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The Tidewater Virginia Osprey Population

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THE TIDEWATER VIRGINIA OSPREY POPULATION

1972 AND 1973

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This thesis is submitted in partial fulfillment of the requirements for the degree of

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ABSTRACT

A population survey of the Tidewater Virginia osprey was conducted to determine reproductive success and to develop methods for enhancing natural productivity. A study area of approximately 1217 square nautical miles was routinely surveyed by boat and airplane from March through July in 1972 and 1973. Osprey breeding success improved consecutively during the years of 1972 and 1973. In 1972 from 344 active nests, 0.74 calculated fledglings per nest were produced. In 1973 0.98 calculated fledglings per nest were produced from 445 active nests. The majority of osprey nests were built on man-made structures situated off-shore. These nests on man-made structures produced the majority of hatchlings and fledglings each year. However the present breeding success is below the necessary reproductive rate needed for population stability.

As a management technique, osprey egg clutches were removed early in the nesting season to induce females to lay second clutches. When egg transfers were made from nests with histories of success to nests with histories of failure, the result was successful hatchings in both the original and the foster nests. Seven nests with successful histories produced 21 fledglings in 1973 when first clutches were removed to nests with unsuccessful histories and second clutches were laid.

THE TIDEWATER VIRGINIA OSPREY POPULATION

1972 AND 1973

INTRODUCTION

The osprey (*Pandion haliaetus carolinensis*) once nested in large colonies (Bent 1937) which occupied most estuarine and river systems of North America. Considered cosmopolitan in its range, the osprey species is now found in less abundance and in fewer locations worldwide. Five subspecies of osprey are the only members of the family, Pandionidae (American Ornithologists' Union 1957). They build huge nests on a myriad of structures that are usually found close to water. Because of its easy recognition and tolerance for man, the osprey provides a model subject for determination of population parameters.

Until Kennedy (1971), ospreys had not been studied in Virginia since 1934 when Tyrrell (1936) visited Smith Point and Reedville. In view of Kennedy's data, it is important to study further the population status of this magnificent bird in order to anticipate future population success or failure and in order to develop management techniques that can improve existing populations and possibly to restore extirpated ones.

The primary purpose of this study is to substantiate the preliminary conclusions about the Tidewater Virginia osprey population drawn by Kennedy (1971). A second purpose is to delineate the area or areas where reproduction is most vulnerable and to experiment with methods for reducing this vulnerability.

MATERIALS AND METHODS

Study Area

The study area (Figure 1) comprises approximately 1217 square nautical miles (sq. naut. mi.) of Tidewater and the Eastern Shore of Virginia. Most characteristic of this region are the estuarine systems which divide the land into a multitude of interwoven marshes, streams and rivers. Much of the terrain surrounding these river systems is used for farmland and/or residential development. Those wooded regions that still exist constitute a limited belt of trees between the water and cleared land.

Nine geographic subdivisions outlined by Kennedy (1971) plus the addition of a tenth subdivision, a portion of the Potomac River, form the study area. More extensive coverage of the region enabled expansion of each subdivision. The name, subdivision abbreviation in parenthesis, and approximate dimension of each subdivision are:

James River (J.R.) - 142 sq. naut. mi.

This area includes the James River and its tributaries, except the Chickahominy River, from the Harrison Bridge crossing at Hopewell eastward to the James River Bridge crossing at Newport News.

Chickahominy River (C.R.) - 21 sq. naut mi.

