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ARTIFICIAL NESTING SITES AND OSPREYS AT OJO DE LIEBRE AND GUERRERO NEGRO LAGOONS, BAJA CALIFORNIA SUR, MEXICO

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Abstract.—Historically the non-migratory Osprey (*Pandion haliaetus*) population at the Ojo de Liebre and Guerrero Negro Lagoons, in Baja California Sur, Mexico, was confined to three small islands. In response to the addition of channel markers, electrical and utility poles and many human-made structures in and around the Lagoons during the 1950s, the Ospreys began nesting on suitable artificial structures. Nesting on artificial structures increased Osprey reproductive success, which caused an increase in Osprey numbers, and the structures themselves influenced nesting distributions. Now, nearly 50% of the Ospreys in the area nest on artificial structures in and around both Lagoons.

LAS ÁGUILAS PESCADORAS Y LOS SITIOS DE ANIDAMIENTO ARTIFICIALES EN LAS LAGUNAS OJO DE LIEBRE Y GUERRERO NEGRO, BAJA CALIFORNIA SUR, MÉXICO

Sinopsis.—Históricamente la población de águila pescadora (*Pandion haliaetus*) no migratoria de las lagunas Ojo de Liebre y Guerrero Negro, en Baja California Sur, México, estuvo confinada a tres pequeñas islas. En respuesta a la adición de torres de señalamiento marítimo, postes de la red eléctrica, y muchas otras estructuras hechas por el hombre dentro y alrededor de las lagunas a partir de los años 1950s, las águilas pescadoras comenzaron a anidar sobre las estructuras artificiales disponibles. El anidamiento en estructuras artificiales incrementó el éxito reproductivo del águila pescadora, lo cual causó un incremento en el tamaño de la población del águila. Asimismo, las estructuras artificiales influenciaron la distribución de las parejas anidantes. Actualmente, cerca del 50% de las águilas pescadoras presentes en el área anidan sobre estructuras artificiales dentro y alrededor de ambas lagunas.

The Osprey (*Pandion haliaetus carolinensis*) has been widely studied in North America over the last two decades (Ames and Mersereau 1964, Henny and Anderson 1979, Henny and Wight 1969), but the non-migratory Ospreys of Mexico (Henny 1977), have received less attention. The historical and current status of this species, as well as aspects of its breeding biology, ecology and conservation needs, are unknown for most of its major coastal populations in Mexico (Castellanos 1983, Henny and Anderson 1979, Judge 1983, Reitherman and Storrer 1981).

The greatest numbers of Ospreys along the northwest Mexican Pacific coast are in the Gulf of California and the Baja California Peninsula (Henny and Anderson 1979). One of the most important breeding areas on the west coast of Mexico is the Ojo de Liebre (Scammon's) and Guerrero Negro Lagoons (Henny and Anderson 1979).

Historically, about 25–30 Osprey pairs nested in the Ojo de Liebre Lagoon (Jehl 1977, Kenyon 1947). In 1946, the ground-nesting Osprey population in the area was restricted to three small islands inside the Ojo de Liebre Lagoon (Kenyon 1947). This population remained stable until the

