REPRODUCTIVE SUCCESS OF OSPREYS IN CENTRAL CHESAPEAKE BAY

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ABSTRACT.—Osprey nest success and factors influencing nest success were studied by frequent annual visits to active nests in a defined area. Of the eggs found in the 1970's, 52% failed to hatch. Eggs disappearing between nest visits and those found damaged (cracked, punctured, etc.) or addled made up 90% of the failures. Shells from failed eggs averaged 11% thinner than eggs collected prior to 1947. The additive effect of increasing human disturbance to Ospreys incubating eggs with shells thinned by environmental contaminants is responsible for the high egg attrition resulting in poor nest success. Constructing artificial nest platforms aids nest success by retaining nesting pairs at established sites where potential for success is greater than if the Ospreys are forced to use an alternate site. Terrestrial nests are 14% less successful than nests on offshore structures. Brood size (1.9) and population productivity (1.08) are among the best in the country, but below brood sizes of Ospreys prior to 1947 and estimated production requirements for population stability.—*Box 298, St. Michaels, Maryland 21663.* Accepted 30 July 1975.

OSPREY (*Pandion haliaetus*) populations in the northeastern United States have experienced serious decreases since the 1950's. Poor reproductive success, as a result of human encroachment and environmental contamination of its estuarine and seacoast nesting habitat, are prime factors in the decline (Ames 1966, Schmid 1966, Hickey and Anderson 1968, Peterson et al. 1969). I have studied the reproductive success of a large concentration of nesting Ospreys within a delimited area of central Chesapeake Bay since 1963. This paper reports comprehensive nest success at accessible sites from 1970 through 1974 and productivity at inaccessible nests from 1966 through 1974. Productivity levels from these two segments of the breeding population are compared with one another, previous years of study, and populations in other parts of the Chesapeake Bay and United States. Major factors influencing reproductive success are documented and discussed. Reproductive success for 1963 through 1969 is given in Reese (1970).

METHODS

The study area of 213 square (statute) miles on Chesapeake Bay includes most of the tidewater portion of Talbot County, Maryland and is described and mapped in Reese (1970). Most nests are on offshore duckblinds, channel markers, and nesting platforms. Others are on terrestrial duckblinds, standing dead snags, live trees, boathouses, utility poles, and grain elevators. Structures supporting nests are located in or along tributaries of Chesapeake Bay and nests were surveyed from a small boat at least once every 12 days from March through August. Most nests are active each year and hence are counted more than once in the total. Previously occupied nest sites that deteriorated or were damaged during the winter are reinforced each spring. Artificial nesting platforms of driftwood built on top of pilings and fallen trees in shallow water encourage nesting.

Whole eggs are marked with a felt-tipped pen when first observed. Damaged, fragmented, addled, and hatched eggshells are collected. Addled eggs are opened at their equator. Eggshells and fragments are cleaned by gently brushing them with a soft artist's brush while submerged in water, then dried at room temperature for several months. Thickness of the shell plus the membranes was determined by averaging five or more measurements taken around the center quarter of the egg with a micrometer calibrated in 0.01 mm units. Significance between means was determined by *t*-test.

All data on nesting success presented here were collected at active nests, i.e. where an adult pair with a nest or eggs were present on at least four consecutive visits in April and/or May. Active nests are classified accessible if the contents could be seen, inaccessible if the contents could not be seen. Success at inaccessible nests was determined by watching the nests with binoculars from far enough away to prevent the adult

TABLE 1

SUCCESS OF ACCESSIBLE ACTIVE OSPREY NESTS

	1970	1971	1972	1973	1974	Mean	SD	Totals
Total active nests found	137	137	131	143	141	138		689
Accessible active nests	102 (74)[1]	106 (77)	101 (77)	114 (80)	115 (82)	107.6 (78)		538
Accessible nests with eggs	96 (94)	96 (91)	98 (97)	110 (96)	113 (98)	102.6 (95)		513
Accessible nests with nestlings	60 (59)	60 (57)	67 (66)	76 (67)	77 (67)	68.0 (63)		340
Accessible nests with fledglings	55 (54)	53 (50)	58 (57)	75 (66)	73 (63)	62.8 (58)		314
Total eggs known	280	272	284	327	329	298.4		1492
Eggs per nest with eggs	2.9	2.8	2.9	3.0	2.9	2.9		
Eggs hatching[2]	120 (43)	113 (42)	146 (51)	177 (54)	165 (50)	144.2 (48)		721
Eggs fledging[2]	106 (38)	91 (33)	112 (39)	163 (50)	141 (43)	122.6 (41)		613
Percent of hatchlings fledged	(88)	(81)	(77)	(92)	(85)	(85)	5.873	
Average number fledged per nest producing fledglings	1.9	1.7	1.9	2.2	1.9	1.95	0.1820	
Average number fledged per accessible active nest	1.04	0.86	1.11	1.43	1.23	1.14	0.2130	

[1] Numbers in parentheses indicate percent.
[2] Percent is based on total eggs known.

from flushing or young from squatting. This was best accomplished during the period young fledged in nearby accessible nests. A successful nest is one that fledged at least one young.

RESULTS AND COMMENTS

Nests.—From 1970 through 1974, 30 accessible active nests were lost during the breeding season. Strong winds blew 20 precarious nests from channel markers, nesting platforms, and duckblinds. Other causes of nest loss include 1 weak nest site that collapsed, 1 nest removed from a railroad bridge by a construction company, and 9 nests removed from channel markers—6 by the U.S. Coast Guard, 2 by local fishermen, and 1 by a construction company.

The percentage of accessible active nests with eggs was 97% or higher in 1972 through 1974, the highest since 1965 when it was 97% (Table 1). The percentage of nests with nestlings increased appreciably in the early 1970's and the 66% and 67% found in 1972 through 1974 far exceeded that of any year in the previous decade. These highs can be attributed to tremendous increases in hatchability those three years. The percentage of nests with fledglings reached a high of 66% in 1973 and dropped slightly to 63% in 1974. The 57% of 1972 was best since 1965 and would have been much better if 26 nestlings had not been killed in hurricane Agnes. The 50% of 1971 was second lowest during the past decade and resulted largely from the loss of 15 nestlings in severe storms that spring.

Eggs.—Hatchability averaged only 44% from 1964 through 1971, but rose above 50% in 1972 through 1974 (Table 1). I cannot offer a positive explanation for the tremendous increase in hatchability, but below normal temperatures during incubation, poor crab catches, and rainy weekends sharply reduced the water sports activities that usually disturb incubating Ospreys. No serious spring storms, practically no evening thunderstorms in April and May, and U.S. Coast Guard restraint probably also aided success. Increased hatchability is responsible for vastly improving productivity since 1972.

