EXPANSION OF THE BREEDING POPULATION OF THE OSPREY ON SAN FRANCISCO BAY

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ABSTRACT: The first known nesting of the Osprey (*Pandion haliaetus*) on San Francisco Bay was in 1990 along the Mare Island Strait in Vallejo. After 2003, the nesting population at Mare Island Strait began to grow, but nesting in San Francisco Bay south of there remained sparse. A survey in 2013 detected 26 territorial pairs about the Bay, most (65%) still concentrated along the Mare Island Strait, but a few Ospreys were found nesting to the south in Contra Costa, Alameda and San Francisco counties. Here I report the results of surveys from 2014 to 2024, which show a continued southward expansion, the greatest concentration of nests now along the Richmond shoreline in Contra Costa County, and a few nests in South San Francisco Bay. In 2024 the number of territorial pairs reached 70. The overall productivity from 2013 to 2024 of 1.40 juveniles fledged per territorial pair appears sufficient to sustain growth of the population. Of the 70 nests active in 2024, 69 were built on anthropogenic structures. In 2024, 16 of the nests were built on artificial platforms, most of which had been installed to attract Ospreys away from nesting on problematic structures such as electrical distribution poles. Effective conservation of San Francisco Bay's urban nesting population will require installation of additional artificial nest platforms to mitigate nest removal or deterrence to protect infrastructure and prevent Osprey electrocutions.

The Osprey (*Pandion haliaetus*) is a piscivorous raptor with an almost global distribution. It occurs in a wide range of habitats with suitable nesting sites in proximity to fish-bearing bodies of fresh or salt water for foraging (Bierregaard et al. 2020). It is recognized as a sentinel species for most aquatic habitats (Grove et al. 2009). By 1950, its nesting populations in many regions had declined from a variety of causes, including shooting, egg collecting, shoreline development, and habitat destruction (Bent 1937, Stone 1939, Bijleveld 1974, Kiff 1980).

Between the 1950s and 1970s, the decline steepened and the range contracted because of the widespread use of organochlorine insecticides, especially DDT (dichlorodiphenyltrichloroethane), which, with its metabolites, resulted in eggshell thinning and frequent nest failure (Ames and Mersereau 1964, Ames 1966). The federal ban on the use of DDT in the United States in 1972 was followed by dramatic recovery of Osprey populations and range expansion (Poole 1989, Henny et al. 2010, Schmidt-Rothmund et al. 2014). The Osprey's adaptation to nesting on anthropogenic structures, including artificial nest platforms, has aided the recovery (Henny and Kaiser 1996, Houston and Scott 2001, Poole 2019, Bierregaard et al. 2020).

Grinnell and Wythe (1927) and Grinnell and Miller (1944) reported that the Osprey had formerly been common throughout California but reported no nesting from San Francisco Bay. By the mid-20th century, the Osprey's nesting nearest San Francisco Bay was 60 km to the north along the Russian River in Sonoma County. In the 1960s, an Osprey nesting colony was established at Kent Lake in Marin County, about 15 km west of San Francisco Bay. By 1994 it had grown to 46 occupied nests, but by 2021 the population there

had declined to 10 occupied nests. All of these nests were constructed on living or dead trees surrounding the lake (Evens and Brake 2022). Since at least the 1970s, Ospreys have nested on the ships of the Maritime Administration National Defense Reserve Fleet in Suisun Bay, 11 km east of the Carquinez Bridge (Rippey 2014), with up to four nests by 2020. Thereafter measures to deter nesting on these ships were taken, and the fleet has now been reduced to only seven ships.

In 1990 Carter et al. (1990) reported an Osprey nest on a pile-driving barge along the Mare Island Strait in Vallejo, Solano County. Over the next decade, nesting on San Francisco Bay remained rare, with only one other nest recorded, in 1998 near Pt. Pinole in Contra Costa County (Glover 2009). From 2003 to 2012, however, the number of active Osprey nests along the Mare Island Strait increased rapidly, reaching 13 by 2012 (Rippey 2014). By then a few Ospreys had also begun nesting farther south in San Francisco Bay (Glover 2009, Brake and H. Wilson unpubl. data). The following year Brake et al. (2014) censused Osprey nests around San Francisco Bay, locating 26 territorial pairs fledging 44 juveniles. Only a single nest was built on a tree, a dying Canary Island Palm (*Phoenix canariensis*) at the decommissioned Mare Island Naval Shipyard, while all other nests were placed on artificial structures, such as cranes, light towers, utility poles, and marine structures such as channel markers and piling structures.

After the 2013 census, it was evident that the Osprey's nesting around San Francisco Bay had continued to increase and spread (Brake 2018). Here I describe results of Osprey monitoring from 2014 to 2024, outline the expansion of San Francisco Bay's nesting population, and discuss its conservation and management.

METHODS

Study Area

My study covered the San Francisco Bay estuary from the Golden Gate Bridge east to the Carquinez Bridge and from Highway 37 south to Alviso, including all lands 500 m inland of the shoreline (Figure 1). I did not survey areas upriver of the Carquinez Bridge or north of Highway 37. The entire study area encompassed about 13,000 km^2 (Figure 1). See Brake et al. (2014) for a detailed description of the study.

Nest Observations

Initially, I observed nests through 10 × 42 binoculars and a 25–60× spotting scope, but as the study proceeded, I increasingly video-recorded them, using a smartphone attached to the spotting scope. This allowed later review of video recordings, facilitating observation of nestlings that was sometimes difficult in the field.

