EFFECT OF MARKING AND REVISITING NESTS ON WHITE PELICAN REPRODUCTIVE SUCCESS

BY DIANE E. BOELLSTORFF[1], DANIEL W. ANDERSON[1],
HARRY M. OHLENDORF[2], AND EDWARD J. O'NEILL[3]

The number of American White Pelican (*Pelecanus erythrorhynchos*) young produced at Lower Klamath and Clear Lake National Wildlife Refuges (NWRs), California sharply declined (Figure 1) from 1907 (Lower Klamath NWR) and the 1930's (Clear Lake NWR) to the 1940's. This decline probably resulted from 1) the draining of most of the marshes in the Klamath Basin to produce agricultural land, 2) the use of organochlorine pesticides beginning in the 1940's, and 3) human disturbance at the breeding colonies.

Over half (18 of 25; Stickel et al. 1979, E.J.O. unpubl. data) of the adult White Pelicans found dead from 1975 to 1980 that were necropsied and analyzed for organochlorine residues had lethal or hazardous levels of the organochlorine pesticide endrin in their brains. In addition, two of three addled eggs collected after young had fledged in 1976 and four of seven in 1977 contained endrin residues up to 0.12 ppm wet-weight (E.J.O. unpubl. data). Endrin at 0.3 ppm in screech owl (*Otus asio*) eggs was associated with impaired reproduction (Fleming et al. 1982).

The objective of this study was to relate reproductive success to organochlorine residues in a statistically representative sample of eggs. Because we were aware that White Pelicans may be especially sensitive to disturbance (Johnson and Sloan 1976) we monitored changes in the breeding colony to determine the effect of obtaining the sample on the production of young in 1981. This paper

reports the effect of disturbance on the White Pelican colony at Lower Klamath NWR in 1981. Evaluation of pollutant residues in this population will be presented separately (Boellstorff et al., in prep.).

STUDY AREA AND METHODS

White Pelicans at Lower Klamath NWR, Siskiyou Co., California (Fig. 2) nest on an island of matted tules (Scirpus acutus). At Clear Lake NWR, Modoc Co., California (35 km east of the Lower Klamath colony) pelicans nest on a peninsula or on rocky islands. Generally, birds from both Clear Lake and Lower Klamath colonies feed at Tule Lake and Lower Klamath marsh. Tule Lake is about 5 km east of Lower Klamath NWR. Fish most commonly found in these feeding areas and in the regurgitations of prefledging White Pelicans are tui chubs (Gila bicolor) and blue chubs (G. coerulea). Because adults from both colonies generally feed in the same areas, annual food-mediated variations in reproductive rates (Anderson et al. 1982) are expected to be similar at both colonies.

We determined productivity by counting nests, young, and adults in photographs of the colonies taken during aerial surveys in 1981 and 1982. Regularly spaced single or paired adults were counted as incubating birds and erratically spaced adults were considered loafing birds (Sidle and Ferguson 1982). Although concurrent ground

counts of birds at the colony, as suggested by Beaver and Lewin (1981) were not feasible, incubating birds seemed to be clearly distinguishable from loafing birds in the photographs. Aerial surveys of the colonies were conducted one to two days before each visit to the Lower Klamath colony in 1981. Visits were made on 17 and 28 April, 21 May, 4 and 18 June, and 6 July 1981 and no visit lasted more than 30 minutes. Pelicans usually arrive and most eggs are laid at the Klamath Basin colonies in early April. Most young hatch during May and fledge in mid-August. The 1981 surveys were conducted at 125 m from 0900 to 1200 hours. In 1982, colonies were photographed on 13 May and 18 June from 175 m altitude between 0800 and 1100 hours. Except during the last survey in 1981, when the larger young swam onto the lake surrounding the island at Lower Klamath NWR, all but a few birds remained on their nests. The Clear Lake colony was not visited in 1981 and neither colony was visited in 1982.