TABLE 2
CAUSES OF EGG (E) AND NESTLING (N) LOSS IN ACCESSIBLE OSPREY NESTS

	1970		1971		1972		1973		1974		Total	
	E	N	E	N	E	N	E	N	E	N	E	N
Disappeared from nest between visits	70	7	50	5	60	6	41	13	62	21	283	52
Eggs found as fragments in nest	33	—	49	—	38	—	57	—	42	—	219	—
Eggs addled	28	—	26	—	16	—	30	—	30	—	130	—
Eggs damaged (cracked, punctured, broken, etc.)	17	—	16	—	12	—	8	—	12	—	65	—
Wind and rain	5	—	4	15	5	26	—	—	3	—	17	41
Predator	4	—	8	2	6	—	—	—	4	—	22	2
Abandoned	—	—	4[1]	—	—	—	6	—	9	—	19	—
Buried in nest material	—	—	2	—	1	—	5	—	—	—	8	—
Weak nest site collapsed	—	—	—	—	—	2	3	—	—	—	3	2
U.S. Coast Guard	3	—	—	—	—	—	—	—	2	—	5	—
Nestlings stolen for pets	—	4	—	—	—	—	—	—	—	—	—	4
Nestlings injured	—	2	—	—	—	—	—	1	—	—	—	3
Nestlings found dead in nest	—	—	—	—	—	—	—	—	—	3	—	3
Nestlings smothered	—	1	—	—	—	—	—	—	—	—	—	1
Totals	160	14	159	22	138	34	150	14	164	24	771	108

[1] Female died covering eggs from male.

Table 2 shows some of the reasons why 52% of the eggs failed to hatch in the early 1970's. Most notable among these are eggs that disappeared between nest visits and those found as fragments, addled, or damaged. Pesticide poisoning has been correlated with egg disappearance, eggshell breakage, and embryonic death (Ames 1966, Ratcliffe 1967, Hickey and Anderson 1968, Porter and Wiemeyer 1969, Heath et al. 1969, Peakall 1970). The possibility of pesticide poisoning in Chesapeake Bay Osprey eggs cannot be discounted, although no chemical analyses could be financed.

I found 7 aberrant eggs that failed to hatch, 4 runts and 3 with unsatisfactory shells. The runt eggs found in 1967, 1970, and 1974 (2) had both ends rounded, an average width and length of 39.8 mm by 49.6 mm (Osprey eggs usually measure about 46 by 62 mm), and an average shell thickness of 0.431 mm. Three of these eggs were addled and in separate nests, each with two other normal sized eggs. The fourth egg was deposited in a nest with two 34-day-old nestlings on 22 June 1974. This egg was glossy white with the shell thickness measuring 0.37 mm. When opened its contents appeared to be those of a good egg. In 1969, 1970, and 1971, I found an egg without a satisfactory shell as part of a clutch in different unsuccessful nests. One totally lacked a shell, one had minute white shell deposits on the outer shell membrane, and one contained a thin (0.36 mm) pigmented shell with large coarse pores.

All whole, partial, or fragmented shells of eggs failing to hatch and half-shells from hatchlings were collected for measurement. A total of 522 eggshell samples were suitable for measuring thickness. The mean shell thickness for 443 eggs failing to hatch during the 11 years was 0.450 mm ± 0.002 SE.

Table 3 shows that mean shell thickness was highest in hatched eggs (0.474 mm), somewhat lower in addled eggs (0.455 mm), and lowest in damaged eggs (0.444 mm). Differences between any combination of these means were significant ($P < 0.001$). Mean shell thickness for eggs hatching and eggs failing ranged from 6–12% thinner than shells of fresh eggs collected in the eastern United States prior to 1947 (Anderson

TABLE 3

AVERAGE EGGSHELL THICKNESS IN SOME U.S. OSPREY POPULATIONS

Location	Period	Condition	Sample size	Mean ± SE	% decrease from pre-1947	Source
Eastern U.S.	Pre-1947	Fresh	365	0.505	—	Anderson and Hickey (1972)
Chesapeake Bay:						
East central portion	1964–74	Damaged	129	0.444 ± 0.004	12	This study
	1964–74	Addled	249	0.455 ± 0.003	10	This study
	1971–74	Hatched	79	0.474 ± 0.004	6	This study
Potomac River, Maryland side	1968–69	Damaged and addled	15	0.443 ± 0.010[1]	12	Wiemeyer et al. (1975)
	1970–71	Damaged, addled, and hatched	24	0.439 ± 0.009[2]	13	Wiemeyer (1977)
Potomac River, Virginia side	1970–71	Damaged, addled, and hatched	11	0.475 ± 0.010[2]	6	Wiemeyer (1977)
Tidewater Virginia	1970–71	Damaged and addled	102	0.386 ± 0.004	24	Kennedy (1971)
Connecticut	1967–69	Damaged and addled	15	0.429 ± 0.012[1]	15	Wiemeyer et al. (1975)
Montana (Flathead Lake)	1966–69	Addled	9	0.407 ± 0.021	—	Koplin (pers. comm.)
Idaho	1970–73	Addled	24	0.472 ± 0.010	—	Melquist (1974)
	1972–73	Fresh	11	0.419 ± 0.013	—	Melquist (1974)

[1] Mean and SE on a clutch basis; 17 eggs in 15 Maryland clutches and 20 eggs in 15 Connecticut clutches. SE from Wiemeyer (pers. comm.).

[2] Mean and SE on a clutch basis; number of eggs in clutches not given. SE from Wiemeyer (pers. comm.).

and Hickey 1972). The central Chesapeake Bay eggshells were not thinned as much as those in tidewater Virginia (Kennedy 1971) and Connecticut (Wiemeyer et al. 1975).

Mean eggshell thickness within clutches that failed was highly variable. The difference between extreme shell thickness within a clutch ranged from 0.01 mm to 0.12 mm and averaged 0.057 mm for 22 complete clutches (72 eggs). The mean shell thickness of the thinnest egg (0.419 mm) from these clutches averaged 8% less than the next thinnest egg (0.456 mm) and 13% less than the thickest egg (0.480 mm). The excessively thin-shelled clutch member was obvious when handling and measuring the shells, and in 64% of the clutches it averaged 11% less than the next thinnest egg. Clutches of four eggs had two eggs of identical or nearly identical (within 0.004 mm) thickness 70% of the time, but these eggs were never an extreme member of the clutch. The thinnest shelled egg was the last laid in 67% of the clutches and next to last in 33% of the clutches.

Only 9% of the addled eggs had developed embryos, while 18% were dried inside, and 73% contained a nebulous liquid. Most of the embryos were over 20 days old. Close shell examination almost always revealed a hidden fracture on eggs with dried contents. Liquid-filled eggs were difficult to autopsy. Some popped from internal gas pressure when handled, some had rotted contents, and all were so muddled inside that visibility of contents was extremely difficult. Several liquid-filled eggs had organic deposits between the outer shell membranes, suggesting that membrane rupture may have caused the egg failure.