I observed most nests from accessible shoreline locations, typically at 10- to 14-day intervals from February through July. I visited a subset of nests along the Richmond shoreline more frequently, typically about twice per week. Once incubation had commenced, the timing of visits could be adjusted on the basis of an incubation period of 35–43 days and age of first flight of 50–60

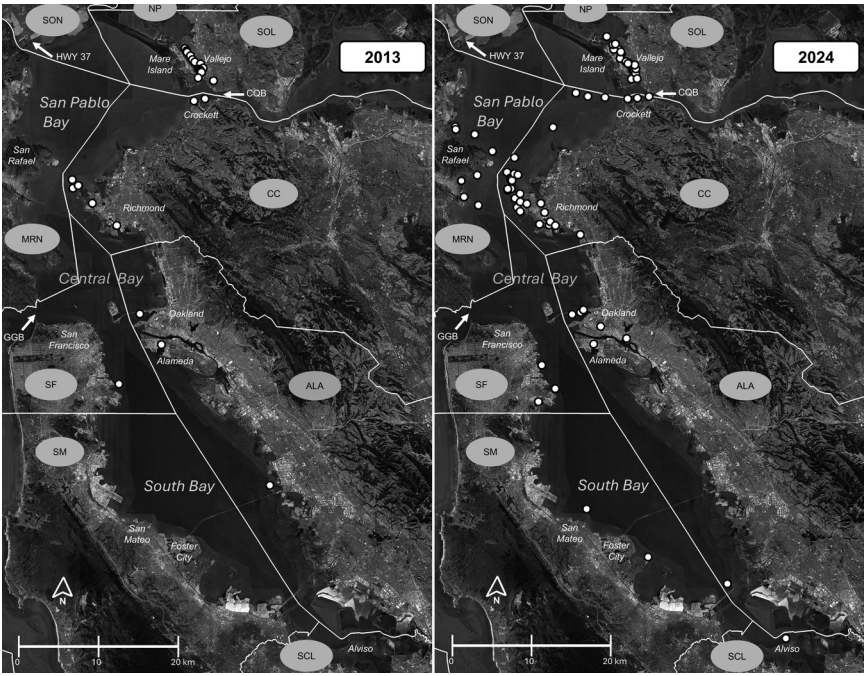

FIGURE 1. Location of Osprey nests around San Francisco Bay from 2013 to 2024. Filled circles, nests of territorial pairs. ALA, Alameda Co.; CC, Contra Costa Co.; MRN, Marin Co.; NP, Napa Co.; SF, San Francisco Co.; SM, San Mateo Co.; SCL, Santa Clara Co.; SOL, Solano Co.; SON, Sonoma Co. Maps were prepared with Google Earth and imagery from Airbus.

days (Poole 1989). I observed some nests from passenger ferries traveling between Vallejo and San Francisco or between Larkspur and San Francisco. In these cases, I photographed the nests with a 100–400-mm telephoto lens for later review since the speed of the ferries made observation difficult. Nest observations were also made from small boats.

Observers continued to locate new nests throughout the study, searching both near known nests and from other accessible shorelines and on boat trips. I learned of several new nests by periodic review of https://eBird.org for Osprey sightings that included photographs or comments indicating the presence of nests. As the nest-monitoring effort became more widely known, observers reported new nests and I confirmed the presence of territorial or egg-laying Osprey pairs on subsequent visits to these locations.

Nest Status and Productivity

I assessed each nest's status on each visit and at the end of the nesting season, defining the pair as *territorial* if the pair was observed building a new nest or attending or refurbishing an established nest. A pair counted as *egg-laying* when a territorial female had laid eggs, as judged by a sustained

incubation posture, by repositioning of the eggs, or by indication of nestlings, whether visible directly or inferred by nestling-feeding behavior by an adult. A pair was *successful* when one or more juveniles reached the age of fledging. Nestlings counted as fledged when they reached an estimated age of 6 weeks, which is approximately 80% of the typical age for first powered flight (Steenhof and Newton 2007). I calculated productivity by dividing the total number of young fledged by the total number of territorial, egg-laying, or successful Osprey pairs observed.

Analysis

I used least-squares linear regression to assess trends across years (2013–2024) for Ospreys that formed pairs, laid eggs, and successfully fledged young, as well as for the total number of fledged young.

RESULTS

Distribution of Osprey Nests around San Francisco Bay

The distribution of Osprey nests around San Francisco Bay changed markedly from 2013 to 2024 (Figure 1). In both years there were high concentrations of nests along the Mare Island Strait (14 in 2013, 18 in 2024), in Solano County, but by 2024 the nests were concentrated farther south, along both sides of the narrow San Pablo Strait, particularly along the Richmond shoreline. Also, by 2024 four pairs were nesting around South San Francisco Bay, up from one in 2013 (Figure 1).

Productivity of San Francisco Bay Osprey Nests

The number of territorial, egg-laying, and successful Osprey pairs as well as the number of young fledged each year all increased significantly from 2013 to 2024 (Figure 2).

Between 2013 and 2024, the overall productivity of Osprey nests was 1.40 young per territorial pair (Figure 3), although in two years (2019 and 2023) productivity was unusually low at 1.06 and 0.88 young per pair, respectively. In these two years the failure rates were 44% and 50%, respectively, significantly higher than in other years. The rate of failure in years other than those two ranged from 17% to 30%. The productivity of successful pairs in 2019 and 2023 was similar to that in other years. There was no significant trend in productivity during this period.

