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Status of the Osprey in Everglades National Park

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INTRODUCTION

Osprey (Pandion haliaetus) populations in various parts of North America decreased during the 1950's and 1960's, primarily because of pesticide contamination, with eastern populations being most affected (Henny and Ogden 1970). These populations are migratory and winter in the West Indies and in Central and South America (Zarn 1974). The Florida population, considered to be non-migratory by Ogden (1978), contained low levels of pesticide contaminates. The major cause of localized population decreases that have taken place in the state has been destruction of habitat (Ogden 1978). These ospreys nest throughout Florida, but nesting birds are less common in northwestern Florida and rare around the Gulf of Mexico (Ogden 1978). Nesting near bodies of water such as lakes, rivers, and coastal areas, breeding ospreys are particularly common along the St. Johns River, in Ocala National Forest and in Everglades National Park. The status of a major segment of the latter population was documented between 1968 and 1974 by Ogden (1975, 1977). He conducted aerial surveys in Florida Bay in the late 1960's and early 1970's and measured nesting effort and productivity on three islands. He concluded that the Florida Bay osprey population was stable (Henny and Ogden 1970) and, on the three study islands, that the number of ospreys and percentage of successful nests remained approximately constant over five years (Ogden 1977).

The stated purpose of the previous study was to provide a base line for monitoring the status of the osprey population in Florida Bay and by extension the ecological well-being of the Florida Bay ecosystem (Ogden 1977). Ten years after the initiation of that study, we began a three-year study of population status to determine whether population changes had occurred in the interim. Concurrently Poole (in prep.) restudied productivity on the same three islands on which Ogden did his work. In this paper we analyze the nesting population of osprey in southern Florida during the breeding seasons of 1978-1980 and compare our findings to those of the previous study. We conclude from this analysis that a substantial decrease has occurred in the number of ospreys nesting in Florida Bay.

METHODS

The nesting population of ospreys in Everglades National Park was censused by air during the breeding seasons ending in 1978, 1979, and 1980. For analysis, the survey area was divided into these three reigons: Florida Bay, Whitewater Bay, and the Gulf Coast (Fig. 1). Florida Bay included all islands (called keys) and the adjoining coast; Whitewater Bay included surrounding rivers, bays and lakes; the Gulf Coast included the Ten Thousand Islands and inland bays and rivers north to Everglades City. Our data did not include the mainline Florida Keys or the lower Atlantic Coast and bays.

We used fixed-wing aircraft to locate nest sites in January 1978; February-March 1979, and February 1980. Flights were conducted at an altitude of 60 m in a Lake amphibious aircraft. The total survey time was 15-20 hours per year. For each nest site we recorded the condition of the nest, the number of eggs, young and adults present, and the activity of occupying birds. All potential nesting areas were searched. In the first year, nests were located exactly and numbered

