080063	72.4	64
12	93	2	40	4	2	1	7	17	5	35	35	35	21							3	1080063	71.3	59
12	93	2	42	1	2	18	6	16	5	35	51	53	36							3	1080063	73.9	13
12	93	3	1	1	1	12	5	16	1	21	54	54	54					0	0	3	1080068	76	12
12	93	3	17	1	2	3	6	19	5	35	35	36	35							3	1080063	74.6	96
12	93	3	17	2	2	3	6	20	5	35	35	36	35							3	1080063	72.7	104
12	93	3	27	1	1	6	5	13	1	21	53	51	51					0	0	3	1080063	73.8	70
12	93	3	29	1	1	30	4	14	1	21	53	53	53					0	0	3	1080063	72.3	41
12	93	3	52	1	1	27	5	19	1	21	91	91	91					0		3	1080063	75.1	38
12	93	3	82	1	1	24	6	15	1	21	51	51	53					0	0	3	1080063	73.1	42
12	93	3	89	1	2	17	6	18	5	35	34	34	36							3	1080063	77.5	103
12	93	3	90	1	2	24	6	23	2	32	67	34	54							3	1080063	71	122
12	93	3	101	1	2	17	6	15	5	45	62	62	69							3	1080063	63.8	50
12	93	3	104	1	1	24	6	10	1	21	62	62	62					0		3	1080068	75.1	39
12	93	3	110	1	1	1	7	16	1	21	41	62						0		3	1080063	74.8	47
12	93	3	118	1	2	8	7	18	5	35	35	53	54							3	1080063	69	105
12	93	3	118	2	2	8	7	19	5	35	35	53	54							3	1080063	70.6	86
12	94	2	1	1	1	3	6	11	1	21	91	91						0		2	1080084	72.1	14
12	94	2	2	1	1	3	6	12	1	21	91	91	91					0		2	1080084	73.8	29
12	94	2	3	1	1	3	6	22	1	21	54	54	54					0	0	2	1080084	75.4	28
12	94	2	4	1	1	3	6	9	1	21	27	91	91					0		2	1080084	73.4	31
12	94	2	5	1	2	3	6		7	47										2	1080084	71.3	8
12	94	3	1	1	1	3	6	22	1	21	54	54	54					0	0	2	1080084	75.6	13
12	94	3	2	1	2	3	6		7	37	54	54	54							2	1080084	73.7	30
12	94	3	3	1	1	3	6	9	1	21	53	53	91					0		2	1080084	74.6	33
12	94	3	4	1	1	3	6	3	3	23	91	91	91							2	1080084	72.7	18
12	94	3	5	1	2	3	6		7	47	92									2	1080084	67.7	17
12	94	3	6	1	1	3	6		7	27	91	91	91							2	1080084	73.9	33
12	94	3	7	1	1	3	6	22	1	21	91	91	91	91	91	91		0		2	1080084	72.9	18
12	95	2	1	1	2	13	6	3	3	43										4	1080090	75.2	21
12	95	2	111	1	2	13	6		7	47										4	1080090	70.2	3.2
12	95	2	202	1	1	13	6	12	2	22	62	62	62	62				1		4	1080090	74.1	31
12	95	2	226	1	2	13	6		7	37	54	54	54							4	1080090	74.6	7.1
12	95	2	236	1	1	13	6	9	1	21	62	62	62					0		4	1080090	74.6	20
12	95	3	1	1	2	13	6		7	37										4	1080090	70.6	23
12	95	3	2	1	2	13	6		7	37										4	1080090	71.6	21
12	95	3	121	1	1	13	6		7	27	69	69	69							4	1080090	72.8	19
12	95	3	134	1	1	13	6		7	27	66	54	54						0	4	1080090	69.2	4.5
12	95	3	154	1	1	13	6		7	27	91	91	91							4	1080090	70.1	13
12	95	3	167	1	1	13	6	15	1	21	54	54	54					0	0	4	1080090	71.1	45
12	95	3	187	1	1	13	6	5	3	23	61	61	61							4	1080090	72.1	32
12	96	3	101	1	1	25	6	9	1	21	91	91	91					0		7	1080122	54.3	14

