Ospreys of the Chesapeake Bay: Population Recovery, Ecological Requirements, and Current Threats

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Abstract.—The Chesapeake Bay supports the largest Osprey (*Pandion haliaetus*) breeding population in the world. The population experienced a dramatic reduction due to biocide-induced reproductive suppression in the post World War II era and reached an estimated low of 1,450 pairs by the early 1970s. By the mid 1990s, the population recovered to an estimated 3,500 pairs and breeding was documented on 427 of 878 named tributaries of the tidal Bay. Recovery has been exponential but spatially variable with average doubling times for defined geographic areas varying by more than an order of magnitude. Rates of population growth have been negatively related to salinity with the highest rates occurring within tidal fresh reaches suggesting that recovery has progressed from the main stem of the Bay toward the fall line. Virtually nothing is known about the breeding ecology of Ospreys in the lower saline waters of the Bay. The increase and diversification of man-made structures used for nesting has made a fundamental contribution to recovery and current distribution. A synthesis of information from several field sites throughout the Bay shows a collective increase in reproductive rate (young/active pair) from less than 0.8 in the 1960s to more than 1.2 by the mid-1980s followed by a reduction to below 1.0 in the late 1980s. Threats to the population continue to be the release of new classes of contaminants into the estuary and anthropogenic activities that have the potential to suppress reproductive rates and juvenile/adult survivorship.

Key words.—Osprey, Chesapeake Bay, breeding population, reproductive rates, recovery, threats, nesting substrates.

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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; Wiemeyer 1971; Kennedy 1971, 1977) induced by environmental contaminants (Via 1975; Wiemeyer *et al.* 1975). The population appears to have reached a low point by the early 1970s when Henny *et al.* (1974) estimated its size to be 1,450 breeding pairs. Since that time, both reproductive performance (Henny 1977; Reese 1975; Byrd 1990) and the overall population size (Spitzer 1989; Westall 1990; Houghton and Rymon 1994; Watts *et al.* 2004) have shown remarkable recoveries. The population more than doubled between the early 1970s and the mid-1990s (Watts *et al.* 2004). However, colonization rates have been highly variable throughout the Bay with most of the advances occurring in the lower salinity reaches where subpopulations were extirpated during the middle 1900s. This pattern of increase is continuing to the present time (Watts, unpubl. data).

During the 1970s and 1980s, the Chesapeake Bay Osprey population was arguably the most intensively studied breeding population in the world. Dozens of studies were conducted over a relatively short time frame that included thousands of breeding attempts distributed over a large geographic area. These studies focused on the population "strongholds" that occurred in the higher salinity waters along the main stem of the Bay (e.g., Stinson 1976; Reese 1977; McLean 1986; Byrd 1988). After 1990, investigations of Chesapeake Bay Ospreys dropped off sharply. As the population has continued to recover in the intervening years, an increasing fraction is supported by the lower salinity reaches of Bay tributaries (Watts *et al.* 2004). At present, virtually nothing is known about the ecology of Ospreys in these waters.

In this paper, we provide a synthesis of available information on the population ecology of Ospreys in the Chesapeake Bay. Investigations of this breeding population spans generations. We attempt to compile what is known about reproductive rates and the history of the population. We draw information from studies conducted in the tidal Chesapeake including Virginia and Maryland.

BREEDING POPULATION

Historic Breeding Population

For the years prior to the broad-scale population decline, information on the status and distribution of breeding Ospreys throughout the Chesapeake Bay and vicinity does not exist. Information during this period is available only from a smattering of local accounts scattered through the years (e.g., Bailey 1876; Tyrrell 1936). However, given the high productivity of Bay waters, the extensive forested shoreline, and the vast shallow waters available for foraging, the Bay has long been believed to have supported the largest breeding population in the world (Henny 1983). This view is supported by available accounts of breeding populations within local areas.