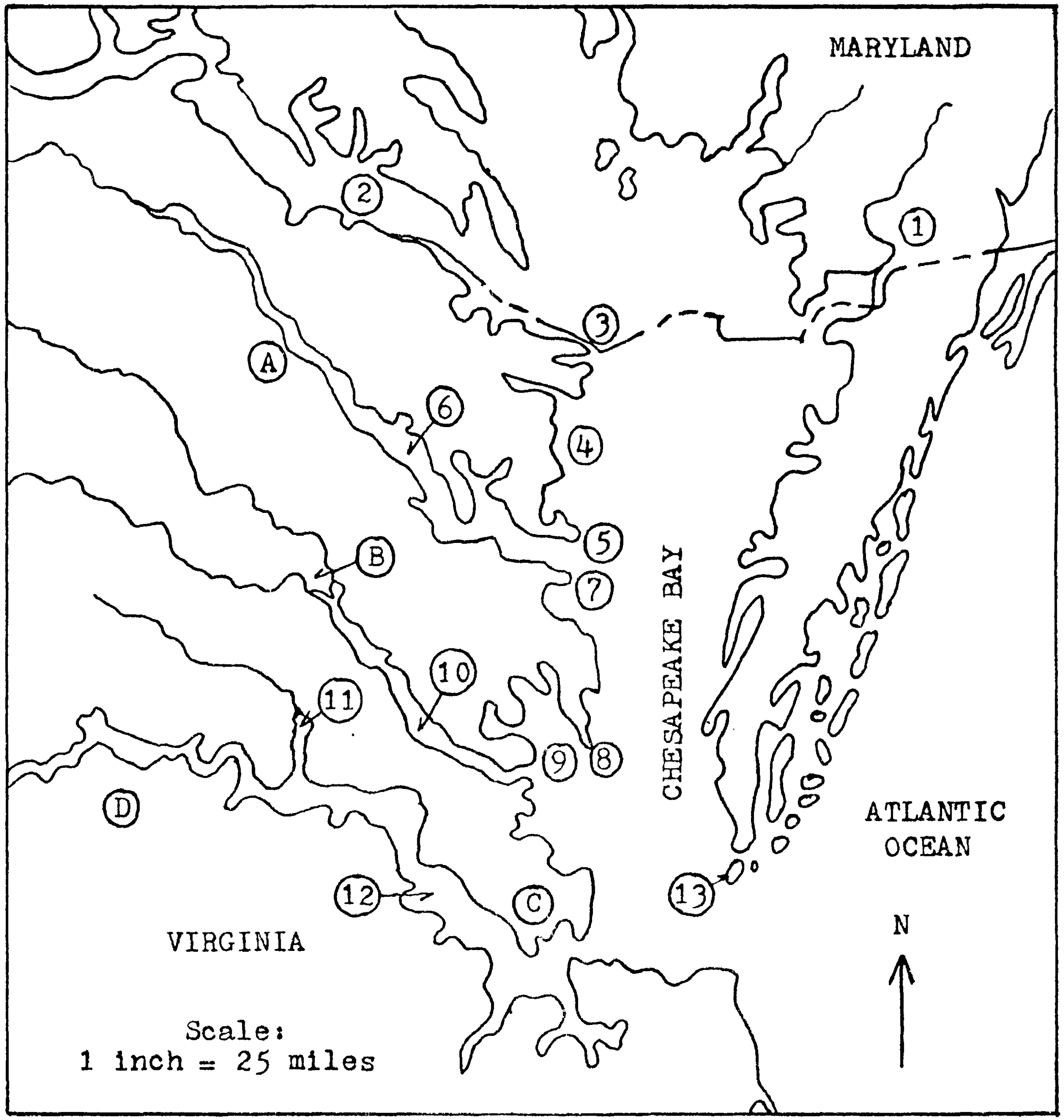
Figure 1

TIDEWATER VIRGINIA
STUDY AREA

Legend

1 Pocomoke River
2 Potomac River
3 Smith Point
4 Fleets Bay
5 Windmill Point
6 Rappahannock River
7 Stingray Point
8 New Point Comfort
9 Mobjack Bay
10 York River
11 Chickahominy River
12 James River
13 Fisherman's Island

A Tappahannock
B West Point
C Newport News
D Hopewell



This area includes the Chickahominy River from 4 miles west of Walkers Dam to the mouth of the river at the Virginia Route 5 highway crossing. This river is considered separately from the James River due to the supposedly less severe conditions of contamination and pollution.

York River (York) - 73 sq. naut. mi.

This area includes the York River and its tributaries from the river's head at West Point eastward to the mouth of the river. The Guinea Marshes mark the northern boundary and Bay Tree Point marks the southern boundary.

Mobjack Bay (M.B.) - 64 sq. naut mi.

This area includes the Severn, Ware, North, and East Rivers as well as the tributaries that flow into Mobjack Bay. It is bounded by the Guinea Marshes to the south and New Point Comfort Island to the north.

New Point Comfort (N.P.C.) - 47 sq. naut. mi.

This area includes the creeks and bays that flow into the Chesapeake Bay from New Point Comfort Island north to Stingray Point including New Point Comfort Island, Gwynn's Island, and the Piankatank River.

Rappahannock River (Rapp.) - 137 sq. naut. mi.

This area includes the Rappahannock River and its tributaries from Blandfield Point (8 miles west of Tappahannock) eastward to the mouth of the river at Stingray Point on the south and Windmill Point on the north. The Corrotoman River is included.

Fleets Bay (F.B.) - 42 sq. naut. mi.

This area includes those creeks and bays that flow into the Chesapeake Bay from Windmill Point northward to Smith Point, including the Great Wicomico River.

Potomac River (Pot.) - 77 sq. naut mi.

This area includes the tributaries of the south shore of the Potomac River from Cabin Point of Lower Machodoc Creek eastward to Smith Point, including the Yeocomico, Coan and Little Wicomico Rivers.

Eastern Shore - Bay Side (Bay) - 260 sq. naut mi.

This area includes those creeks and bays that flow into the Chesapeake Bay from Fisherman's Island north to the Virginia-Maryland border on the Pocomoke River, and Watts Island which is located 4 miles west in the Chesapeake Bay.

Eastern Shore - Atlantic Side (Ocean) - 354 sq. naut. mi.

This area includes all creeks, bays and barrier islands that border the Atlantic Ocean from Fisherman's Island northward to the Virginia-Maryland border on Assateague Island.

Population Surveys

The ten subdivisions were routinely visited from the last of March through the end of July in 1972 and 1973. Locations of nest sites and the dates of egg laying were recorded during March, April and May. Hatching and fledging success was recorded during May, June and July. Banding operations began in late May and were completed in July. Although subdivisions were not surveyed an equal number of times, each was visited at least twice. In 1972 and 1973, each nest site was visited an average of 3.1 and 3.5 times, respectively. Nest locations were indicated on U.S. Coast and Geodetic Survey 7.5 minute quadrangles and numbered sequentially. Field notes included the condition of nest contents (eggs or chicks), the condition and make-up of the nests and supporting structures, the behavior of adult and nestling ospreys, and in 1973, the weights of some young nestlings.

A sixteen foot Boston Whaler was employed as a sea-worthy mode of transportation in which to navigate the water systems of Tidewater Virginia. This craft provided speed and efficiency while traveling to nest site locations. Observations of nest contents were greatly improved by the use of a mirror and pole assembly which often eliminated the time consuming job of climbing to nests. In addition to visitations by water, aerial surveys were conducted twice each season to enhance the coverage of the Bay and Ocean sides of the Eastern Shore.

Determination of Nesting Status

Active nests were classified according to the following procedure initiated at William and Mary in 1970. Nests were termed active whenever adult osprey pairs were seen on the nest site regardless of the degree of nest accessibility or egg content. The degree of accessibility of each nest site and the amount of information gained determined the classification of nest sites into six categories.

Class 1 : Unknown Egg Production - No Hatchlings Produced

Generally these were nests which were inaccessible for study and were later found abandoned by the adults. Included in this category are those accessible nests where the absolute egg number was not determined and subsequently failed to produce any hatchlings.

Class 2 : Known Egg Production - No Hatchlings Produced

This class included those active nests where absolute clutch size was determined but subsequently failed to produce any hatchlings.

Class 3 : Unknown Egg and Known Hatchling Production

This category includes those active nests where clutch size was unknown or incomplete, but subsequent visits proved the existence of hatchlings and/or fledglings. Unlike Kennedy (1971), the current study excludes from this category those inaccessible nests where hatchlings and fledglings were observed only with binoculars.

Class 4 : Known Egg and Known Hatchling Production

Included in this category are those active nests where absolute clutch size and hatching success were determined by direct observation into the nest.

Class 5 : Unknown Egg and Unknown Hatching Success

Generally these active nests were inaccessible for securing definite clutch numbers and hatching success data, but were considered productive due to the maternal behavior of the female at the nest site which suggested the presence of young. Included are those nests where hatchlings and fledglings were observed by binoculars only. (This change in nest site classification was felt necessary due to the probability of more young being present in the nest than could be detected by the observer.)