Other causes of hatching failure shown in Table 2 were not serious. Weather did not influence hatchability during the 5 years as it had in 1967 and 1968 (Reese 1970). Predation, which remained fairly constant as in previous years, involved only terrestrial nests; raccoons were suspected. Egg abandonment was first observed in the 1970's. In 1971 four eggs were abandoned by the male after the female of the pair died. One pair of Ospreys abandoned three eggs in both 1973 and 1974 after being constantly disturbed by people crabbing or fishing beneath their nest on an old railroad bridge. In 1973 another pair abandoned three eggs in two different nests after they apparently could not agree which nest to claim. There was an active nest between the two abandoned nests and territorial disputes between the pairs probably contributed to the abandonment. In 1974 six eggs in six different nests were abandoned for no apparent reason.

The percentage of eggs producing fledglings ranged from 33% to 50% during the 5 years (Table 1). The low of 33% in 1971 resulted from the loss or disappearance of 20 nestlings during severe storms. Good hatchability kept this percentage high (39) in 1972 despite similar large nestling losses during the hurricane. The high of 50% in 1973 can be attributed to the best hatchability in the past decade and good weather.

Young.—Nestling mortality ranged from 8–23% during the 5 years. Chilling during exposure to severe wind and rain in 1971 and 1972 was the primary cause of nestling mortality (Table 2). Most of the nestlings that disappeared between my nest visits were less than 2 weeks old. A few nestlings disappeared just before taking their first flight and I suspect people crabbing near the nest frightened or provoked a premature flight, with the physically weak and inexperienced young collapsing into the water or vegetation a short distance away. A raccoon and a suspected avian predator took two nestlings in 1971. Accidents resulting in dislocated or broken bones shortly after hatching made three nestlings useless. Theft for pets was previously suspected, but never proved until a federal agent got the band number from a

TABLE 4

Fledgling Success at Inaccessible Active Osprey Nests

	1966	1967	1968	1969	1970	1971	1972	1973	1974	Mean	Totals
Inaccessible active nests	36	36	38	33	35	31	30	29	26	32.7	294
Nests with known outcome	34	36	37	33	33	31	29	28	25	31.8	286
Nests with fledglings	12 (35)[1]	12 (33)	11 (30)	12 (36)	12 (36)	18 (58)	14 (48)	13 (46)	15 (60)	13.2 (42)	119
Total fledglings observed	21	16	18	17	21	34	27	23	23	22.2	200
Average number fledged per nest with fledglings	1.8	1.3	1.6	1.4	1.8	1.9	1.9	1.8	1.5	1.4	—
Average number fledged per nest with known outcome	0.62	0.44	0.49	0.52	0.64	1.10	0.93	0.82	0.92	0.70	—

[1] Number in parentheses indicates percent of nests with known outcome.

TABLE 5

Osprey Nest Success at Artificial Nesting Platforms

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	Mean	Totals
Total platforms available[1]	11	22	20	20	33	22	24	34	42	30	27	26	285
Platforms utilized	8	14	13	7	18	13	20	23	25	16	7	15	164 (58)[2,3]
Platforms built at sites active in previous year	4	9	12	5	17	7	18	23	26	13	8	13	142 (50)[3]
Platform nests with fledglings	6	8	8	3	9	6	12	14	11	7	5	8	89 (54)[4]
Young fledged in platform nests	11	18	13	6	16	14	24	25	20	15	9	15	171
Average number of young fledged per utilized platform	1.38	1.29	1.00	0.86	0.89	1.08	1.20	1.09	0.80	0.94	1.29	1.04	—

[1] Includes platforms built that year plus nonutilized ones built in previous years.
[2] Number in parentheses indicates percent.
[3] Percent based on total platforms available.
[4] Percent based on platforms utilized.

nestling he spotted on the shoulder of a youngster walking down a street in Washington, D.C. in 1970. One nestling smothered under a piece of rubber matting used as nest material.

Inaccessible nests.—Nests classified as inaccessible are in standing trees or similar tall structures and are not included with the reproductive success data presented above or in previous papers as nest contents could not be checked. From 1966 through 1974, I found 294 nesting attempts inaccessible (Table 4). Of these, 191 (65%) were in standing dead snags, 87 in live trees, 7 on boathouses, 6 on utility poles, 2 on grain elevators, and 1 on a channel marker. Success at these nests depends greatly on wind force and at dead snag nests also upon the strength of the decaying tree. During the 9 years, winter storms destroyed 14% of the active inaccessible nests before the nesting season and summer storms destroyed 18% during the season. Higher losses during warm months are attributable to the frequent evening thunderstorms and increased rate of deterioration in dead snags.

Fledgling success for 286 inaccessible nests is presented in Table 4 for comparison with fledgling success in accessible nests (Table 1). I may have failed to see a few young, but the figures presented here represent a good approximation of fledging success in inaccessible nests.

From 1966 through 1974, 42% (n = 286) of the inaccessible nests and 56% (n = 885) of the accessible nests successfully fledged young (Reese 1970, Tables 1 and 4). The average number of fledglings per successful nest was 1.7 in inaccessible nests and 1.9 in accessible nests, while the average number of fledglings per active nest was 0.70 in inaccessible nests and 1.08 in accessible nests during the same period. This comparison shows inaccessible nests are 14% less successful and produce 0.37 fewer fledglings per active nest than accessible nests, which can be attributed largely to inaccessible nests lost each summer due to thunderstorms, decaying snags, and terrestrial predation. Nest success and productivity at inaccessible nests exceeded that of accessible nests in 1971, largely because of the accessible nest sites lost during storms in the 1970–71 winter and 1971 summer. For instance, winter storms of 1970–71 destroyed 30 accessible nest sites active in 1970. In 1971 summer storms destroyed 12 and people (U.S.C.G., utility companies, etc.) removed 5 from man-made structures during the nesting season. Inaccessible nest losses at the same time were 8, 2, and 1 respectively.

Artificial nest platforms.—Each spring I build nest platforms on offshore pilings remaining from duckblinds destroyed by preceding winter storms to maintain a maximum number of accessible nests, keep established sites suitable for nesting each year, and to have enough sites available for newly recruited members of the population. Platforms not utilized in the year built are considered available each year until used or destroyed; consequently a few platforms are counted more than once in the totals.

I have made a total of 285 platforms available to nesting Ospreys since 1964 (Table 5), of which the birds used 164 (58%). I built 142 (50%) of the platforms at sites active the previous year. The percentage of successful platform nests (54) and the number of fledglings per utilized platform (1.04) are about the same as at all the accessible nests in the population (Table 1). Hurricane Agnes killed nine young in platform nests in 1972 and birds failing to build nests on three platforms in 1973 crushed eight eggs, sharply reducing platform productivity.