Nest Substrates

As in 2013, from 2014 to 2024 all nests but one were built on artificial structures. These included light towers, channel markers and other marine structures, transmission towers, cranes, and electrical distribution poles (Figure 4). In addition, numerous nests were on artificial nest platforms placed mostly as mitigation for removal of nests that had been built on energized electrical distribution poles.

The distribution of types of nest substrates used changed over the course of this study (Figure 5). Light towers remain the most common, but artificial nest platforms are now used commonly. Use of marine structures, such as

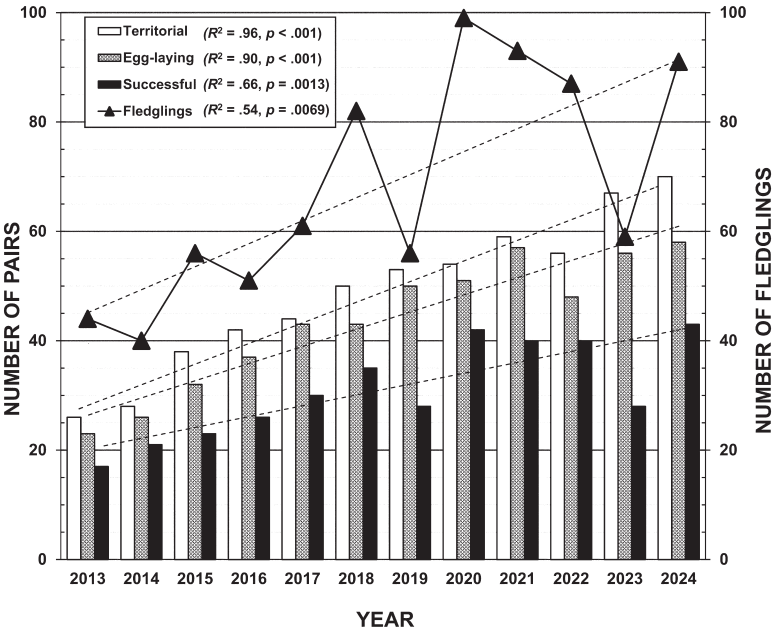

FIGURE 2. Number of pairs of Ospreys around San Francisco Bay, assessed annually (2013–2024) according to reproductive stage or outcome, including those that formed pairs (open bar), those that laid eggs (cross-hatched bar), those that successfully fledged young (filled bar), and total number of young fledged (solid line). Linear least-squares lines are shown for each series by dashed lines.

channel markers and piling structures, as well as transmission towers had become more frequent by 2024 as well.

Interspecific Competition for Osprey Nests

I observed five instances of other species usurping a previous year's Osprey nest, including three by Canada Geese (*Branta canadensis*) and two by Peregrine Falcons (*Falco peregrinus*). Over several nesting seasons I also observed interspecific competition between Ospreys and Great Blue Herons (*Ardea herodias*) for a 3-tiered nest structure on a light tower at Mare Island in Vallejo. In various years this structure was occupied by either Ospreys or up to three pairs of Great Blue Herons (Figure 6).

Breeding Phenology

Ospreys' return to established nest territories began by the second week of February and continued through March. Egg laying usually extended from the first week of March through April. In a few instances, egg laying began as early as the last week of February. Some new pairs did not begin incubation until May. In a few instances, early nesting failures were followed by an attempt at a second brood, four of which were successful. All four successful replacement clutches had been laid in the same nest as the failed first clutch.

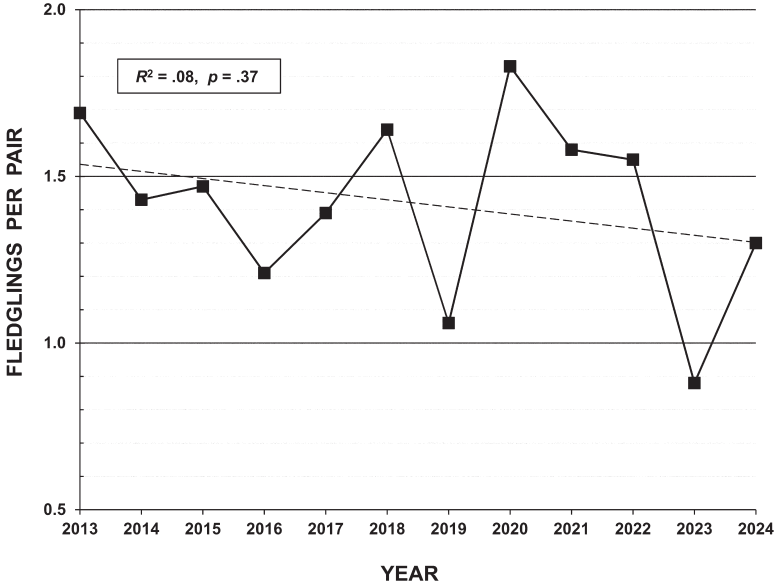

FIGURE 3. Annual productivity of San Francisco Bay Osprey nests from 2013 to 2024 expressed as the number of juveniles fledged per territorial pair (solid line) each year. Result from linear least-squares regression are shown at the upper left.

By the end of July nearly all surviving young had reached six weeks of age and were thus counted as fledged.