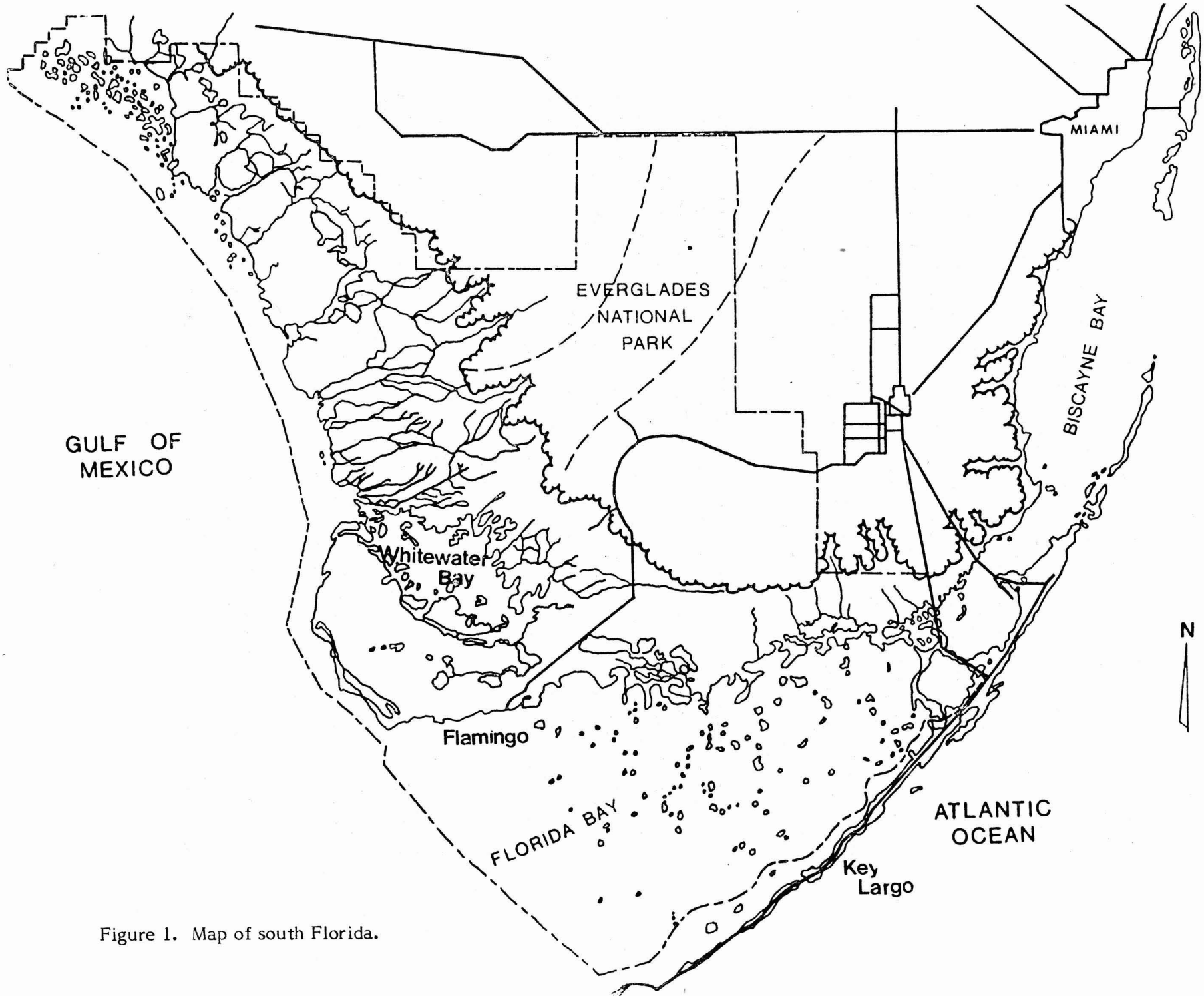

Figure 1. Map of south Florida.

consecutively for each region on detailed Florida general highway maps of Monroe, Dade, and Collier Counties (Appen. I, A-C). These were then used to relocate sites during subsequent surveys. We attempted to observe previously occupied sites carefully and those not occupied in subsequent surveys were noted (Appen. II). We used helicopters to determine the number of young per successful nest in Florida Bay. We flew at an altitude of 50 m and recorded the number of young per nest for all nests in March-April 1978, and in April 1979 and 1980.

We classified nests as being occupied if eggs or young were present, if adults were at the nest or nearby, or if the nest was clean, lined, or otherwise showed signs of being recently reworked. These are the same criteria used by Ogden in his surveys and seem to include nests that were early failures. Nests were classified as being unoccupied if none of these criteria was met. Henny and Van Velzen (1972) estimated that 5 to 10% of the nests in their surveys were occupied by non-breeding birds. Thus, extrapolating the number of breeding pairs from the number of occupied nests counted will include some birds that did not actually breed that year. Our census data are the number of occupied nests.

For the three study islands near Flamingo we had an independent ground count of the number and location of nests in 1979 (Poole pers. comm.). This permitted calculation of a visibility factor, which was used to adjust the aerial counts. We follow Henny et al. (1974) in using $N = n_1 n_2/m$, where N is the estimated population of occupied nests, n_1 is the number of specific nests located by aerial census, n_2 is the number of specific nests located by ground census, and m is the number of specific nests located by both methods. In the present study, the visibility factor was 1.33, which we used to correct census data. Although it is possible that visibility factors might differ in different parts of southern Florida or under different nest dispersal patterns, we are unable to evaluate any such differences and so report the total nesting population as corrected by this factor. We express total counts as $\bar{x} \pm SD$.

We also analyzed population trends by making use of data obtained during Christmas counts near Flamingo and upper Florida Keys. These data, published in American Birds, are expressed as the number of birds per party hour.

RESULTS

Nesting Population

In our three years of aerial censuses, we found an average of 188 ± 13.1 osprey nests in Florida Bay, Whitewater Bay, the Gulf Coast, and adjacent mainland (Table 1). Applying the correction factor, we estimate the total population to be 249 ± 17.6, or about 250 nesting pairs.

Most nests were located in Florida Bay (Table 1), where we counted an average of 102 ± 7.3 nests per year, giving an estimated population of 136 nesting pairs. Fewer nests were found in Whitewater Bay or along the Gulf Coast. Nests in Florida Bay were more abundant in the eastern than in the western portions of the bay. Over the census period, 62% of the nests were in the eastern bay (Table 2).

Table 1. Number of active osprey nests counted in aerial censuses in 3 areas, and the estimated breeding population.

	Florida Bay	Whitewater Bay	Gulf Coast	Total Nests Counted	Estimated Breeding Pairs[1]
1968	195				
1973	222				
1978	111	16	44	171	227
1979	102	38	63	203	270
1980	93	33	63	189	251

[1]Population estimated by applying visibility index following Henny and Van Velzen, 1973

Table 2. Statistics on the number of osprey nests and occupied islands and island groups in Florida Bay during surveys in 1968 and 1973, and comparable surveys in 1978-80. See Figure 1 for locations of areas considered.

	1968	1973	Mean	1968	1979	1980	Mean
Occupied islands - eastern bay	32	34	33	33	31	28	31
Occupied islands - western bay	22	23	23	13	12	12	12
Occupied islands	54	57	56	45	44	40	43
Islands deserted from previous year	-	5		17	1	5	
Number of nests - eastern bay	91	108	100	72	65	53	63
Number of nests - western bay	104	114	109	39	37	40	39
Number of nests counted	195	222	209	111	102	93	102

The numbers of occupied nests differed in the three years of the study, decreasing in Florida Bay but increasing on the Gulf Coast. The latter increase was due to better censuses in later years, as we spent more time covering the area. The apparent loss in Florida Bay was not due to differences in censuses and suggests to us a decreasing trend of 16% over the study period. Because of the studies of Poole and Ogden, the numbers of nests on three islands near Flamingo, Murray, Palm, and Frank Keys are of particular interest. We found 18 nests on these islands in 1978, 17 in 1979, and 18 in 1980 (Table 3), an approximately stable situation.

Ospreys seem to move nesting sites frequently (Table 4). A minimum estimate of such site switching is provided by the number of specific sites that contained nests one year but were empty the next year. The percentages of the previous year's nest sites that were definitely unoccupied the following year were 27% in 1979 and 42% in 1980. Because of the difficulty of determining nest sites precisely, we were unable to determine the fate of many nest sites. Based on these data, we suspect that about one third of nest sites are switched each year.