To determine organochlorine residues in a statistically representative sample of eggs, we removed one egg for organochlorine analysis from each of 26 marked nests at the Lower Klamath colony on 17 April 1981. We revisited the colony at approximately 10-day intervals (dates are given above) to determine the fate of the remaining egg (according to the methods described by Blus et al. 1974 and Blus 1982, in brown pelican (P. occidentalis) colonies) and to determine the effect of collecting the eggs. We approached

the colony on an airboat, landed at the far side of the island, and entered on foot. An effort was made to reduce disturbance by collecting eggs from only one end of the colony; however, when we entered the colony usually all adults left the island. No gulls were observed in the colony during our visits or as we left the island. The island varies in size from year to year depending on how much bulrush is trampled by the pelicans. In 1981 the colony was about one-half ha and nesting adults were grouped into two subcolonies. During visits we were visible to all adults in the colony, thus all adults were subject to about the same degree of disturbance.

RESULTS AND DISCUSSION

Embryos in all eggs collected on 17 April were less than 3 mm long, indicating incubation had only recently begun. When we revisited the island 11 days later, we found that 18 of 26 marked nests (69%) were inactive. Twelve nests were empty (egg missing), five were abandoned and one had been destroyed. Twenty-three days later (the potential harm of unseasonally cold weather to unprotected chicks precluded our visiting the colony earlier), eggs were missing in five of the remaining eight active nests (possibly the eggs had hatched and young were already in pods); one nest was abandoned; and one young was found in each of two nests. Fourteen days later, one young was present and the other was missing or had joined a pod.

The "sampled-egg colony" had significantly lower productivity than either the undisturbed colony in 1981 or both undisturbed colonies in 1982 (Table 1). Productivities in the undisturbed colonies in 1982, 1.03 young/nest at Lower Klamath and 1.09 young/nest at Clear Lake, were not significantly different. Strait and Sloan (1974) suggest that a fledging rate of 1.08 young/nest is necessary for population maintenance in White Pelicans. Therefore, it appears that in the absence of disturbance at the breeding colonies, pelicans at Lower Klamath and Clear Lake NWRs are reproducing adequately. We suggest that the significant differences in productivity between undisturbed colonies in 1981 and 1982 (Table 1) represent normal annual variation. There were no appreciable water level changes in the study areas in 1981 (such as those affecting pelicans nesting at East Shoal Lake, Manitoba; Evans 1972) that might have been associated with the lower productivity at Lower Klamath in 1981.

Although only nests on one side of the colony were marked, reproductive success must have decreased throughout the colony because loss of marked and unmarked nests in the sampled area cannot alone account for lower productivity at Lower Klamath in 1981. Examination of photographs of the colony taken during aerial surveys showed a general decrease in the number of nests over the breeding season. Individual nests outside of the sampling site could not be monitored because trampling of bulrushes by the pelicans caused the

island's topography to constantly change. Bunnell et al. (1981) report that low-flying aircraft may affect White Pelican productivity by causing adults to break eggs as they flee the colony and by allowing predators to enter the colony before incubating adults return. During the aerial surveys we did not observe adults apparently panicing and flying from their nests at either colony.

Avian reproductive success is commonly measured by marking and revisiting nests, although other studies (Reid 1968, Schreiber and Risebrough 1972, Robert and Ralph 1975, Anderson et al. 1976, Ellison and Cleary 1978, Anderson and Keith 1980) suggest that use of this technique during critical periods of the nesting season may decrease reproductive success by increasing nest abandonment, predation, and nestling temperature stress. The results of this study indicate that the potential harm done to especially sensitive species by disturbance during systematic sampling may outweigh the benefit of having a representative sample for chemical analyses. Thus, for species especially sensitive to disturbance, collection of addled eggs after all young have fledged is preferable.

SUMMARY

The sample-egg technique commonly used to obtain statistically representative samples of fresh eggs for chemical analyses and to determine individual nest success

may seriously decrease productivity of species such as the American White Pelican. We suggest that low-disturbance methods be used to assess reproductive parameters in especially sensitive colonially-nesting species.

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1) Division of Wildlife and Fisheries Biology, University of California, Davis, California 95616 USA; 2) U. S. Fish and Wildlife Service, c/o Division of Wildlife and Fisheries Biology, University of California, Davis, California 95616 USA; and 3) U. S. Fish and Wildlife Service, Klamath Basin National Wildlife Refuges, Tulelake, California 96134 USA (Present Address: Box 69, Merrill, Oregon 97633 USA)

Table 1. Proportions of eggs surviving to fledglings in disturbed and undisturbed American White Pelican colonies, Klamath Basin, California, 1981-1982.