Class 6 : Manipulated Nests

These nest sites were manipulated during the breeding season by removal of the clutch either for laboratory incubation or for placement into foster nests. These nests were deleted from calculations of the total population productivity and were included only in the total nest number.

Egg Collection

Whole eggs and egg fragments were routinely collected during the census of the populations. Whole eggs were collected when, upon examination, the contents sloshed within the shell or when the egg was known to have been in the nest at least five days past the normal incubation period of 35 to 37 days (Bent 1937, Kennedy 1971). Shell fragments were also collected from broken eggs and from eggs from which chicks had hatched. Eggs and fragments were transported in egg cartons to the laboratory where each was further labeled with the nest site number, date of collection, and condition (rotten, broken in nest, or shell from hatchling). This material was subsequently measured and analyzed by Mr. Jerry W. Via for the determination of shell parameters and egg content pollutants.

The collection is housed in the Biology Department, College of William and Mary, for future reference.

Nesting Platforms

The construction of artificial nesting platforms has provided nest sites for ospreys in many regions of the country (Ames and Mersereau 1964, Valentine 1967, Peterson 1969a, Reese 1970). Therefore, in an attempt to provide suitable nesting structures in areas where such sites are minimal, a total of five aluminum pole platforms were erected on New Point Comfort Island (N.P.C. subdivision) and Mockhorn Island (Ocean subdivision) in 1972. In addition, twelve such platforms were made available to the National Audubon Society and the U.S. Bureau of Sport Fisheries and Wildlife. These platforms and the procedure for their installation have been described by Kennedy (1971).

Banding Methods

Aluminum clip-on and plastic wrap-around color bands were used in combination on both legs of fledgling ospreys to allow for distinct individual color coding (Buckley and Hancock, 1968). At most, one aluminum band and three plastic bands were used, two bands per leg, on each bird banded. Duplication of band combinations used during the 1970-1971 study was avoided by the aid of a computer printout of color combinations.

The U.S. Fish and Wildlife Service granted permission to band and color-band ospreys in Virginia, Maryland and

North Carolina. Size 8 lock-on aluminum bands with prefix 608 were used in preference to standard butt-end aluminum bands because of their superior retention qualities on birds of prey (Berger and Mueller, 1960). Nine colors of Darvic bird bands (white, grey, yellow, brown, red, light green, blue, dark green and black), were supplied by Mr. I Dennison.[a] These bands were 17 millimeters inside diameter and 10 millimeters in height, thus enabling two bands to fit comfortably on the tarsometatarsus of the bird's leg. Because exposure of young to heat is detrimental, the time spent in and around the nest while banding was kept to a minimum.

Manipulation Experiments

1972

Management techniques started by Kennedy in 1971 at the College of William and Mary were continued and expanded in 1972 and 1973. In 1972, twenty clutches of eggs were randomly chosen from nest sites in the York River, Mobjack Bay, New Point Comfort, and Fleets Bay subdivisions. Clutches were collected as close to the completion of laying as possible. They were transported via a foam rubber lined suitcase with a hot water bottle heat source to the biology department for laboratory incubation. Sample clutches were collected

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[a]116 Moor Crescent, High Grange Estate, Belmont Co., Durham, England.

from nest sites having either a history of success or failure in order to test the effectiveness of laboratory techniques where such factors as breakage and predation are absent. The indicated reproductive history of a particular nest site assumed the same adult breeding pair returned seasonally to the same nesting site.

A Humidaire Incubator (Model 300A) was programmed to operate at 99.0° F. incubation temperature and 61 percent (%) relative humidity and to rotate the eggs eight times daily. The hatching weight and the subsequent weight gains of the chicks were recorded along with data on the daily feeding program. Small fresh fish bits soaked in cod liver oil and water were given four times a day at approximately 8 am, 12 noon, 4 pm and 8 pm.

The incubator-reared young were air-dried in a Humidaire Hatcher (Model 300A) for several hours, weighed, and placed in a simulated nest in a Sherer Controlled Environment Chamber (Model CEL 25-7HL). Here they were fed for about a week to ten days before being transported to foster nests. The hatcher operated at a temperature of 96° F. and 77% relative humidity; the environmental growth chamber operated at 88° F. and 54% relative humidity.

The percentage of manipulated nest sites producing second clutches was obtained from field observations. The rate of production from the second clutches was compared with incubator hatching success and with the production rate from control nests in each subdivision.

Foster nests for introduction of laboratory-reared nestlings were chosen by two methods. Either the nestling was placed in a foster nest in which the young present were of equivalent age or the nestling was placed in a nest where the eggs were addled and the age of the nestling would not be a deterrent to acceptance by the foster adults. Success of these introduced nestlings was monitored and compared to the fledging success of the control nests in each subdivision.

Also during 1972 eleven randomly chosen clutches of eggs from Potomac River nests were collected and flown to Vineland, New Jersey by Mr. Paul Spitzer. There incubation following the standard methods for chickens was employed at the Rutgers Poultry Health Laboratory. Hatching and subsequent fledging success was reported for these clutches by Spitzer (personal communication 25 January 1973) and compared to that of the Potomac River control nests. In contrast to the technique employed at William and Mary, Spitzer did not feed the young artificially in the laboratory but introduced the incubator-hatched young into foster nests on the day of hatching.

1973

On April 29, 1973, seven osprey nests from New Point Comfort and seven nests from York River subdivisions were manipulated. For this manipulation experiment, seven clutches of eggs from nest sites in New Point Comfort having a history of success were transported to seven nest sites in the York River having a history of failure. The eggs from the York River sites which had failed previously were transported to the laboratory for incubation.

All egg transfers were made with the aid of foam rubber-lined suitcases heated with hot water bottles. Incubation in the laboratory again made use of the Humidaire Incubator set at 99.5° F. incubation temperature, a lower relative humidity (52%) and eight rotations daily. The Humidaire Hatcher was set at 95.0° F. drying temperature and 79% relative humidity. Hatchlings surviving in 1973 were not reared in the environmental growth chamber, but were placed in foster nests soon after drying in the hatcher.

Hatching success and hatching weights of the laboratory-reared clutches were compared with the success of the seven clutches from previously successful nest sites placed in foster nests and with control clutches in the respective subdivisions.

