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STATUS AND DISTRIBUTION OF BREEDING OSPREYS IN THE CHESAPEAKE BAY: 1995–96

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ABSTRACT.—We surveyed the tidal portions of the Chesapeake Bay for nesting Ospreys (*Pandion haliaetus*) during the breeding seasons of 1995–96. The population was estimated to contain 3473 ± 75 (SE) breeding pairs. The population has more than doubled since the comprehensive survey conducted in 1973. During this recovery, there has been considerable spatial variation in the rates of population growth. Mean doubling times for well-defined subregions varied from a low of 4.3 yr to more than 40 yr. In general, growth rates have been highest in the tidal fresh and upper estuarine areas, where few pairs occurred in 1973. Based on the pattern and magnitude of the recovery, it seems that the Chesapeake Bay population experienced a greater decline during the post World War II era than was previously believed. Nesting substrate use by Chesapeake Bay Ospreys has shifted since 1973. The use of trees for nesting has declined from 31.7–7.2% in 23 yr. Channel markers accounted for 53.5% of all nest structures in the current study. Platforms established specifically for Ospreys supported 12.1% of pairs. The proliferation and diversification of artificial substrates throughout the Chesapeake Bay has been one of the most important factors contributing to recent population expansion.

KEY WORDS: *Osprey; Pandion haliaetus; Chesapeake Bay; nest substrate; population increase.*

ESTATUS Y DISTRIBUCIÓN DE ÁGUILAS PESCADORAS DURANTE SU REPRODUCCIÓN EN LA BAHÍA DE CHESAPEAKE: 1995–96

RESUMEN.—Estudiamos las porciones maréales de la bahía de Chesapeake en busca de águilas pescadoras (*Pandion haliaetus*) que estuvieran anidando durante las estaciones reproductivas de 1995–96. Se estimó que la población contenía 3473 ± 75 parejas en reproducción. La población ha aumentado mas del doble desde que el completo estudio se llevó a cabo en 1973. Durante esta recuperación, ha habido una considerable variación temporal en las tasas de crecimiento poblacional. La media de los tiempos de duplicación para sub regiones bien definidas varió desde un promedio bajo de 4.3 años a uno de mas de 40 años. En general, las tasas de crecimiento mas altas han ocurrido en las zonas de marea fresca y en las áreas altas de los estuarios, donde se presentaron pocas parejas en 1973. Con base en el patrón y magnitud de la recuperación, parece que la población de la bahía de Chesapeake experimentó un declive más grande de lo que se creía, durante la post guerra de la segunda guerra mundial. El uso del sustrato de anidación por las águilas de la bahía de Chesapeake ha cambiado desde 1973. El uso de árboles para anidar ha diminuido de 31.7% a 7.2% en 23 años. Los marcadores de canales dan cuenta del 53.5% de todas las estructuras de anidación en el presente estudio. Las plataformas establecidas específicamente para las águilas albergaron 12.1% de las parejas. La proliferación y diversificación de sustratos artificiales a lo largo de la bahía de Chesapeake ha sido uno de los factores más importantes que ha contribuido en la reciente expansión de la población.

[Traducción de César Márquez]

The Chesapeake Bay supports one of the largest Osprey (*Pandion haliaetus*) breeding populations in the world (Henny 1983). As with many similar populations, Ospreys in the Chesapeake Bay experienced dramatic declines in the post World War II era due to reproductive suppression (Truitt 1969, Kennedy 1971, 1977, Wiemeyer 1971) induced by environmental contaminants (Via 1975, Wiemeyer et al. 1975). The Chesapeake Bay population appeared to have reached a low point by 1973 when Henny et al. (1974) estimated its size to be 1450 breeding pairs. Since that time, both reproductive performance (Reese, 1975, Henny 1977) and overall population size (Spitzer 1989, Westall 1990, Houghton and Rymon 1994) have shown remarkable recoveries.

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Henny and Ogden (1970) indicated that the magnitude of the decline experienced by the Chesapeake Bay Osprey population was considerably less than that observed further north in New England. However, estimating the size of the historical population in the Chesapeake Bay has been difficult because no bay-wide surveys were conducted prior to declines. Comparisons made between surveys conducted in the 1970s and published observations prior to 1947 for selected areas have produced varied results (Reese 1969, Stinson and Byrd 1976, Schmid 1977). These differences suggest that, even for areas within the bay, declines varied spatially.