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Site	Year	Species	Nest	Egg	Type	Day	Month	Stage	Condition	Fate	Sib1	Sib2	Sib3	Sib4	Sib5	Sib6	Sib7	Logistic-Egg	Logistic-Clutch	Lab	Catalog	Moisture	Selenium
12	96	3	102	1	1	25	6	6	6	26	92									7	1080122	74.8	13
12	98	3	9	1	1	4	6	11	1	21								0		6			37
12	98	3	14	1	1	4	6	13	1	21								0		6			16
12	98	3	15	1	1	4	6	16	1	21								0		6			19
12	98	3	18	1	1	4	6	16	1	21								0		6			4.9
12	98	3	19	1	1	4	6	13	1	21								0		6			9.7
13	92	2	1	1	1	27	4	0	7	27	91	92								2	1080016	74	20
13	92	2	2	1	1	11	5	0	7	27	92									2	1080016	73.4	12
13	93	2	1	1	1	29	4	2	7	27										3	1080067	74.2	6
13	93	2	2	1	2	29	4	0	7	47	47									3	1080063	73.5	17
13	93	2	2	2	2	29	4	0	7	47	47									3	1080063	73.5	21
13	93	2	3	1	2	29	4	9	4	44										3	1080063	73	26
13	93	2	4	1	1	6	5	20	1	21								0		3	1080067	74.5	35
13	93	2	5	1	1	6	5	0	7	27										3	1080067	73.2	41
13	93	2	6	1	1	6	5	0	7	27										3	1080067	73.8	16
13	93	3	1	1	1	29	4	0	7	27										3	1080063	73.9	15
13	93	3	2	1	1	29	4	19	1	21								0		3	1080063	74.7	38
13	93	3	3	1	1	29	4	14	1	21								0		3	1080063	73.7	53
13	93	3	4	1	1	6	5	0	7	27										3	1080063	74.2	12
16	91	2	1	1	1	20	6	8	1	21								0		3	1080007	73.5	3.3
16	91	2	2	1	1	20	6	3	7	27										3	1080007	73.5	3
16	91	2	3	1	1	20	6	1	7	27										3	1080007	73.7	3.1
16	92	2	1	1	1	13	5	5	3	23	91	91	91							2	1080016	75.6	3.7
16	92	2	2	1	1	13	5	10	1	21	91	91	91					0		2	1080016	74.3	3.6
16	92	2	3	1	1	13	5	0	7	27	92									2	1080016	75.1	4.1
16	92	2	4	1	1	13	5	15	1	21	91	91	91					0		2	1080016	73.1	4
16	92	2	5	1	1	13	5	5	3	23	91	91	91							2	1080016	73.7	3.8
16	92	3	1	1	1	13	5	0	7	27	92									2	1080016	73.3	3.9
16	92	3	2	1	1	13	5	0	7	27	91	91	91							2	1080016	73.2	3.6
16	92	3	3	1	1	13	5	3	3	23	91	91	91							2	1080016	73.7	3
16	92	3	4	1	1	13	5	0	7	27	91	91	91							2	1080016	74.8	3.1
16	92	3	5	1	1	13	5	0	7	27	91	92								2	1080016	75	3.9
17	93	2	1	1	1	7	5	4	3	23										3	1080063	72.8	3.3
17	93	2	2	1	1	7	5	0	7	27										3	1080063	73.5	2.9
17	93	2	3	1	1	7	5	0	7	27										3	1080063	73.4	9.8
17	93	3	1	1	1	7	5	12	1	21								0		3	1080063	73.9	2.6
17	93	3	2	1	1	7	5	3	7	27										3	1080063	75	2.9
17	93	3	3	1	1	7	5	0	7	27										3	1080063	73.4	2.6
17	93	3	4	1	1	7	5	8	6	26										3	1080063	70.7	4.2
17	93	3	5	1	1	7	5	6	3	23										3	1080063	72.4	2.1
19	92	2	1	1	1	5	6	9	1	21	91	91	91					0		2	1080016	73.7	13
19	92	2	2	1	1	5	6	1	7	27	91	91	92							2	1080016	74.9	13
19	92	2	3	1	1	5	6	19	1	21	91	91	91					0		2	1080016	73.8	22
19	92	2	4	1	2	5	6	1	7	47										2	1080016	72.2	8.9
19	92	2	5	1	1	5	6	9	1	21	91	91	91					0		2	1080016	74.6	12
19	92	2	6	1	1	5	6	3	6	26	91	91	91							2	1080016	74.4	15
19	92	2	101	1	2	23	6		7	47										2	1080016	75.1	5.3
19	92	2	102	1	1	23	6	12	1	21	91	91	91					0		2	1080016	74.1	11
19	92	2	103	1	1	23	6	13	1	21	91	91	91					0		2	1080016	74.5	11
19	92	2	105	1	1	23	6	12	1	21	91	91	91					0		2	1080016	71.9	9.4
19	92	2	106	1	1	23	6	13	1	21	91	91	91					0		2	1080016	70.9	13
19	92	2	108	1	1	23	6	14	1	21	91	91	91					0		2	1080016	73.9	11
19	92	3	1	1	1	5	6	1	7	27	91	91	92							2	1080016	75.5	8.9
19	92	3	2	1	1	5	6	2	7	27	91	91	91							2	1080016	73.5	8.4
19	92	3	3	1	1	5	6	1	7	27	91	91	92							2	1080016	73.3	8.6
19	92	3	4	1	1	5	6	1	7	27	92									2	1080016	75.8	6.1
19	92	3	5	1	1	5	6		7	27	69	69	69							2	1080016	74.2	15
19	92	3	6	1	2	5	6		7	47	92									2	1080016	67	6.5