DISCUSSION

The breeding status and distribution of the Osprey on San Francisco Bay have changed strikingly within only two decades. Osprey nesting has gone from what Glover (2009) described for Contra Costa County as "the rarest of the rare" to being fairly common, at least in the northern half of San Francisco Bay. Since 2003, the population has continued to expand in both overall distribution of nests and total numbers of birds (Figure 1). Nests are mainly in the northern portion of San Francisco Bay, particularly along the Mare Island Strait in Vallejo and the San Pablo Strait between the Richmond and San Rafael shorelines. Only a few nests have been established in South San Francisco Bay. Considering that Ospreys build their nests on such a wide range of anthropogenic structures and that such structures are readily available in the South Bay, nest-site availability is not a likely cause of low numbers in this portion of the bay.

The northern portion of San Francisco Bay is a river-influenced estuary, with fresh water from the Sacramento and San Joaquin rivers flowing through the delta and into San Pablo Bay. South San Francisco Bay is more of a lagoon-type estuary (Conomos et al. 1985, Cloern et al. 2017). Properties

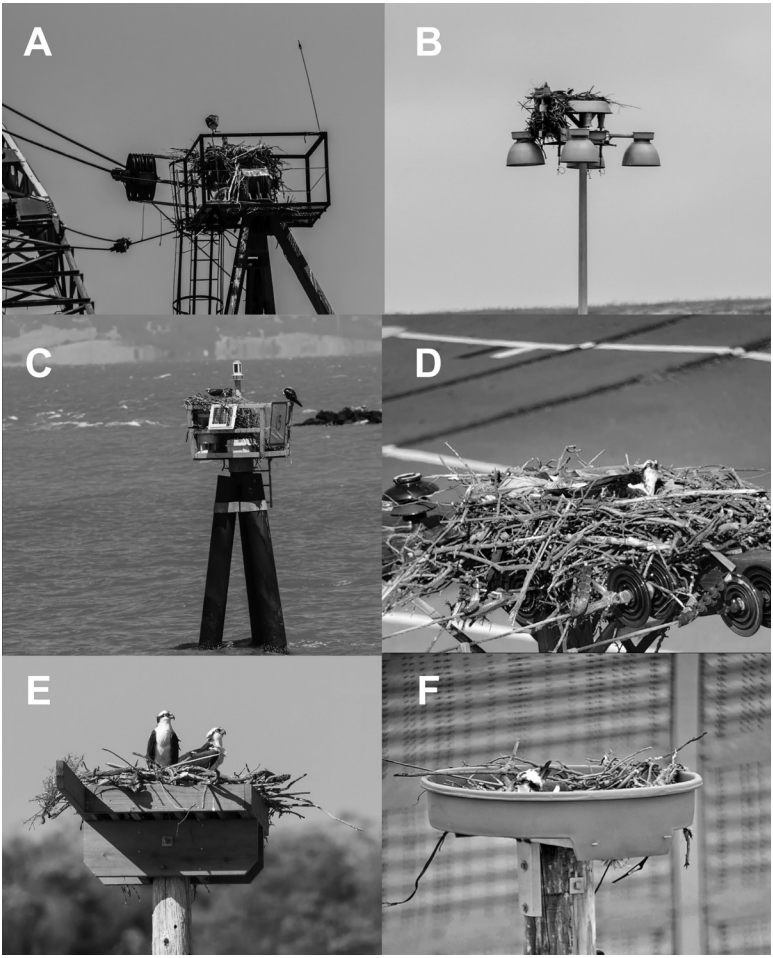

FIGURE 4. Examples of Osprey nests on artificial structures: (A) Disused crane at the port of Richmond; (B) Light tower on decommissioned dock, San Pablo Peninsula; (C) Channel marker (with operational fog horn), San Pablo Bay; (D) Electrical distribution pole, port of Richmond; (E) Artificial nest platform installed at a Chevron oil refinery, San Pablo Peninsula; (F) Artificial nest structure installed by Pacific Gas & Electric to replace the nest site on the energized electrical pole shown in (D), port of Richmond.

Photos by Anthony J. Brake

such as salinity, temperature, depth, and turbidity can vary greatly in different regions of San Francisco Bay, affecting the availability of preferred species and sizes of fish and therefore the quality of foraging (Armor and Herrgesell 1985, Dege and Brown 2004, MacWilliams et al. 2016). In Chesapeake Bay, the productivity of nests in areas of lower salinity was significantly higher

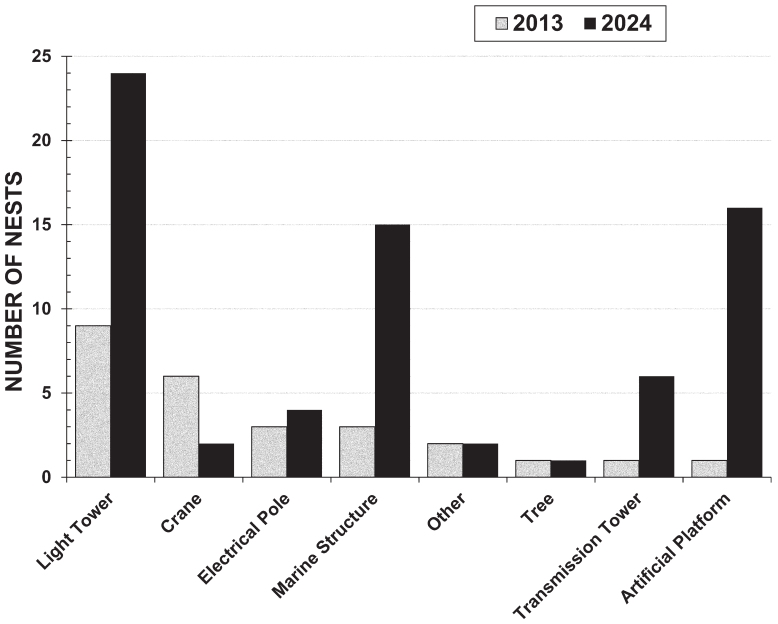

FIGURE 5. Change in distribution of platform types used by territorial Osprey pairs from 2013 (gray bars) to 2024 (black bars). Marine structures include channel markers, piers, and other marine pilings. The "other" category includes roofs of buildings and a shipyard gantry structure.

than near highly saline waters, apparently in response to the distribution and abundance of prey fish (Glass and Watts 2009, Academia and Watts 2023).