In both years of the manipulation experiments, when a second clutch was produced in a nest from which the first had been removed, the two clutches were compared with those of the control nests in the respective subidvisions.

Calculations

A compensating polar planimeter was employed to measure individually the area of each subdivision including approximately 0.5 mi. of surrounding shoreline. The total number of nests in each subdivision was then divided by the resulting sq. naut mi. multiplied by one hundred to express nest density per 100 sq. naut. mi.

Productivity of natural and man-made nesting structures was expressed as hatchlings or fledglings per nest. These figures were obtained by dividing the total number of individual types of nesting structures into the total number of hatchlings or fledglings produced on each type structure.

Productivity of on-shore and off-shore structures was expressed as hatchlings or fledglings per nest. These figures were obtained by dividing the total number of on-shore or off-shore nesting structures from each subdivision into the total number of hatchlings or fledglings produced in each subdivision.

The date of laying the first egg for each nest site was approximated from field observations of clutch size and chick age early in the breeding season, following the procedure initiated at William and Mary in 1970. For example, if a nest contained two eggs on one date and later was found to contain three or four eggs, the date of the initial egg laying would be four days prior to the date when two eggs were observed, assuming two days between layings. The age of the chicks in the nest could be accurately estimated soon after hatching and this enabled the approximation of the first egg laying date, assuming an incubation period of 35 to 37 days. These dates were grouped by subdivision and the mean date of first egg laying computed with standard error.

Average clutch size and standard error were calculated from the total number of nests with known clutch size (two, three, or four eggs) for each subdivision. The percentage of hatchings for each respective clutch size was calculated.

The average number of hatchlings and the standard error were calculated from the total number of nests with known hatchling production (one, two, three, or four hatchlings) for each subdivision. The percentage of successful fledglings from each respective hatchling group was calculated.

Calculated hatchlings and fledglings per active nest were computed using data generated in Tables 9a and 9b and these formulae:

(1) $$\frac{\text{Hatchlings per Known Productive Nest} + (\text{Hatchlings per Known Productive Nest} \times \text{Nests with Unknown Production})}{\text{Total Active Nests}}$$

(2) $$\frac{\text{Fledglings per Known Productive Nest} + (\text{Fledglings per Known Productive Nest} \times \text{Nests with Unknown Production})}{\text{Total Active Nests}}$$

Total active nests include all nest classes except class six (Manipulated nests).

Average numbers fledged per nest producing fledglings were computed by dividing the total number of fledglings produced by the total number of nests that produced at least one fledgling. Further, the average number fledged per active accessible nest was computed by dividing the total number of fledglings produced by the total number of active accessible nests. These data are computed in a manner comparable to data presentations by Reese (1968, 1969, 1970, 1972, 1975) and Wiemeyer (1971, 1975).

The minimal annual rate of change was calculated using the formula developed by Henny and Wight (1969) from banding returns used in the dynamic life tables from Hickey (1952) and further employed by Henny and Ogden (1970). The formula states that $1 + u - s = \bar{m} s_o s^2$ where:

u = Annual rate of change in the population.

s = Annual adult survival rate of 1 - annual mortality rate.

s_o = Annual first year (immature) survival rate.

$\bar{m}$ = Average number of female fledglings produced per breeding age female. This assumes that all females three years of age and older breed, and that: $2\bar{m}$ = the total number of fledglings produced per breeding age female assuming an equal sex ratio.

Values for $\bar{m}$ were determined by dividing the calculated fledglings per active nest by two, assuming an equal sex ratio. S_o and s values are maximum survival rates and were adapted from Henny and Wight (1969), where $s_o = 64.7\%$ and $s = 81.5\%$. The annual rate of change measures a minimal amount of change because the survival rates are maximum, the formula assumes that all females three years old or older breed, and the actual decline rates in northeastern states (Ames and Mersereau, 1964 and Peterson, 1969b) are far greater than that measurable by this formula.

RESULTS

Nest Classification

The classification of active osprey nests studied during the 1972 and 1973 breeding seasons is summarized in Table 1. Increases in total active nests from 1972 to 1973 are not the result of increased population numbers, but are due to more intensive surveillance, particularly on the Potomac River and the Bay and Ocean sides of the Eastern Shore. In 1972, no nest sites inactive during 1971 were reused; 21.4% of the total number 1971 nest sites were not used; and there was a 33.0% increase of new nest sites over the total number of 1971 nest sites. In 1973, 3.5% of those nest sites not used during 1972 were again utilized; 20.8% of the total number of 1972 nest sites were not used; and there was a 37.9% increase of new nest sites over the total number of 1972 nest sites.

Nest sites were termed productive when hatchlings were noted (Classes 3 through 6, Table 1); nonproductive nest sites produced no hatchlings (Classes 1 and 2, Table 1). In 1972, productive nest sites constituted 50.1% of all active nest sites, and in 1973, 52.8% of all active nest sites were productive.

Table 1

CLASSIFICATION OF ACTIVE OSPREY NESTS STUDIED DURING THE 1972 AND 1973 BREEDING SEASON

Study Area	Class 1 Nests With Unknown Egg Production - No Hatchlings Produced		Class 2 Nests With Known Egg Production - No Hatchlings Produced		Class 3 Nests With Unknown Egg Production - Known Hatchling Production		Class 4 Nests With Known Egg And Known Hatchling Production		Class 5 Nests With Unknown Egg And Unknown Hatchling Production		Class 6 Manipulated Nests		Total Active Nests	
	1972	1973	1972	1973	1972	1973	1972	1973	1972	1973	1972	1973	1972	1973
J.R.	4	4	1	-	-	-	-	-	-	-	-	1	5	5
C.R.	7	4	5	-	2	4	-	1	-	-	-	-	14	9
York	9	9	8	6	1	1	5	11	4	6	2	3	29	36
M.B.	9	6	2	4		1	3	5	-	1	3	-	17	17
N.P.C.	15	11	7	9	-	2	19	18	2	7	11	11	54	58
Rapp.	28	20	9	19	11	6	32	39	11	9	-		91	93
F.B.	11	8	7	6	1	3	13	19	8	4	4		44	40
Pot.	6	15		6	3	9	6	17	1		11		27	47
Bay	26	46	3	3	1	5	4	10	16	23			50	87
Ocean	11	29	19	12	1	5	11	14	2	8	-	-	44	68
Total	126	152	61	65	20	36	93	134	44	58	31	15	375	460