Appendix 1

Site	Year	Species	Nest	Egg	Type	Day	Month	Stage	Condition	Fate	Sib1	Sib2	Sib3	Sib4	Sib5	Sib6	Sib7	Logistic-Egg	Logistic-Clutch	Lab	Catalog	Moisture	Selenium
19	92	3	7	1	1	5	6		7	27	69	69	69							2	1080016	71.6	8.2
19	92	3	101	1	1	23	6	12	1	21	91	92						0		2	1080016	73.1	9.8
19	92	3	103	1	1	23	6	12	1	21	91	91						0		2	1080016	73.5	7.7
19	92	3	104	1	2	23	6	0	7	47	47	92								2	1080016	72.4	12
19	92	3	104	2	2	23	6	0	7	47	47	92								2	1080016	73.2	12
19	93	2	2	1	1	14	5	12	1	21								0		3	1080067	73.1	16
19	93	2	4	1	1	14	5	11	1	21								0		3	1080067	75.4	8.1
19	93	2	5	1	1	14	5	12	1	21								0		3	1080063	72.9	17
19	93	2	6	1	1	14	5	14	1	21								0		3	1080067	74.2	14
19	93	2	8	1	1	14	5	11	1	21								0		3	1080063	73.1	13
19	93	2	9	1	1	14	5	11	1	21								0		3	1080063	74.7	10
19	93	2	10	1	1	14	5	1	3	23										3	1080068	74.3	8.5
19	93	2	11	1	1	14	5	12	1	21								0		3	1080063	73.5	13
19	93	2	12	1	1	14	5	7	1	21								0		3	1080063	73.8	13
19	93	2	13	1	1	14	5	16	1	21								0		3	1080067	74.5	11
19	93	2	14	1	1	14	5	11	1	21								0		3	1080063	74.2	5.8
19	93	2	15	1	1	14	5	16	1	21								0		3	1080063	74	12
19	93	2	16	1	1	14	5	8	1	21								0		3	1080067	72.3	6.2
19	93	2	17	1	1	14	5	11	1	21								0		3	1080063	73.4	3.4
19	93	3	2	1	1	14	5	12	1	21								0		3	1080063	73.6	11
19	93	3	5	1	1	14	5	9	1	21								0		3	1080063	73.9	14
19	93	3	6	1	1	14	5	11	1	21								0		3	1080063	71.7	8.6
19	93	3	7	1	1	14	5	11	1	21								0		3	1080063	74.2	10
19	93	3	9	1	1	14	5	12	1	21								0		3	1080063	68.8	15
19	94	2	1	1	2	2	6		7	47										2	1080084	75.2	17
19	94	3	1	1	1	25	5	14	1	21								0		2	1080084	73.2	6.2
19	95	2	1	1	1	1	6		7	27										1	1080096	70.8	11
19	95	2	2	1	1	1	6	3	7	27										1	1080096	67.5	9.1
19	95	2	3	1	2	1	6	14	1	41										1	1080096	70.3	10
19	95	2	5	1	1	1	6	9	1	21								0		1	1080096	74.9	14
19	95	3	4	1	1	1	6		7	27										1	1080096	75.1	16
19	96	2	1	1	1	24	6	1	7	27	91	91	91							7	1080122	75	29
19	96	2	2	1	1	24	6	13	4	24	91	91	92					0		7	1080122	68.8	28
19	96	2	3	1	1	24	6	12	1	21	91	91	92					0		7	1080122	74.2	15
19	96	2	4	1	1	24	6	7	3	23	91	91	91							7	1080122	74.2	18
19	96	2	5	1	1	24	6	0	7	27	91	91	91							7	1080122	70.3	14
19	97	2	1	1	1	30	5	3	7	27										3	1080134	74.3	20
19	97	2	2	1	1	30	5	0	7	27										3	1080134	72.7	24
22	93	2	1	1	1	30	4	8	1	21								0		3	1080063	73	1.4
22	93	2	2	1	1	30	4		7	27										3	1080063	71.8	1.4
22	93	3	1	1	1	30	4	0	7	27										3	1080063	72.4	2.6
22	93	3	2	1	1	30	4	3	3	23										3	1080063	74.7	1.8
23	91	2	12.1	1	2	29	5		7	47										3	8510007	73.7	1.9
23	91	2	35.1	1	1	29	5	3	3	23	91	91	91							3	8510007	74.1	1.7
23	91	2	57	1	1	29	5	12	1	21	53	53	53					0	0	3	8510007	74.9	2
23	91	3	15	1	1	22	5	18	1	21	54	54	54					0	0	3	8510007	74.8	1.4
23	91	3	55	1	1	29	5	15	1	21	54	54	54					0	0	3	8510007	72.8	2.2
24	91	2	1	1	1	31	5	19	1	21	37	53	53					0	1	3	8510007	76	9.3
24	91	2	3	1	1	6	6	13	1	21	54	54	54					0	0	3	8510007	74.1	9.2
24	91	2	7	1	1	31	5	13	1	21	54	54	61					0	0	3	8510007	49.4	8.5
24	91	2	15	1	1	22	5	21	1	21	53	53	54					0	0	3	8510007	70.4	7.1
24	91	2	47	1	1	6	6	12	1	21	51	51	53					0	0	3	8510007	74	9.6
24	91	3	35.1	1	1	31	5	12	1	21	54	54	54					0	0	3	8510007	73.3	13
24	91	3	41	1	1	22	5	16	1	21	53	53	54					0	0	3	8510007	75.5	3.1
24	91	3	49	1	1	22	5	11	1	21	53	53	54					0	0	3	8510007	73.6	6.9
24	91	3	57	1	1	22	5	19	1	21	53	53	53					0	0	3	8510007	74.2	8.4
24	91	3	61	1	1	22	5	16	1	21	53	54	54					0	0	3	8510007	74.4	14
24	95	2	1	1	1	15	7	4	6	26	91	91	91							4	1080090	71.2	3.1