Nest Sites

Osprey nests were closer together in Florida Bay than in other regions surveyed. From one to seven nests were found per island (key), with some nests situated less than 50 m apart. We found nests in both dead and living trees, including black mangrove (Avicennia germinans), red mangrove (Rhizophora mangle), and buttonwood (Conocarpus erectus). Storm-killed black mangrove snags were also used. Osprey often nest on man-made structures, and Henny et al. (1974) found 68% of the osprey nests in Chesapeake Bay on artificial supports. Few suitable artificial structures are available in the study area, and only one such nest site was found. Most nests were placed one to seven meters above ground and were most often on top of the supporting vegetation. We found two nests on the ground.

In the Whitewater Bay region, nests were located along rivers and bays, and on mangrove-covered islands. The largest concentrations of nests were near Ponce de Leon Bay on the mangrove-lined islands, which contained over 60% of the nest sites in the region. In Whitewater Bay, nests were spaced farther apart than in Florida Bay, with the nearest nests being more than 150 m apart. Black and red mangroves were the most frequently used living trees, but most (60%) of the nests in this region were placed in the tops of dead snags. Nests were 6-12 m above ground.

Ospreys nesting along the Gulf Coast were concentrated at the mouths of rivers, and in the Ten Thousand Islands. Only eight nests were found around the inland bays, where they were spaced widely, more than 1 km apart. On the Gulf Coast, ospreys nested most commonly on the tops of black and red mangrove trees 3-12 m tall. Dead snags were used frequently.

Population Trends

To examine trends in the numbers of ospreys present, we analyzed two sets of Christmas count data (Fig. 2). These counts are centered near Flamingo in western Florida Bay and on the upper Florida Keys in eastern Florida Bay. The longest

Table 3. Number of osprey nests and their productivity on Murray (M), Palm (P) and Frank (F) Keys, Florida Bay. Data for 1968-74 from Ogden (1975) which differs from those provided in Table 4 (Ogden pers. comm.). Productivity for 1978 and 1980 from Poole (in prep.). ND indicates no data are available.

	Active Nests				Young/Active Nest			
	M	P	F	Total	M	P	F	Total
1968	11	25	15	51	0.90	1.20	0.80	1.02
1969	10	24	15	49	1.30	0.83	0.80	0.92
1970	10	23	14	47	1.20	0.60	0.78	0.78
1971	11	25	19	55	1.18	0.76	0.57	0.78
1972	11	24	18	53	0.36	0.70	1.10	0.77
1973	9	21	13	43	0	0.09	0.46	0.16
1974	6	20	12	38	1.16	1.30	0.91	1.15
1978	4	7	7	18	ND	ND	ND	ND
1979	4	6	7	17	ND	ND	ND	ND
1980	4	7	7	18	ND	ND	ND	ND

Table 4. Number of occupied nests on each occupied island in Florida Bay for 1968, 1973, and 1978-1980. Data for 1968 and 1973 provided by Ogden (pers. comm.). Areas of the bay are east (E) and west (W), see Figure 1.

	Area of Bay	1968	1973	1978	1979	1980
Blackwater Pass	E	-	-	1	1	1
Boggies-Little Buttonwood Sound	E	8	8	2	1	2
Bob Allen Keys	E	-	-	1	1	1
Snipe Point	E	1	1	1	1	0
Whaleback Key	E	1	1	0	0	0
Swash Keys	E	4	3	5	3	3
Butternut Key	E	3	1	2	2	1
Nest Keys	E	1	2	1	1	1
Duck Key	E	1	0	0	0	0
Deer Key	E	0	1	1	1	0
Tern Keys	E	3	3	3	3	2
Eagle Key	E	1	2	0	0	0
Pass Key	E	1	2	2	2	2
Lake Key	E	1	2	3	3	3
Bob Keys	E	3	5	4	4	3
Bottle Key	E	0	5	2	1	1
Low Key	E	0	2	1	1	1
Stake Key	E	2	3	3	3	2
Manatee Keys	E	5	5	6	6	3
Crane and East Keys	E	7	6	2	2	2
West and Crab Keys	E	9	10	3	3	2
Captain Key	E	2	1	0	0	0
Jimmie Channel Key	E	4	5	2	2	3
Russell Key	E	2	2	0	0	0
Black Betsy Keys	E	6	3	1	1	1
End-Buttonwood Keys	E	0	1	1	1	0
Calusa Key	E	0	1	1	1	1
Foxtrot Keys	E	1	2	4	3	3
Coon-Whipray Keys	E	1	2	0	0	0
Corinne Key	E	0	1	1	0	0
Spy Key	E	1	0	0	0	0
Gopher Keys	E	2	2	1	1	0
Twin Keys	E	2	2	0	0	0
Peterson Keys	E	3	4	2	2	2
Buchanan Keys	E	4	7	5	3	2
Green Mangrove Key	E	1	1	1	1	1
Barnes Key	E	5	6	4	4	4
Arsnicker Keys	E	4	6	4	4	3
Sid Key	E	1	0	0	0	0
Park Key	E	0	0	0	0	1