Throughout the 1980s, evidence began to suggest that the Osprey population was approaching the carrying capacity of the Chesapeake Bay. Comparisons of selected geographic areas indicated that the number of breeding pairs had recovered to levels documented prior to the decline (Reese 1996). Sibling aggression and associated brood reduction in other locations suggested food stress (Roberts 1982, McLean and Byrd 1991, P. Spitzer unpubl. data). Available nesting substrate appeared to be saturated within selected locations and age at first reproduction had increased, likely in response to nest-site limitation (Spitzer 1989). These views were based on observations from a limited number of geographic areas. No bay-wide survey has been attempted since 1973.

Here we report the results of a comprehensive survey for Chesapeake Bay Ospreys conducted during the breeding seasons of 1995–96. We compare status, distribution, and the use of substrate types to Henny et al. (1974), and also assess spatial variation in population growth during the time period between the two comprehensive surveys.

METHODS

This study included the entire tidal portion of the Chesapeake Bay (Fig. 1). The Chesapeake Bay is the largest estuary in the United States, containing more than 19 000 km of tidal shoreline. The bay's wide salinity gradient, shallow water, and climate have made it one of the most productive aquatic ecosystems in North America. Osprey now breed throughout the estuary, from the Atlantic Ocean to the fall line. The fall line is an erosional scarp where the metamorphic rocks of the Piedmont meet the sedimentary rocks of the Coastal Plain. The geologic formations along this boundary frequently determine the landward extent of tidal influence. Over the last several decades, expansion of the human population within waterfront areas has altered the nature of the shoreline. The physical infrastructure associated with this expanding human population led to a dramatic shift in the distribution and availability of nesting substrates for the Osprey population. Breeding Ospreys have adapted to numerous types of artificial substrates, so both distribution and abundance of breeding pairs have been influenced by the distribution of human settlement.

We located Osprey nests by piloting a small boat along the shoreline of the Chesapeake Bay and its tributaries. All tributaries were followed and surveyed to the fall line or to their navigational limits. In total, more than 800 major and minor tributaries were surveyed. Due to the size of the study area and limitations in manpower, it was not feasible to survey the entire Chesapeake Bay during a single breeding season. Portions of the bay within Virginia were surveyed during the breeding season of 1995 and those within Maryland were surveyed in 1996. We do not feel that the primary objectives (i.e., reassess population status during a narrow point in time and compare survey results to previous benchmark) of this investigation were compromised by this approach.

Because of the extensive area of coverage, it was not feasible to visit nests multiple times throughout the season. The term "occupied nest" as used here followed the definition applied in the 1973 survey (referred to as "active nests" in that survey; Henny et al. 1974). Nests were considered to be occupied if they had Ospreys on the nest or in the immediate vicinity or had evidence of use during the current breeding season. As in 1973, nearly all nests designated as occupied had attending adults or young present. One potential problem pointed out by Henny and VanVelzen (1972) and Henny et al. (1974) is that in many populations, 5–10% of individuals associated with nests are nonbreeders. Although the majority of nests surveyed had direct evidence of a breeding attempt (eggs or young present), it is possible that some nests attended by nonbreeders were included in the population estimate. Nest sites were separated into seven categories: (1) day markers, (2) light markers, (3) Osprey platforms, (4) duck blinds, (5) other man-made structures, (6) pine trees (*Pinus* spp.), and (7) hardwood trees. All duck blinds detected were recorded and mapped. The list of navigational aids from the late 1990s (United States Coast Guard 1999) was compiled for the tidal portion of the Chesapeake Bay to estimate availability of day and light markers. No attempt was made to map all platforms erected for Ospreys.

To determine growth rates for different areas throughout the Chesapeake Bay, population estimates for geographic areas defined in the early 1970s (Kennedy 1971, Henny et al. 1974, M. Byrd unpubl. data) were compared to those from the mid-1990s. Growth rates were expressed using the mean time (in years) required for the breeding population to double in size (t_{double}). Doubling time was calculated using the growth equation $N_t = N_0e^{rt}$ where N_t is the estimated population size in the mid-1990s, N_0 is the estimated population size in 1973. Mean doubling time is estimated as $t_{double} = \ln(2)/r$.

