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# REGION-WIDE TRENDS OF NESTING OSPREYS IN NORTHWESTERN MEXICO: A THREE-DECADE PERSPECTIVE

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ABSTRACT.—We used a double-sampling technique (air plus ground survey) in 2006, with partial double coverage, to estimate the present size of the Osprey (*Pandion haliaetus*) nesting population in northwestern Mexico (coastal Baja California, islands in the Gulf of California, and coastal Sonora and Sinaloa). With the exception of Natividad, Cedros, and San Benitos islands along the Pacific coast of Baja California (all three excluded from our coverage in 2006 due to fog), this survey was a repeat of previous surveys conducted by us with the same protocol in 1977 and 1992/1993, allowing for estimates of regional population trends. The minimum population estimate for the area we surveyed in 2006 was 1343 nesting pairs, an 81% increase since 1977, but only a 3% increase since 1992/1993. The population on the Gulf side of Baja California generally remained stable during the three surveys (255, 236, and 252 pairs, respectively). The population of the Midriff Islands (Gulf of California in the vicinity of 29°N latitude) remained similar from 1992/1993 (308 pairs) to 2006 (289 pairs), but with notable population changes on the largest two islands (Guardian Angel: 45 to 105 pairs [133% increase]; Tiburón: 164 to 109 pairs [34% decrease]). The minimum estimated Osprey population on the Sonora mainland decreased in a manner similar to adjacent Isla Tiburón, i.e., by 26%, from 214 pairs in 1993 to 158 pairs in 2006. In contrast, the population in coastal Sinaloa, which had increased by 150% between 1977 and 1993, grew again by 58% between 1993 and 2006, from 180 to 285 pairs. Our survey confirmed previously described patterns of rapid population changes at a local level, coupled with apparent shifts in spatial distribution. The large ground-nesting population that until recently nested on two islands in San Ignacio Lagoon ( Pacific Ocean side, Baja California) was no longer present on the islands in 2006, but an equivalent number of pairs were found to the north and south of the lagoon, nesting in small towns and along adjoining overhead electric lines, with no overall change in population size for that general area (198 pairs in 1992; 199 in 2006). Use of artificial nesting structures was 4.3% in 1977 and 6.2% in 1992/1993, but jumped to 26.4% in 2006. Use of poles that support overhead electric lines poses a risk of electrocution to Ospreys and also causes power outages and fires. We recommend modification of these poles to safely accommodate Osprey nests, as has been successfully accomplished in many countries.

KEY WORDS: *Osprey*; Pandion haliaetus; *abundance*; *distribution*; *nests*; *population status*; *population trends*.

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TENDENCIAS REGIONALES DE ANIDACIÓN DE *PANDION HALIAETUS* EN EL NOROESTE DE MÉXICO: UNA PERSPECTIVA DE TRES DÉCADAS

RESUMEN.—Usamos una técnica de muestreo doble (muestreos aéreos y terrestres) en 2006, con cobertura doble parcial, para estimar el tamaño poblacional actual de las poblaciones reproductivas de *Pandion haliaetus* en el noroeste de México (costa de Baja California, islas en el Golfo de California y las costas de Sonora y Sinaloa). Con excepción de las islas de Natividad, Cedros y San Benitos a lo largo de la costa pacífica de Baja California (las tres fueron excluidas de nuestra cobertura en 2006 debido a la niebla), este estudio repitió los muestreos que habíamos realizado con el mismo protocolo en 1977 y 1992/1993, lo que nos permitió estimar las tendencias poblacionales a nivel regional. El tamaño poblacional mínimo estimado para el área de estudio en 2006 fue de 1343 parejas anidando, lo que significa un aumento de 81% desde 1977, pero sólo de 3% desde 1992/1993. La población de Baja California del lado del Golfo permaneció generalmente estable durante los tres muestreos (255, 236 y 252 parejas, respectivamente). Las poblaciones de las Islas Midriff (Golfo de California, próximas a la latitud 29°N) permanecieron similares desde 1992/1993 (308 parejas) hasta 2006 (289 parejas), pero con cambios poblacionales notables en las dos islas más grandes (Ángel Guardián: 45 a 105 parejas [133% de aumento]; Tiburón: 164 a 109 parejas [34% de disminución]). El tamaño estimado mínimo de la población de *P. haliaetus* en Sonora continental disminuyó de manera similar al de la Isla Tiburón adyacente, i.e., en un 26%, desde 214 parejas en 1993 a 158 parejas en 2006. En contraste, la población en la costa de Sinaloa, que había disminuido en un 150% entre 1977 y 1993, creció de nuevo en un 58% entre 1993 y 2006, desde 180 hasta 285 parejas. Nuestros estudios confirmaron los patrones descriptos previamente de cambios poblacionales rápidos a escala local, junto con cambios aparentes en la distribución espacial. La gran población que nidifica en el suelo, que hasta hace poco anidaba en dos islas en la laguna San Ignacio (lado del Océano Pacífico, Baja California), no estuvo presente en las islas en 2006. Sin embargo, un número equivalente de parejas fue encontrado al norte y al sur de la laguna, anidando en pueblos y a lo largo de líneas eléctricas elevadas, sin un cambio global en el tamaño poblacional para esta área en general (198 parejas en 1992; 199 en 2006). El uso de estructuras artificiales de anidación fue de 4.3% en 1977 y de 6.2% en 1992/1993, pero aumentó a 26.4% en 2006. El uso de los postes que sostienen las líneas eléctricas elevadas representa un riesgo de electrocución para *P. haliaetus* y también causa cortes de energía e incendios. Recomendamos la modificación de estos postes para que puedan alojar de modo seguro los nidos de *P. haliaetus*, como se ha logrado exitosamente en muchos países.

[Traducción del equipo editorial]

The Baja California and Gulf of California region in Mexico harbors a large resident Osprey (*Pandion haliaetus*) population (Henny and Anderson 1979, 2004, Cartron et al. in press). An early qualitative assessment of that population was provided by Grinnell (1928), but only for the eastern and western coastlines of Baja California and adjacent islands. For decades thereafter, the status and distribution of the Osprey along the eastern side of the Gulf of California remained essentially unknown, with only a few reports of the species' occurrence on offshore islands (Cartron et al. 2006 in press).

Based on aerial and ground surveys conducted in 1977, Henny and Anderson (1979) provided the first Osprey population estimates for the entire Baja California and Gulf of California region and for each of seven subregions, including coastal areas of the states of Sonora and Sinaloa along the eastern side of the Gulf of California (Fig. 1). At the time, Henny and Anderson (1979) envisioned that the regional Osprey population could be monitored on a long-term basis to serve as an indicator of ecosystem health and track anthropogenic impacts. Henny and Anderson (2004) repeated the region-wide survey in 1992/1993 (survey split into two years) and documented an important increase in Osprey numbers. Beginning in the 1980s, monitoring studies were also conducted on a local scale (e.g., Carmona et al. 1994, Castellanos and Ortega-Rubio 1995, Cartron 2000, Cartron et al. 2006, Rodríguez-Estrella et al. 2006). Some of these local studies documented sharp fluctuations in the reproductive success of Osprey pairs, and rapid and pronounced changes in the number of nesting pairs, often with no clear underlying explanation.