Table 4: continued

	Area of Bay	1968	1973	1978	1979	1980
Keys south of Park Key	E	0	0	1	1	0
Madeira Bay	E	0	0	1	1	1
Trout Creek	E	0	0	1	1	1
Rabbit Keys	W	3	3	2	2	2
Dead Terrapin Key	W	0	1	1	0	0
Jim Foot Key	W	1	1	1	1	1
Roscoe Key	W	3	2	0	0	0
Dump Keys	W	1	0	0	0	0
Derelict Key	W	1	0	0	0	0
Umbrella Key	W	1	2	0	0	0
Rankin Key North	W	7	10	6	6	6
Camp Key	W	3	3	0	0	0
Buoy-Little Buoy Keys	W	4	5	1	1	1
Curlew Key	W	2	2	2	2	4
Cormorant Key	W	1	2	0	0	0
Key east of Pelican Keys	W	1	1	1	1	1
Pelican Keys	W	5	4	0	0	0
Dildo Key	W	3	3	0	0	0
Johnson Key	W	1	3	0	0	0
Man-O-War Key	W	1	1	0	0	0
Cluett Key	W	0	3	1	1	1
Sandy Key	W	1	4	3	3	3
Catfish Key	W	1	1	0	0	0
Oyster Keys	W	0	2	0	0	0
Murray Key	W	13	12	4	4	4
Frank Key	W	15	18	7	7	7
Palm Key	W	32	27	7	6	7
Clive Key	W	4	4	3	3	3

record, 31 years, is from Flamingo, an area that includes the densely occupied islands studied by Ogden and Poole. The populations in the late 1960's and early 1970's were higher than before or after and have decreased in both areas since the 1970's. During the late 1960's and early 1970's these islands were censused by Ogden, who was conducting his nesting study at the time. However, the high levels were reached in 1963, before Ogden began his work and, as a result, it does not seem that the high population index was due only to his attentiveness. The lower population levels of the 1950's may reflect actual numbers present or less intensive coverage, which of these is the case is not known. We can, however, tentatively conclude that a decrease in osprey numbers from the 1960's to the 1970's is indicated by these data. There is also a suggestion that the decrease may be part of a decade-long population cycle. Too few years are present to be sure. Osprey numbers along the Florida Keys, and eastern Florida Bay show a similar trend in fluctuation over the same period of time (Fig. 2). These data indicate that loss of osprey in the western bay was not compensated by increases along the upper Florida Keys or eastern bay. It appears that an overall decrease in the number of osprey has occurred throughout Florida Bay.

Nesting Success

Unlike the migratory northern osprey populations that nest in spring and summer, ospreys in Everglades National Park breed in winter and spring. In Florida Bay, egg laying occurs between late November and March with most fledging in April and May. Ogden (1978) reported that clutch sizes for ospreys in Florida Bay were from one to four eggs. Although sizes of final clutches could not be determined from our infrequent census data, we found a similar range, one to three eggs, in the nests we censused.

Where possible, we attempted to use a helicopter to count large young in nests to determine the number of young fledged per successful nest. We found from one to three young fledged per successful nest, averaging 1.5 (n = 75) over three years in Florida Bay 1.7 (n = 29) in 1978; 1.4 (n = 32) in 1979; 1.4 (n = 14) in 1980). This average is similar to that, 1.6 young per successful nest, found by Ogden in 1968-1971. Poole (in prep.) found 1.1 and 1.2 young fledged per successful nest on Frank, Murray, and Palm Keys in 1979 and 1980. Such data provide an index useful in year-to-year comparisons but fail to account for unsuccessful nests and so are not a fair measure of population productivity. Ogden (Table 3) found an overall productivity of 0.80 osprey/active nest during 1968-74. Poole (pers. comm.) indicated that his data were 0.50-0.75 osprey/active nest during 1978-1980, which he considers to be comparable to Ogden's.

Pesticides

Certain osprey populations, beginning in the 1950's, suffered decreases because of the effects of pesticide accumulation (Ames 1966, Wiemeyer et al. 1975, Spitzer et al. 1978). These decreases were later reversed (Spitzer and Poole 1980). The most recent analysis of pesticides in ospreys in southern Florida was conducted on eggs collected in 1971. Concentrations of organochloride pesticides tested were low (Ogden 1977).