Most sites are active each year once they have been used. If platforms are not built at remains of previously occupied sites there is no assurance returning Ospreys can

TABLE 6
SUMMARY OF ACCESSIBLE OSPREY PAIRS WITHOUT EGGS

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	Total	Percent[1]
Total pairs without eggs	11	7	10	11	9	10	6	10	3	9	6	92	—
Anomalous pairs with a nest	10	5	5	5	5	4	5	4	1	5	2	51	55
Anomalous pairs utilizing a site active the previous year:	7	5	7	7	4	8	4	8	2	2	3	57	62
Site with nest in previous year	7	5	5	7	1	7	4	7	2	2	3	50	54
Site with eggs in previous year	2	3	5	4	–	6	3	6	1	1	2	33	36
Site with young in previous year	1	2	3	2	–	2	2	2	1	1	–	16	17

[1] Percent is based on total pairs without eggs.

nest successfully at nearby alternate sites (trees, shoreblinds, etc.) or elsewhere. Terrestrial nests are less successful than offshore nests as shown by inaccessible nest productivity (Tables 1 and 4). In the Eastern Bay and Choptank River control sites (Reese 1972, 1975), for example, I do not build nest platforms at active sites destroyed by winter weather. Active nests were built on alternate structures in the territory of 36 (71%) of 51 destroyed sites there from 1966 through 1974. Only 36% of the Ospreys using alternate sites were successful and fledged a mere 0.50 per active nest, well below the ratios for the accessible nesting population. The remaining 29% of the destroyed sites had no alternate sites available nearby and were not active.

In evaluating the contribution of nest platforms to population productivity, we may assume Ospreys using nest platforms installed at destroyed sites and those relocated at alternate sites have an equal potential for fledging three young. Dividing the total number of young fledged in either platform or alternate sites by three times the number of nests involved in that category gives the percentage of potential success achieved. Pairs nesting on platforms achieved 35% of their potential during the past decade (from Table 5 figures), while pairs at alternate sites achieved only 17% of their potential (compiled from data in Reese 1972, 1975, MS). Some of this difference may be attributed to pairs forced to relocate at terrestrial sites where nest success is inhibited by predation and human disturbance. These facts show Ospreys provided with nest platforms produce young at a rate equal to that of all accessible nests studied, while Ospreys forced to use alternate sites produce young at only about half that rate. This suggests platforms are enhancing population productivity by retaining nesters at established sites where potential for nest success is greater than if the Ospreys are forced to use an alternate site.

Recruitment into the breeding population may be responsible for 8% of the platforms attracting pairs not previously detected in the immediate area.

Rhodes (1972), Postupalsky and Stackpole (1974), and Garber et al. (1974) found artificial platforms maintained nesting at established locations, provided suitable sites for newly recruited breeding pairs, and eliminated some factors normally responsible for egg and young losses. This resulted in less mortality, improved production, and increased breeding population on platforms as opposed to natural nest sites.

Nests without eggs.—Of the total accessible pairs in the study area from 1964 through 1974, 9% laid no eggs. These anomalous pairs are comprised of a male and female that arrive on the breeding ground about the same time, remain together at a

TABLE 7
IMPLIED CAUSES FOR SOME NESTS WITHOUT EGGS

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	Total	Percent[1]
U.S. Coast Guard	3	2	2	2	2	2	1	2	–	–	–	16	—
Tenacious attachment to an inadequate site	–	–	2	2	1	–	–	1	1	–	–	7	—
Long period between nest visits	3	2	1	–	–	–	–	–	–	–	–	6	—
Predation	2	1	–	–	–	–	–	–	–	–	1	4	—
Destroyed by people	–	–	–	–	–	1	–	2	–	–	–	3	—
Wind	–	–	–	–	–	1	–	1	–	–	–	2	—
Wave action	–	–	–	–	1	–	–	1	–	–	–	2	—
Totals	8	5	5	4	4	4	1	7	1	–	1	40	43

[1] Percent is based on total pairs without eggs (Table 6).

chosen site throughout the nesting season, and leave with the rest of the population. Their behavior is usually not so pronounced as the more active breeders, but does range from shy to aggressive in courtship and defense of territories and sites. Nest construction varies from a few twigs to excellent structures suitable for supporting eggs or young. Table 6 shows that from a total of 92 pairs without eggs during the 11 years, 55% built satisfactory nests.

Several studies (Österlöf 1951, Henny and Wight 1969, Henny and Van Velzen 1972) indicate that some Ospreys return to their natal area as 2-year-olds, but do not breed until 3 years old. Henny and Van Velzen (1972) assumed that banded 2-year-old Ospreys recovered in nesting areas were nonbreeders analogous to pairs without eggs reported in nesting studies and claim that recruitment rates will be underestimated if pairs without eggs are counted as active breeders. This assumption overlooks the possibility of unpaired, randomly distributed drifters, valid 2-year-old nesting, and failure to lay by Ospreys more than 2 years old. The band-return studies mentioned above are based on band recoveries of single 2-year-olds in breeding areas during the nesting period. It is not known if these recoveries were paired birds attending nest sites and territories. Ospreys without eggs in this study were definitely paired birds on nest sites and territories. Furthermore, Table 6 shows that in the previous year, 62% of these sites without eggs were occupied, 54% contained good nests, 36% produced eggs, and 17% fledged young. These facts do not support the 2-year-old hypothesis of Henny and Van Velzen (1972) and suggest that excluding pairs without eggs from productivity calculations may cause an overestimate of the recruitment rate.

A few case histories will further question the possibility that some pairs without eggs are 2-year-olds. One pair failed to lay eggs in a poor nest they built at a newly occupied site in 1967. The following year they laid one egg and in 1969 and 1970 full clutches. In 1971 and 1973 they produced no eggs; they laid only one egg in 1972, and two eggs in 1974. All the eggs broke within a few days of laying, the pair never built a good nest, and were shy in their defensive behavior. This pair occupied a nest unsuccessfully for 8 consecutive years, produced eggs in 5 of those years, and full clutches in only 2 years. The female of the pair was banded, suggesting the same birds were involved each year. Another pair at an old established nest site built good nests, but exhibited poor aggressive behavior. This pair produced eggs throughout the 11 years except in 1969 when they mysteriously skipped a year. Both good nests and aggressive behavior characterized another pair of Ospreys that produced eggs each year from 1964 to 1966, no eggs from 1967 to 1970, and eggs in 1971 through 1974. I assumed the same pairs were involved each year in the examples above, but no Ospreys were color marked or trapped for confirmation. My assumptions are based on familiarity with behavioral characteristics of individual nesting Ospreys and nest histories spanning over a decade.