Alternatively, the low number of Ospreys nesting in southern San Francisco Bay may not yet be sufficient to trigger the social attraction that has been observed to play a role for recovering or expanding Osprey populations, sometimes leading to semi-colonial nesting (Lohmus 2001). Social attraction might also lead to more territorial interactions with other Ospreys, as I observed during my study where the density of nests was high, i.e., up to 21 within a 3-km radius. In a recovering Osprey nesting population in Corsica, the expansion occurred in two phases, first an increase, followed by a stabilization, suggesting a density dependence that was correlated with the increased behavioral interference by nonbreeding floaters (Bretagnolle et al. 2008). Airola and Estep (2024) also suggested that a low rate of population increase (4.5% per year) in central interior California may indicate habitat saturation.

Although the number of territorial pairs around San Francisco Bay has continued to increase, the rate of growth in numbers of egg-laying pairs appears to have slowed (Figure 2), despite the abundance of possible nest sites and the ample number of nonbreeding floaters observed throughout the nesting season. In most cases, territorial pairs that failed to progress to egg laying seemed to be new pairs that had not previously nested. I do not know

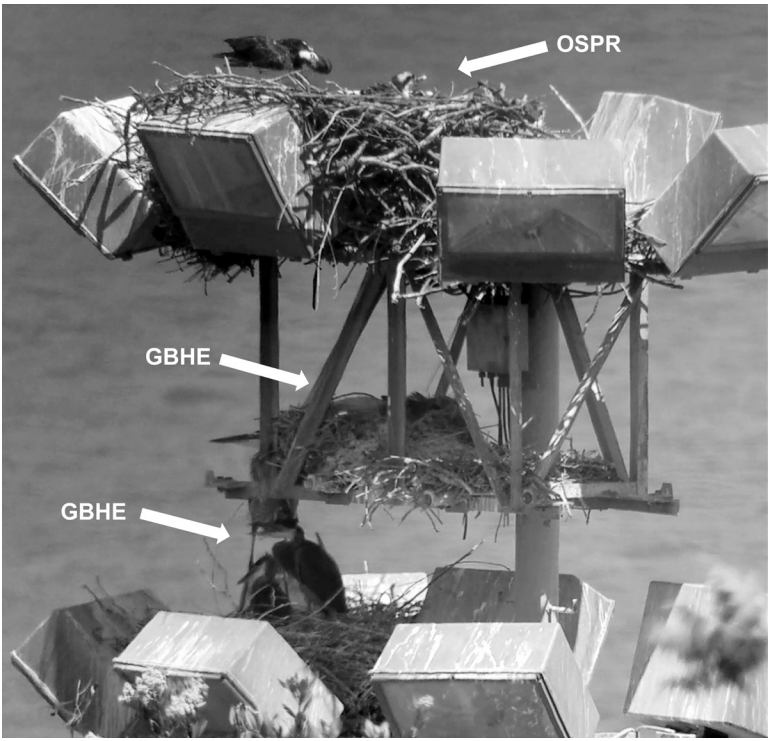

FIGURE 6. Light tower at the decommissioned naval shipyard at Mare Island, Vallejo, in 2019. In 2019 and 2020 both Ospreys and Great Blue Herons nested on the tower, but in all other years only one of these two species occupied the site.

Photo by Anthony J. Brake

if this slowing in the rate of increase of reproductive pairs is merely a pause in the expansion of nesting until more floaters manage to secure mates and nest sites, or whether this population is approaching a plateau.

The productivity of Osprey nests I observed, 1.40 fledglings per territorial pair (1.56 per egg-laying pair), is substantially above the threshold of 0.8 to 1.15 thought necessary to support stable or growing Osprey populations (Spitzer et al. 1983, Watts and Paxton 2007). The low nest productivity and high rate of nest failure seen in 2019 and 2023 may have been due to spring weather atypical for the region. In 2019, there was unusually heavy rain and a windstorm in May, when many of the nests had young nestlings or eggs close to hatching. In 2023, sustained rain fell throughout March, as nesting activity was intensifying. Such weather has been suggested to reduce Ospreys' breeding success (Reese 1977, Johnson et al. 2008) by compromising the eggs' viability, increasing the nestlings' mortality, or interfering with foraging. In 2019 a high level of turbidity due to sediment was evident in San Francisco Bay

through much of the nesting season, resulting from the exceptional amount of precipitation and the resulting runoff entering the bay.

Although each year the number of Ospreys in San Francisco Bay declined markedly after breeding, a substantial number continued to be observed through the fall and winter. It is unclear if these Ospreys are migrants from other regions or are a nonmigratory part of the local breeding population, as in Florida (Martell et al. 2004). Verifying the extent to which the birds are migratory could require a robust banding effort and possibly the use of transmitters for tracking the Ospreys' movements. Given the wide range of climate and habitats in which the Osprey nests in California, its behaviors with respect to migration may range widely.