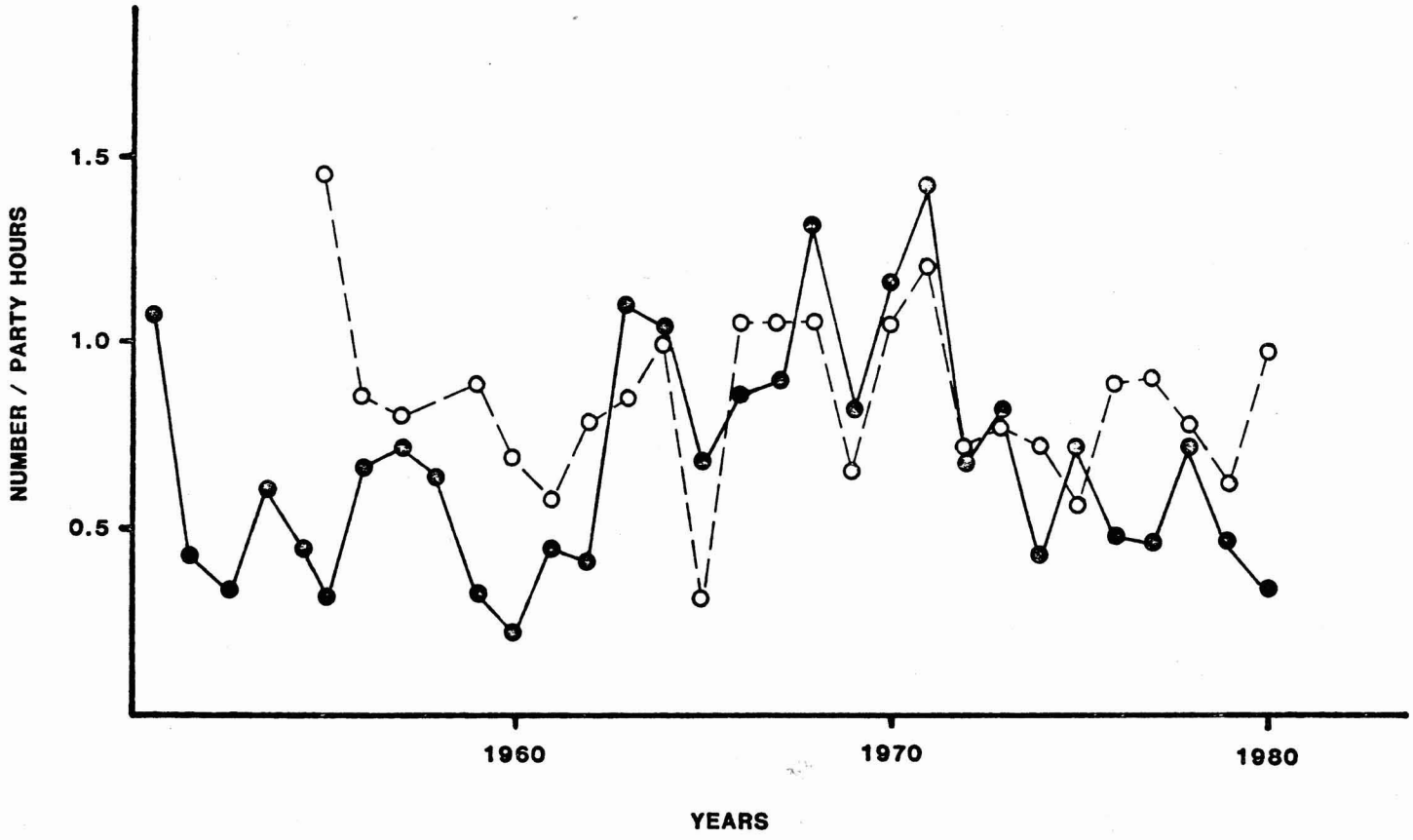

Figure 2. Trend of wintering osprey as revealed by Christmas count data. The population is indexed by the number counted per party hour. Solid line is from the Coot Bay Christmas Count near Flamingo, Florida, Everglades National Park. The dotted line is from the Key Largo-Plantation Key Christmas Count on the upper Florida Keys.

DISCUSSION

Based on our study, our best population estimate is 250 nests in the early 1980's. Based on his study of ospreys in Florida Bay in the early 1970's, Ogden concluded that the population was stable (Henny and Ogden 1970, Ogden 1977). His estimate of the breeding population is not directly comparable to ours because he did not correct his counts for visibility and only censused Florida Bay. To compare these data, we constrast the number of nests we counted in Florida Bay, without correction, with the number counted by Ogden. Ogden (pers. comm.) conducted three aerial censuses, but he indicated that the survey of 1969 was incomplete. This leaves data from surveys in 1968 and 1973 to be compared to our own. Unfortunately, several interpretations of the previous data exist. One (Ogden 1970) was preliminary in nature and was not meant for publication (Ogden pers. comm.). The numbers in that report included only nests with adults in residence during the survey rather than all occupied nests (Ogden pers. comm.). The number of occupied nests was reported to be 203 in 1968, and 229 in 1973 in Ogden (1975), using similar criteria to ours to judge occupied nests. Ogden (pers. comm.) has provided us with a more recent interpretation of these data as 195 nests in 1968 and 222 nests in 1973, which he believes to be the figure most representative of the number of breeding pairs. We use this latest interpretation for our comparision. The data Ogden (pers. comm.) has provided also enables us to compare changes in numbers of nests on an island-by-island basis (Table 4).

If we accept our counts for Florida Bay and those of Ogden as being approximately correct and comparable, they indicate an increase in nesting pairs from 1968 to 1973 followed by a decline by 1978, which appears to be continuing (Table 1). From 1973 to 1980, the number of nests fell from 222 to 93, a 58% decrease. An alternative analysis is to compare averages of the two previous censuses, which represent status in the early 1970's, and the average for the last three censuses, which represent status in the early 1980's. According to this comparison, the average number of occupied nests decreased from 209 to 102, or 51%. By either analyses, these data indicate a drastic decline on the order of 19 nests per year or 8.6% of the 1973 population per year since 1973.

We believe this comparison and the indicated decrease to be valid because of the highly comparable nature of the two data bases. The methods, coverage, and aircraft were similar between the two studies. Furthermore both sets of data were based on single late winter censuses. There is no reason to think that nest placement, timing, or visibility has changed between the studies. We also believe all observers were similarly skillful, as all had considerable experience in surveying the same area for nests of eagles and colonial water birds.

To dissect the nature of the decrease we examined changes in nesting status on each island and island group supporting osprey nests in Florida Bay. Table 4 provides a breakdown of the number of occupied nests found on each island in Florida Bay. To see if a pattern of loss appeared, we compared the average number of nests on each island in 1968 and 1973 with similar information from 1978-80. The average number of osprey nests increased on 16 islands, decreased on 48 islands, and remained the same on 4 islands, suggesting the loss was widely spread over the nesting habitat.

We then asked whether particular islands were being deserted by osprey. Osprey deserted five islands (9%) from 1968 to 1973 (2.3%/year), however, seven islands used in 1973 were not used in 1968 for a net gain of two islands occupied. Over the next five years, 17 islands were deserted, or 3.4%/year, and three were added for a net loss of 14 islands. In one year, from 1979 to 1980, ospreys deserted five islands (12.5%/year), three in eastern Florida Bay and two in western Florida Bay and colonized only one. The total number of occupied islands decreased from 57 to 40 from 1973 to 1980 and showed a continued downward trend through the three years of the recent study.