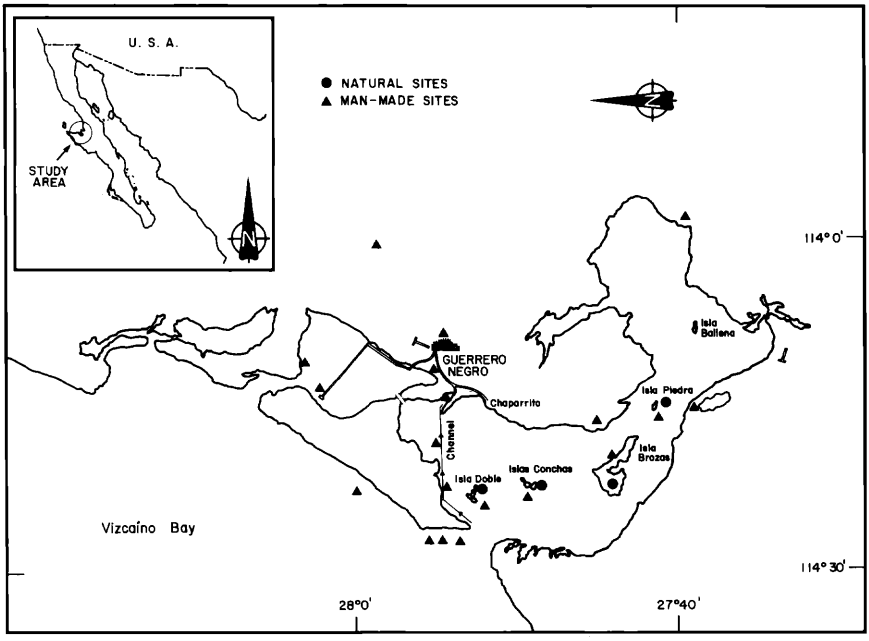

FIGURE 1. Location of the Ojo de Liebre and Guerrero Negro lagoons, B. C. S., México. The main Osprey nesting sites are marked.

early 1970s (Jehl 1977). As a consequence of the establishment of a salt production company in the 1950s, however, the pristine conditions of the lagoons and vicinity began to change. The Osprey habitat was modified by the addition of channel markers, towers, electrical and utility poles and many other artificial structures, which proliferated in the area. As with northern populations (Henny et al. 1974), the Ospreys quickly responded to these changes and opportunities. Nests began to be constructed on artificial structures and, after several years, the Ospreys were accepted by the local community and became one of the symbols of the area.

The purpose of this report is to present a description of Osprey population status and its responses to habitat alterations at Ojo de Liebre and Guerrero Negro Lagoons, Baja California Sur, Mexico. We discuss productivity rates as well as the influence of artificial nesting sites on the Osprey's present population size and distribution.

STUDY SITE AND METHODS

Ojo de Liebre and Guerrero Negro Lagoons are located on the west coast of the middle Baja California Peninsula (27°37′–28°05′N, 113°55′–114°19′W) (Fig. 1). Both lagoons comprise about 500 km^2, with depths of 6–12 m, and are surrounded by dunes, natural and artificial brine pans

and salt flats, saline marshes, and the Vizcaino Desert flats. The vegetation of the zone is mainly halofitic, no higher than 30 cm. Inside Ojo de Liebre Lagoon, there exist five small islands and several channel markers and towers. These lagoons have been considered one of the most beautiful, pristine and productive areas in the world (Bostic 1975), offering favorable habitats for a great number of wintering waterfowl and resident shore and marine birds.

During 1980, 1981, 1982 and 1993, we located all the occupied Osprey nests by boat and ground surveys. Each nest was checked 6–14 times between late November and late June each year. Nest categories were defined in accordance with Postupalsky (1977); productivity was based on active nests (Henny and Van Velzen 1972) of known outcome. Population rates of increase, estimated on the basis of an initial count and a recent count, were determined following procedures recommended by Caughley (1978). Statistical analyses followed Fowler and Cohen (1989).

RESULTS AND DISCUSSION

Nest arrangement.—In the breeding season of 1993, we found 126 occupied Osprey nests. Four islands in the Ojo de Liebre Lagoon contained 67.4% of the breeding pairs. In addition, 32.5% of occupied nests were located outside the islands. Piedras was the island with the most occupied nests, followed by Alambre (Brozas), Conchas and Zacatoza (Doble). Outside the islands, breeding pairs were concentrated at the navigation channel El Chaparrito, and inland in the Geurrero Negro town and the industrial zone El Chaparrito. There were also five sites, each with one pair, scattered in the study area (Fig. 1, Table 1).

Population changes from 1946 to 1993.—Between 1946 and 1993, the number of breeding pairs at the study area increased 366%. Two phases can be identified in these changes, however. First, from 1946 to 1971, when the population went from 27 to 30 pairs (Jehl 1977, Kenyon 1947). Second, from 1971 to 1993, when the population increased to 126 pairs (320%). Changes during these 47 yr are summarized in Table 2.

When compared with the Osprey's distribution from 1946 (Kenyon 1947) to the early 1970s (Jehl 1977), the pattern of occupancy existing during 1980–1982 shows that (1) Piedras Island was reoccupied as an important nesting area (Table 1), (2) the number of nests on Conchas Island was greater than previous reports, and (3) an increasing number of nests were built on artificial structures in and around the Lagoons. Comparing the 1993 pattern of areas/occupancy with that of the early 1980s, the number of ground-nesting breeding pairs on the islands is similar in both periods (62 vs. 68 respectively, $\chi^2 = 0.1922$, $P > 0.05$) (Table 1). Conchas Island, however, now has fewer occupied ground nests than in 1982 (35 vs. 3, $\chi^2 = 25.28$, $P < 0.01$). Also, Piedras Island, had almost twice the number of ground nests, in 1993 as in 1982 (51 vs. 27, respectively, $\chi^2 = 6.78$, $P < 0.01$) (Table 1).