Conservation Considerations

Although San Francisco Bay's population of nesting Ospreys is currently robust and stable, nesting in such a highly urbanized region presents many challenges and hazards, as all urban-nesting birds face. Collisions with vehicles, buildings, and other structures are a potential hazard (Bullock et al. 2024). Ospreys' frequent use of electrical distribution poles as nest platforms makes electrocution another potential hazard (Harness and Wilson 1998).

The Osprey's propensity to gather man-made objects as nest material makes the birds particularly susceptible to entanglement. I have observed several nestling and adult Ospreys entangled by monofilament fishing line, synthetic twine, or other materials. In at least three cases they were discovered early enough that the nests could be reached and nestlings could be untangled (see examples in Figure 7). In other cases, entanglement was discovered too late for intervention, either because the Ospreys had already died or because the nest was not accessible or capture was not possible. It is likely that other such incidents went unobserved, given the significant amount of discarded monofilament fishing line and synthetic twine and cord along San Francisco Bay's shorelines.

Some of the bay's Osprey nests have been built on old, dilapidated structures that may collapse or be removed because of safety concerns or property redevelopment. Furthermore, nearly all (>98%) Osprey nests about the heavily urbanized bay are built on anthropogenic structures, presenting perceived and actual conflicts for land managers to resolve by either deterring nesting or removing nests. Because of their pronounced nest-site fidelity, Ospreys usually persist in rebuilding on the original structure or others nearby, rendering attempts at deterrence problematic. Fortunately, this problem can usually be mitigated to the benefit of both land managers and Ospreys by the installation of alternative nest substrates to divert Osprey nesting to a nearby location that avoids potential conflict (Austin-Smith and Rhodenizer 1983). This approach has been successfully used around San Francisco Bay and elsewhere in California (Airola and Estep 2022) to deter nesting on several electrical distribution poles. Pacific Gas and Electric, Southern California Edison, and Island Energy routinely use alternative nesting poles or platforms (see Figure 4) as an effective mitigation measure, eliminating the possibility of both the hazard of electrocution of Ospreys and the resulting power outages (APLIC 2012, Washburn 2014, Airola and Estep 2022).

Other expanding Osprey nesting populations in California's Central Valley

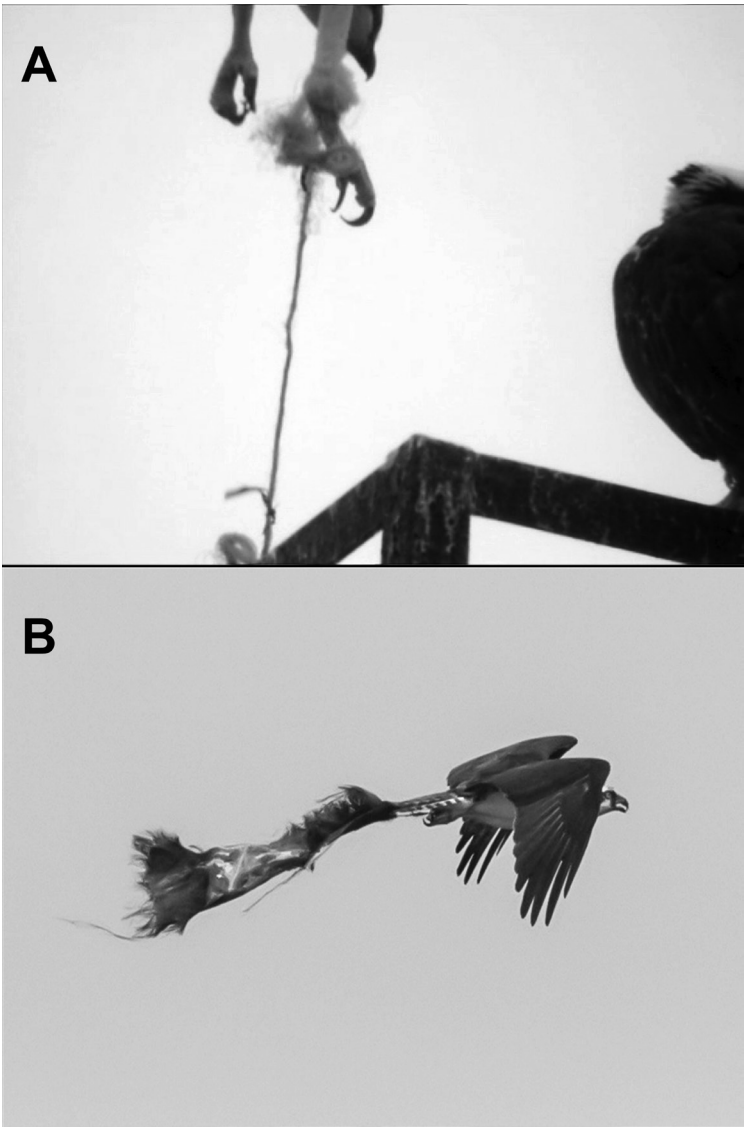

Figure 7. Osprey entanglements: (A) Osprey nestling attempting to fly but caught in frayed plastic twine tethered to the nest site on a crane at the port of Richmond in 2014. Female parent perched to the right. (B) Incubating female with a large piece of construction fabric attached to one foot at the port of Alameda in 2020. This bird was captured by Craig Nikitas (BayRaptorRescue.org), freed of the entanglement, and returned to the nest to continuing incubation.