To examine geographical effects, we divided Florida Bay into eastern and western sections. Eastern Florida Bay is characterized by poor circulation and seasonally high salinities affected by upland runoff. Western Florida Bay experiences oceanic influences. The decrease in the number of islands occupied between the two studies was primarily in the western bay (23 to 12 in the west vs. 33 to 31 in the east). Similarly, despite a downward trend, the reduction is not nearly as drastic in the eastern bay in the number of nests counted as in the western bay (70 nests lost vs. 37, 64% decrease vs. 37% (Table 2)). Thus, in both measures the reduction of nesting effort appears more drastic in the western than in the eastern bay. An observation of Ogden (pers. comm.) suggests that birds have moved from one area to the other. He found that an osprey banded as a nestling in the western bay (Murray Key) nested on a key (Tern) in the eastern bay.

Florida Bay islands generally support one to three osprey nests, but it is instructive to examine particular islands on which nesting effort has been more concentrated. We examined the years in the two surveys having the most nests, in order to compare the most favorable seasons. We tallied islands that held more than five nests in 1973, the year with the largest nesting effort (Table 4). Ten islands met these criteria, accounting for nearly half (110/222) of the nests reported that year. These same islands held 36 nests in 1980. This 67% reduction is greater than the 58% decrease in the population as a whole, indicating that the reduction was to some extent concentrated on densely occupied islands. Most of the loss on densely occupied islands occurred on the four heavily populated islands in the western bay, which lost 43 of the 71 nests.

These particularly dramatic reductions included the three heavily populated western islands of Murray, Frank, and Palm Keys studied by Ogden (1975) and Poole (in prep.). For these islands we are able to compare the actual number of occupied nests (Table 2). Over 1968-1974 an average of 48 ± 5.5 occupied nests were located on these islands. Over 1978-1980, 18 ± 0.5 nests were located there. An approximately 63% reduction occurred in the interim. Whereas the aerial census data may be subject to survey error, these data should not, as they are based on both aerial census and field work on the ground.

To examine the cause of the population decrease, we need to consider several aspects of the biology of the Florida Bay osprey population. Obviously, a crucial aspect of population stability is its productivity. Ogden (1975) concluded that interactions with Bald Eagles were one cause of lowered productivity in Florida Bay ospreys. A third explanation might be that the populations may have shifted nest sites. A fourth possibility is that food stress may be occurring. We examine each of these aspects of osprey population biology.

Productivity changes can be analyzed using data from Ogden's and Poole's studies. Ogden's data (Table 3) indicate an annual average productivity of 0.80 young per active nest (n = 7) in the early 1970's; Poole found 0.50-0.75 young per active nest in the late 1970's. Although the latter data may be biased by his not locating nests early in the season, correction for such early failures would reduce Poole's productivity estimate further. Based on his first five years of data during which he found production of 0.84 young per active nest, Ogden (1977) concluded that ospreys were maintaining stable numbers in spite of the fact that productivity "... is less than the 0.95-1.30 young per active nest calculated by Henny and Wight (1969)" to be required for population stability. Spitzer (Spitzer and Poole 1980) has calculated that 0.79 young per active nest were required to balance mortality and maintain populations in the northeastern United States. In that area productivity from 1975 to 1979 averaged 1.86 young per successful nest and 1.08 young per active nest, much higher than either set of Florida Bay data. Productivity in Florida Bay has been close to or less than that required for stability by northeastern osprey populations. Both Ogden (1977) and Poole (pers. comm.) believed such production is adequate for stabilizing the Florida Bay population, because the birds do not migrate and so probably sustain lower post-fledging mortality. However, no analysis of survivorship has been made to quantify the exact productivity required for stability. It would seem that the productivity found by Ogden and Poole has not in itself resulted in population stability in Florida Bay, in as far as the population has decreased in recent years.

Ogden's (1975) study suggested that low productivity can be caused by interference by Bald Eagles. He concluded that establishment of an eagle nest caused a reduction in nesting success and nest site relocation in neighboring ospreys. He found this occurrence on one island (Murray Key) in one year (1972). To show this, he contrasted nesting success on this island to the average and to that on other nearby islands (data in Table 2) but did not analyze his data statistically. Before examining the possible effects of eagles, it is best to reconsider Ogden's (1975) analyses. To do so, we take the "average" production of young per active nest to be the mean of all years of the study other than the one compared. We find that production for 1968-1971, 1973-1974 was 0.9 ± 0.45 for Murray, 0.8 ± 0.40 for Palm, and 0.7 ± 0.15 for Frank. Although in 1972 production was below the average for Murray and Palm and above average for Frank, in comparing the productivities statistically, we find that production was different only on Frank Key in 1972 contrasted with the six-year mean ($t = 2.11$, $p > .05$). Productivity on Murray and Frank Keys was not different than the mean ($t = 1.15$ for Murray, and $t = 0.18$ for Palm; $p < .05$ for both). Ogden (pers. comm.) in comparing productivity from 1972, prefers to eliminate data from 1973, during which he believed production was low due to local food shortages caused by weather conditions. We find then that production for 1968-1971 and 1974 was 1.1 ± 0.13 for Murray, 0.9 ± 0.27 for Palm, and 0.8 ± 0.11 for Frank Keys. By this analysis, the 1972 production was below average for Murray and Palm Keys and above average for Frank Key. Statistically this analysis confirms Ogden's conclusion that Murray Key had lower production ($t = 5.41$, $p > .05$, one tail). Frank Key had higher production ($t = 2.70$, $p > .05$, one tail), Palm Key was not different than average. Thus a statistical analysis of Ogden's data, excluding 1973 from the average, generally supports his conclusions about the effects of eagles on osprey production on Murray Key.