Productivity reported in recent Osprey studies (Ames and Mersereau 1964, Kury 1966, Dunstan 1968, Kennedy 1971, Sindelar 1971, Wiemeyer 1971, Lind 1971, Rhodes 1972, Garber 1972, Reese 1972, 1975, Mathisen 1973, Melquist 1974, Swenson 1975) is based on two or only a few nest visits during the breeding season. Long periods between nest visits may result in errors in counting active nests as eggs may be laid and lost between visits, resulting in classification of a nest as inactive or without eggs. That possible error is not considered serious in this study where nests with long histories were visited at 10- to 12-day intervals throughout the breeding season. In fact, this information and method of study enabled me to implicate several factors as responsible for 43% of the observed nests without eggs (Table 7). Foremost here are pairs nesting on channel markers where the U.S. Coast Guard repeatedly removed nests that Ospreys easily rebuilt in a few days. Misinterpretation occurred at nests receiving eggs shortly after one of my visits, but subsequently removed by the U.S. Coast Guard and a new nest built before my next visit. This same misinterpretation could occur at nests with contents destroyed by people, wind, or tide between my visits. If we assume these implications are valid then only 5% of the total accessible pairs in the study area were without eggs.

Some published productivity ratios are based only on pairs with eggs (Wiemeyer 1971, Melquist 1974), while others include all pairs seen on nests (Sindelar 1971, Kennedy 1971, Garber 1972, Reese 1972, 1975). Productivity ratios presented in a previous paper (Reese 1970) on this study included only those pairs without eggs that I thought were actively breeding, based on long nest site histories and familiarity with behavior of each pair. These three different interpretations of active nests yield maximum, minimum, and estimated mean productivity ratios for the various different geographical breeding populations studied. Caution should be taken when making direct comparisons of ratios calculated from differing interpretations of active nests in published papers and lack of standardized terminology. Postupalsky (1974) offers well-defined terminology that should be adhered to by raptorial researchers in the future. Pairs without eggs must be defined positively before they can be safely included or excluded from active breeding status. Until this can be achieved, it is essential that all published figures on Osprey reproduction include all pairs observed and the investigator's interpretation of active nests. All data should be presented in such a manner that other researchers can calculate productivity with or without nests containing no eggs.

In summary, band recoveries lack much-needed information to confirm 2-year-olds as nonbreeders. Reproductive success studies with frequent nest visits have produced information contrary to the 2-year-old-nonbreeder hypothesis. Infrequent or two-visit nest success studies lend themselves to misinterpretation of nests without eggs. Furthermore it is not known if calculated productivity ratios are true estimates if all pairs without eggs are included or excluded as active breeders. Until the pairs without eggs can be correctly defined and their significance in the breeding population determined, researchers should include them in published materials so others can calculate the productivity with or without those pairs.

Disease.—Disease can kill large numbers of Ospreys in a short time, but has not been of serious consequence during the study. An outbreak of bacterial pneumonia occurred about 9 August 1968, when I collected one dead and one dying Osprey from nests. Lungs of both birds had necrotic spots. Tissue and alveolar fluid contained massive quantities of gram variable pleomorphic small rods that failed to grow on unenriched bacteriological media. Another dying Osprey seen hanging from a limb near a nest could not be retrieved. A reliable source reported finding a dead Osprey a short distance from a nest 2 days before. These victims were found in different parts of the study area and all were fledglings that had been flying at least 21 days. The impact of the disease is suspected to have been greater than detected as young fledged several weeks before and many Ospreys no longer frequented their nest site. Temperly (1950) reports a similar outbreak of pneumonia in British Ospreys in May 1949. On 22 May 1971 I found an adult female dead in its nest sitting on four eggs. Gross autopsy revealed no external source of death and this bird is suspected of dying from some disease other than pneumonia.

Weather.—Losses cited in Table 2 were obvious examples of the influence of inclement weather on nest success. I investigated the relationship between nine weather parameters and nest success since 1963 to see if moderately unusual or extended climatic conditions also influence reproduction. Weather parameters included the average temperature, wind speed, and precipitation; the percent of days with wind >18 mph, measurable precipitation, and any precipitation; the percent of possible sunshine, and days with near zero visibility or thunderstorms. I calculated a mean for each weather parameter for three different periods each year. The periods include 16 March through 14 April (I), 15 April through 19 May (II), and 20 May through 30 June (III). These periods correspond to peak courtship-nest building, egg laying-incubation, and nestling-fledgling periods in Chesapeake Bay Ospreys. The means were used to make identical scale graphs of each parameter in each period. The percent of eggs hatching and hatchlings fledged (from Reese 1970 and Table 1) were also graphed to this scale. Graphs for the various weather parameters were then individually superimposed over the nest success graphs to detect relationships. I found a direct correlative relationship between the following factors: average precipitation in period II, and percent of days in period II characterized by precipitation correlated with the percent of eggs hatching; and the average temperature in period III, and the percent of possible sunshine in period III correlated with the percent of nestlings fledged. I found an inverse relationship between these factors: the percent of possible sunshine in period II, and the percent of days in period II characterized by wind >18 mph were converse with percent of eggs hatching; and the average precipitation in period III, and percent of days in period III characterized by precipitation were converse with the percent of nestlings fledged.

In summary, incubation periods characterized by a high percentage of rainy or overcast days and winds below 18 mph resulted in the best hatchability. Nestling periods with much sunshine and high temperatures had the best fledgling success. These findings suggest high humidity may aid the physiological well-being of the incubated eggs while lack of high wind prevents some accidental egg breakage by birds blown off balance while incubating. Also, more young will survive exposure if temperatures are high and precipitation low during the nestling period. This is especially true after 20 days of age when the brooding bird cannot adequately protect all members of large broods from the weather.

Indirect results of these favorable weather conditions may be more important.

During the incubation period water sports and shellfish harvesting are active in the Chesapeake. Rainy days, threatened rain, or forecast rainy weekends sharply reduce these water-related activities, lessen the disturbance to nesting Ospreys, and improve hatchability. Balmy weather during the nestling period creates optimum fishing conditions that enable efficient capture of prey for rearing healthy young with a maximum growth rate.

Predation.—Predation has not influenced nest success seriously in this study (Reese 1970, Table 2). Raccoons are most important, taking eggs mostly from terrestrial nests. The use of offshore structures for nesting deters most terrestrial predators. Common and Fish Crows (*Corvus brachyrhynchos* and *C. ossifragus*) nest throughout the study area and Herring Gulls (*Larus argentatus*) are occasionally seen harassing Ospreys in early spring. I suspect these three species are responsible for a few egg losses in offshore nests.

In 1971 I visited a disrupted terrestrial shoreblind nest with a single broken egg and a dead 6-day-old nestling. The blind was on dredged mud spoils and fresh raccoon tracks were all around it. Apparently the brooding Osprey accidentally stepped on the egg and nestling in defending the nest against the plundering raccoon. Raccoons had taken eggs from this nest in all previous study years. At another vulnerable site I found several hundred feathers and a small portion of one wing from a 6-week-old nestling in the nest. This nest was on a duckblind over water, but only 3 m from the beach, where raccoon tracks were found, but no Osprey remains were found in the blind or on the beach. The nest was not disrupted and another nestling was not harmed. It seems peculiar that a predator would consume just one nestling while another stands by watching. Also, I cannot imagine the live nestling not trying to escape, in which case it would have fallen overboard. I suspect an avian predator carried its victim away to eat elsewhere.