The 1973 survey was an aerial-based survey supplemented with ground surveys over much of the study area. Henny et al. (1974) used a modified Petersen Estimator (Overton and Davis 1969) to derive a series of correction factors that were specific to both geographic area and type of nesting substrate. Correction factors were designed to account for differences in field crews between

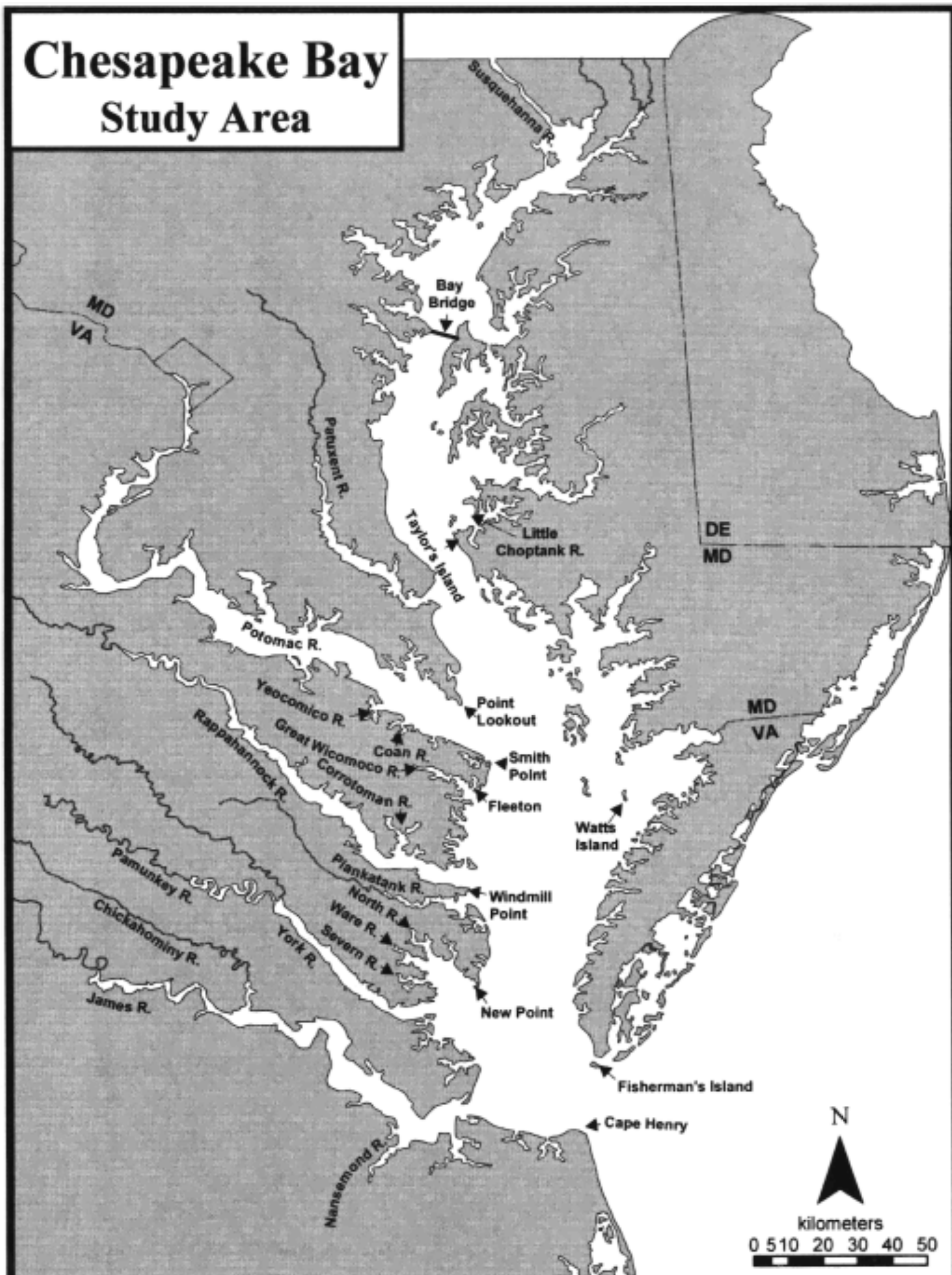

Figure 1. Map of the Chesapeake Bay study area including tributaries and landmarks used to delineate geographic areas.

Table 1. A comparison of Osprey nests detected by boat and additional nests detected from a fixed-wing aircraft inland of the shoreline (boat undercount) for ten tributaries in 1996. Mean correction factor was applied to survey results to improve the overall Chesapeake Bay population estimate.