Several accounts of Ospreys breeding within identified areas throughout the region are available between the mid 1800s and the 1940s (pre-DDT era). Bailey (1876) described approximately 50 pairs of Ospreys in the summer of 1875 on Hog Island along the Delmarva Peninsula. In late May of 1892, Kirkwood (as reported in Reese 1969) documented 32 pairs in parts of Queen Anne and Kent counties around Eastern Bay and the Chester River on the Eastern Shore of Maryland. On 7 May 1890, White (1891) collected 25 clutches of eggs from Gwynn's Island at the mouth of the Rappahannock River. This is an underestimate of the population since White describes a number of empty nests on this date. Jones (1936) estimated 25 nests on Bay Tree Neck near the mouth of the York River in 1936. In June of 1936 Tyrrell documented 42 pairs within Smith's Point at the mouth of the Potomac. Smith (1931) reported approximately 50 pairs of Ospreys near Ocean City, Maryland in April of 1926.

Historically, Ospreys appear to have nested throughout the Chesapeake Bay estuary including the upper reaches. Coues and Prentiss (1862) described Ospreys as common on the upper Potomac River around Washington D.C. Cooke (1929) described the Osprey as a common nesting species within the same area during the early 1900s. Stewart and Robbins (1958) described the status of breeding Ospreys in Maryland as common in the tidewater areas of the Eastern Shore, western shore, and upper Chesapeake sections. By the time that intensive work was initiated with Ospreys in the 1960s and 1970s the population appeared to have contracted to the main stem of the Bay with no pairs reported from low-salinity upper estuaries (Kennedy 1971; Henny *et al.* 1974).

Breeding Population Decline

Because there were no Bay-wide surveys conducted prior to population declines, estimating the magnitude of Osprey declines in the Chesapeake Bay has been problematic. Many factors (e.g., disturbance, shooting and collecting, overfishing) likely contributed to declines prior to, during, and after the DDT era. Egg collecting throughout the late 1800s and early 1900s was widespread throughout the region. White (1891) collected 25 clutches of eggs in a single day on Gwynn's Island. Schmid (1977) refers to early observations of Osprey shooting to protect hatchery fish. Wiemeyer (1971) lost one nest in his 1970 study area on the Potomac River when the male was shot on the nest. Reese (1970, 1977) refers to human disturbance around active nests as one of the most important sources of reproductive loss in his study area on the Eastern Shore of Maryland. The relative magnitude and timing of these impacts are not known. However, the most dramatic phase of this decline occurred in the post World War II era when DDT and like compounds came into common use in the region.

By the 1960s it was clear to the scientific community that Osprey populations over a broad geographic area were experiencing severe declines (e.g., Ames and Mersereau 1964; Peterson 1969). Annual rates of declines within some areas were as high as twelve to 14% (Henny and Ogden 1970). The most significant declines were documented along the northeast coast. Some well-known examples include the Gardner's Island population on Long Island that declined from 300 pairs in 1945 to 27 pairs in 1976 (Spitzer 1980), Eastern Long Island population that declined from approximately 500 pairs in 1941 to 69 pairs in 1976 (Peterson 1969; Spitzer 1980), and the Connecticut River population that declined from 200 pairs in 1938 to ten pairs in 1968 (Henny and Ogden 1970).

It has been generally believed that the magnitude of the decline experienced by the Chesapeake Bay Osprey population was considerably less than that observed further north in New England (Henny and Ogden 1970; Reese 1970, 1977). However, 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). Reese (1969) compared population information collected by Kirkwood in 1892 within his study area to information collected in 1968. The two surveys were comparable with Kirkwood reporting 32 nests and Reese reporting 31. From production rates reported by Reese, Henny and Ogden (1970) calculated an annual decline rate of only two to 4%. Stinson and Byrd (1976) compared numbers from the few published accounts of Ospreys in Virginia with survey data from the same areas in 1975. The survey data from six sites in Virginia (1876-1936) was approximately 160 pairs. The same areas in 1975 supported 34 pairs. The decline in the size of the breeding populations within these historic sites ranged from zero to 100%. Collectively, these values suggest an 80% reduction in the breeding population from early periods to 1975. These discrepancies in results suggest that, even for areas within the Bay, declines varied spatially. By the 1970s there were no known breeding pairs in the lower salinity reaches of Virginia tributaries (Henny *et al.* 1974; Kennedy 1971, 1977; M. A. Byrd, College of William and Mary, pers. comm.). These areas apparently did support birds in the early 1900s (McAtee 1921) and currently support the fastest growing portion of the breeding population (Watts *et al.* 2004) suggesting that populations within these areas were extirpated prior to survey efforts in the early 1970s. The breeding population appeared to have reached a low point by 1973 when Henny *et al.* (1974) estimated its size to be 1,450 breeding pairs. At this time, pairs occurred primarily in the main stem of the Bay.