In 2006, we conducted a third survey of the Osprey population in the Baja California and Gulf of California region. The main objective of this survey was to document any population trends region-wide and for each of the seven subregions, using 1977 and 1992/1993 numbers for comparisons. Additional goals of our survey were (1) to determine whether some of the

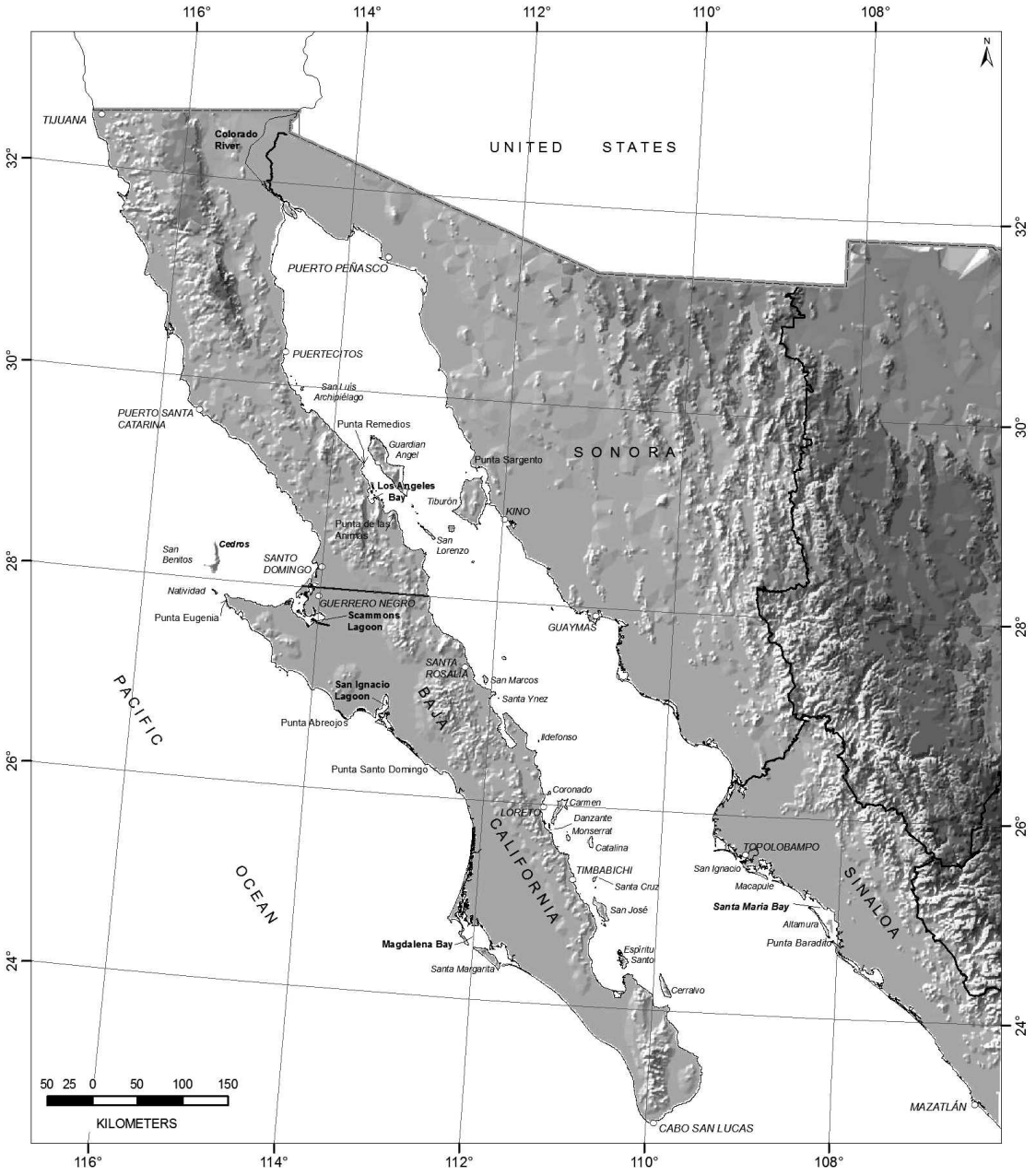


Figure 1. The Baja California and Gulf of California study area for Ospreys.

patterns described at a local level could be detected on a larger scale, and (2) to assess possible causes associated with shifts in the distribution of nesting pairs or changes in reproductive rates, including whether they were indicative of widespread changes in the environment, either natural or anthropogenic.

## STUDY AREAS

Our study area consisted of seven designated regions within northwestern Mexico (Fig. 1). (1) The Northwest Baja California region extends along the Pacific coast of Baja California from the U.S.-Mexico border south to and including Scammon's Lagoon,

and west to Punta Eugenia, including Natividad, Cedros, and San Benitos islands. (2) The Southwest Baja California extends south from Punta Eugenia along the Pacific coast to Cabo San Lucas at the southern tip of the peninsula. (3) The Northeast Baja California region includes the coast of the Gulf of California from the mouth of the Colorado River south to the town of Santa Rosalia. The terrain from the Colorado River south to Puertecitos is flat and contains few cacti suitable for nesting sites (such as the giant cardon [*Pachycereus pringlei*]). (4) The Southeast Baja California region extends along the coast from Santa Rosalia south to Cabo San Lucas, including associated islands of Carmen, San Marcos, Cerralvo, Santa Cruz, Coronado and Santa Catalina, Monserrat, San Jose, Partida, and Espíritu Santo. (5) The Midriff Islands region comprises several islands located in the Gulf of California in the vicinity of 29°N latitude. (6) The Coastal Sonora region included the coastline of the entire state of Sonora, from the Colorado River in the north to the border with the state of Sinaloa in the south. The extreme northern portion of the region is flat with no cacti; then cardon cactus appear sporadically. Further south along the coast, there are a few sandy cliffs and, eventually, some rocky cliffs. (7) The Coastal Sinaloa region extended along the Gulf of California coastline from the border with the state of Sonora in the north to Mazatlan in the south in 1977 and 1993, but in 2006 the survey extended further south to San Blas, Nayarit, although no nesting Ospreys were seen south of Mazatlan. Detailed ecological and physical descriptions of habitats in this general region can be found in Part I of Cartron et al. (2005).