Nest Density

Osprey nest density per 100 sq. naut. mi. and the approximate sq. naut. mi. for each subdivision are tabulated for 1972 and 1973 (Table 2). Included in these tabulations are those nest sites omitted from production results because of insufficient information (Appendix Table 1). The James River subdivision shows a conspicuously low nest density (3.53 nests per 100 sq. naut. mi.) for both years. The New Point Comfort subdivision shows the highest nest density for both years (114.89 nests per 100 sq. naut. mi. in 1972 and 127.66 nests per 100 sq. naut. mi. in 1973). Nest site dispersion within each subdivision is evenly distributed with some clumping of nest sites at the mouths of creeks and rivers. Locations of exceptional high nest density included Milford Haven which is part of the New Point Comfort subdivision, Rosegill pond near Urbanna which is part of the Rappahannock River subdivision, and Ingram Bay at the mouth of the Great Wicomico River which is part of the Fleets Bay subdivision. The yearly average nest densities increased 19.4%, from 33.44 nests per 100 sq. naut. mi. in 1972 to 39.93 nests per 100 sq naut. mi. in 1973.

Nest Structures

The wide variety of structures on which ospreys build their nests is summarized by structure and year in Tables 3a and 3b and Appendix Table 2. Structures were classified as either natural or man-made. Man-made structures were

Table 2

OSPREY NEST DENSITY, 1972 - 1973

Study Area	Approximate Square Miles (Nautical)	Nest Density/ 100 Square Miles 1972	Nest Density/ 100 Square Miles 1973
J. R.	142	3.52	3.52
C. R.	21	66.67	42.86
York	73	39.73	52.05*
M. B.	64	29.69*	26.56
N. P. C.	47	114.89	127.66*
Rapp.	137	71.53*	73.72*
F. B.	42	107.14*	95.24
Pot.	77	35.06	76.62*
Bay	260	23.46*	33.85*
Ocean	354	15.54*	19.49*
Total	1217	33.44*	39.93*

*Values adjusted to include all nests. See Appendix Table 1

Table 3a

TYPES OF NATURAL NESTING STRUCTURES USED BY OSPREYS, 1972 - 1973

Study Area		Snags	Live Pines	Bald Cypress	Other Live Trees	Total
J.R.	72	-	-	4	-	4
	73	-	-	4	-	4
C.R.	72	-	-	14	-	14
	73	-	-	9	-	9
York	72	6	1	-	-	7
	73	4	3	-	-	7
M.B.	72	5	-	-	-	5
	73	2	-	-	-	2
N.P.C.	72	11	5	-	-	16
	73	11	5	-	1	17
Rapp.	72	19	14	-	1	34
	73	15	15	-	3	33
F.B.	72	14	4	-	1	19
	73	6	6	-	1	13
Pot.	72	-	4	-	1	5
	73	3	6	-	1	10
Bay	72	33	4	-	-	37
	73	46	9	-	3	58
Ocean	72	16	2	-	-	18
	73	17	4	-	-	21
Percent of	72	27.7	9.1	4.8	0.8	42.4
Total	73	22.6	10.4	2.8	2.0	37.8

Table 3b

TYPES OF MAN-MADE NESTING STRUCTURES USED BY OSPREYS, 1972 - 1973

Study Area		Day Beacons	Lighted Beacons	Duck Blinds	Others	Total
J.R.	72	1	-	-	-	1
	73	1	-	-	-	1
C.R.	72	-	-	-	-	-
	73	-	-	-	-	-
York	72	1	6	7	8	22
	73	1	7	8	13	29
M.B.	72	4	5	-	3	12
	73	6	5	2	2	15
N.P.C.	72	9	13	7	9	38
	73	9	12	10	10	41
Rapp.	72	11	19	15	12	57
	73	12	20	16	12	60
F.B.	72	3	8	14	-	25
	73	2	8	16	1	27
Pot.	72	12	2	6	2	22
	73	23	6	8	-	37
Bay	72	-	5	4	4	13
	73	3	9	8	9	29
Ocean	72	1	7	1	17	26
	73	1	12	1	33	47
Percent of	72	11.2	17.3	14.4	14.7	57.6
Total	73	12.6	17.2	15.0	17.4	62.2

not necessarily built for the express purpose of providing nest sites for birds. In 1972, ospreys build 42.4% of their nests on natural nesting structures (Table 3a), such as dead trees (snags), live pine trees (Pinus spp.), Bald Cypress (Taxodium distichum), and other live trees. The majority (27.7%) was built in snags. In 1973, 37.8% of all osprey nests were on natural nesting structures with the majority (22.6%) in snags. A total of 57.6% in 1972 and 62.2% in 1973 were built on man-made structures with the majority each year built on navigational aids (28.5% in 1972 and 29.8% in 1973). Statistically, the number of man-made nesting structures used in 1973 per subdivision is significantly greater than the number used in 1972 (Student's t-test for paired data; $p < 0.02$).

The snags used for nest sites were usually dead Virginia Pine (Pinus virginiana), Loblolly Pine (Pinus taeda), and dead Red Cedars (Juniperus virginiana) with an occasional dead oak (Quercus spp.) The live trees used for nest sites included Virginia Pine, Loblolly Pine, Bald Cypress, Tulip Poplar (Liriodendron tulipifera), Live Oak (Quercus virginiana), Sycamore (Platanus occidentalis), hickory (Carya spp.), spruce (Picea spp.) and Pecan (Carya illinoensis).

Man-made nesting structures were generally located off-shore and included day markers, lighted beacons and permanent duck blinds. A great variety of other man-made structures used as nest sites are listed in Appendix Table 2. One other type of structure used by ospreys as nesting sites was the aluminum platforms constructed and erected in the New Point Comfort and Ocean subdivisions. Table 4 summarized the total number of these platforms available for nesting and the yearly utilization for nest sites. Although relatively few were utilized (26.9% in 1972 and 30.8% in 1973), the platforms were utilized in locations where few natural or man-made sites for nesting are available.