Breeding Population Recovery

By the mid-1970s, the Chesapeake Bay Osprey population began to show signs of recovery. Breeding populations within several major tributaries under study were increasing annually (Fig. 1). Although the recovery was initially slow, by the mid-1980s evidence began to suggest that some local populations were approaching carrying capacity. Comparisons of selected geographic areas indicated that the number of breeding pairs had recovered to levels documented prior to the decline (Reese 1991). Sibling aggression and associated brood reduction in other locations suggested food stress (Roberts 1982; McLean and Byrd 1991; P. R. Spitzer, unpublished 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.

In the mid-1990s (1995-1996), a systematic survey of the Chesapeake Bay was conducted to estimate the size of the Osprey breeding population (Watts *et al.* 2004). The breeding

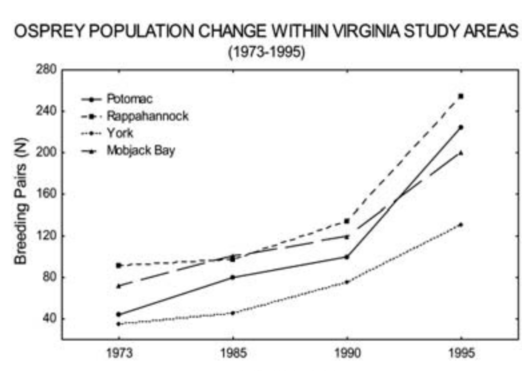

Figure 1. Population recovery within four geographic areas in the Chesapeake Bay (1973-1995). Data for 1973, 1985, 1990, and 1995 are taken from Henny *et al.* 1974, Byrd 1987, Byrd 1990, and Watts *et al.* 2004, respectively.

population was estimated to be just below 3,500 pairs. In little more than twenty years, the Bay population had more than doubled in size. However, the growth rate over this time period varied widely among regions within the Bay. Average doubling times for well-defined geographic areas varied from a low of 4.3 yrs on the James River to more than 40 yrs 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. Virtually all of the areas considered to be "strongholds" for the species in the 1970s have showed relatively little growth over the twenty-year period. The lack of rapid growth within these locations supports earlier suggestions that these areas were less affected 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., Stinson 1976; Reese 1970, 1977; McLean 1986; Spitzer 1989). This relationship 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. Since the survey of the mid-1990s, these populations have continued to gain momentum. An example of this rapid population growth is the tidal fresh reach of the James River. This area supported no pairs in the 1970s but by 1995 supported 73 pairs (Watts *et al.* 2004). This same reach was surveyed in the summer of 2006 and contained 190 breeding pairs (BDW and M. U. Watts, unpublished data). Average doubling times between the 1970s and the 2000s for several tidal fresh and oligohaline reaches of the lower Chesapeake appear to be less than four years. The ecology of the emerging Osprey populations within these lower salinity reaches is virtually unknown.

Reproductive Rates

The reproductive rate required for population maintenance in Ospreys appears to lie somewhere between 0.8 and 1.3 chicks/active nest (Poole 1989) and has likely changed in the Chesapeake Bay along with demographic shifts in the population. Henny and Wight (1969) used band returns to generate a survivorship curve and estimated reproductive requirements to fall between 0.95 and 1.3. Spitzer (1980) utilized a combination of population trend data and productivity to determine that the reproductive rate required for stability between New York City and Boston was 0.8. Poole (1989) pointed out that reproductive requirements are sensitive to age-to-first-reproduction and that for a population with a mean first breeding age of 5.7 yrs (as reported by Spitzer for a portion of the Chesapeake Bay) reproductive rate of 1.15 would be required based on Spitzer's assessment.