Tributary	Pairs Detected by Boat	Additional Nests Detected from Air	Correction Factor
Nansemond River	20	2	1.10
Piankatank River	41	5	1.12
Great Wicomoco River	32	4	1.13
Yeocomico River	29	2	1.07
Coan River	33	5	1.15
Corrotoman River	23	2	1.09
Ware River	16	2	1.13
North River	11	1	1.09
Pamunkey River	28	4	1.14
Severn River	18	2	1.11
Mean (SD)			1.11 (0.024)

geographic areas and anticipated variation in detection rates with substrate type. Nest detection rates were shown to be higher for ground surveys compared to aerial surveys across all geographic areas and substrate types. Within the areas surveyed by both techniques, 702 (88.2%) of 796 nests recorded were detected during ground surveys. Of 94 nests not detected during ground surveys, 77 (81.9%) were in trees (it was not determined how many of these were not detected by boat because they were inland of the primary shoreline).

This study used a ground-based approach and all areas were surveyed by the same field crew. We assumed that all Osprey nests over water or along the shoreline were detected (100% visibility rate) during the boat surveys. Based on detection patterns derived from the 1973 survey, this assumption may have led to an underestimate as high as 10%. Throughout the 1980s and 1990s a growing number of Osprey have colonized areas increasingly inland of the primary shoreline (B. Watts and M. Byrd pers. observ.). Most of these nests occur on cell towers, transmission towers, and other man-made structures and are not detectable from a boat. In an effort to estimate the magnitude of this inland undercount, aerial surveys were conducted along ten tributaries during the breeding season of 1996. To detect Osprey nests, a high-wing Cessna 172 aircraft was used to systematically overfly the land surface at an altitude of ca. 100 m. The aircraft was maneuvered systematically between the shoreline and a distance of approximately 1 km inland to cover the most probable breeding locations. Boat and aerial surveys were compared to determine the number of Osprey nests that were not detected during boat surveys due to their inland location (Table 1). A simple correction factor was calculated for each of the 10 rivers by dividing the total number of undetected (sum of boat and air) by the number of nests detected during the boat survey. The mean of these correction factors was then used bay-wide to refine population estimates.

Table 2. A summary of Osprey pairs detected in the Chesapeake Bay by geographic area. Counts refer to breeding pairs mapped during boat surveys. Estimates were made by applying a correction factor derived from aerial surveys (see Methods and Table 1).

Geographic Area	Count	Estimate
Maryland		
Western Shore		
Susquehanna to Bay Bridge	86	95.5
Bay Bridge to Potomac River	492	546.1
Eastern Shore		
Susquehanna to Bay Bridge	162	179.8
Bay Bridge to Little Choptank River	324	359.6
Little Choptank to VA/MD Border	428	475.1
Maryland Total	1492	1656.1
Virginia		
Western Shore		
Potomac River to New Point	806	894.7
New Point to Cape Henry	680	754.8
Eastern Shore		
VA/MD Border to Fisherman's Island	151	167.6
Virginia Total	1637	1817.1
Chesapeake Bay Total	3129	3473.2

RESULTS

We estimated the breeding population of Ospreys in the Chesapeake Bay to contain 3473 breeding pairs in the mid-1990s. Maryland and Virginia portions of the bay supported 1656 and 1817 pairs, respectively (Table 2). In Maryland, the tributaries and bays of the eastern shore supported 61.3% of the breeding pairs. In contrast, the extensive tributaries on the western shore supported 90.8% of the breeding pairs in Virginia. This difference is consistent with the distribution of open water and shoreline within these two states.

All major tidal-tributaries of the Chesapeake Bay now support large breeding populations. These include the Potomac River (797 estimated breeding pairs), James River (362), Rappahannock River (285), Choptank River (228), York River (188), Patuxent River (155), and Chester River (129). Al-

Table 3. Population comparison between 1973 and 1995–96 for geographic areas delineated by Kennedy (1971), and Henny et al. (1974). Values of r refer to intrinsic rates of increase. Values of t_{double} refer to estimated doubling time in years.