## METHODS

We located Osprey nests in 2006 from a twin-engine fixed-wing aircraft (Partenavia PN68TC) with excellent visibility and a Global Positioning System (GPS). The survey was flown at an altitude of 60–100 m between 23 March and 1 April. The GPS allowed us to record the location of each occupied nest in 2006, as in 1992/1993. No GPS was available during the 1977 survey. The surveys in 1977 and 1992/1993 had been flown at about the same time (24 March–1 April, and 20 March–2 April, respectively). A pilot and two observers (same as in 1977 and 1992/1993: CJH and DWA) were present in the plane. Surveys were conducted in ca. 80 h of flying time, again similar to the 1977 and 1992/1993 surveys.

To locate nests during the aerial survey, we made a single pass along the shore to census rocky or sandy cliffs adjacent to the shoreline or flat terrain with no cacti. In areas where large cactus or mangrove forests existed near the shoreline, we flew transects at increasing distances inland from the shore looking for Osprey nests until no more were observed. Emphasis was also placed on locating nests on poles supporting overhead electric lines (power poles) and other structures in towns. Generally, we did not find nesting pairs more than 2 km inland from the shoreline, but when nests were found on power poles, we extended the survey inland along the overhead electric line, 1 km beyond the last nest observed. The same locations were surveyed in 1977, 1992/1993 and 2006 except for three islands along the Pacific coast of Baja California that were missed in 2006 due to fog.

We classified nests observed during the aerial survey as occupied if an adult was present on or in the immediate vicinity of the nest, or if young/eggs were seen in the nest. An attempt was made to schedule the aerial survey during the peak of the nesting cycle, although the season is not well synchronized in southern latitudes. Occupied nests would have been missed if a bird was not at or near a nest when it was surveyed, the nest was abandoned before the area was surveyed, nesting was initiated after the area was surveyed, or we failed to see the nest. Unoccupied nests we detected were also recorded.

Because it is costly and time-consuming to conduct the ground or boat survey portion of the double survey, we surveyed all the study area by air but covered <10% of the population from the ground, to develop a partial double-survey population estimate and its associated variance. The ground surveys were made by boat, from a 4-wheel-drive vehicle, or on foot. The ground surveys were conducted within a few days to 2 wk of the aerial survey, and made it possible to compare numbers of occupied nests at the time of census in various areas seen from air, ground, and both air and ground. Comparing data from both counts allowed us to obtain a visibility rate for adjusting aerial counts to the total nesting population at the time of the survey, by use of a modification of the Petersen Estimator (Henny and Anderson 2004). We sampled a finite population of size $N$ ($N$ unknown) by use of the two methods. Variables were defined as:

$s_a$ = the number of nests observed by aerial survey (method 1)
$s_g$ = the number of nests observed by ground survey (method 2)
m = the number of nests observed by both methods.

Then,

Table 1. Number of occupied Osprey nests (nesting pairs) seen from the air and ground.

| YEAR<br>NEST SUBSTRATE | AIR ($s_a$) | GROUND ($s_g$) | BOTH (m) | ESTIMATED TOTAL ($N$) | VISIBILITY RATE ($\hat{N}/s_a$) |
|---|---|---|---|---|---|
| 1977 | | | | | |
| Cliffs | 88 | 121 | 74 | 143.89 | 1.64[a] |
| Cactus | 7 | 9 | 6 | 10.50 | 1.50 |
| Cliffs and cactus (combined) | 95 | 130 | 80 | 154.38 | 1.63 |
| Ground (Scammon's Lagoon) | 26 | 23 | 22 | 27.18 | 1.05 |
| 1992, 1993 | | | | | |
| Cliffs (Los Angeles Bay)[b] | 32 | 43 | 25 | 55.04 | 1.72 |
| Cactus (Kino) | 16 | 27 | 16 | 27.00 | 1.69 |
| Cliffs and cactus (combined) | 48 | 70 | 41 | 81.95 | 1.71 |
| 2006 | | | | | |
| Cliffs (Los Angeles Bay) | 25 | 37 | 22 | 40.22 | 1.61 |
| Cactus and other (Kino and vicinity) | 23 | 33 | 18 | 42.17 | 1.83 |
| All combined | 48 | 70 | 40 | 84.00 | 1.75 |

[a] Values for three locations sampled in 1977 were 1.54, 1.75 and 1.77.
[b] Combined information for both 1992 and 1993.

$$\hat{N} = s_a s_g / m$$

is a reasonably good estimator of $N$. In this approach we assumed statistical independence of $s_a$ and $s_g$.

In sampling Osprey nests, it was also necessary to assume $N$ was not changing during the time between the ground and air survey. With the ground and aerial counts made within 2 wk of each other, it is doubtful that significant changes had taken place. Then $\hat{N}/s_a$ is a reasonably good estimator of the aerial Visibility Rate. The aerial count was multiplied by the aerial Visibility Rate to obtain population estimates for areas where only aerial counts were made. Separate Visibility Rates were initially estimated for nests in cacti, nests on cliffs, and ground nests on small islands. Several nests on other structures (power poles) were included at the air-to-ground comparison study area near Kino in 2006. For the current study, the nests on cliffs, cacti and other structures were combined because of their similar Visibility Rates (Table 1). Visibility Rates (combined nesting substrates) in 1977, in 1992–93, and in 2006 were similar (1.63, 1.71 and 1.75). No Visibility Rates were available for nests in mangroves; therefore, the combined value for cacti, cliffs and other nests was used. We believe nests in mangroves were more difficult to locate from the air, thus, nesting pairs in mangroves in coastal Sinaloa and perhaps Magdalena Bay may have been underestimated.

Scammon's Lagoon and vicinity, in the Northwest Baja California region, included large numbers of nesting Ospreys in several relatively small areas. Therefore, we relied upon detailed ground counts of that area by Castellanos and Ortega-Rubio (1995) and Castellanos et al. (1999) from 1993 for our earlier survey and counts by A. Castellanos (unpubl. data) from 2004 for this survey. For our study area, nests occupied at the time of the survey, but believed to have been missed by both air and ground surveys, were included in the Petersen Estimates presented here.

However, occupied nests abandoned before the survey, or initiated after the survey, are not included in our initial population estimates. In the text, we refer to ''observed'' occupied nests (nesting pairs) when raw counts were used and ''estimated'' occupied nests (nesting pairs) when Visibility-Rate-adjusted counts were used. For simplicity, we refer to these as either observed nesting pairs or estimated nesting pairs.

The variance estimate was detailed in our earlier report and included separate estimating procedures for areas with both aerial and ground surveys and for areas with aerial surveys only (Henny and Anderson 2004), but will not be described here. It is assumed that aerial visibility of occupied nests is the same in areas with aerial and ground coverage and in areas with only aerial coverage, and that the air and ground counts are statistically independent.