Documented reproductive rates within the Chesapeake Bay have varied through space and time (Table 1). Although temporal patterns have varied across study areas, reproductive rates within several areas appear to have reached a low in the 1960s and early 1970s. When a composite is produced from all available data across the Bay, an increase from less than 0.8 to more than 1.2 chicks/active nest in Bay-wide reproductive rates is observed from the 1960s to the mid-1980s (Fig. 2). Reproductive rates collectively declined in the late 1980s to less than 1.0. The Chesapeake Bay population was generally considered to be "recovered" in the early 1990s so much of the intensive reproductive work was discontinued. For this reason, we know very little about the trend in productivity over the past 15 years. An assessment of reproductive rates in Mobjack Bay, Virginia (one of the historic study sites), in 2006 resulted in a value of 0.8 (Glass, unpublished data). This value is less than that reported by Byrd (1990) for the late 1980s. Broad-scale work is currently needed to update estimates of reproductive rates.

NON-BREEDING SEASON

A very small number of Ospreys overwinter in the Chesapeake Bay and as far north as New England (Poole and Agler 1987). Re-

Table 1. Summary of Osprey reproductive rates and sources from study sites throughout the Chesapeake Bay (1956-1990).

Years	Location	Breeding attempts	Productivity chicks/active	Source
1956-1958	Eastern Bay, MD	61	1.10	Henny and Stotts 1975
1963-1964	Talbot County, MD	107	0.78	Reese 1970
1965-1969	Talbot County, MD	420	1.01	Reese 1970
1970-1974	Talbot County, MD	538	1.14	Reese 1977
1983-1984	Talbot County, MD	134	1.04	Spitzer, unpublished
1985-1987	Talbot County, MD	198	1.06	Spitzer, unpublished
1966-1969	Eastern Bay, MD	107	0.64	Reese 1975
1970-1974	Eastern Bay, MD	134	1.00	Reese 1975
1968-1969	Smith Island, MD	31	1.16	Rhodes 1972
1970-1971	Smith Island, MD	40	1.55	Rhodes 1972
1963	Potomac River, MD	13	0.54	Wiemeyer 1971
1970	Potomac River, MD	46	0.70	Wiemeyer 1971
1970-1974	Delmarva Seaside, VA	256	0.68	Henny *et al.* 1977
1970-1973	York River, VA	98	0.71	Byrd, unpublished
1975-1979	York River, VA	74	1.30	Byrd, unpublished
1982-1984	York River, VA	121	1.23	Byrd 1987
1985-1989	York River, VA	172	1.22	Byrd 1988, 1990
1970-1973	Mobjack Bay, VA	63	0.71	Byrd, unpublished
1983-1984	Mobjack Bay, VA	146	1.39	Byrd 1987
1985-1989	Mobjack Bay, VA	292	0.91	Byrd 1988, 1990
1970-1973	Rappahannock River, VA	330	1.06	Byrd, unpublished
1975-1979	Rappahannock River, VA	164	1.04	Byrd, unpublished
1983-1984	Rappahannock River, VA	169	1.24	Byrd 1987
1985-1989	Rappahannock River, VA	359	0.93	Byrd 1988, 1990
1972-1973	Potomac River, VA	71	1.07	Byrd, unpublished
1975-1979	Potomac River, VA	121	0.95	Byrd, unpublished
1980-1984	Potomac River, VA	147	1.18	Byrd 1987
1985-1989	Potomac River, VA	226	1.07	Byrd 1988, 1990
1970-1973	Fleets Bay, VA	121	1.23	Byrd, unpublished
1975-1979	Fleets Bay, VA	55	1.29	Byrd, unpublished
1980-1984	Fleets Bay, VA	61	1.08	Byrd 1987
1985-1989	Fleets Bay, VA	149	0.67	Byrd 1988, 1990

ports of Ospreys during the winter from the Audubon Society's Christmas Bird Counts within the Bay region have changed over time with the first bird reported in 1944, sporadic observations in the 1970s and 1980s, and consistent observations since the mid-1980s (http://www.audubon.org). Since 1985, the number of birds reported on Christmas counts within the Bay has increased significantly ($R^2 = 0.63$, $F_{1,18} = 30.5$, $P < 0.001$) with a high number of 13 reported in both 2000 and 2005. Given the relatively small portion of the Bay that is included within Christmas counts, the number of Ospreys overwintering within the Bay may be a multiple of the number detected. The number of birds detected during mid-winter aerial surveys (BDW, pers. obs.) support this suggestion and the notion that birds do spend the entire winter in the Bay. However, even if these birds are from the regional breeding population, they represent an insignificant fraction of the total such that they are not of population-level importance. The age, gender, and condition of these birds are unknown.