GEOGRAPHIC AREA	1971–73[b]	1995–96	r-VALUE	t_{double}
Western Shore				
Susquehanna River to Bay Bridge	12.1	95.5	0.090	7.7
Bay Bridge to Point Lookout	38.8	390.7	0.100	6.9
Patuxent River	22	155.4	0.085	8.2
Potomac River (MD)	198.3	363.0	0.026	
Potomac River (VA)	87.5	320.8	0.059	
Smith Point Area	22	57.7	0.044	15.8
Fleeton to Windmill Point	48.7	81.0	0.023	26.4
Rappahannock River	126.7	252.0	0.031	11.7
Between Rappahannock and York Rivers	114.8	217.6	0.029	23.9
York River[b]	23.4	145.4	0.083	8.4
James River[b]	6	245.3	0.161	4.3
Chickahominy River, Eastern shore	12	115.4	0.098	7.0
Susquehanna River to Bay Bridge	69.1	179.8	0.042	16.7
Bay Bridge to Taylor's Island	242.3	359.6	0.017	40.4
Taylor's Island to Virginia Border	159.9	309.7	0.029	24.1
Virginia Shoreline and Watts Island[b]	49	125.4	0.041	17.0

[a] Whole values are from total ground counts rather than corrected estimates (see Methods and Table 1).
[b] Survey from Kennedy 1971.

though breeding density remains highest near the main stem of the bay, breeding pairs occur in low densities near the fall line of virtually every major tributary.

The Chesapeake Bay Osprey population has more than doubled since the comprehensive surveys conducted in 1973. Over this time period, growth rates have varied considerably among regions of the bay (Table 3). Estimated mean doubling times for well-defined geographic areas varied from a low of 4.3 yr on the James River to more than 40 yr on the eastern shore below the Bay Bridge. In general, growth rates have been highest in the upper reaches of the estuary where very few pairs occurred in 1973.

Nesting substrates used by Chesapeake Bay Ospreys shifted between 1973 and the mid-1990s. Man-made structures were used by 68.3% of the population in 1973 compared to 92.8% in the mid-1990s. Part of this shift is due to the increase in availability and use by Osprey of navigational aids. These structures represented 21.8% and 53.5% of all substrates documented in the 1973 and 1995–96 surveys. respectively. Current use is split between day (944, 30.2% of total substrates) and light markers (728, 23.3%). Osprey nesting platforms were experimental in 1973, but represented 12.1% of all substrates used in the mid-1990s. Duck blinds have declined in relative use over the 20-yr period from 28.7–9.7%. Other man-made structures accounted for 17.6% of used substrates in the mid-1990s, and included boat houses, chimneys, docks, ships, electrical power poles, bridges, cell phone towers, and pilings. The portion of the breeding population that nested in trees declined considerably over the 20-yr period from 31.7–7.2% (5.0% pines, 2.2% hardwoods).

DISCUSSION

In little more than twenty years, the Chesapeake Bay Osprey population has more than doubled in size. The increase in numbers is obvious throughout the entire estuary. However, the growth rate over this time period has varied widely among regions within the bay. Virtually all of the areas considered to be "strongholds" for the species in the 1970s have shown relatively little growth since that time. The lack of rapid growth within these locations supports earlier suggestions that these areas were less effected by contaminants than populations elsewhere (Reese 1969, 1970). Not coincidentally, these are the same areas from which most of the ecological information concerning Chesapeake Bay Ospreys has been collected (e.g., Reese

1970, 1977, Stinson 1976, McLean 1986, Spitzer 1989). This relationship has understandably led to a limited perspective, both on the decline of the broader Chesapeake Bay population and on its recovery.

Osprey populations within the tidal fresh and brackish portions of the Chesapeake Bay have experienced the most rapid growth rates since the 1970s. In recent years, after this survey of the mid-1990s, these populations have continued to grow (B. Watts and M. Byrd pers. observ.). Comparisons for some of these areas were not included in Table 3 because they were excluded from the Henny et al. (1974) survey. These areas were not surveyed in 1973 apparently because they supported no known breeding pairs at that time. Assuming this to be true, growth rates for populations within several of these areas since that time would be the highest in the bay. The lack of any historic accounts within these areas prior to the bay-wide decline makes it difficult to determine if the lack of birds there in the early 1970s reflects the historical distribution of the species in the bay or a total population collapse. The rapid colonization of these areas throughout the 1980s and 1990s makes it difficult to believe that they were not occupied historically.