Accidents.—I could not attribute any mortality to accidents prior to 1969 (Reese 1970). I found one dead nestling beneath a terrestrial nest in 1970. In 1971 I found two dead nestlings tangled in brush on the side of separate offshore duckblind nest sites and three on the floors of duckblinds. I found single live nestlings tangled in coarse sticks beneath two different duckblind nests in 1973. These nestlings were less than 10 days old and would surely have died had I not placed them back in the nest. I found two live nestlings, four fledglings (two dead), and four adults (three dead) inside offshore duckblinds. All these incidents suggest that falling accidents are probably common, but usually go undetected because fallen young from offshore nests are quickly washed away and scavengers get any beneath terrestrial nests. Most falls are probably the indirect result of wind gusts or a clumsy takeoff or landing that could be detrimental to the flying bird as well as frightening and throwing a nestling off balance.

I collected a live fledgling with a dislocated femur in both 1970 and 1971 and a fledgling with a broken tibia that had healed crookedly in 1973. Autopsy showed these injuries occurred at a very early age suggesting the brooding adult may have crushed the young as a hatchling.

Interspecific strife.—Green Herons (*Butorides virescens*), Mallards (*Anas platyrhynchos*), Black Ducks (*Anas rubripes*), Barn Owls (*Tyto alba*), Barn Swallows (*Hirundo rustica*), House Sparrows (*Passer domesticus*), and Common Grackles (*Quiscalus quiscula*) also nest in offshore duckblinds and may influence Osprey nest success. Ducks nest either inside or on top of the blind; owls inside; swallows on the roof or floor joists; herons, grackles, and sparrows usually in brush covering the outside; and Ospreys on the blind's pinnacle. All these species have been found nesting within inches of one another though usually separated by a board or by brush. Ospreys will stoop on Green Herons flushed from the blind and young herons scurrying across the top of the blind are sometimes killed. I saw no contacts between Ospreys and Black Ducks or Barn Swallows.

Ospreys occasionally dive at Mallards swimming from the blind and I once saw an Osprey stoop on a Mallard flushed from the top of the blind. Mallards frequently nest on top of blinds and sometimes in the lower periphery of Osprey nests for camouflage or protection against wind, rain, and sun. Ospreys sharing a nest site with Mallards are seldom successful. Ospreys sharing an offshore duckblind top with three pairs of Mallards fledged only one young in 5 consecutive years (1968–72). Ospreys and Mallards returned to the blind in 1973, but the Ospreys soon abandoned the blind to nest on a channel marker about 17 m away. The Ospreys raised three young each year after moving to the marker. At another offshore blind, three Osprey eggs that had been incubated for 25 days disappeared with the appearance of a Mallard nest directly beside the Osprey's nest. The female Osprey was shy and infrequently on the blind while the Mallard successfully incubated its 11 eggs. After the Mallard hatched its eggs and abandoned the site, the Osprey laid a second clutch of two eggs and hatched and fledged both. A female Mallard was seen vying with a pair of Ospreys for the top of an offshore duckblind on 8 April 1972. At that time the Mallard had no nest, but the Ospreys had a newly constructed nest ready for eggs. On 15 April the Mallard was still without a nest, but definitely intent on remaining at the blind while the Osprey defended its nest without eggs. On 23 April the Mallard was not present and the Osprey had four fresh eggs in a new nest on an artificial nest platform about 1 km away. The male Osprey still defended the blind nest and evidently included it within his new territory. By the first of May the Mallard had taken over the Ospreys' first nest, modified it suitably, and laid the first egg on 13 May. The clutch of 11 eggs was completed about 25 May, successfully incubated, and hatched later that spring. I found Mallard eggs in Osprey clutches or replacing Osprey clutches several times during the study. Parasitism by Anatinae has been reported by Weller (1959), Stotts and Davis (1960), and Joyner (1973). Mallard populations in the Chesapeake Bay are flourishing with continuous releasing of game-farm-bred birds to bolster the fall hunting industry. Osprey-Mallard relations will receive more attention in the future as conflict, eviction, and parasitism are suggested.

Diurnally-flushed Barn Owls receive the Ospreys' complete attention and attacks on owls are much more deliberate and severe than on other species. In going to and from their nest inside the blind most owls have to pass within inches of the Ospreys' nest above the gunner's opening. These nocturnal activities may cause egg breakage if the Osprey is suddenly frightened off the nest. Eggs and nestlings may quickly chill, be damaged, or injured if the Osprey has difficulty returning to and landing at the nest in darkness.

House Sparrows frequently tunnel in to nest among sticks of Osprey nests, and Common Grackles sometimes suspend their nests in coarse sticks of bulky Osprey nests. Grackles are the commonest nesters on offshore duckblinds and I have seen as many as 25 active nests on a single blind. Both these species remain at the blind during my visits and occasionally mob flushed Ospreys. As several authors (Davis 1944, Taylor 1958, Meanley and Webb 1963, Fisk 1970) report grackle predation on eggs and small birds of other species, possible grackle predation on Osprey eggs cannot be discounted.

Several authors noted Red-tailed Hawk (*Buteo jamaicensis*), Bald Eagle (*Haliaeetus leucocephalus*), California Gull (*Larus californicus*), Common Tern (*Sterna hirundo*), Eastern Kingbird (*Tyrannus tyrannus*), and Red-winged Blackbird (*Agelaius phoeniceus*) attacks on Ospreys, but found no conflict between the Osprey and Common Flicker (*Colaptes auratus*), Lewis' Woodpecker (*Asyndesmus lewis*), Western Kingbird (*Tyrannus verticalis*), Violet-green Swallow (*Tachycineta thalassina*), Tree Swallow (*Iridoprocne bicolor*), House Wren (*Troglodytes aedon*), House Sparrow, Starling (*Sturnus vulgaris*), and Common Grackles nesting among sticks of bulky nests (Allen 1892, Bahr 1907, Abbott 1911, Garber 1972, Melquist 1974, Swenson 1975). Bent (1937) reports Magnificent Frigatebird (*Fregata magnificens*), crows (*Corvus* sp.), Common Grackle, Starling, and Barn Swallow attacks on Ospreys. I have witnessed Herring Gull, Great Black-backed Gull (*Larus marinus*), Common Tern, Least Tern (*Sterna albifrons*), Eastern Kingbird, and Red-winged Blackbird attack Ospreys. Conversely, Osprey attacks on Canada Geese (*Branta canadensis*), Turkey Vulture (*Cathartes aura*), Red-tailed Hawk, Swainson's Hawk (*Buteo swainsoni*), Marsh Hawk (*Circus cyaneus*), Bald Eagle, Great-blue Heron (*Ardea herodias*), Black-crowned Night Heron (*Nycticorax nycticorax*), gulls (*Larus* sp.), and Common Raven (*Corvus corax*) wandering or feeding near active Osprey nests are mentioned in other studies (Allen 1892, Skinner 1917, Stone 1937, Ames and Mersereau 1964, Dunstan 1968, Garber 1972, Swenson 1975). Flath (1972) and Melquist (1974) report Ospreys evicting Canada Geese from tree nests. I have seen Ospreys stoop on Great-blue Herons, Herring Gulls, and Bald Eagles straying near active Osprey nests.