Appendix 1

Site	Year	Species	Nest	Egg	Type	Day	Month	Stage	Condition	Fate	Sib1	Sib2	Sib3	Sib4	Sib5	Sib6	Sib7	Logistic-Egg	Logistic-Clutch	Lab	Catalog	Moisture	Selenium
24	95	2	2	1	1	15	7	22	1	21	91	91	91					0		4	1080090	74.6	3.9
24	95	2	3	1	1	15	7	14	1	21	91	91	91					0		4	1080090	74.9	3.5
24	95	3	1	1	1	15	7	12	4	24	91	91	91					0		4	1080090	73.3	13
24	95	3	2	1	1	15	7	15	4	24	91	91	91					0		4	1080090	71.7	7.1
24	95	3	3	1	1	15	7		7	27	91	91	91							4	1080090	70.9	4.4
24	95	3	4	1	1	15	7	17	4	24	91	91	91					0		4	1080090	74.1	8.2
24	95	3	5	1	1	15	7		7	27	91	91	91							4	1080090	70.3	3.1
25	93	2	1	1	1	30	4	8	1	21								0		3	1080063	74.3	0.9
25	93	2	2	1	1	30	4	12	1	21								0		3	1080063	72.6	0.6
25	93	2	3	1	1	30	4	11	1	21								0		3	1080063	73.7	0.5
25	93	2	4	1	1	30	4	5	3	23										3	1080063	73.9	0.6
25	93	2	5	1	1	30	4	16	1	21								0		3	1080063	72.4	0.8
25	93	3	1	1	1	30	4	12	1	21								0		3	1080063	72.4	2.2
25	93	3	2	1	1	30	4	12	1	21								0		3	1080063	71.6	5.1
26	91	2	2	1	1	25	6	16	1	21	54	54	54					0	0	3	1080007	74.1	3
26	91	2	4	1	1	25	6	10	1	21	54	54	54					0	0	3	1080007	73.5	2.9
26	91	2	6	1	1	25	6	8	1	21	54	54	54					0	0	3	1080007	74.8	2.8
26	91	3	1	1	1	25	6	15	4	24	61	61	44					0		3	1080007	62.5	4.8
26	92	2	0	1	1	1	6	0	7	27										3	8510010	73.1	1.2
26	92	2	7	1	1	1	6	4	7	27	53	54	54	34					1	3	8510010	72.2	3.2
26	92	3	1	1	1	1	6	11	1	21	61	61	61					0		3	8510010	72.6	17
26	93	2	2	1	1	23	6	11	1	21								0		3	1080063	74.4	2.1
26	93	2	3	1	1	23	6	21	1	21								0		3	1080063	76.1	3.5
26	93	2	4	1	1	23	6	2	7	27										3	1080063	73.2	2.9
26	93	2	5	1	1	23	6	7	4	24								0		3	1080063	73.6	1
26	93	2	6	1	1	23	6	11	1	21								0		3	1080063	74	2.6
26	93	3	1	1	1	6	5	0	7	27										3	1080063	73.2	4