Generally, in more northern latitudes where this type of survey approach was first conducted (Henny et al. 1974), the nesting cycle is more synchronized; however, this tight synchrony does not occur in Mexico. Our surveys in late March nearly coincided with the peak of occupancy as determined by Danemann (1994) in detailed studies of Ospreys nesting in San Ignacio Lagoon; however, only 83.9% of San Ignacio Lagoon's total nests occupied at one point or another during the nesting season would have been found occupied had one survey been conducted in late March, requiring a correction using a multiplication factor of 1.19 (see Henny and Anderson 2004). That same number was used here; we multiplied the estimated number of occupied nests at the time of the survey by 1.19 to compensate for nesting asynchrony. Note that because of this lack of nesting synchrony, there was no survey time when all nests for the year were occupied simultaneously. The final adjustment of population estimates for 2006 was also made for 1977 and 1992/1993 for the purpose of comparing double-adjusted estimates (for birds missed that were nesting at the time of the surveys and for those nesting earlier or later) and will only be presented in the last table. Future studies may show variability in nesting chronology among regions, but only one detailed chronology dataset currently exists. The same adjustment for nesting chronology was used for all regions and all survey time periods (1977, 1992/1993, and 2006).

In this paper, we thus present raw (or observed) numbers of occupied nests, numbers adjusted for visibility, and numbers adjusted for both visibility and nesting asynchrony. Numbers of nests adjusted for visibility correspond to our minimum estimated size of numbers of nesting pairs. Numbers of nests adjusted for both visibility and nesting asynchrony yield another estimate of the Osprey nesting population. Both the minimum estimate and the double-adjusted estimate are important to consider, until more research is conducted on a large scale to fine-tune the adjustment for nesting asynchrony.

## RESULTS

We summarized distribution and abundance in the seven designated regions.

**Northwest Baja California.** The estimated Osprey population in Northwest Baja California (excluding Natividad, Cedros, and San Benito islands, not surveyed in 2006 because of fog) increased from 1977 (70 pairs) to 1992 (167 pairs). However, there was little change between 1992 and 2006 (160 pairs; Table 2).

Specifically, no nesting pairs were observed between the border and Desembarcadero de Santa Catarina in either 1977 or 1992 with the northernmost nesting pair observed near Santa Catarina at 29°35′N, 115°22′W. From this point south to Morro Santo Domingo, an estimated 20 pairs were nesting in cliffs in 1977, with an estimated 31 pairs nesting in cliffs in 1992. However, by 2006 the nesting range extended north of Santa Catarina to 29°52′N, 115°4′W where a nest was built on a platform near a house, and a few other nests were on cliffs (Table 2). The estimated nesting population between Santa Catarina and Morro Santo Domingo was essentially unchanged at 32 pairs in 2006.

At Scammon's Lagoon, a part of the El Vizcaino Biosphere Reserve since 1988, the population increased from 50 to 86 nesting pairs between 1977 and 1982 when artificial structures (channel markers, power poles, platforms, etc.) became important nesting substrates (Henny and Anderson 2004), and then further increased to 126 in 1993 and 120 in 2004 (including 30 in the town of Guerrero Negro) when artificial nesting structures became even more important.

No nesting pairs were observed to the west along ''Scavenger's Beach'' between Scammon's Lagoon and Punta Eugenia in 1977, but an estimated 10 pairs were present in 1992. However, in 2006 only two pairs were estimated in the area. Due to fog in 2006, Natividad, Cedros, and San Benito islands (where an estimated 68 and 60 nesting pairs were present during the two earlier surveys) could not be surveyed.

**Southwest Baja California.** The total estimated population of this region increased from 35 pairs in 1977 to 198 pairs in 1992, which remained unchanged at 199 pairs in 2006. Interestingly, there was a major redistribution in 2006 to towns both north and south of the original nest sites (Table 2).

In 1977, only 35 pairs of Osprey were estimated nesting in the region with the majority (27 pairs) nesting on the ground on two small islands in San Ignacio Lagoon. However, Reitherman and Storrer (1981) reported 129 occupied nests on the two islands only 4 yr later in 1981. Danemann (1994) visited the islands regularly between January and June 1989 and counted 143 occupied nests (total count). During the 1992 survey of the lagoon, we counted Ospreys at 85 nests, and no Ospreys at 50 nests, but our counting technique for the dense colony was inadequate, especially when many adults were flying. Therefore, because the nesting colony re-

Table 2. Distribution and abundance of occupied Osprey nests at the time of the aerial survey on the Pacific side of Baja California in 1977, 1992, and 2006.

| Location | 1977 Total Estimate[a] | 1992 Total Estimate[b] | 2006 Cliff | 2006 Cactus | 2006 Ground | 2006 Other | 2006 Maximum Observed | 2006 Total Estimate |
|---|---|---|---|---|---|---|---|---|
| **Northwest Baja California** | | | | | | | | |
| U.S. border to Puerto Santa Catarina | 0 | 0 | 5.25 | 0 | 0 | 1.75 | 4 | 7.0 |
| Puerto Santa Catarina to Morro Santa Domingo | 19.5 | 30.8 | 26.25 | 0 | 0 | 5.25 | 18 | 31.5 |
| Scammon's Lagoon and vicinity | 50.1 | 126.0 | 0 | 0 | 18[c] | 102[c] | 120 | 120.0 |
| Punta Mallarrimo to Punta Eugenia | 0 | 10.2 | 0 | 0 | 0 | 1.75 | 1 | 1.8 |
| Natividad Island | 22.8 | 8.6 | | | | | | NS[d] |
| Cedros Island | 19.6 | 18.8 | | | | | | NS |
| San Benitos Islands | 26.0 | 32.5 | | | | | | NS |
| **Subtotal** | 138.0 (69.6)[e] | 226.9 (167.0)[e] | 31.50 | 0 | 18 | 110.75 | 143 | 160.3 |
| **Southwest Baja California** | | | | | | | | |
| Punta Eugenia to Punta Abreojos | 1.6 | 5.1 | 14.00 | 0 | 0 | 54.25 | 39 | 68.3 |
| San Ignacio Lagoon | 27.3 | 143.0 | 0 | 0 | 3[f] | 0 | 3 | 3.0 |
| El Datil to Cabo San Lucas | 6.5 | 49.6 | 7.00 | 0 | 0 | 120.75 | 73 | 127.8 |
| **Subtotal** | 34.5 | 197.7 | 21.00 | 0 | 3 | 175.00 | 115 | 199.0 |
| **Grand Total** | **173.4 (104.1)[e]** | **424.6 (364.7)[e]** | **52.50** | **0** | **21** | **285.75** | **255** | **359.3** |

[a] From Henny and Anderson (1979).
[b] From Henny and Anderson (2004).
[c] Ground count by A. Castellanos Vera, 5–7 Feb 2004.
[d] NS = not surveyed in 2006 due to fog.
[e] Value in ( ) = estimate without Natividad, Cedros and San Benitos islands (comparable to 2006 total estimate).
[f] Ground count by R. Carmona, 25 Jan 2006.

mained large in 1992, we opted to use the 1989 complete count of Danemann in the report. Excluding San Ignacio Lagoon, only eight other pairs were estimated nesting in the region in 1977 and 55 additional pairs in 1992, with most nesting south of the lagoon (Table 2).