The vast majority of Ospreys that breed in the Chesapeake Bay are migratory, appearing in the Bay during March and April and departing the Bay in August and September (Bent 1937; Reese 1991). Analysis of band recoveries has shown that Chesapeake Bay Ospreys winter in the West Indies, northwestern South America, and southern Central America with most recoveries coming from inland rivers of Colombia, Brazil, and Venezuela (Henny and Van Velzen 1972;

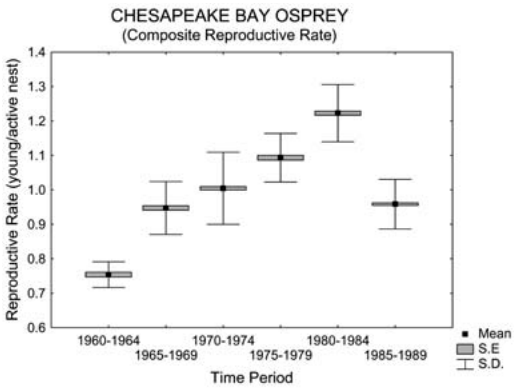

Figure 2. Temporal pattern in reproductive rates measured within major field sites throughout the Chesapeake Bay. Values represent mean (black squares), standard error (shaded boxes), and standard deviations (error bars). Data are taken from Table 1 where each site and time period is considered a sample.

Kennedy 1973; Poole and Agler 1987). Stewart and Robbins (1958) reported a nestling banded at Turkey Point in Cecil County, Maryland, on 2 July 1954, was recovered in Brazil on 24 September 1954. There appears to be longitudinal separation of wintering areas for eastern, mid-western, and western populations but no spatial segregation by age within populations (Poole and Agler 1987). First-year birds remain on the wintering grounds during their second summer (Henny and Van Velzen 1972). Examination of recoveries of two-year-old Ospreys suggests that birds return to or near their natal areas but do not breed (Henny and Van Velzen 1972). Further analysis by Poole and Agler (1987) suggest that these birds migrate later than adults and do not appear on the breeding grounds until May or June. This age class appears to account for the so called "house keepers" that begin building nests in mid to late summer but do not make breeding attempts (e.g., Stone 1937; Reese 1970; Henny and Van Velzen 1972).

Band recoveries (Henny and Van Velzen 1972; Kennedy 1973; Poole and Agler 1987) and satellite telemetry (Martell *et al.* 2001) have been used to delineate migration routes for Osprey breeding populations. During fall migration, birds from the Chesapeake Bay that are moving to South America appear to follow a narrow route down the Atlantic Coast to Florida, over the Florida Keys to Cuba, down to Hispaniola and then 600 km over the open Caribbean to make landfall in Columbia or Venezuela. In general, females depart earlier than males and the length of fall migration varies from several days to several weeks (Martell *et al.* 2001). Spring migration is suggested to be much faster with birds covering the same distance in 1/2 to 1/3 the time (Poole and Agler 1987).

ECOLOGICAL REQUIREMENTS

Nesting Substrate

Ospreys in the Chesapeake Bay have exhibited a remarkable ability to adapt to a wide array of nest substrates. Aside from the banning of important chemical compounds, the increase in nesting substrates has likely been the most important factor fueling the recovery of the Chesapeake Bay population. The change in substrate use between the early 1970s and the mid-1990s demonstrates the shift of Chesapeake Bay Ospreys to artificial structures that has apparently been ongoing 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% (Watts *et al.* 2004). In just 50-years 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. In the mid-1990s, 380 Osprey pairs were nesting on 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 3,000 duck blinds were mapped during shoreline surveys in the mid-1990s 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 suggesting that nearly all isolated duck blinds were utilized.