Osprey numbers and artificial nest sites.—During 1993, 58 occupied nests, nearly one-half of the population, were supported by artificial structures,

TABLE 1. Osprey breeding pairs and types of structure supporting nests in the Ojo de Liebre-Guerrero Negro lagoons and vicinity, during 1993.

Area	# breeding pairs		Types of structure used by breeding pairs during 1993					
			Artificial				Natural	
	1993	1982	Platforms[a]	Electrical poles[b]	Channel markers	Other[c]	Ground	Shrub
Islands								
Piedras	55 (51)[d]	31 (27)	2	—	—	2	23	28
Conchas	13 (3)	39 (35)	10	—	—	—	3	—
Zacatosa	1	3	1	—	—	—	—	—
Alambre	16 (14)	0	2	—	—	—	7	7
Total Islands	85 [67.4][e] (68)	73 (62)	15	—	—	—	33	35
Outside islands								
Chaparrito Channel	13	10	—	—	11	2	—	—
Town and Inland	28	3	11	15	—	2	—	—
Total outside islands	41 [32.5]	13	—	—	—	—	—	—
Total	126 (68)	86 (62)	26 [20.6]	15 [11.8]	11 [8.6]	6 [4.7]	33 [2.61]	35 [27.7]

[a] Constructed specifically as land elevated nesting sites.
[b] Includes two poles modified with platforms over the electric wires.
[c] Includes over-water and coastline markers.
[d] Number in parentheses indicates pairs nesting on natural sites.
[e] Number in parentheses indicates percent of total.

TABLE 2. Osprey breeding pairs and artificial nest sites on the Ojo de Liebre-Guerrero Negro lagoons and vicinity, during 1946 to 1993.

Year	# pairs	# breeding pairs		% pairs on structures	% population increase
		Artificial sites	Natural sites		
1946[a]	27	—	27	—	—
1971[b]	30*	—	30	—	11.1
1977[c]	50*	NA	NA	NA	66.6
1980	71	13	58	18.3	42.0
1981	76	16	60	21.0	7.0
1982	86	24	62	27.9	13.1
1993	126	58	68	46.0	46.5

* Indicates data estimated by the authors.
[a] Kenyon (1947).
[b] Jehl (1977).
[c] Henny and Anderson (1979).
NA = not available.

including: nest platforms (on poles or small size towers), electrical poles (some adapted with a platform above the electric wires), navigation lights (channel markers above the water or land elevated along the shoreline), a highway signal, two ship-wrecks and other structures. Nest platforms and electrical poles were most frequently used, followed by channel markers (Table 1).

During 1946, the 27 ground-nesting Osprey pairs were confined to three small islands inside Ojo de Liebre Lagoon (Kenyon 1947). In the early 1970s Ospreys were still ground-nesting and confined to the islets in Ojo de Liebre Lagoon. In 1977 when the first Osprey nests were observed outside the islands, 27 of 50 estimated pairs were nesting on the ground. The others were on channel markers and other structures including debris that washed ashore. Some were along the coastline outside the Ojo de Liebre Lagoon (Henny and Anderson 1979). Nest platforms were constructed on three islands at the beginning of the 1982 breeding season, four at Conchas, six at Piedras and four at Zacatoza. Eleven platforms were quickly occupied by Ospreys (A. Castellanos, pers. obs.). In total, during 1982, 24 occupied nests were located on artificial structures both in and around the islands. These 24 nests represent 27.9% of the total pairs counted in the whole area (Table 2).

Between 1982 and 1993, the number of occupied nests on artificial structures in the islands increased 54.5%, and off the islands 215%. The Osprey population expanded and grew between 1971 and 1993, and this seems to be associated with the availability and use of artificial nesting sites (Table 2).

Nesting success and productivity rates.—There do not exist any productivity records for the whole Osprey population at the study area prior to 1980. Productivity rates were obtained, however, for 3 yr in the early 1980s and for 1993.