In contrast to the two earlier surveys, the San Ignacio Lagoon nesting colony of Ospreys was no longer present in 2006. A ground count was made on the islands in 2006 and only three occupied nests were reported (R. Carmona pers. comm.). Therefore, we did not fly low over the islands and only saw one flying Osprey from our higher-altitude flyover. In contrast, birds nesting on power poles and other artificial structures in nearby towns in the region increased from 1992 (an estimated eight pairs; Henny and Anderson 2004) to 2006, when we estimated 175 such pairs (Table 2). The towns with the greatest numbers of nesting pairs (from highest counts to lowest counts) and distance (north or south) away from San Ignacio Lagoon included: Puerto San Carlos (south 263 km), Punta Abreojos (north 46 km), Puerto Adolfo Lopez Mateos (south 217 km), La Bocana (north 56 km), Las Barrancas (south 139 km).

**Northeast Baja California.** An estimated 117 pairs of Ospreys nested in this region in 1977, 106 pairs in 1992, and 126 pairs in 2006 (Table 3). The Osprey breeding range has extended north from a tripod nesting structure placed on top of a building (30°45′N, 114°42′W) first observed occupied in 1992 and still occupied in 2006. The most northern nest in 2006 was on a power pole at San Felipe (31°03′N, 114°49′W), with two additional nests observed north of the tripod nesting structure (another power pole at 30°56′N, 114°43′W, and a cactus at 30°46′N, 114°42′W). Bancroft (1927, 1932) stated that historically the San Luis Archipelago (29°57′N

Table 3. Distribution and abundance of occupied Osprey nests at the time of the aerial survey on the Gulf side of Baja California and Midriff Islands in 1977, 1992, and 2006.

| LOCATION | 1977 TOTAL ESTIMATE[a] | 1992 TOTAL ESTIMATE[b] | 2006 CLIFF | 2006 CACTUS | 2006 GROUND | 2006 OTHER | 2006 MAXIMUM OBSERVED | 2006 TOTAL ESTIMATE |
|---|---|---|---|---|---|---|---|---|
| **Northeast Baja California** | | | | | | | | |
| Colorado River to Punta Remedios | 37.4 | 23.9 | 21.00 | 3.50 | 0 | 5.25 | 17 | 29.8 |
| Punta Remedios to Punta de las Animas | | | | | | | | |
| Los Angeles Bay (islands) | 35.0 | 29.3[c] | 40.22 | 0 | 0 | 0 | 39 | 40.2[d] |
| Other locations | 22.1 | 17.1 | 21.00 | 0 | 0 | 0 | 12 | 21.0 |
| Punta de las Animas to Santa Rosalia | 22.8 | 35.9 | 24.50 | 8.75 | 0 | 1.75 | 20 | 35.0 |
| **Subtotal** | 117.3 | 106.2 | 106.72 | 12.25 | 0 | 7.00 | 88 | 126.0 |
| **Southeast Baja California** | | | | | | | | |
| Santa Rosalia to Loreto | 65.6 | 49.5 | 42.00 | 0 | 0 | 14.00 | 32 | 56.0 |
| Loreto to Timbabichi | 42.4 | 49.6 | 36.75 | 0 | 0 | 1.75 | 22 | 38.5 |
| Timbabichi to Cabo San Lucas | 29.3 | 30.8 | 22.75 | 0 | 0 | 8.75 | 18 | 31.5 |
| **Subtotal** | 137.3 | 129.9 | 101.50 | 0 | 0 | 24.50 | 72 | 126.0 |
| **Grand Total (Gulf Coast Baja California)** | **254.6** | **236.1** | **208.22** | **12.25** | **0** | **31.50** | **160** | **252.0** |
| **Midriff Islands** | | | | | | | | |
| Guardian Angel | 40.8 | 44.5 | 105.00 | 0 | 0 | 0 | 60 | 105.0 |
| San Lorenzo, San Lorenzo Norte, | | | | | | | | |
| Partida, Salispuedes, Rasa | 52.2 | 53.0 | 36.75 | 0 | 0 | 0 | 21 | 36.8 |
| Tiburón | 71.8 | 164.2[e] | 40.25 | 66.50 | 0 | 1.75[f] | 62 | 108.5 |
| San Estaban, Turner, Cholla[g] | 22.8 | 46.2[e] | 39.00 | 0 | 0 | 0 | 29 | 39.0 |
| **Grand Total (Midriff Islands)** | **187.6** | **307.9** | **221.00** | **66.50** | **0** | **1.75** | **172** | **289.3** |

[a] From Henny and Anderson (1979).
[b] From Henny and Anderson (2004).
[c] Total estimate for 1993 was 25.2.
[d] Used adjustment factor determined for Los Angeles Bay in 2006.
[e] Aerial survey conducted in 1993.
[f] Only tree nest in Midriff Islands (near a well).
[g] Includes ground count by Tad Pfister in 2006 (4 occupied nests).

to 30°06′N) was the location of the northernmost nesting of the species in the region with about 60–75 nesting pairs. The estimated number of nesting pairs at the San Luis Archipelago in 1977 declined to 16 pairs, then further declined to seven pairs in 1992 and remained unchanged at seven in 2006.

Los Angeles Bay and the nesting population on its small islands have been a focal point for Osprey studies for many years. The estimated population on the islands was 35 pairs in 1977, 29 pairs in 1992 and 40 pairs in 2006, with the pattern over time paralleling that observed for the whole region, except perhaps for the southernmost part of the region (Punta de las Animas to Santa Rosalia), which is a more remote area. Isla Tortuga was not surveyed in 1977 and 2006 (fog), but two occupied nests were located in 1992. The southern area showed an increase from an estimated 23 pairs in 1977 to 36 pairs in 1992 and then stabilized at 35 pairs in 2006.