U.S. Coast Guard.—Formerly the U.S. Coast Guard indiscriminately destroyed Osprey nests and contents from navigational markers to keep them unobstructed for mariners. This practice was responsible for the failure of 8% of all nests studied between 1963 and 1969 (Reese 1970). The Coast Guard destroyed 4 nests and 3 eggs in 1970 and 3 empty nests in 1971. In 1972 they adopted and enforced a new Operation Plan protecting birds' nests on navigational markers and have not purposely destroyed any nests since. It is hoped the Coast Guard will continue to abide by their Operation Plan and thus eliminate one of the most serious factors influencing Osprey reproduction in Chesapeake Bay.

Disturbance.—I suspect human disturbance of incubating or brooding Ospreys may be the most serious factor influencing nest success. Eggshells are easily cracked or broken in nests where the incubating bird is flushed suddenly. The risk is even greater if the shells have been thinned by environmental contaminants. Death may occur if eggs or nestlings become overheated or chilled when adult Ospreys are scared away from the nest frequently or for long periods of time. Nest contents are also susceptible to predation at these times.

Evaluating the extent of disturbance on reproductive success is extremely difficult without continuous monitoring at a select group of nests. One approach is investigating the magnitude of potential sources of disturbance. Terrestrial sources (cars, constant noise, bright lights, etc.) of disturbance are least important in my study area as most nests are on offshore structures. People living at waterfront locations or operating a boat present the biggest problem. The resident population in the county is presently less than 24,000 and rose only 10% during the 1960's (1970 population census). The study area contains no big industry, but land development for waterfront living has consumed nearly all the available shoreline. Consequently most of the human population in the region lives on the waterfront. Water sports are a favorite pastime and the most intense activities coincide with critical stages of Osprey reproduction.

In Talbot County 1575 boats were registered in 1973 representing a 35% increase since 1963 (Dept. Nat. Res. Boating Adm., annual reports). Statewide boat registration is probably more meaningful where disturbance is concerned. Over 81,135 boats with engines exceeding 7.5 horsepower were registered in Maryland in 1973, an increase of 51% since 1963. Of this total, 46% are kept on trailers and 30% are registered in nontidewater counties. These portions of the total involve boats not necessarily kept or used in counties where they are registered. The study area has 23 county-built public boat landings giving water access to people not living on the waterfront or in the county, and providing a place to launch portable boats. These landings are extremely popular on summer weekends when hundreds of people from large metropolitan areas west of the bay flock to them to launch their portable boats to fish, crab, swim, water-ski, picnic, ride, or sight-see. Of the total Maryland boats, 38% are registered in the Annapolis-Baltimore metropolitan region, only 19 to 48 km from the study area by water and 1 h away by highway. Some of the Chesapeake Bay's finest marinas, regattas, harbors, fishing grounds, crabbing spots, and sightseeing attractions are in the study area, which is centrally located in the bay. Thus the actual number of boats in the area at a given time probably far exceeds those registered there.

The quest for Chesapeake Bay blue crabs attracts the most people and boats to the Osprey study area tributaries. The crabs are captured by several methods, but wading in shallow water with a dip net is by far the most popular. Offshore Osprey nest structures are in these same shallow waters and people wading for crabs cause serious disturbance to nesting Ospreys. Sailboats, high speed cruisers, shallow draft houseboats, speed boats, seaplanes, and military aircraft are among the many craft creating disturbance for nesting Ospreys. The significance of human disturbance will be more pronounced in the future as human populations, boat sales and registration, vehicular camper sales, construction of private piers, marinas, and land development soar higher each year.

I attempted to evaluate the influence of disturbance on nest success by comparing nest success in areas classified suitable and not suitable for Osprey nesting in respect to permanently existing terrestrial habitat alterations and human activities. Suitable area includes shoreline characterized by trees fit for a nest site and near absence of permanent human development. The exception here is areas with widely separated waterfront homes on five or more wooded acres of land. Unsuitable area includes shoreline void of trees, dense waterfront housing, waterfront communities, and commercialized shoreline. The study area contains 149 km of shoreline classified suitable and 100 km classified not suitable. I arbitrarily took all the nesting attempts from 1968 through 1973, separated individual attempts into the category characteristic of their nest site, and then computed the percentage of successful nests in each area. From a total of 806 nesting attempts, 72% occurred in habitat classified suitable and 52% of the nests in the suitable area were successful. Only 48% of the nests were successful in the unsuitable area.

Uneven distribution of nest sites between the two types of habitat classification could bias this approach. Most of the offshore structures used for nest sites (channel markers and duckblinds) are in areas classified not suitable, i.e. harbors and dense waterfront housing, while nearly all the available tree nest sites are in the area classified suitable. Offshore structures contained 78% of all nests studied despite the presence of suitable tree sites throughout the study area. Ospreys that lost their nest site always used my offshore platforms if one was available nearby.

Discussion

The average number of young fledged per successful nest (1.9 in accessible nests and 1.7 in inaccessible nests for the periods of study, Tables 1 and 4) is the only estimate of success that may be compared directly with some of the prepesticide era estimates of production in presumably stable east coast populations. The prepesticide averages range between 2.1 to 2.3 (Tyrrell 1936, Wilcox 1944, Schmid 1966), and are based on banding records made at primarily accessible nests. Banders did not revisit these nests after banding the young, thus late nestling mortality was overlooked. As nestlings are known to have flown from the nest in this study, the average number of fledglings per successful nest may now be slightly closer to the prepesticide averages than indicated. Osprey studies in the Chesapeake Bay report averages from 1.8 to 2.0 in accessible nests (Wiemeyer 1971, Kennedy 1971, Rhodes 1972, Reese 1972, 1975) and 1.4 to 1.6 in inaccessible nests during the past decade. Tree-nesting Ospreys averaged 1.6 to 1.9 in Michigan, Wisconsin, and Minnesota (Dunstan 1968, Sindelar 1971, Postupalsky 1977, Mathisen 1973), 1.6 to 2.1 in Wyoming and Idaho (Melquist 1974, Swenson 1975), and 1.9 to 2.0 in Oregon and northern California (Lind 1971, Garber 1972).