In 1980–1982 the Osprey population productivity varied between 0.52 and 0.89 young/active nest (Table 3). The 3-yr productivity was 0.69 young/active nest, which is consistent with productivity reports of other non-migratory Osprey populations in the region (San Ignacio Lagoon 0.88, 0.43 young/active nest according to Reitherman and Storrer (1981, 1982); Bahía de Los Angeles according to Judge (1983), 0.90 young/active nest). During 1980–1982, the productivity of nests at artificial sites was significantly greater than that observed at natural sites ($\chi^2 = 20.94$, $P < 0.01$) (Table 3). Although the number of nests on artificial structures was only 29% of the total active pairs (Table 4), they produced nearly one-half of the young fledged in the 3 yr (Table 3). Our 1980–1982 yearly production rate estimates were lower than the productivity rates suggested by Henny and Wight (1969) and in 2 of the 3 yr even lower than the Spitzer et al. (1983) estimate to maintain a stable population in eastern North America, but those nesting on artificial structures were within or above the normal average. During 1982, Ospreys quickly accepted the nests platforms constructed on the islands. Of 14 platforms erected, 11 were occupied and 10 of these were active, producing 13 fledglings, 33.3% of the total young produced in the area. The proportion of young produced from nests built on artificial structures in 1982 represents 74.3% of the total fledglings produced (Table 3).

During the period 1980–1982 the proportion of successful nests on artificial sites was higher than in natural sites. These differences were statistically significant ($\chi^2 = 17.38$, $P < 0.01$) (Table 4). The average number of fledglings produced per successful nest was very close in both sites (Tables 3, 4). Total failure (the loss of whole clutches or broods) rates of nests in natural sites were higher than in artificial structures. Poole (1989a, b) reported that in some regions of North America, Osprey nests on natural nesting sites exhibit a higher vulnerability to effects of windstorms and predation and consequently greater total failures compared with nests on artificial sites. In the Ojo de Liebre Lagoon, coyote predation on ground-nesting Ospreys has been documented (Castellanos 1983, Henny and Anderson 1979, Kenyon 1947). There are also previous reports of frequent Osprey nest destruction on Conchas and Zacatosa Islands by high-tides and storms (Castellanos 1983, pers. obs.). Thus, the greater percentage of total failures observed on Osprey nests at natural sites could be attributable to the vulnerability of ground nesting sites to high-tides, storms and land predators.

During the 1993 breeding season, 112 young were reared for a productivity rate of 1.28 young/active nest, which is higher than the 1980–1982 productivity for the study area. This particularly high productivity seems to be the result of more breeding pairs than in the early 1980s and higher productivity of ground nests (most of them on two small islands well protected against high-tides) than previously reported. In 1993, the percentage of nests on natural sites that failed totally was similar to the percentage of such failure nests on artificial structures (32.6 vs. 36.5%,

TABLE 3. Osprey production on the Ojo de Liebre-Guerrero Negro lagoons and vicinity.

Year	# young produced			Average young produced per active nest			Average young per successful nest
	Artificial sites	Natural sites	Total	Artificial sites	Natural sites	Total	
1980	11 (45.8)[a]	13 (54.1)	24	0.91	0.38	0.52	1.33
1981	14 (28.5)	35 (71.4)	49	1.07	0.83	0.89	1.81
1982	29 (74.3) 54*	10 (25.6) 58*	39 112*	1.31 [1.14][b]	0.25 [0.50]	0.63 [0.69]	1.69
1993	53 (47.3)	59 (52.6)	112	1.29	1.28	1.28	1.96

* Indicates total numbers of young produced between 1980 and 1982.
[a] Number in parentheses indicates percent of total.
[b] Number in parentheses indicates 1980–1982 productivity.

TABLE 4. Osprey active nests and nest sites utilization on the Ojo de Liebre-Guerrero Negro lagoons and vicinity.

Year	# active nests			Successful nests		Failed nests	
	Artificial sites	Natural sites	Total	Artificial sites	Natural sites	Artificial sites	Natural sites
1980	12	34	46	8 (66.6)[a]	10 (29.4)	4 (33.3)	24 (70.5)
1981	13	42	55	7 (53.8)	20 (47.6)	6 (46.1)	22 (52.3)
1982	22	39	61	17 (77.2)	6 (15.3)	5 (22.7)	33 (84.6)
1980–1982	47	115	162	32 (68.1)	36 (31.3)	15 (31.9)	79 (68.7)
1993	41	46	87	26 (63.4)	31 (67.3)	15 (32.6)	15 (32.6)
1980–1993	88	161	249	58 (65.9)	67 (41.6)	30 (34.1)	94 (58.4)

[a] Number in parentheses indicates percent of active nests.

respectively, $\chi^2 = 0.155$, $P > 0.05$) and lower than that observed in 1980–1982 (68.7% vs. 31.9%, respectively, $\chi^2 = 17.05$, $P < 0.01$) (Table 4).