It is also useful to reconsider the analysis of how eagles affect relocation of nest sites by osprey. Ogden (1975) demonstrated that 62% of osprey nest sites occupied on Murray Key in 1971 were unoccupied in 1972, a figure more than in other years for that key. However, no similar analyses were provided for Frank and Palm Keys in 1972 to discount that the nest site shifts were a phenomenon of the year rather than being related to events on Murray Key. Ogden (pers. comm.) has provided this information. On Palm Key 19 of 24 nests (79%) were again active in 1972, on Frank Key 13 of 18 (72%) were active in 1972. These data confirm the proposition that a high number of nests were moved on Murray Key in 1972.

Thus we need to account for the possibility of the effect of eagles in the present reduction of osprey numbers. However, no shifts of eagle nests occurred on the three islands during the study, and no extensive change in eagle nest numbers or locations has taken place within Florida Bay during the study (Robertson pers. comm.). Thus, we can conclude that interactions with eagles, although potentially disruptive, were not the cause of the widespread population reductions we have found.

Another possible explanation for the osprey population reduction is a shift in nesting sites. It is possible that the densities of osprey found during Ogden's study on the three islands near Flamingo were unusually high. If so, the reduction to current levels may have been a relaxation to densities comparable to other Florida Bay islands. This is supported by one interpretation of Christmas count data from Flamingo, which suggests a long-term cycling of the population size has occurred. However, ospreys characteristically nest in high densities (Spitzer and Poole 1980), and it seems unlikely that the reduction we found throughout the bay was due to abnormally high densities. Lacking survey data from the Gulf Coast and Florida Keys for the earlier period, it is not known whether shifts to those areas have occurred. However, the number of ospreys on the west coast is not enough to account for the loss in Florida Bay. Osprey now appear to nest on artificial structures in the keys more than previously and could have shifted from the bay (Ogden pers. comm.). The Christmas count data for the keys, however, do not indicate such a compensatory shift has taken place.

We are left with a nesting population about 60% below that found by Ogden, that is presently producing at a low rate, which may or may not be adequate to maintain itself. One implication is that environmental conditions are poorer in osprey nesting areas in Florida Bay than five to ten years ago. Because nest sites are fully protected, the cause of poor conditions should be sought in the quality of the feeding habitat. In this respect, Poole (1979 in prep.) has concluded that the nesting ospreys he studied in Florida Bay were food stressed in 1979 and 1980, resulting in brood reduction and unusually high levels of sibling aggression.

Ogden (1977) began his study "to establish ospreys as an indicator species for measuring the ecological well-being of the Florida Bay estuarine ecosystem." Although it has not been conclusively established that ospreys are suitable indicators of ecosystem processes, the possibility that they might be raises questions as to the present viability of their support system. It is important to note however that productivity and numbers of Bald Eagles have remained stable in Florida Bay over the same period (Robertson pers. comm.). The effects of

environmental conditions on the osprey population are thus unclear. The need to study production, survival, and environmental effects on feeding conditions is indicated. The hypothesis that lowered food availability has led to reduced productivity needs to be tested.

RECOMMENDATIONS

Because of the dramatic decrease in the osprey nesting population in Florida Bay, the following is recommended for study:

1. The osprey nesting population data base should be maintained. All nests in Everglades National Park should be located and mapped each year until the population returns to the level of the early 1970's. Nests should also be censused on the Florida keys.

2. To understand the decrease in ospreys in Florida Bay, reproductive success must be determined. This should be done three times during the nesting season: 1) at the beginning of nesting (December); 2) during the peak of incubation of brooding (February), and; 3) when peak number of young are in the nests (March or April). Productivity should be expressed as young per attempted nest and all attempted nestings should be recorded. These evaluations should be done by monitoring individual nests.

3. To assess possible food stress, on-the-ground observations should be made of food and feeding rates at selected nest sites. After nesting season, food remains should be selected from a randomized sample of osprey nests.

4. To further assess possible interference with nesting ospreys by Bald Eagles, monthly checks should be made of activity at osprey nests on all Florida Bay keys shared with nesting Bald Eagles.

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Appendix I: Location of osprey nests in Everglades National Park, 1978-1980. Maps A, B, and C enclosed in pocket at end of report.

Key to maps

A: Florida Bay region with location of nests 1-109, and 113-118.

B: Florida Bay region, with location of nests 89-112. Whitewater Bay region, with location of nests 1-7, and 12-57. Gulf Coast region, with location of nests 1-58, and 96-104.

C: Part 1. Florida Bay region, with location of nests 1, 40, and 43. Whitewater Bay region, with location of nests 8-11.

Part 2. Gulf Coast region, with location of nests 59-95, and 105.

Appendix II: Osprey annual nesting activity record by regions, 1978-80.

Key:

1, 2, 3 . . . = Nest number--number corresponds to that on appropriate regional maps (A, B, and/or C)

O = Occupied nest--a nest with eggs, young and/or adults present, or a nest showing signs of being recently reworked (cleaned, lined etc.).

U = Unoccupied nest--no sign of above mentioned activities.