26	93	3	2	1	1	23	6	16	4	24								0		3	1080063	69.5	4.4
26	93	3	3	1	1	23	6	22	4	24								0		3	1080063	75.2	3.1
26	93	3	4	1	1	23	6	21	4	24								0		3	1080063	75.3	3.1
26	93	3	5	1	1	23	6	21	4	24								0		3	1080063	74.5	3
26	93	3	7	1	1	23	6	12	4	24								0		3	1080063	73.4	2.7
26	94	2	1	1	1	8	6	0	7	27	91	91	91							2	1080084	74.8	6.2
27	91	2	1	1	1	11	5	9	1	21	51	51	51					0	0	3	8510007	71.6	1.7
27	91	2	2	1	1	11	5	2	7	27	47	44	44							3	8510007	72.2	1.3
27	91	2	3	1	1	26	5	6	3	23	61	61	61							3	8510007	73	2
27	91	2	4	1	1	26	5	2	7	27	51	53	53						0	3	8510007	73.8	1.1
27	91	2	5	1	1	26	5	3	3	23	64	64	64							3	8510007	72.1	1.3
27	91	3	1	1	1	11	5	1	7	27	62	62								3	8510007	73.9	2.4
27	92	2	1	1	1	22	5	6	3	23	66	91	91							3	8510010	73.5	2.1
27	92	3	1	1	1	22	5	11	1	21	91	91	91					0		3	8510010	73.8	1.1
27	94	2	1	1	1	23	5	17	1	21								0		2	1080084	73.6	2.2
28	91	2	1	1	1	30	6	4	7	27										3	1080007	73.2	14
28	91	2	2	1	1	4	7	5	3	23	91	91	91							3	8510007	74.8	10
28	91	2	2	1	1	30	6	5	3	23										3	1080007	74.1	4.7
28	91	2	10	1	1	13	7	9	1	21								0		3	8510007	73.9	4.9
28	91	3	1	1	1	30	6	3	3	23										3	1080007	77.3	18
28	91	3	2	1	1	30	6	4	3	23										3	1080007	75.7	24
28	91	3	3	1	1	30	6	3	7	27	91	91	91							3	8510007	74.2	23
28	91	3	4.1	1	1	30	6	1	7	27	91	91	92							3	8510007	74.2	20
28	91	3	5	1	1	30	6	6	3	23	91	91	91							3	8510007	74.2	31
28	92	2	1	1	1	2	7	11	5	25								1		3	8510010	72.1	3.2
28	92	2	2	1	1	2	7	5	6	26										3	8510010	74	2.7
28	92	3	1	1	1	2	7	13	1	21	54	54	54					0	0	3	8510010	74	3.8
28	92	3	2	1	1	2	7	11	1	21								0		3	8510010	74.6	2.8
28	94	3	1	1	1	8	6	2	7	27	91	91	92							2	1080084	74.4	20
28	94	3	2	1	1	8	6	4	3	23										2	1080084	73.7	19
28	95	2	300	1	1	29	6	0	7	27										4	1080090	72.6	4.5