Indications that the Osprey population was reaching the capacity of the Chesapeake Bay during the 1980s, reflect conditions within the few locations for which information was available rather than bay-wide patterns. Reese (1969, 1970) documented recovery of the population below the Bay Bridge on the eastern shore to pre-DDT levels when the bay-wide population was still below 1500 pairs in the early 1970s. Ospreys within this location had the slowest growth rates compared to all other identified areas (Table 3). In Mobjack Bay, where an increase in sibling aggression and brood reduction was documented between the 1970s (Stinson 1976) and the 1980s (McLean 1986), the population has remained relatively stable since the mid-1980s (M. Byrd unpubl. data). No information is currently available on the occurrence of food stress throughout different geographic areas or its importance to the bay-wide population. Saturation of available nesting substrate has been documented along the Choptank River (Spitzer 1989). Substrate limitation is a widespread and natural condition throughout the bay especially within areas with extensive wetlands devoid of trees. The dramatic response of breeding Ospreys to nest platforms established on Smith Island (Rhodes 1972) reflects this limitation. However, from a bay-wide perspective, the continued expansion of the human population throughout the Chesapeake Bay estuary has provided for a consistent increase and diversification of nesting structures for breeding Ospreys.

Aside from the banning of key chemical compounds, the increase in nesting substrates has likely been the most important factor fueling the recovery of the Chesapeake Bay Osprey population. The change in substrate use between the early 1970s and the mid-1990s continues the ongoing shift of Chesapeake Bay Ospreys to artificial structures that has been apparent throughout the latter half of the twentieth century. All accounts prior to 1950 describe nearly all Osprey nests observed as in either live or dead trees (Jones 1936, Tyrrell 1936, Reese 1969). In 1973, more than 65% of Ospreys were nesting on man-made structures (Henny et al. 1974). By the 1990s this portion of the population had increased to more than 90%. In just 50 yr time, the population has progressed through an almost complete shift from trees to artificial structures.

Numerous classes of structures have contributed to the shift in substrate use. Osprey nesting platforms were not in use in the Chesapeake Bay until the 1960s and 1970s (Reese 1970, Rhodes 1972). The widespread placement of platforms by the general public during the 1980s and 1990s has greatly improved substrate availability in many areas. No attempt was made during boat surveys to determine the availability of platforms. However, 380 Osprey pairs were nesting on such platforms. Duck blinds have been common throughout the Chesapeake Bay at least since the 1920s but have fluctuated dramatically in numbers through the decades (Stotts 1958, Henny et al. 1974). Approximately 3000 duck blinds were mapped during shoreline surveys including just over 300 that were more than 25 m offshore. Ospreys rarely utilize duck blinds that are not isolated from the shoreline. A total of 303 duck blinds supported nesting pairs, during the current survey suggesting that nearly all isolated duck blinds were used.

Aides to navigation or "channel markers" have become the most common substrates used for nesting by Ospreys throughout the Chesapeake Bay. In 1973, Henny et al. (1974) report 316 nests on channel markers. These pairs represented 21.8% of the population. There were 1875 navigational structures maintained in the bay in 1973, suggesting an occupation rate of just below 17%. In the mid-1990s we recorded 1672 nests on channel markers representing 53.4% of nests counted during boat surveys. These included 944 on day markers and 728 on light markers. In the late 1990s, the U.S. Coast Guard listed 1680 day markers and 1249 light markers maintained throughout the Chesapeake Bay (United States Coast Guard 1999). This suggests an occupation rate of 56.2% and 58.3% for day and light markers, respectively, and a combined occupation rate of 57.1%. Clearly the increase in navigational structures from 1875–1929 over the 20-yr period has elevated their relative importance to Ospreys in the bay. It is also likely that the attitude of the Coast Guard toward nesting Ospreys has increased the occupation rates. Throughout the 1960s and early 1970s it was standard operating procedure for the Coast Guard to remove Osprey nests from navigational aides during any period of the nesting cycle or to alter structures to prevent nesting. A shift to a more Osprey-friendly policy during the late 1970s has likely had a positive impact on the bay-wide population.

In terms of factors relevant to the Osprey breeding population, the Chesapeake Bay is a different system than it was during the early 1970s. Likewise, the bay in the 1970s was a different place than it was during historical times. Fish populations have changed, the shoreline has undergone rapid alteration, and structures suitable for nesting have increased. Based on available information, it has not been possible to determine the size of the historical, bay-wide Osprey population. Given ongoing changes in the bay system that are functionally relevant to the Osprey population, it is also not clear that historical status and distribution information would be useful in predicting current and future population patterns. However, based on the variation in recovery rates throughout the bay, it does appear that the population experienced a decline of a greater magnitude than was previously believed. Additional benchmark surveys will be required to project when and under what circumstances the bay-wide population may begin to approach some upper limit.

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