**Southeast Baja California.** This region contained an estimated 137 pairs in 1977, 130 pairs in 1992 and 126 pairs in 2006 (Table 3). The islands along the coast listed in order of importance (nesting pairs) included Carmen, San Marcos, Cerralvo, Santa Cruz, Coronado, and Santa Catalina; and those with only one nest located include Monserrat, San Jose, Partida, Espíritu Santo, and three small near-shore islands. These islands accounted for an estimated 70 of the 126 nesting pairs in the region in 2006. At Isla Santa Ynez, where five occupied nests were observed on the ground and one on a fishing shelter in 1977, only one occupied nest was observed on the ground and one on a tower in 1992, but none were observed in 2006. A new southern record for nesting Osprey in Baja California was

Table 4. Distribution and abundance of occupied Osprey nests at the time of the aerial survey in coastal Sonora and Sinaloa in 1977, 1993, and 2006.

| Location | 1977 Total Estimate[a] | 1993 Total Estimate[b] | 2006[c] Cliff | Cactus | Mangrove[d] | Other | Maximum Observed | Total Estimate |
|---|---|---|---|---|---|---|---|---|
| **Coastal Sonora** | | | | | | | | |
| Colorado River to Punta Sargento | 78.4 | 106.0 | 12.25 | 66.50 | 0 | 15.75 | 61 | 94.5 |
| Punta Sargento to Sinaloa border | 45.6 | 107.7 | 21.00 | 31.50 | 0 | 10.50 | 39 | 63.0 |
| **Subtotal** | 124.0 | 213.7 | 33.25 | 98.00 | 0 | 26.25 | 100 | 157.5 |
| **Coastal Sinaloa** | | | | | | | | |
| Sonora border to Topolobampo | 6.5 | 13.7 | 0 | 15.75 | 0 | 7.00 | 13 | 22.8 |
| Topolobampo to Punta Baradito | 61.9 | 165.9 | 0 | 243.25 | 15.75 | 3.50 | 150 | 262.5 |
| Punta Baradito to Mazatlan | 1.6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Subtotal** | 70.0 | 179.6 | 0 | 259.00 | 15.75 | 10.50 | 163 | 285.3 |
| **Grand Total** | **194.0** | **393.3** | **33.25** | **357.00** | **15.75** | **36.75** | **263** | **442.8** |

[a] From Henny and Anderson (1979).
[b] From Henny and Anderson (2004).
[c] Survey extended south from Mazatlan to San Blas, Nayarit in 2006, but no nesting Ospreys located.
[d] Or other trees/bushes.

located on a rock pinnacle about 53 km northeast of San José del Cabo at 23°26′N, 109°25′W.

**Midriff Islands.** An estimated 188 pairs nested on the islands in 1977, 308 pairs in 1992/1993 and 289 pairs in 2006 (Table 3). The two largest islands, Guardian Angel and Tiburón, on opposite sides of the Gulf accounted for an increasing percentage of the total during the surveys; an estimated 113 pairs (60% of the total) in 1977, 209 pairs (67.8%) in 1992/1993 and 214 pairs (73.8%) in 2006. However, the relative importance of the two islands varied during the interval of surveys: Guardian Angel accounted for an estimated 21.7% of the population in the region in 1977, 14.5% in 1992/1993, and 36.3% in 2006. Conversely, Tiburón Island accounted for an estimated 38.3% of the population in 1977, 53.3% in 1992/1993 and 37.5% in 2006. The other islands on the Baja California side (San Lorenzo, San Lorenzo Norte, Partida, Salsipuedes, Rasa) showed a consistent decline as a percentage of the total in the region (1977, 27.8%; 1992/1993, 17.2%; 2006, 12.7%), whereas those on the Sonora side (San Esteban, Turner, Cholla) remained fairly consistent (1977, 12.2%; 1992/1993, 15.0%; 2006, 13.5%).

**Coastal Sonora.** An estimated 124 pairs nested in the region in 1977, 214 pairs in 1993 and 158 pairs in 2006 (Table 4). The highest population estimate for Sonora occurred in 1993, but was followed by a general decline in 2006, which appeared more precipitous south of Punta Sargento. Cartron (2000) reported some years with extremely poor reproduction in his study area in coastal Sonora. During the 2006 ground surveys, the number of nesting pairs in that same study area and southwards to Estero Cruz at Bahia Kino appeared stable only along large esteros (negative estuaries). Some pairs in this region nested in cliffs, but most were in cardon cacti. The most northern occupied nest located in 2006 along the mainland of Mexico was on a power pole at 31°18′N, 113°13′W. Another nest was on a platform at 31°16′N, 113°27′W with two other nests on artificial (concrete and rebar) cactus at 31°14′N, 113°13′W, all located in the vicinity of Puerto Peñasco, an area of rapid and extensive development. No Osprey in Sonora were nesting on artificial structures in 1977, but overhead electric line towers were constructed shortly after our first survey in 1978 and 1979 (Mellink and Palacios 1993). In 1993, 3.2% of Ospreys in the region were nesting on artificial structures, a value that increased to 16.7% in 2006.

**Coastal Sinaloa.** An estimated 70 pairs nested in the region in 1977, 180 pairs in 1993, and 285 pairs in 2006 (Table 4). From the Sonora border to Topolobampo, an estimated seven pairs nested in 1977, 14 pairs in 1993 and 23 pairs in 2006. The majority of the nests were located between Topolobampo and Punta Baradito: an estimated 62 pairs in 1977, 166 pairs in 1993, and 263 pairs in 2006. This area was further subdivided into two areas with the split at 25°10′N. From Topolobampo south to

Table 5. Types of nest sites selected by Ospreys in the study area, 1977, 1992/1993, and 2006.

| | Estimated Number of Occupied Nests[a] | | |
|---|---|---|---|
| Nest Site Substrate | 1977 | 1992/1993 | 2006 |
| Cliff | 479 (59.1%) | 542 (39.8%) | 515 (38.3%) |
| Cacti | 213 (26.3%) | 506 (37.2%) | 436 (32.5%) |
| Ground | 59 (7.3%) | 213 (15.6%) | 21 (1.6%) |
| Artificial structures | 35 (4.3%) | 85 (6.2%) | 354 (26.4%) |
| Mangrove/other trees | 24 (3.0%) | 16 (1.2%) | 17 (1.3%) |
| **Total** | **810 (100.0%)** | **1362 (100.0%)** | **1343 (100.1%)** |

[a] No adjustment of aerial survey population estimates was made here for nesting chronology. Data reflect the time of aerial survey.

25°10′N, which included the barrier islands of San Ignacio and Macapule, there were an estimated 31 pairs nesting in 1977, an estimated 118 pairs in 1993, and 213 pairs in 2006. South of 25°10′N, which included Santa Maria Bay and the barrier island of Altamura, we estimated 31 pairs in 1977, 48 pairs in 1993 and 49 pairs in 2006. Most Ospreys nesting in Sinaloa were nesting on barrier islands and peninsulas associated with several large bays. Mangroves and other brushy trees were abundant and some Ospreys nested in them. The species of cacti was a type that branches about 1.5 m above the ground (*Pachycereus pecten-aboriginum*), and most pairs here nested in cactus. The most rapid increase from 1993 to 2006 occurred at the barrier islands of San Ignacio and Macapule. The most southern nesting Osprey along the mainland was south of Punta Bardito in 1977 at Ensenada del Pabellón (24°38′N) in a mangrove, although an occupied nest was reported on an island in Mazatlan harbor (~23°13′N) in March 1978 (see addendum to Henny and Anderson [1979]). No nests were located south of Punta Baradito in 1993 or 2006 (Fig. 1).