Nest Structure Productivity

The productive success of nests on natural and man-made structures is summarized in Tables 5a and 5b for both years of the survey. In 1972, nests on natural structures produced 18.5% of all hatchlings and 19.6% of all fledglings. A similar situation resulted in 1973 with nests on natural structures producing 16.6% of all hatchlings and 16.9% of all fledglings. Nests on man-made structures produced 81.5% of all hatchlings and 80.4% of all fledglings in 1972, and 83.4% of all hatchlings and 83.1% of all fledglings in 1973. During both years, differences between nest success on natural nesting structures and man-made nesting structures are statistically significant. The number of hatchlings and fledglings produced per man-made nesting structure is greater than the respective numbers produced per natural nesting structure in 1972 (Student's t-test for unpaired data; $p < 0.01$) and 1973 (Student's t-test for unpaired data; $p < 0.05$).

The success of nests on man-made nesting structures

Table 4

OSPREY UTILIZATION OF WILLIAM AND MARY ALUMINUM NESTING PLATFORMS, 1972 and 1973

Study Area	Total Aluminum Platforms Constructed	1972 Nests	1973 Nests
N.P.C.	10	3 (30.0)	3 (30.0)
Ocean	16	4 (25.0)	5 (31.3)
Total	26	7 (26.9)	8 (30.8)

Numbers in Parentheses Indicate Percent

Table 5a

PRODUCTIVITY OF NATURAL NESTING STRUCTURES, 1972 and 1973*

	Dead Snags		Live Pines		Bald Cypress		Live Trees		Total	
	1972	1973	1972	1973	1972	1973	1972	1973	1972	1973
Total Nests	103(29.9)	104(23.4)	33(9.6)	48(10.8)	18(5.2)	13(2.9)	3(0.9)	9(2.0)	157(45.6)	174(39.1)
Hatchlings Produced	23(10.1)	15(4.2)	16(7.0)	30(8.5)	3(1.3)	7(2.0)		7(2.0)	42(18.5)	59(16.6)
Hatchlings Per Nest	0.22	0.14	0.48	0.63	0.17	0.54		0.78	0.27	0.34
Fledglings Produced	19(10.3)	12(3.7)	14(7.6)	29(8.9)	3(1.6)	7(2.2)		7(2.2)	36(19.6)	55(16.9)
Fledglings Per Nest	0.18	0.12	0.42	0.60	0.17	0.54	-	0.78	0.23	0.32

*Data Excludes Manipulated Nests

Numbers In Parentheses Indicate Percent of Yearly Totals

Table 5b

PRODUCTIVITY OF MAN-MADE NESTING STRUCTURES, 1972 and 1973*

	Day Markers		Lighted Beacon		Duck Blinds		Others		Total	
	1972	1973	1972	1973	1972	1973	1972	1973	1972	1973
Total Nests	32(9.3)	53(11.9)	57(16.6)	74(16.6)	46(13.3)	66(14.8)	52(15.1)	78(17.5)	187(54.4)	271(60.9)
Hatchlings Produced	43(18.9)	59(16.6)	52(22.9)	98(27.6)	44(19.4)	81(22.8)	46(20.3)	58(16.3)	185(81.5)	296(83.4)
Hatchlings Per Nest	1.34	1.11	0,91	1.32	0.96	1.23	0.88	0.74	0.99	1.09
Fledglings Produced	35(19.0)	57(17.5)	47(25.5)	87(26.8)	35(19.0)	76(23.4)	31(16.8)	50(15.4)	148(80.4)	270(83.1)
Fledglings Per Nest	1.09	1.08	0.82	1.18	0.76	1.15	0.60	0.64	0.79	1.00

*Data Excludes Manipulated Nests

Numbers in Parentheses Indicate Percent Of Yearly Totals

was greatest on navigational aids. The combined percentages of production results for day markers and lighted beacons show that of all hatchlings produced, 41.8% in 1972 and 44.2% in 1973 were from navigational aid nests. Of all fledglings produced, 44.5% in 1972 and 44.3% in 1973 were from navigational aid nests.

The lowest hatchling and fledgling production for both years was from nests on dead snags. These nests produced 10.1% of all hatchlings and 10.3% of all fledglings in 1972 and in 1973 only 4.2% of all hatchlings and 3.7% of all fledglings. Although the total number of nests in dead snags remained nearly constant (103 in 1972 and 104 in 1973), the rates of success decreased. The 1972 production rates of 0.22 hatchlings and 0.18 fledglings per nest decreased in 1973 to 0.14 hatchlings and 0.12 fledglings per nest.

Production results are also indicated by nesting structure as shown in Tables 6a and 6b. Nest sites have been divided into on-shore and off-shore locations and the resulting data tabulated for 1972 and 1973. The percentage of on-shore nest sites shows a slight decline from 1972 (42.3%) to 1973 (38.2%). Similarly, the percentage of hatchlings and fledglings produced from on-shore nest sites decreased from 1972 to 1973. Production rates for hatchlings and fledglings per on-shore nest in 1972 (0.43 and 0.34 respectively) increased slightly in 1973 (0.51 and 0.44 respectively). Greater increases in production rates for

Table 6a

PRODUCTIVITY OF ON-SHORE OSPREY NESTING STRUCTURES, 1972 - 1973*

Study Area	1972 Nests	Hatchlings Produced	Fledglings Produced	Hatchlings Per Nest	Fledglings Per Nest	1973 Nests	Hatchlings Produced	Fledglings Produced	Hatchlings Per Nest	Fledglings Per Nest
J.R.	-	-	-	-	-	-	-	-	-	-
C.R.	-					-	-	-	-	-
York	4					2	2	2	1.00	1.00
M.B.	6	-	-	-	-	1	-	-	-	-
N.P.C.	18	17	12	0.94	0.67	14	11	7	0.78	0.50
Rapp.	28	15	15	0.54	0.54	28	22	19	0.78	0.68
F.B.	11	-	-	-	-	10	8	8	0.80	0.80
Pot.	4	2	1	0.50	0.25	10	11	11	1.10	1.10
Bay	25	2	2	0.08	0.08	40	3	2	0.08	0.05
Ocean	31	19	13	0.61	0.42	43	18	16	0.42	0.37
Total	127	55	43	0.43	0.34	148	75	65	0.51	0.44
Percent of Total	42.3	24.2	23.4			38.2	21.1	20.0		