1F20 From FY97 Submission

use surveys. Westlake Farms will also be reconfiguring evaporation ponds on an experimental basis to reduce their attractiveness to birds. Westlake farms will also provide at least 400 acrefeet of water. The total contribution from westlake Farms, both direct and indirect is expected to be in the range of one million dollars.

National Biological Survey, Pacific Science Center.

NBS will provide GIS capability, a part of a researcher salary, computers, and all telemetry receivers. The estimated net contribution of NBS is in the range of $55,000.

California Department of Water Resources

DWR has in the past funded FWS research on evaporation ponds through contracts and have also provided in-kind services in the form of field staff and analytical chemistry support. The DWR will also provide approximately 1000 acre feet of water for the demonstration wetland. DWR in-kind support and funding will be no more than $100,000 but this support will assist greatly in expanding the number of sites and analyses which can be done. DWR support is contingent upon DOI funding.

In 1996 DWR provided funding for a masters student to assess invertebrate productivity at three sites. They also provided approximately 30 biologist days of assistance to FWS monitoring efforts at alternative wetlands to assess nest success and density. DWR provided water to part of Westlake Farms demonstration wetland and covered analytical chemistry costs of 20 eggs collected from agriforestry plots.

VII. BUDGET

VII. A. Previously Allocated Expenditures

FY 1996

Operational	$ 131,019
Analytical (PACF + non-PACF)	$ 36,400

VII.B. Funds Requested for FY 1997 (this proposal)

OPERATIONAL

Personnel Costs (salaries, benefits, travel, and overhead) (FWS, Sacramento Field Office) $485/BD x 144 BDs	$69,840
Supplies and equipment (routine sampling supplies included in biologist day cost)	$ 0

NBS telemetry
$55,000 in kind costs + overhead waiver
$58,400 carried over from last fiscal year funding

Sub-total for Operational Costs	**$ 69,840**
ANALYTICAL	
PACF (direct or through contract)	$ 30,900
	100,740
Sub-total for Analytical	$ 30,900
Total Funds Requested for FY 1997	$ ~~99,840~~ 100,740
GRAND TOTAL OF PROJECT COSTS TO DATE	$167,419

VII.C. Estimated Future Costs

FY 1998	
Operational	$ 45,000
Analytical (PACF + non-PACF)	$ 15,000
FY 1999.....	
Operational	$ 45,000
Analytical (PACF + non-PACF)	$ 15,000

VIII. APPROVALS

Submitted by: _____ Date: _____
Contaminant Specialist, Field Office

Reviewed by: _____ Date: _____
Environmental Contaminants Coordinator

Approved by: _____ Date: _____
Assistant Regional Director, (ES and/or GARD)