**Nesting Sites.** In our study area in Mexico, trees, with the exception of mangroves at more southern latitudes, were rare, but other options including cliffs, rock pinnacles, cacti, and the ground on small islands provided the historic nesting substrates. Numerically, the most important nesting substrate throughout the years was large cliffs adjacent to the sea (1977, 59%; 1992/1993, 40%; 2006, 38%; Table 5) both on the mainland and on islands. Sometimes the cliffs consist of large pinnacles or stacks upon which the Ospreys built their nests. However, small sandy cliffs contained nesting Ospreys in a few areas. Large cacti comprised the next-most significant substrate (1977, 26%; 1992/1993, 37%; 2006, 33%), especially in flat terrain, and were numerically most important in Sonora, Sinaloa, and Tiburón Island. Mangroves and other trees were generally available only in the southern portion of the study area. Ground-nesting Ospreys during the studies were restricted to very small islands at three locations: Scammon's Lagoon, San Ignacio Lagoon, and Santa Ynez Island.

By 1977, Ospreys were using artificial nesting structures, primarily at Scammon's Lagoon; however, towers, pilings, channel markers, debris washed ashore, boats (sunk and aground), and power poles were occasionally used at various locations in the study area. In the 1992/1993 survey, we recorded not only an increase in the overall nesting population, but also an increase in the percentage of the population (from 4.3% to 6.2%) nesting on artificial structures. Some artificial structures used in flat terrain with no suitable cacti resulted in relatively short northward range expansions for the species. By 2006, artificial structures became much more important, accounting for 26.4% of all nests, including 79.5% of nests on the western side of Baja California, but only 6.9% of nests elsewhere.

**Northwestern Mexico Survey Totals.** The estimated number of occupied nests reported for each region at the time of the survey is shown in Table 6, as well as the double-adjusted estimated size of the population, which accounts for the nesting asynchrony at southern latitudes. Estimates of precision are provided by 95% C.I.s. We note that the change in population size between the three survey periods was not a function of changes in Visibility Rates, which were very similar for the three surveys (1.63, 1.71, and 1.75).

## Discussion

We found that the general distribution of Ospreys in the northwestern Mexico survey area did not

Table 6. A summary of estimated number of occupied Osprey nests ±95% C.I. in the study area, 1977, 1992/1993, and 2006.

| LOCATION | 1977[a] | 1992–1993[a] | 2006[a] |
|---|---|---|---|
| NW Baja Calif. | 138.0 (164.2) | 226.9 ± 20.6[b] (246.1)[c] | 160.3 ± 7.4 [bd] (190.8)[d] |
| SW Baja Calif. | 35.4 (42.1) | 197.7 ± 11.1[b] (208.1)[c] | 199.0 ± 36.4 (236.8) |
| NE Baja Calif. | 117.3 (139.6) | 106.2 ± 21.6 (126.4) | 126.0 ± 23.1 (149.9) |
| SE Baja Calif. | 137.3 (163.4) | 129.9 ± 26.5 (154.6) | 126.0 ± 23.1 (149.9) |
| Midriff Is. | 187.6 (223.2) | 307.9 ± 62.8 (366.4) | 289.3 ± 52.9 (344.3) |
| Sonora | 124.0 (140.7)[c] | 213.7 ± 43.6 (254.3) | 157.5 ± 28.8 (187.4) |
| Sinaloa | 70.0 (83.3) | 179.6 ± 36.6 (213.7) | 285.3 ± 52.2 (339.5) |
| **Totals** | **810 (957)** | **1362 ± 278 (1570)** | **1343 ± 246[d] (1598)[d]** |

[a] First estimate refers to those nesting at the time of the survey including those missed by aerial survey; estimate in parentheses refers to double-adjusted population estimate which includes those not nesting at the time of the survey due to asynchronized nesting season at southern latitudes (initial estimate multiplied by 1.19, see Henny and Anderson 2004).

[b] N ± 95% C.I. for regional population estimates (C.I., assumes variance 0 for total counts at Scammon's and San Ignacio Lagoons).

[c] Complete counts used for Scammon's Lagoon (1993), San Ignacio Lagoon 1989 for 1992 survey, and behind Punta Sargento (1977), thus those portions not adjusted for asynchronized nesting. Ground count at Scammon's Lagoon for the recent survey was conducted over short time interval, therefore, counts adjusted for asynchronized nesting.

[d] Estimated numbers not comparable to earlier years because of fog at several islands (see text).

change (with the exception of some short range expansions) between 1977 and 2006, although local and regional changes in abundance were apparent and variable.

**Northwest Baja California.** This region has the best-documented historical changes in Osprey population numbers over time in Mexico. These changes were summarized in detail in our earlier reports (Henny and Anderson 1979, 2004). The four most northern islands or groups of islands (Los Coronados, Todos Santos, San Martín, and San Gerónimo) had no nesting Ospreys during our three surveys. Los Coronados historically had no known nesting pairs, but Ospreys were common on the other three islands (Jehl 1977). The last pair was observed at San Martin in 1971 (Jehl 1977). These extirpations were concomitant with extirpations on islands off southern California (Kiff 1980). The population is now, however, slowly re-extending its range from the south, and by 2006 the range extended northward from 29°35′N, 115°22′W to 29°52′N, 115°41′W (ca. 42 km in 14 yr, or ca. 3 km/yr). We suggest that Osprey reintroductions from Scammon's Lagoon north to California's Channel Islands could expedite the repopulation of Ospreys where they have been missing for decades. Four young Ospreys were successfully hacked at a release tower on Santa Catalina Island in southern California in 2000 (D. Garcelon pers. comm.), but the program was not continued. Scammon's Lagoon is the focal point for Ospreys in this region and the large population there, now mostly nesting on artificial structures, stabilized between 1992 and 2006 with much higher numbers than in the 1940s, or even the 1980s. Unfortunately, we have no recent information to report for the islands to the west (Natividad, Cedros, and San Benitos); they were not surveyed in 2006 because of fog.

**Southwest Baja California.** Perhaps the most dynamic region is Southwest Baja California where ground-nesting Osprey at San Ignacio Lagoon were at apparently low numbers in 1977 (27 pairs), but increased tremendously (129 pairs) by 1981 (Reithermann and Storrer 1981) and where 143 pairs were counted nesting in 1989 (Danemann 1994). Rodríguez-Estrella et al. (2006) reported 116 active nests on the islands in San Ignacio Lagoon in 1998, 93 active nests in 2000, and 78 active nests in 2001, with production declining over time, 0.95, 0.83, and 0.53 fledglings/active nest, respectively. When the survey was repeated in 2006, only three pairs were likely nesting on the islands, but the numbers lost at San Ignacio Lagoon could be accounted for at nearby towns and associated power lines. Thus, nesting pairs on the islands were declining from the peak by 1998 and continued to decline through 2001 with productivity rates also declining. Large counts of nesting Ospreys at the towns of Puerto San Carlos and Puerto Adolpho Lopez Mateos were already observed in 2002 (E. Palacios and colleagues pers. comm.). Together, these observations indicated that Osprey had not completely abandoned the islands by 2001, although a reduction in nesting numbers occurred. Thus, the redistribution away from

San Ignacio Lagoon to the adjacent towns appeared gradual and continued after the 2001 nesting season. The cause remains uncertain and may not be a single factor. Possible explanations for the redistribution include: (1) reduction in fish availability in the lagoon, (2) increased acceptance or tolerance of nests in towns, due in part to education and the presence of wildlife personnel, (3) a combination of the two factors. Human disturbance on the islands is not likely a factor because the area is patrolled by wildlife personnel.