- = No information available

Appendix II a = Florida Bay Region

Appendix II b = Whitewater Bay Region

Appendix II c = West Coast Region

Appendix II a: Florida Bay Region

Nest No.	1978	1979	1980
1	O	O	U
2	O	O	O
3	O	-	O
4	O	-	O
5	O	O	O
6	O	O	-
7	O	O	O
8	O	-	O
9	O	O	-
10	O	-	-
11	O	O	O
12	O	O	-
13	O	O	-
14	O	-	O
15	O	O	O
16	O	O	-
17	O	O	O
18	O	O	O
19	O	O	-
20	O	O	O
21	U	U	-
22	O	O	O
23	O	O	O
24	O	O	-
25	O	O	O
26	O	O	O
27	O	O	O
28	O	O	-
29	O	O	-
30	-	-	O
31	O	O	O
32	O	U	U
33	U	O	O
34	O	U	U
35	O	O	O
36	O	O	-
37	O	O	O
38	O	O	O
39	O	O	-
40	O	O	O
41	O	-	O
42	-	-	U

Appendix II a: continued

Nest No.	1978	1979	1980
43	O	O	O
44	O	O	O
45	-	-	O
46	O	O	O
47	U	O	O
48	O	O	O
49	O	O	O
50	O	O	O
51	U	O	O
52	O	O	-
53	O	O	O
54	O	O	O
55	O	O	O
56	O	-	O
57	O	O	-
58	O	O	O
59	O	O	O
60	O	U	-
61	U	-	-
62	O	O	-
63	O	O	O
64	O	O	O
65	O	O	O
66	O	O	-
67	O	-	O
68	O	O	-
69	O	O	-
70	O	O	O
71	O	O	O
72	O	O	O
73	O	O	O
74	O	O	O
75	O	O	O
76	O	O	O
77	O	O	O
78	O	O	O
79	O	O	O
80	O	U	U
81	O	O	O
82	O	O	O
83	O	O	O
84	-	-	O
85	O	O	O
86	-	-	O
87	O	O	O
88	O	O	O
89	O	O	O
90	O	O	O
91	O	O	O

Appendix II a: continued

Nest No.	1978	1979	1980
92	O	O	O
93	O	O	O
94	O	O	O
95	O	-	O
96	O	O	O
97	U	U	U
98	O	O	O
99	O	O	O
100	O	O	O
101	O	O	O
102	O	O	O
103	O	O	O
104	O	O	O
105	O	O	O
106	O	O	O
107	O	O	O
108	O	O	O
109	O	O	O
110	O	O	O
111	O	O	O
112	O	O	O
113	O	-	-
114	O	O	O
115	O	O	O
116	O	O	O
117	U	U	U
118	U	U	U

Appendix II b: Whitewater Bay Region

Nest No.	1978	1979	1980
1	O	-	-
2	U	-	-
3	O	-	-
4	O	O	O
5	O	O	O
6	-	O	O
7	-	O	O
8	-	O	O
9	-	O	O
10	-	O	O
11	-	O	U
12	-	O	O
13	-	O	-
14	-	O	O
15	-	O	O
16	-	U	-
17	-	U	U
18	-	U	O
19	-	O	O
20	-	U	-
21	-	U	-
22	-	U	U
23	-	U	-
24	O	-	-
25	O	-	-
26	-	O	O
27	-	O	O
28	O	-	-
29	-	O	-
30	O	O	O
31	-	O	O
32	-	O	O
33	-	O	O
34	-	O	O
35	-	O	O
36	-	O	O
37	-	O	O
38	-	O	-
39	-	O	O
40	-	O	O
41	-	O	O

Appendix II b: continued

Nest No.	1978	1979	1980
42	O	O	-
43	-	O	O
44	-	O	-
45	-	O	O
46	O	O	O
47	O	O	O
48	-	O	O
49	-	U	-
50	-	-	O
51	-	O	O
52	-	O	-
53	O	O	O
54	O	-	-
55	O	-	-
56	O	-	-
57	O	-	-

Appendix II c: West Coast Region

Nest No.	1978	1979	1980
1	-	O	O
2	-	U	U
3	-	O	O
4	-	-	O
5	-	O	O
6	-	O	O
7	-	O	-
8	-	O	O
9	U	U	O
10	-	O	-
11	O	O	O
12	-	O	-
13	O	O	O
14	O	U	-
15	O	-	-
16	-	O	O
17	O	-	-
18	O	-	-
19	-	-	O
20	-	-	O
21	O	-	-
22	O	-	-
23	O	-	-
24	O	-	-
25	O	O	O
26	O	O	O
27	O	-	-
28	-	O	O
29	O	U	U
30	-	O	O
31	-	O	O
32	O	O	O
33	O	O	O
34	-	O	-
35	O	-	-
36	O	-	-
37	O	-	-
38	O	-	-
39	-	O	O
40	O	-	-
41	O	O	O
42	O	-	-

Appendix II c: continued

Nest No.	1978	1979	1980
43	O	-	-
44	O	-	-
45	-	O	O
46	O	-	-
47	-	O	O
48	-	O	O
49	-	O	O
50	-	O	O
51	-	-	O
52	-	-	O
53	-	O	O
54	-	-	O
55	-	O	O
56	O	-	-
57	-	O	O
58	O	-	-
59	O	-	-
60	-	O	O
61	-	O	O
62	-	O	-
63	-	O	O
64	-	O	-
65	-	O	O
66	O	-	-
67	O	O	O
68	O	-	-
69	O	-	-
70	-	O	O
71	-	O	O
72	-	-	O
73	-	-	O
74	O	U	O
75	O	O	O
76	-	O	O
77	-	O	-
78	-	O	O
79	-	O	O
80	-	O	O
81	O	O	O
82	-	O	-
83	O	-	-
84	-	O	O
85	O	O	O
86	-	O	O
87	O	-	-
88	O	O	O
89	O	-	-

Appendix II c: continued

Nest No.	1978	1979	1980
90	O	-	-
91	-	O	O
92	-	O	O
93	-	O	-
94	-	O	-
95	-	O	O
96	-	O	O
97	-	O	O
98	-	O	O
99	-	O	O
100	O	O	O
101	O	-	-
102	-	O	O
103	-	O	O
104	-	O	O
105	-	U	U