When taking in account the 4 yr of study, productivity became closer (0.89 young/active nest) to the production rates proposed by Henny and Wight (1969) or even slightly higher than the productivity rate (0.80 young/active nest) suggested by Spitzer et al. (1983) as sufficient to maintain a healthy migratory Osprey population in eastern North America. Also, the 4 yr showed an increasing number of active nests, higher productivity and a greater percentage of successful nests yearly on artificial sites than on natural sites. Both sites had similar productivity per successful nest, but natural nesting sites experienced higher total failure rates (58.7% vs. 34.1%, respectively, $\chi^2 = 12.46$, $P < 0.01$) (Table 4).

Habitat changes and conclusions.—The occupation and use of artificial structures and nest platforms by the Osprey in North America is well documented in the literature (Poole 1989b, Reese 1970, Rhodes 1977, Westall 1983). Ospreys in Mexico, however, are mainly coastal breeders, occupying uninhabited and frequently inaccessible islands or coasts (Henny and Anderson 1979, Kenyon 1947). Thus, the image of the Osprey as a bird found close to towns and houses (Bent 1937, Poole 1989b) is less common in Mexico than in northern populations.

The Ojo de Liebre and Guerrero Negro Lagoons and vicinity were still in pristine condition during the 1940s and early 1950s (Kenyon 1947, Leopold 1977, Saunders and Saunders 1981). In 1953, however, a salt production company was established in the area. In the following decades the habitat was modified by the creation of a small town (Guerrero Negro), and an industrial area and navigation channel with the accompanying channel markers, tower, highway signals (1970s), and utility poles (1980s). Some of these structures were quickly invaded by Ospreys. In 1982 nest platforms were erected on three islands in Ojo de Liebre Lagoon to prevent coyote depredation and high-tides related nests destruction. More platforms were provided in 1984 on islands and inland

through utility pole modification and tower construction by a government electrical agency and salt production companies.

Osprey productivity rates in this area for 2 of the 4 yr of the period analyzed have been below the level required for healthy northern migratory populations; however, the increasing number of breeding pairs registered in the last 47 yr suggests that the population is reproducing at a rate sufficient to maintain and even increase this southern nonmigratory population. The ground nesting pairs on the islands have remained quite stable during the last 13 yr, which suggests that these islands probably have reached their maximum ground-nest density.

Other Osprey populations in the region (Cedros Island, San Ignacio Lagoon, Bahía de Los Angeles) are at a distance of 115–430 km from Ojo de Liebre and Guerrero Negro Lagoons. These distances, the low frequency of long-distance dispersion exhibited by Ospreys from other areas in North America (Henny 1977, 1983; Spitzer et al. 1983), the nesting site fidelity characteristic of the species (Poole 1989b), and the fact that Ospreys banded during the early 1980s at San Ignacio Lagoon (Reitherman and Storrer 1981, 1982), which also have increased over the last 13 yr, have never been detected in the study area, suggest that immigration is not causing the population increase at Ojo de Liebre and Guerrero Negro Lagoons. The population increase seems to be determined by local reproduction and local conditions.

Our analysis shows that the Ojo de Liebre and Guerrero Negro Lagoons Osprey population adapted well to some of the human-induced habitat alterations in the area, specifically to the offering of artificial nesting sites. Up to now, we have established that the productivity rates have been sufficient to increase the Osprey population size and distribution at the Ojo de Liebre and Guerrero Negro Lagoons, and that such increase is, at least in part, attributable to the availability of suitable artificial nesting sites where production is higher than at nests on natural sites.

In spite of the currently healthy condition of the Osprey population at the Ojo de Liebre and Guerrero Negro Lagoons, an area of the federal "El Vizcaíno" biosphere reserve, more information on Osprey reproductive biology and nesting ecology is needed to protect the species in the area. The establishment of a considerable number of Osprey nests on utility poles, towers in the town and industrial area, has produced an environment for further study. We recommend conducting studies to determine the impacts on Osprey reproductive success of: (1) felling of young and nests due to wind; (2) electrocution of adult Ospreys; (3) increasing human activities. This information will be useful in responding adequately to Osprey conservation needs and to institute the appropriate protection measures.

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