**Gulf Coast Baja California.** Both the North and South coasts showed the least change over the span of the three surveys, perhaps somewhat surprisingly, as large population increases were recorded for all other regions between 1977 and 1992/1993. Although the population appeared stable during the three surveys in the last 29 yr, there is evidence that it was historically much larger at least in the San Luis Archipelago (Bancroft 1927, 1932). This regional population now primarily nests on cliffs (82.6%) with artificial structures (12.5%) of minor importance, although nests were occasionally located in towns. In general, the present distribution of the scattered nesting is quite similar to earlier years. However, at one location, Espiritu Santo Island, the population seems quite dynamic, with only one occupied nest observed during our 1977 survey, but 22 occupied nests in 1986 (Carmona et al. 1994). Only a single occupied nest was on the island during our 1992 survey, although 16 unoccupied nests were observed. The Espiritu Santo count was again only one occupied nest in 1999 and 2006 (the most recent survey). Thus, short-term local changes can certainly occur during the long interval between the regional aerial surveys.

**Midriff Islands.** These islands in the Gulf of California showed an interesting dichotomy during the 1977 and 1992/1993 surveys: specifically, the islands near the Gulf coast of Baja (Guardian Angel and the series of islands associated with San Lorenzo) maintained nearly identical numbers (93 pairs vs. 98 pairs), while those closer to Sonora (Tiburón, San Esteban, Turner, and Cholla) showed major increases (95 pairs vs. 210 pairs). These findings paralleled those reported for the adjacent mainlands for the same time periods. However, in 2006, the nesting population on the islands nearer Baja California increased to an estimated 142 pairs, while the island population nearer Sonora decreased to 148 pairs. Thus, the sizes of the two populations were again similar in 2006 (142 and 148 pairs), but at higher numbers than in 1977 (93 and 98 pairs). Factors responsible for the Osprey increase in the early 1990s on the islands off the Sonora coast and eventual decrease by 2006 may include reduced fish availability and the associated lower reproductive success. Reduced reproductive success over a long period of time associated with food shortages (as reported along the coast of Sonora; Cartron et al. 2000, 2006) could account for the population reduction, and likewise increased reproductive success could also account for the population increase at the other islands.

**Coastal Sonora and Sinaloa.** The estimated Osprey population along mainland Mexico (Sonora and Sinaloa) doubled (194 pairs to 393 pairs) between 1977 and 1993 with the increase more pronounced in Sinaloa than Sonora. By 2006, the mainland Mexico population continued to increase (443 pairs), but the increase was solely due to Sinaloa, as the population in Sonora declined (much like the population on the adjacent Midriff Islands). Most of the increase occurred on the relatively remote barrier islands of San Ignacio (different from San Ignacio Lagoon mentioned earlier) and Macapule. Both these islands and all others in the area are designated an ''Area de Proteccion de Flora y Fauna (Islas e Islotes)''; (Carabias-Lillo et al. 2000). Carmona and Danemann (1994) mentioned the possibility of agricultural pesticides flowing into the bays and estuaries from streams that drain Sinaloa farmlands. The unique pattern of a continued population increase of this barrier island population that nests on natural substrates (cacti and mangrove, 98.7%) may be the result of the reduction or termination of persistent pesticide use. This location with natural nesting sites seems ideal for Ospreys. If DDT/DDE or other persistent pesticides were involved in an earlier (pre-1977) Osprey population decline in Sinaloa (the location most likely influenced by agricultural pesticides) then a population recovery and increased productivity (Wiemeyer et al. 1988) would be expected. Unfortunately, no pesticide studies of Ospreys and no Osprey productivity studies were conducted in the region to evaluate possible effects of pesticides in earlier years. Our explanation for the observed increase is therefore strictly speculative.

**Nesting Sites.** Artificial structures used by Ospreys in Mexico increased from 4.3% in 1977 and 6.2% in 1992/1993 to 26.4% in 2006. This increase primarily occurred on the Pacific Ocean side of Baja California, and included many nests on power poles. Artificial structures likely became more important on the western coast of Baja California because of

two factors: (1) the apparent shift of ground-nesting birds on the small islands in San Ignacio Lagoon to power poles and towers at nearby towns, and (2) the development of the salt industry at Scammon's Lagoon beginning in 1953 (Castellanos et al. 1999), which resulted in power poles, channel markers, and other associated structures being built in the area. At many locations in the United States and elsewhere in the world, the percentage of Ospreys nesting on artificial nest structures is extremely high, e.g., 85% along the Willamette River in western Oregon (Henny and Kaiser 1996). With many Ospreys now nesting on power poles and transmission towers, the utility companies need to address, and in many places have already addressed, the issue of power outages caused by nests as well as Osprey electrocutions. Modification of some nests on power poles has already occurred at several locations in Mexico. The science of managing Osprey nests on power poles is rapidly developing (APLIC 2006).

**Utility of Survey.** Overall, our surveys show local population changes that are not synchronous, coupled with apparent shifts in spatial distribution. The significance of these dynamic patterns remains somewhat unclear, with the exception of increases in numbers of nests in areas where power poles or other structures have been newly erected. Elsewhere, changes in the number of nesting pairs could be linked to natural local fluctuations in food availability, or to local anthropogenic factors, whether overfishing, disturbance, or historical use of pesticides. Long-term regional studies, associated with more detailed localized studies, now are being more fully appreciated. Our studies of the resident nesting Osprey population in northwestern Mexico, along with a companion study on nesting Brown Pelicans (*Pelecanus occidentalis*), provides a basis for future population evaluations.

**ADDENDA:** On 14 March 2008, DWA visited by boat a small group of near-shore, sandy islands near the northern tip of Altamura Island, Sinaloa (Fig. 1). Four active Osprey nests were observed on Islas el Rancho (25°09.5′N, 108°21.4′W) with other Ospreys seen at a distance. About one-sixth of the total area with suitable habitat was checked, and if projected to the total area, we estimate that ca. 24 nests may be present in this unusual area. Most importantly, these were all isolated ground nests, a substrate seldom used in recent years for nesting and not previously reported at islands along the mainland of Mexico. We did not see nests here in 2006, probably because our search image was not set for ground nests on small sandy islands with occasional tufts of vegetation. We assume these nests, nonetheless, were accounted for by the correction factor described in the text.

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