

Reproductive Impairment of Bald Eagles *Haliaeetus leucocephalus* along the Great Lakes Shorelines of Michigan and Ohio

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ABSTRACT

The Bald Eagle, *Haliaeetus leucocephalus*, population of the Great Lakes and adjacent interior areas has rebounded since the early 1960s. In the states of Michigan and Ohio, the number of breeding pairs on the Great Lakes increased from 17 to 57 in 1981-1990 and from 93 to 141 in adjacent interior regions. Reproduction, however, is still impaired along the Great Lakes shorelines of Michigan and Ohio and at inland sites accessible to runs of anadromous Great Lakes fish. Mean productivity in these areas, respectively, in 1981-1990 was 0.68 (N = 342) and 0.66 (N = 53), significantly lower than the productivity in interior regions of 1.00 (N = 1,040). Inexperienced, newly-established pairs have significantly lower reproductive success than experienced, established pairs, but experienced Great Lakes breeding pairs reproduce at levels similar to those of inexperienced pairs, significantly lower than those of experienced pairs in inland breeding areas. The data indicate that the increase in the coastal breeding population is a result of immigration of young birds from inland areas.

INTRODUCTION

Bald Eagles were nearly extirpated along the Great Lakes shorelines in the 1950s and early 1960s and along with the Peregrine Falcons, *Falco peregrinus*, were the early sentinels of *p,p'*-DDE reproductive effects. After the ending of DDT use in the early 1970s in the United States and Canada, eagle populations began to recover (Postupalsky 1978). Productivity of these reestablished populations, however, does not appear to be uniform. In order to understand the recovery of Bald Eagles in the Great Lakes Basin, we examined the current population trends, the effects of the length of site occupancy on productivity, and the influence of inexperienced breeding pairs of

eagles breeding on the shorelines of the Great Lakes and in interior regions of Michigan and Ohio.

METHODS

Productivity Analysis

We analyzed Bald Eagle productivity data for all breeding areas within Michigan and Ohio, 1981-90. Breeding areas were assigned three categories: *Great Lakes*, those breeding areas within 8.0 km of a Great Lake shoreline; *interior*, those breeding areas 8.0 km or further from a Great Lakes shoreline; and *anadromous*, those inland breeding areas accessible to runs of anadromous Great Lakes fish. Productivity for each category was determined by dividing the total number of young by the number of occupied breeding areas for each year (Postupalsky 1974).

Occupancy Analysis

Productivity as a function of occupancy was analyzed by comparing breeding attempts for each breeding area sequentially from year of initiation (Year 1) through Year 9 of breeding. We analyzed productivity data of all new or re-established breeding areas within Michigan and Ohio, 1975-90. Breeding areas were assigned three categories: *interior*; *Lakes Michigan/Huron*, Great Lakes and anadromous breeding areas within those watersheds; and *Lakes Superior/Erie*, Great Lakes and anadromous breeding areas within those watersheds. Great Lakes breeding areas were grouped based on no significant differences in addled egg residues and previous reproductive outcomes (Kubiak & Best 1991).

Experience Analysis

The effect of breeding pair experience was analyzed by comparing breeding attempts for each breeding area on a time sequence analysis, 1981-90. Breeding areas were assigned two categories: *experienced breeding pairs*, those occupying a breeding area 3 or more years; and *inexperienced breeding pairs*, those occupying a breeding area less than 3 years, including those breeding areas reoccupied after a 4 year or greater abandonment. A paired *t*-test was used to compare productivity between experienced and inexperienced pairs among years. Experienced breeding pairs were then split into two categories for comparison against inexperienced pairs: *experienced interior pairs*, interior pairs occupying a breeding area 3 or more years; and *experienced Great Lakes pairs*, Great Lakes and anadromous pairs occupying a breeding area 3 or more years.

Statistical Analysis

Data analysis were performed by ANOVA using SAS/STAT 6.03 for microcomputers (SAS Institute Inc. 1988). Differences between categories were determined using Tukey's (HSD) Studentized Range Test (Tukey 1951).