*Data Excludes Manipulated Nests and Nests with Unknown Production

Table 6b

PRODUCTIVITY OF OFF-SHORE OSPREY NESTING STRUCTURES, 1972 - 1973*

Study Area	1972 Nests	Hatchlings Produced	Fledglings Produced	Hatchlings Per Nest	Fledglings Per Nest	1973 Nests	Hatchlings Produced	Fledglings Produced	Hatchlings Per Nest	Fledglings Per Nest
J.R.	5	-	-	-	-	4	-	-	-	-
C.R.	14	3	3	0.21	0.21	9	7	7	0.78	0.78
York	19	14	12	0.74	0.63	25	23	16	0.92	0.64
M.B.	8	6	6	0.75	0.75	15	11	11	0.73	0.73
N.P.C.	23	25	21	1.09	0.91	26	30	27	1.15	1.04
Rapp.	52	67	53	1.29	1.02	56	78	75	1.39	1.34
F.B.	21	27	23	1.28	1.10	26	43	43	1.65	1.65
Pot.	11	19	13	1.73	1.18	37	44	42	1.19	1.14
Bay	9	7	6	0.77	0.67	24	32	29	1.33	1.21
Ocean	11	4	4	0.36	0.36	17	12	10	0.70	0.59
Total	173	172	141	0.99	0.82	239	280	260	1.17	1.09
Percent of Total	57.7	75.8	76.6			61.8	78.9	80.0		

*Data Excludes Manipulated Nests and Nests with Unknown Production hatchlings and fledglings per off-shore nest were observed from 1972 (0.99 and 0.82 respectively) to 1973 (1.17 and 1.09 respectively).

Statistically, the difference between on-shore and off-shore hatchlings per nest in 1972 and 1973 are significant (Student's t-test for unpaired data; $p<0.05$ and $p<0.01$ respectively). Differences between on-shore and off-shore fledglings per nest are also statistically significant for both years (Student's t-test for unpaired data; $p<0.02$).

Nests built on off-shore structures in the Potomac River showed the best 1972 production (1.73 hatchlings and 1.18 fledglings per nest). Nests built on off-shore structures in Fleets Bay showed the best 1973 production (1.65 hatchlings and 1.65 fledglings per nest). The subdivisions with the best production rates for on-shore nesting structures were New Point Comfort in 1972 (0.94 hatchlings and 0.67 fledglings per nest) and the Potomac River in 1973 (1.10 hatchlings and 1.10 fledglings per nest).

Egg Numbers and Hatching Success

Figures 2a and 2b represent the estimated date of first egg laying for those nest sites where such an estimate could be determined. The whole study area is represented yearly by histograms with the date on the abscissa and the number of clutches on the ordinate. Egg laying extended from March

Figure 2a

ESTIMATED DATE OF FIRST EGG LAYING, 1972

Study Area	n	Mean ± Standard Error
C.R.	1	10.0 ± 0.0
York	16	20.9 ± 4.3
M.B.	6	9.7 ± 2.6
N.P.C.	32	11.3 ± 1.5
Rapp.	32	18.8 ± 1.9
F.B.	13	18.2 ± 1.5
Pot.	10	20.3 ± 1.6
Bay	2	13.0 ± 0.0
Ocean	8	18.9 ± 3.3
Total	120	16.7 ± 1.0