Photos by Shirley Doell (A) and Anthony J. Brake (B)

(Airola and Estep 2024) and in coastal San Diego (Unitt 2004) and Orange (Kerr 2007, Brake unpubl. data) counties have availed themselves of artificial structures, often near roads, as sites for nests. Osprey nesting and human activity increasingly overlap. Many nesting Ospreys appear to be tolerant of humans or vehicles passing by, particularly when such activity was present when these nest sites were first established. Although nest removal or deterrence is permissible under the Migratory Bird Treaty Act before eggs are laid, under real-life conditions an accurate assessment of whether a nest contains eggs requires experience and time. Routinely applying the recommended best-practice mitigation of providing alternative nest structures and removing nests prior to the nesting season can be effective in avoiding potential conflicts.

It would also be beneficial for the California Department of Fish and Wildlife to update the information on the Osprey in Zeiner et al. (1990) to better account for the now regular nesting in urbanized areas of coastal California as well as exurban portions of the Central Valley, especially as a great majority of nests are built on artificial structures. The information on San Francisco Bay's population of nesting Ospreys should be useful for this species' conservation of throughout California.

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LITERATURE CITED

Academia, M. H., and Watts, B. D. 2023. Food supplementation increases reproductive performance of Ospreys in the lower Chesapeake Bay. Front. Mar. Sci. 10.1172787; doi.org/10.3389/fmars.2023.1172787.

Airola, D. A., and Estep, J. A. 2022. Habitat use and reproductive success of Ospreys in central interior California. Calif. Fish and Wildlife J. 108:1–18; doi.org/10.51492/cfwj.108.7.

Airola, D. A., and Estep, J. A. 2024. Osprey population increase and nesting success over five years in central interior California. W. Birds 55:183–192; doi.org/10.21199/WB55.3.2.

Ames, P. L. 1966. DDT residues in the eggs of the Osprey in the north-eastern United States and their relation to nesting success. J. Appl. Ecol. 3:87–97; doi.org/10.2307/2401447.

Ames, P. L., and Mersereau, G. S. 1964. Some factors in the decline of the Osprey in Connecticut. Auk 81:173–185; doi.org/10.2307/4082767.

Armor, C., and Herrgesell, P. L. 1985. Distribution and abundance of fishes in the San Francisco Bay estuary between 1980 and 1982. Hydrobiologia 129:211–227; doi.org/10.1007/BF00048696.

Austin-Smith, P. J., and Rhodenizer, G. 1983. Ospreys, *Pandion haliaetus*, relocate nests from power poles to substitute sites. Can. Field-Nat. 97:315–319; doi.org/10.5962/p.355013.

Avian Power Line Interaction Committee [APLIC]. 2012. Reducing Avian Collisions with Power Lines. Edison Electric Inst. and APLIC, Washington, DC.

Bent, A. C. 1937. Life histories of North American birds of prey: Order Falconiformes (part I). U.S. Natl. Mus. Bull. 167; doi.org/10.5479/si.03629236.167.i.

Bierregaard, R. O., Poole, A. F., Martell, M. S., Pyle, P., and Patten, M. A. 2020. Osprey (*Pandion haliaetus*), *in* Birds of the World (P. G. Rodewald, ed.). Cornell Lab Ornithol., Ithaca, NY; doi.org/10.2173/bow.osprey.02.

Bijleveld, M. 1974. Birds of Prey in Europe. Macmillan Education UK; doi.org/10.1007/978-1-349-02393-6.

Brake, A. J. 2018. Osprey of San Francisco Bay: A 2018 update. Pac. Raptor Rep. 40:45–48.

Brake, A. J., Wilson, H. A., Leong, R., and Fish, A. M. 2014. Status of Ospreys nesting on San Francisco Bay. W. Birds 45:190–198.

Bretagnolle, V., Mougeot, F., and Thibault, J.-C. 2008. Density dependence in a recovering Osprey population: Demographic and behavioural processes. J. Anim. Ecol. 77:998–1007; doi.org/10.1111/j.1365-2656.2008.01418.x.

Bullock, H. E., Panter, C. T., and Miller, T. A. 2024. Conservation letter: Raptor collisions in built environments. J. Raptor Res. 58:396–406; doi.org/10.3356/jrr248.

Carter, H. R., Leong, R., and Coburn, V. 1990. Osprey nesting at Mare Island. Am. Birds 44:1181.

Cloern, J. E., Jassby, A. D., Schraga, T. S., Nejad, E., and Martin, C. 2017. Ecosystem variability along the estuarine salinity gradient: Examples from long-term study of San Francisco Bay. Limnol. and Oceanogr. 62(S1):S272–S291; doi.org/10.1002/lno.10537.

Conomos, T. J., Smith, R. E., and Gartner, J. W. 1985. Environmental setting of San Francisco Bay. Hydrobiologia 129:1–12; doi.org/10.1007/978-94-009-5528-8_1.

Dege, M., and Brown, L. R. 2004. Effect of outflow on spring and summertime distribution and abundance of larval and juvenile fishes in the upper San Francisco Estuary. Am. Fisheries Soc. Symp. 39:49–65.

Evens, J., and Brake, A. J. 2022. Osprey shift from nesting in trees to artificial structures in the San Francisco Bay area, California. Northwest. Nat. 103:259–262; doi.org/10.1898/1051-1733-103.3.259.

Glass, K. A., and Watts, B. D. 2009. Osprey diet composition and quality in high- and low- salinity areas of lower Chesapeake Bay. J. Raptor Res. 43:27–36; doi.org/10.3356/JRR-08-22.1.