The average number of fledglings per active nest ranged from 0.86 to 1.43 annually in accessible nests and 0.64 to 1.10 in inaccessible nests during the 1970's (Tables 1 and 4). Means for the study were 1.14 and 0.88 respectively, or 1.08 for all active nests with known outcome (n = 684) in the early 1970's. No comparable productivity values are available from presumably stable populations in the prepesticide era. Henny and Wight's (1969) estimate based on combined (shot and found dead) band recoveries for New York and New Jersey Ospreys from 1926 to 1961 show each breeding-age female must produce from 1.22 to 1.30 immatures each year to ensure population stability. Productivity in the past 2 years has been in or near the estimate given for stability, but the 5-year population mean (1.08) is below this requirement. If the estimated range for stability is accurate the population should be declining, but no significant decrease in the number of active nests was noted during the study. Discretion should be used in drawing conclusions from a comparison of Henny and Wight's requirements and actual productivity of the population. Henny et al. (1969, 1970, 1972) give the assumptions, possible sampling errors, mortality differences between periods, misinterpretations, and other biases that could occur when employing the statistical model used to compute the estimated stability requirements. Henny and Wight's estimated mortality rate was higher for shot birds than for birds found dead. Some researchers believe combining these two series will unjustifiably bias mortality rates too high, causing an overestimate of the productivity requirements. Furthermore we do not know what influence nest platforms have on recruitment rates and productivity, the significance on population dynamics of pairs without eggs, that immigration into the population is not occurring, the extent and result of environmental contamination on nest success, and what effect human disturbance is having on the population. Any of these factors could easily conceal a small trend in the status of the population.

Most phases of reproduction decreased after 1965: fewer nests produced eggs, fewer eggs hatched, and fewer hatchlings fledged (Reese 1970). This pattern con-

TABLE 8

RECENT NEST SUCCESS IN U.S. OSPREY POPULATIONS[1]

Location	Years	Nests	Nests Successful	Young Produced	Brood Size	Fledglings per nest	Reference
S. Massachusetts	1970–74	73	42	82	1.9	1.12	Fernandez (pers. comm.)
Chesapeake Bay:							
Eastern Bay	1966–74	323	128	229	1.8	0.71	Reese (1975)
This study	1970–74	684	386	741	1.9	1.08	
Choptank River	1968–74	188	106	190	1.8	1.01	Reese (1972, MS)
Smith Island	1968–71	71	55	98	1.8	1.38	Rhodes (1972)
Potomac River	1970–71	237	81	135	1.7	0.57	Wiemeyer (1971, 1977)
Virginia	1970–71	416	203	333	1.6	0.80	Kennedy (1971)
Michigan	1969–74	463	205	405	2.0	0.88	Postupalsky (1977 and pers. comm.)
Wisconsin	1966–69	237	111	193	1.7	0.81	Sindelar (1971)
Minnesota (Chippewa Nat. For.)	1968–72	249	120	216	1.8	0.87	Mathisen (1973)
Wyoming (Yellowstone Nat. Park)	1972–74	107	44	68	1.5	0.64	Swenson (1975)
Montana (Flathead Lake)	1967–70	80	42	77	1.8	0.96	Koplin (pers. comm.)
N. Idaho-E. Washington	1972–73	342	233	481	2.1	1.41	Melquist (1974)
Oregon (Deschutes Nat. For.)	1971	52	31	60	1.9	1.15	Lind (1971)
N. California	1969–71	136	71	139	2.0	1.02	Garber (1972)

[1] Data for all except this study were collected by two or infrequent nest visits and may not allow for mortality between final visit and fledging. Unpublished data are subject to revision.

tinued into the 1970's, but suddenly reversed in 1972 through 1974 when the percentage of successful nests increased by 2–11%, the percentage of eggs hatching increased by 6–9%, and productivity increased by 7–28% (Table 1). I am not aware of any environmental factors that might enable a sudden increase in nest success. Chemical analysis of materials from the study area were beyond the financial abilities of this study. The gradual phasing out of DDT in the late 1960's with enactment of a nationwide ban on DDT in 1972 may have permitted physiological changes in the Osprey resulting in improved nest success.

The central Choptank River on the southeast side of the study area and Eastern Bay directly north of the study area were surveyed twice annually for nesting Ospreys (Reese 1972, 1975). Since nests were not frequently disturbed nor platforms built in these adjoining areas, they were surveyed as control areas, and their productivity was used for comparison with the major study area. Productivity for 188 nests in the Choptank River area during the period 1968–74 ranged from 0.67 to 1.31 annually and averaged 1.01 young per active nest for the 7 years (Reese 1972, MS). Productivity for 323 nests in Eastern Bay during 1966–74 ranged from 0.31 to 1.59 annually and averaged 0.71 young per active nest for the 9 years (Reese 1975). Productivity similar to the Choptank area suggests frequent nest visits in the major study area are not appreciably influencing nest success there. The much poorer productivity in the Eastern Bay is attributed to human disturbance and environmental pollution as a result of the bay's proximity to large metropolitan areas, development, Chesapeake bridge crossings, and Susquehanna River effluent, the major source of Chesapeake Bay pollution (Reese 1975).

Productivity reported from other sections of the Chesapeake Bay during the early

1970's indicate Ospreys there are generally producing less than one (0.90 combining all studies) young per nesting attempt (Table 8) and the best success is in the eastern shore region extending from this study area south to Tangier Sound (Rhodes 1972, Reese 1972) and in the Rappahannock and Piankatank Rivers on the western shore (Kennedy 1971). Productivity is poorer elsewhere, especially in tributaries near large metropolitan regions and areas of extensive development (Wiemeyer 1971, Kennedy 1971, Reese 1975).

Fledgling success of Ospreys in other areas of the United States during the early 1970's is given in Table 8; that for earlier studies was listed in Reese (1970). Productivity in the study area continues to be among the best in the country despite extremely poor reproductive success in some nearby tributaries. Most portions of the country show an improvement in nest success during the 1970's and newly investigated western populations appear to be producing better than central and east coast populations.

Weather, predation, interspecific strife, accidents, and disease are naturally occurring factors impeding Osprey nest success occasionally, but must be contemplated. Environmental pollution, human disturbance, and U.S. Coast Guard activities are much more detrimental, but they can be prevented or curtailed. A nationwide ban on DDT usage and U.S. Coast Guard cooperation during the past few years have probably aided Osprey nest success in the Chesapeake Bay and may be partly responsible for the big increase in reproductive success since 1972 (Table 1). Results presented here suggest Chesapeake Ospreys are not producing at rates comparable to Ospreys during the first half of the century or Ospreys in less populated areas of the country today. Environmental pollution and human disturbance are believed to be primarily responsible for poor reproductive success and decreasing numbers of Ospreys. It is imperative that monitoring of this species continue in an effort to maintain a perspective on the status of this troubled bird and bring public attention to the factors responsible for the Ospreys' predicament.

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