Aides to navigation or "channel markers" have become the most significant substrates used for nesting by Ospreys throughout the Chesapeake Bay. In 1973, Henny *et al.* (1974) reported 316 nests on channel markers. These pairs represented 21.8% of the population. There were 1,875 navigational structures maintained in the Bay in 1973, suggesting an occupation rate of just below 17%. In the mid-1990s, 1,672 nests were documented on channel markers representing 53.4% of nests counted during boat surveys (Watts *et al.* 2004). These included 944 on day markers and 728 on light markers. In the late 1990s, the U.S. Coast Guard (1999) listed 1,680 day markers and 1,249 light markers maintained throughout the Chesapeake Bay. 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 1,875 to 2,929 over the twenty-year 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 had a very positive impact on the Bay-wide population.

Prey Use

Ospreys specialize on fish throughout their global range with live fish representing 99% of prey items taken in virtually every published account (Poole *et al.* 2002). Given the large number of intensive studies of breeding Osprey that have been conducted throughout the Chesapeake Bay watershed, it is surprising how little is currently known about diet. The single quantitative diet study for Ospreys in the Bay was conducted by McLean (1986) in the main stem of the Bay along the lower western shore (Mobjack Bay). McLean observed seven nests during the brood-rearing period and identified 340 fish delivered to nests including 15 species (McLean and Byrd 1991). The diet was dominated by Menhaden (*Brevoortia tyrannus*) (74.7%), followed by White Perch (*Morone americana*) (7.2%), Atlantic Croaker (*Micropogonias undulates*) (3.9%), Oyster Toadfish (*Opsanus tau*) (3.3%), and American Eel (*Anguilla rostrata*) (2.9%). The remaining ten species accounted for less than 8% of the diet collectively.

There is currently no quantitative information on the diet of Ospreys outside of the polyhaline reach of the Bay. Given that the lower salinity reaches are supporting an increasing portion of the population, efforts are needed to characterize diet there. An ongoing investigation of diet and breeding ecology within selected oligohaline and tidal fresh reaches was initiated in 2006 (Glass and BDW, unpublished data). Preliminary observations suggest that catfish (*Ictalurus* spp.) may play an important role within these salinity zones.

CURRENT THREATS TO CHESAPEAKE BAY OSPREY

Contaminants

Due to their position as a top predator, Ospreys will always be vulnerable to contaminants that are introduced into the aquatic food chain. Exposure to organochlorine pesticides was the primary cause for the decline in Osprey populations worldwide during the 1950s and 1960s. The DDT/DDE complex has been associated with a depression in reproductive rates in selected populations (Spitzer *et al.* 1978; Wiemeyer *et al.* 1975, 1978, 1988). DDE concentrations of 4.2 ppm have been shown to cause egg-shell thinning of >15% which is a threshold that has been associated with population stability in various raptor populations (Anderson and Hickey 1972). Concentrations of ≥12 ppm have been associated with complete reproductive failure in Ospreys (Wiemeyer *et al.* 1975). Throughout the 1960s and 1970s it was common to find thin-shelled and broken eggs in Chesapeake Bay nests (Wiemeyer 1971; Reese 1977; M. A. Byrd, unpublished data). Eggs collected for chemical analysis during this time period had mixed results with some having DDE concentrations well above and others below the 4.2 ppm threshold (Via 1975; Wiemeyer *et al.* 1975; Henny *et al.* 1977).

In an eloquent study of contaminant exposure within Ospreys, Rattner *et al.* (2004) compared egg-shell thickness, productivity, and a wide range of contaminants between some of the most highly contaminated tributaries of the Bay and a set of reference sites. Shell thickness was found to be greater than that reported from the 1960s and 1970s with all but two sites comparable to pre-DDT era eggs. Productivity was found to be higher than that reported in 1970-1971 for areas of Maryland and Virginia and most areas met or exceeded rates believed to be required to sustain a stable population. Levels of organochlorine contaminants were less than half of what was reported during the 1960s and 1970s with some study areas being an order of magnitude less. Within some study areas, concentrations of PCBs were only slightly diminished from earlier levels and mercury concentrations were similar to historic levels. In general, contaminants believed to be responsible for earlier population declines appear to have declined to levels that are no longer suppressing reproductive rates below maintenance levels (see Rattner and McGowan, this volume, for a more complete overview of contaminant trends in this species).

Due to their common status, wide distribution, and direct ties to Bay resources, breeding Ospreys make good ecological indicators. With the intensification of human activities within and around the Chesapeake Bay, it is likely that new classes of contaminants with the potential to impact the Osprey population will emerge on a consistent basis. Regular monitoring of reproductive rates and contaminant levels is needed to detect potential problems as they arise.