Glover, S. A. 2009. Breeding Bird Atlas of Contra Costa County. Mount Diablo Audubon Soc., Walnut Creek, CA.

Grinnell, J., and Miller, A. H. 1944. The distribution of the birds of California. Pac. Coast Avifauna 27.

Grinnell, J., and Wythe, M. W. 1927. Directory to the bird-life of the San Francisco Bay region. Pac. Coast Avifauna 18.

Grove, R. A., Henny, C. J., and Kaiser, J. L. 2009. Osprey: Worldwide sentinel species for assessing and monitoring environmental contamination in rivers, lakes, reservoirs, and estuaries. J. Toxicol. Env. Health B 12:25–44; doi.org/10.1080/10937400802545078.

Harness, R. D., and Wilson, K. 1998. Raptor electrocutions. IEEE Industry Appl. Mag. 4:25–31; doi.org/10.1109/2943.667904.

Henny, C. J., and Kaiser, J. L. 1996. Osprey population increase along the Willamette

River, Oregon, and the role of utility structures, 1976–93, *in* Raptors in Human Landscapes (D. M. Bird, D. E. Varland, and J. J. Negro, eds.), pp. 97–108. Academic Press, San Diego; doi.org/10.1016/B978-012100130-8/50014-6.
Henny, C. J., Grove, R. A., Kaiser, J. L., and Johnson, B. L. 2010. North American Osprey populations and contaminants: Historic and contemporary perspectives. J. Toxicol. Env. Health B 13:579–603; doi.org/10.1080/10937404.2010.538658.
Houston, C. S., and Scott, F. 2001. Power poles assist range expansion of Ospreys in Saskatchewan. Blue Jay 59:182–188; doi.org/10.29173/bluejay5529.
Johnson, D. R., Melquist, W. E., and Fleming, T. L. 2008. Rainstorm effects on Osprey brood survival. J. Raptor Res. 42:51–53; doi.org10.3356/JRR-07-14.1.
Kerr, R. 2007. The Ospreys have landed. Outdoor Calif. 68:4–11.
Kiff, L. F. 1980. Historical changes in resident populations of California islands raptors, *in* The California Islands: Proceedings of a Multidisciplinary Symposium (D. M. Power, ed.), pp. 651–673. Santa Barbara Mus. Nat. Hist., Santa Barbara, CA.
Lohmus, A. 2001. Habitat selection in a recovering Osprey *Pandion haliaetus* population. Ibis 143:651–657; doi.org/10.1111/j.1474-919X.2001.tb04893.x.
MacWilliams, M., Bever, A. J., and Foresman, E. 2016. 3-d simulations of the San Francisco estuary with subgrid bathymetry to explore long-term trends in salinity distribution and fish abundance. San Francisco Estuary and Watershed Science 14(2, article 3):1–24; doi.org/10.15447/sfews.2016v14iss2art3.
Martell, M. S., McMillian, M. A., Solensky, M. J., and Mealey, B. K. 2004. Partial migration and wintering use of Florida by Ospreys. J. Raptor Res. 38:55–61.
Poole, A. F. 1989. Ospreys: A Natural and Unnatural History. Cambridge Univ. Press, Cambridge, England.
Poole, A. F. 2019. Ospreys: The Revival of a Global Raptor. Johns Hopkins Univ. Press, Baltimore.
Reese, J. G. 1977. Reproductive success of Ospreys in central Chesapeake Bay. Auk 94: 202–221; doi.org/10.1093/auk/94.2.202.
Rippey, M. 2014. Breeding Birds of Solano County. Napa-Solano Audubon Soc., Napa, CA.
Schmidt-Rothmund, D., Dennis, R., and Saurola, P. 2014. The Osprey in the western Palearctic: Breeding population size and trends in the early 21st century. J. Raptor Res. 48:375–386; doi.org/10.3356/JRR-13-OSPR-13-03.1.
Spitzer, P. R., Poole, A. F., and Scheibel, M. 1983. Initial population recovery of breeding Ospreys in the region between New York City and Boston, *in* Biology and Management of Bald Eagles and Ospreys (D. M. Bird ed.), pp. 231–256. Harpell Press, Ste. Anne de Bellevue, Quebec.
Steenhof, K., and Newton, I. 2007. Assessing nesting success and productivity, *in* Raptor Research and Management Techniques (K. L. Bildstein, D. M. Bird, D. R. Barber, and A. Zimmerman, eds.), pp. 181–192. Hancock House, Surrey, BC.
Stone, W. 1939. Bird Studies at Old Cape May: An Ornithology of Coastal New Jersey. Stackpole Books, Mechanicsburg, PA.
Unitt, P. 2004. San Diego County Bird Atlas. Proc. San Diego Soc. Nat. Hist. 39.
Washburn, B. E. 2014. Human–Osprey conflicts: Industry, utilities, communication, and transportation. J. Raptor Res. 48:387–395; doi.org/10.3356/JRR-OSPR-13-04.1
Watts, B. D., and Paxton, B. J. 2007. Ospreys of the Chesapeake Bay: Population recovery, ecological requirements, and current threats. Waterbirds 30 (Spec. Publ. 1):39–49; doi.org/10.1675/1524-4695(2007)030[0039:OOTCBP]2.0.CO;2.
Zeiner, D. C., Laudenslayer, W. F. Jr., Mayer, K. E., and White, M. 1990. California's Wildlife, vol. II: Birds. Calif. Dept. Fish and Game, Sacramento.

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