RESULTS

The Bald Eagle population has continued to grow during the 1980s; in the states of Michigan and Ohio, the number of breeding pairs on the Great Lakes increased from 17 to 57 in 1981-1990 and from 93 to 141 in adjacent interior regions (Table 1). Productivity, however, has varied among breeding areas, with interior breeding areas having significantly greater productivity (Anova, $F_{2,27} = 8.2$, $P = 0.0017$) than Great Lakes and anadromous breeding areas (Table 1). No changes in productivity were found between 1981 and 1990 ($F_{9,20} = 0.55$, $P = 0.82$).

Productivity increased between the first and third-fourth year of occupancy in inland areas and on the shores of Lakes Superior and Erie (Figure 1); this is attributed to experience (see below). Productivity on the shores of Lakes Michigan and Huron remained low during the first four years of occupancy and thereafter (Figure 1). Among the regions, the interior breeding areas had significantly greater productivity ($F_{1,18} = 36$, $P = 0.0001$); nest locations explained 66.7% of the variation in productivity.

Table 1. Number of nests, fledged young, and productivity¹ of Bald Eagles in Michigan and Ohio, 1981-90.

Area	Total	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Nests											
Interior	1,040	87	86	93	93	100	96	105	124	124	132
Great Lakes	342	17	17	22	22	29	35	46	51	46	57
Anadromous	53	6	4	5	5	5	4	4	3	8	9
Young											
Interior	1,041	96	81	90	90	105	89	113	125	127	125
Great Lakes	234	14	14	14	12	14	22	41	37	24	42
Anadromous	35	3	0	1	3	3	3	4	1	9	8
Productivity¹											
Interior	1.00 ^a	1.10	0.94	0.97	0.97	1.05	0.93	1.08	1.01	1.02	0.95
Great Lakes	0.68 ^b	0.82	0.82	0.64	0.55	0.48	0.63	0.89	0.73	0.52	0.74
Anadromous	0.66 ^b	0.50	0.00	0.20	0.60	0.60	0.75	1.00	0.33	1.13	0.89

¹ Productivity measured as young per occupied nest. Letters signify significant differences between means ($P < 0.002$).

Figure 1. Productivity of Bald Eagles in two shoreline regions of the Great Lakes and in the interior region of Michigan and Ohio vs. year of nest occupancy.

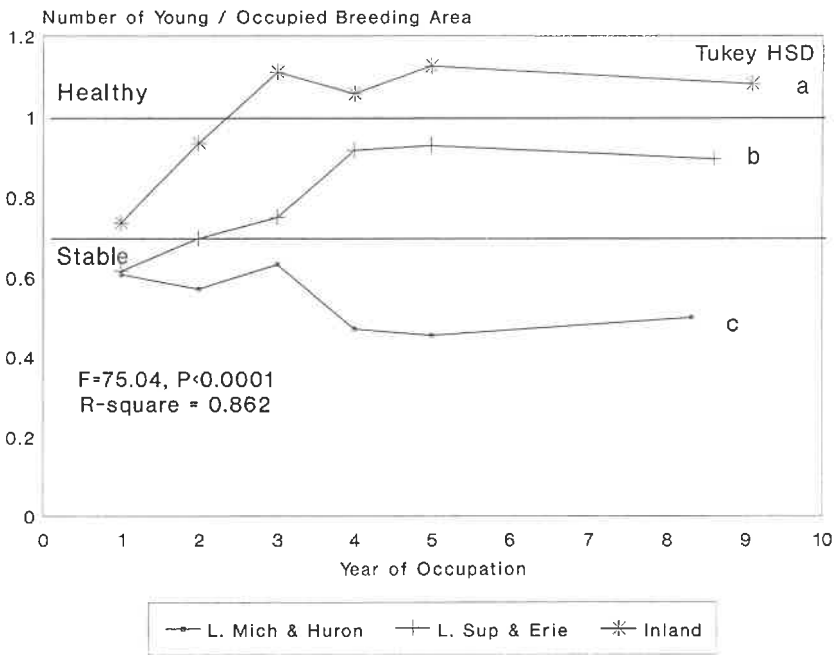
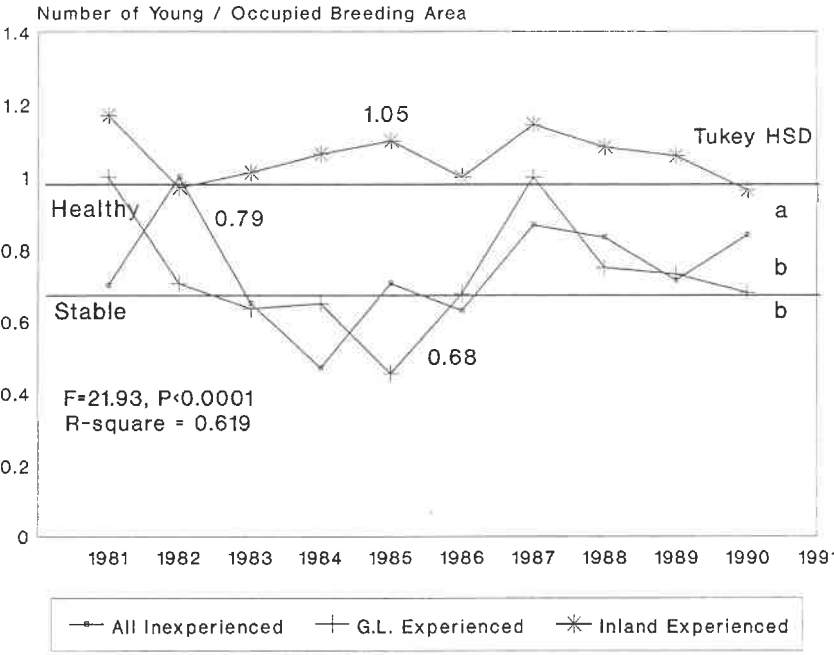