Colony and Treatment (location/date)[a]	Estimated Number of Eggs[b] Laid	Number Young Fledged	Percent Eggs Surviving to Fledge	Young Fledged Per Nest	Significance Level[c]
1. Disturbed (LK/81)	782	193	24.7	0.49	**
2. Undisturbed (CL/81)	800	472	59.0	1.18	
3. Undisturbed (LK/82)	996	514	51.6	1.03	ns
4. Undisturbed (CL/82)	2008	1094	54.5	1.09	
5. Undisturbed (BOTH/82)	3004	1608	53.5	1.07	* **

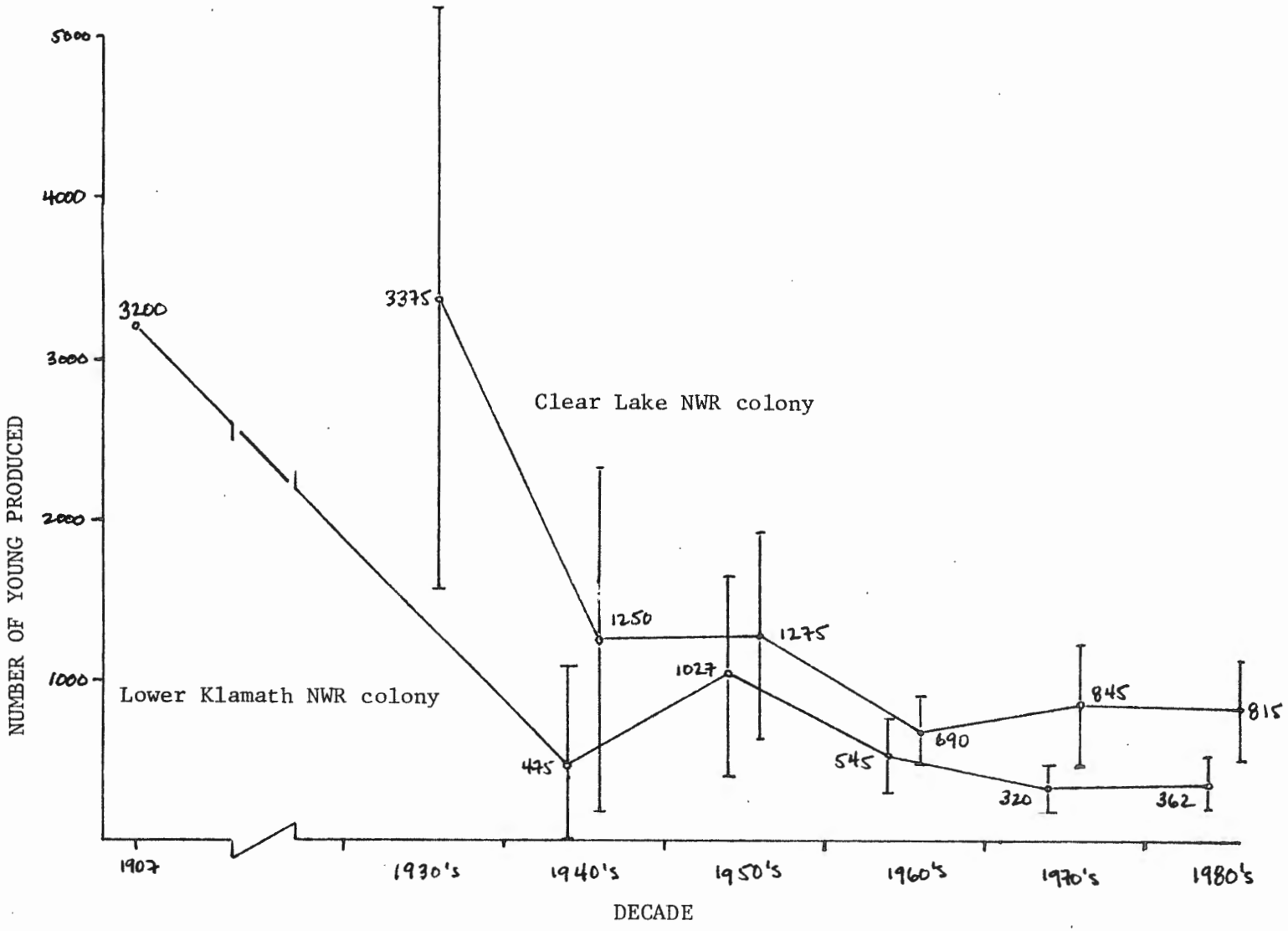
[a] LK = Lower Klamath; CL = Clear Lake.