Diseases

A broad array of pathogens and parasites have been identified in Chesapeake Bay Ospreys (Reese 1991). However, most of these do not have the potential to cause population-level impacts. In 1994, an outbreak of avian cholera (*Pasteurella multocida*) occurred in the Maryland and Virginia portion of the Bay that killed a documented 36,700 birds of 57 species including Ospreys (Hindman *et al.* 1997). Although transmission of cholera to most birds of prey has been through ingestion, it appears that transmission to Ospreys was caused by the birds incorporating duck carcasses into the nest structure. The impacts of future outbreaks of cholera on Osprey should be monitored to assess possible population-level effects. Other pathogens such as the West Nile virus have moved through the region and clearly have the potential to pose population-level concerns. To date, such impacts have not been observed.

Human Activities and Hazards

The human population and its associated infrastructure now dominate the Chesapeake Bay and its surrounding landscape. While it is clear that some of this infrastructure has led to an expansion in the Osprey population by providing nesting substrate, some structures represent hazards that may have population-level impacts. There are currently no broad statistics that allow for an assessment of relative impacts of various artificial structures on survivorship within the Bay population. However, there are various classes of structures that pose threats to Ospreys and may have population-level implications. Interactions between Ospreys and the electrical infrastructure that surrounds and crosses the Bay are common. Ospreys are vulnerable to both mid-line strikes and pole electrocutions. Risks to birds are elevated when nests are built on active electrical poles or when lines cross water bodies or are placed along the shoreline. The proposed construction of wind turbines over water may pose threats to Ospreys as has been shown with other large raptors (e.g., Orloff and Flannery 1992; Barrios and Rodriguez 2004). Duck blinds are a common nesting substrate for Ospreys in the Bay but under some circumstances chicks near fledging age may fall down within blinds and become trapped. It also appears that near-water structures such as bridges, antennas, light poles, and high-rise buildings are a significant source of mortality for young just after fledging. Collisions with cars, particularly around bridges, are also common.

In earlier periods, shooting both in the Chesapeake Bay and on the wintering grounds was likely a significant source of adult mortality (e.g., Reese 1968; Wiemeyer 1971; Henny and Van Velzen 1972; Poole and Agler 1987; Poole *et al.* 2002). Poole and Agler (1987) reported that 30% of 451 band returns between 1972 and 1984 were from shot birds compared to 61% of recoveries between 1914 and 1972 suggesting a reduction in shooting pressure (Poole *et al.* 2002). Shooting still occurs within the Chesapeake Bay but the incidence seems to have declined a great deal since the 1970s (M. A. Byrd, pers. comm).

As the use of the Chesapeake Bay by recreational anglers has increased over the past two decades there has been an apparent increase in the availability of discarded monofilament line and associated impacts to Ospreys. Adults encounter masses of line with floating debris and pick the material up to use as nest lining. The line is persistent and entangles both adults and nestlings. It is not uncommon to find dead young in nests entangled in line or adults with feet and legs entangled with balls of line (BDW, pers. obs.). Although no systematic work has been conducted to estimate the impact of monofilament on fledging success and juvenile/adult survivorship, the problem appears to be widespread.

CONCLUSIONS

The Chesapeake Bay supports the largest breeding population of Ospreys in the world. This population experienced a dramatic decline due to the widespread use of pesticides followed by an equally dramatic recovery. The decline was coupled with a contraction of the population down to the main stem of the Bay. With recovery, the population is radiating along the tributaries toward the fall line such that the fastest growth rates are occurring within low salinity waters. The ecology of Ospreys within tidal freshwater reaches is virtually unknown. Within the main stem, reproductive rates increased following the ban on DDT and like compounds reaching a high in the mid 1980s only to decline in the late 1980s. Population expansion has followed the proliferation of manmade structures throughout the watershed that are used for nesting substrate. Due to their position in the food web and their wide distribution, Ospreys are now one of the best biological indicators within the Chesapeake Bay. The population continues to be vulnerable to new compounds introduced into the Bay, factors that may regulate fish stocks, and manmade hazards.

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