Figure 2. Productivities of Interior and Great Lakes experienced pairs of Bald Eagles and of all inexperienced breeding pairs in Michigan and Ohio, 1981-90.



Interior experienced pairs had higher productivity than either the Great Lakes experienced pairs or all inexperienced pairs (Figure 2; $F_{2,27} = 21.9$, $P = 0.0001$). No significant differences were found between all inexperienced pairs and Great Lakes experienced pairs ($F_{9,10} = 0.26$, $P = 0.97$), nor were there any detectable trends over time ($F_{9,10} = 0.26$, $P = 0.97$).

DISCUSSION

Bald Eagles nesting along the Great Lakes shorelines and interior areas accessible to runs of Great Lakes anadromous fish have higher organochlorine contaminant concentrations in blood plasma and addled eggs than those eagles from more interior sites (Bowerman *et al.* 1990; Kubiak & Best 1991; Bowerman *et al.* this volume); these data provide additional confirmation of the link between the observed depressed productivity and organochlorine contamination.

The mean productivities of 0.68 of the Great Lakes pairs over 1981-1990 ($N = 342$) and 0.66 of the "anadromous" pairs ($N = 53$) are considered barely marginal to maintain a population, let alone to permit an increase (Sprunt *et al.* 1973). The number of breeding pairs on the Great Lakes increased from 17 in 1981 to 57 in 1990 (Table 1). We attribute this growth to the relatively high productivity of the interior-nesting birds of 1.0 ($N = 1,040$ over 1981-1990), which has provided not only enough young to produce an increase in numbers of interior-breeding pairs from 86-87 in 1981-1982 to 132 in 1990, but to repopulate historic and other available habitat on the Great Lakes shorelines.

A visual examination of Figure 1 indicates that productivity does not change with years of occupancy, i.e. that after year 4 continued exposure to contaminants does not further depress productivity. Our definition of "experienced" pairs would include pairs in which one member has been replaced; the maintenance of mean productivity might therefore be due at least in part to a high incidence of young, relatively uncontaminated birds in the breeding population. Whether productivity decreases over the life-time of individual highly-contaminated individuals will be determined only by continuing research. Whether the shore-nesting birds experience higher mortalities as a result of feeding on Great Lakes fish, as has been suggested (Kozie 1985; Bowerman 1991), is also the subject of continuing investigations.

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Steller's Sea Eagle *Haliaeetus pelagicus*