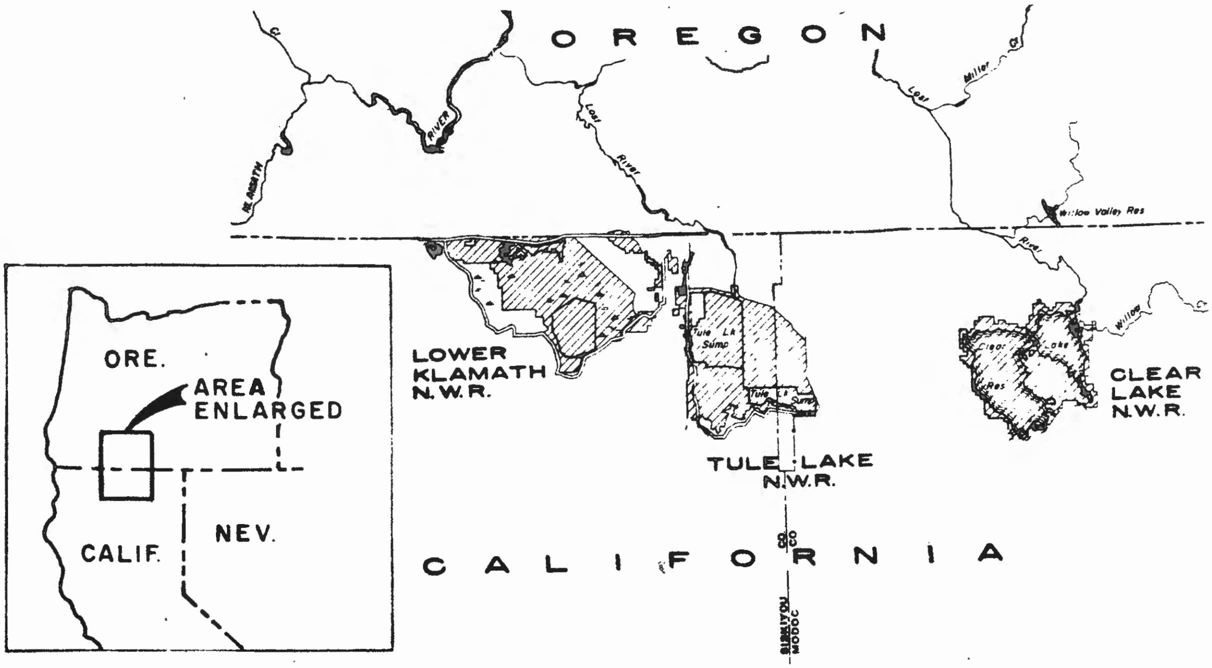
[b] Assuming 2.0 eggs/clutch (Knopf 1979, Bunnell et al. 1981).

[c] Chi^2 values: 1. vs. 2. = 191.2; 3. vs. 4. = 2.21; 2. vs. 5. = 7.63; 1. vs. 5. = 209.1. Significance levels are marked as follows: ns = not significant ($P > 0.05$); * = $P < 0.01$; ** = $P < 0.001$.

Figure 1. Mean number by decade of young American White Pelicans produced at Lower Klamath and Clear Lake NWRs. Counts were taken from files at the Klamath Basin NWRs and were made by different observers and at different times of the breeding season. The count for 1907 is based on one report (Finley 1907). Other data points are shown about in the middle of the decade but slightly offset to enable showing standard deviations within the decade for each colony.

Figure 2. Map of the Klamath Basin showing locations of Lower Klamath, Tule Lake, and Clear Lake National Wildlife Refuges.


5000
4000
3000
2000
1000
NUMBER OF YOUNG PRODUCED
3200
3375
Clear Lake NWR colony
Lower Klamath NWR colony
1250
1275
1027
475
690
545
845
815
320
362
1907
1930's
1940's
1950's
1960's
1970's
1980's
DECADE



OREGON
CALIFORNIA
LOWER KLAMATH N.W.R.
TULE LAKE N.W.R.
CLEAR LAKE N.W.R.
ORE.
AREA ENLARGED
CALIF.
NEV.