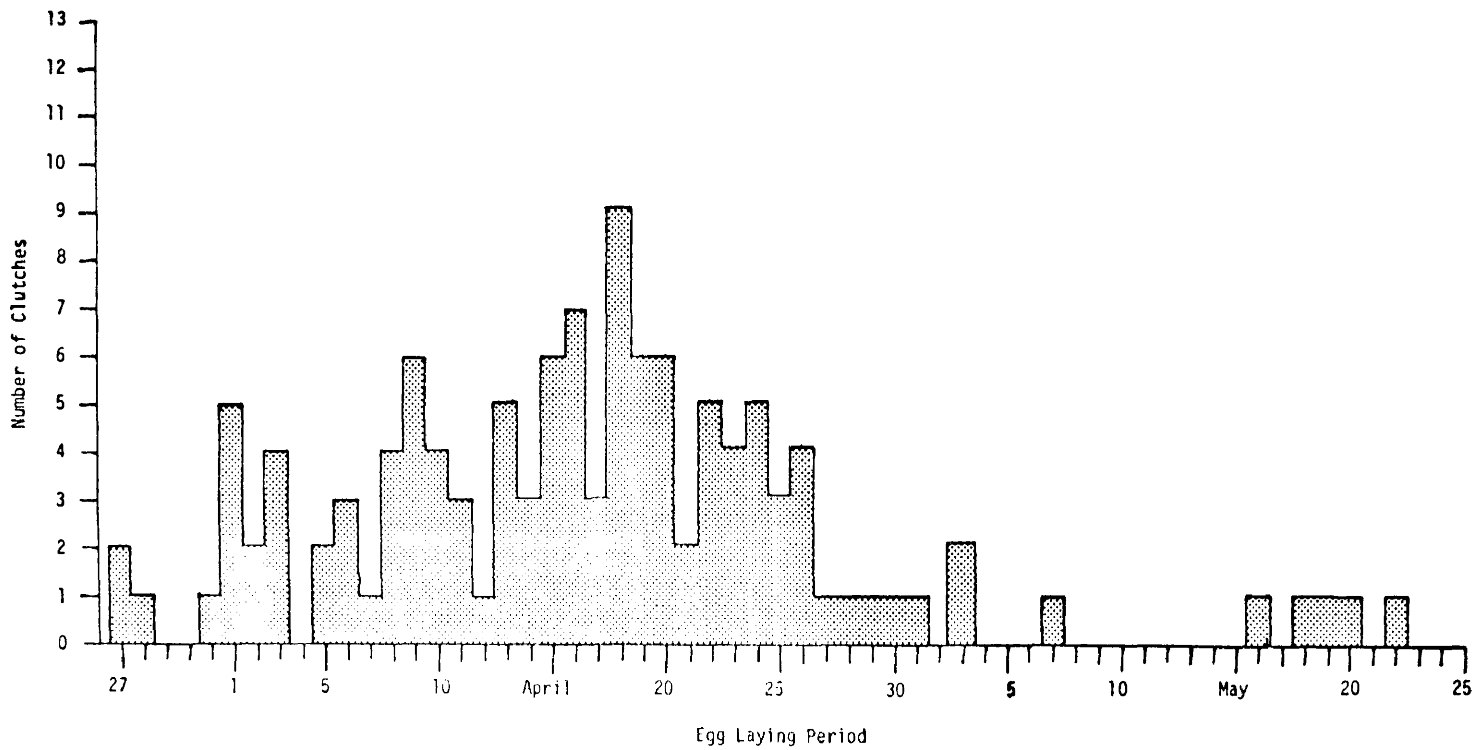
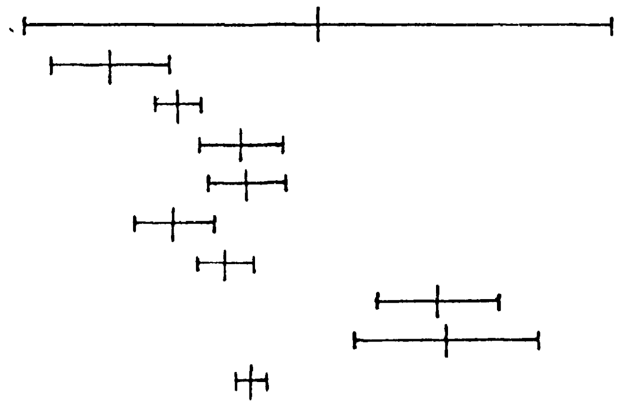
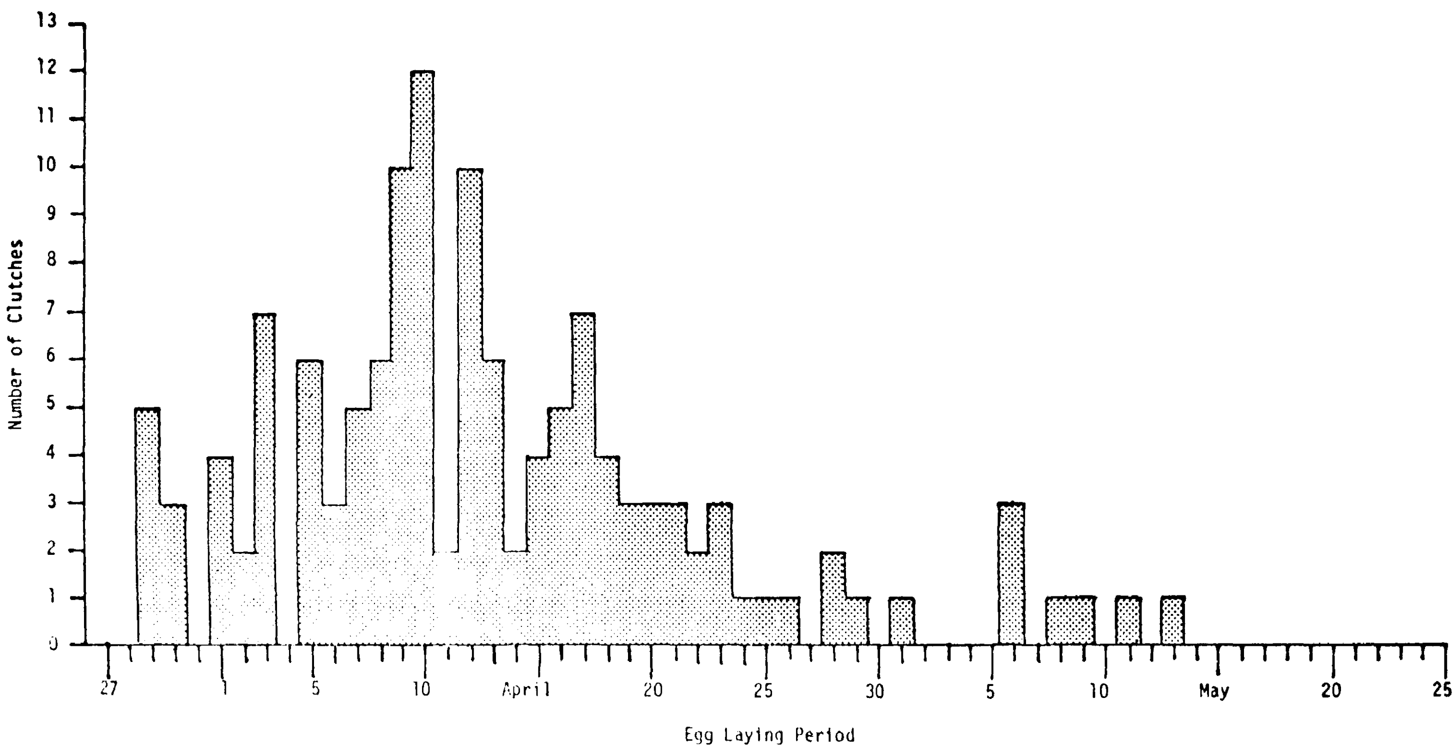


Figure 2b

ESTIMATED DATE OF FIRST EGG LAYING, 1973

Study Area	n	Mean ± Standard Error
C.R.	2	16.0 ± 13.0
York	9	6.9 ± 2.7
M.B.	5	9.8 ± 1.0
N.P.C.	23	12.5 ± 1.8
Rapp.	38	12.8 ± 1.7
F.B.	17	9.6 ± 1.8
Pot.	19	11.8 ± 1.4
Bay	11.	21.2 ± 2.7
Ocean	7	21.6 ± 4.0
Total	131	12.9 ± 0.8





through April into May for both years, with peaks of laying occurring on April 4, 14 and 23 in 1972 and on April 3, 15 and 22 in 1973. Above each yearly histogram, the first egg laying dates for nests in each subdivision are represented by horizontal lines; the midpoint equals the mean date of first egg laying and the endpoints equal the standard error spread.

The mean dates of first egg laying for each subdivision cluster around the total mean date for the whole study area for both years. A slight trend is apparent in 1972 for a progressively later mean date for first egg laying northward among the subdivisions between Mobjack Bay and the Potomac River.

Clutch size data are presented in Tables 7a and 7b, indicating hatching success and average clutch size. Yearly, the average clutch size and percentage of two, three and four egg clutches remained nearly constant. The majority of clutches contained three eggs (68.2% in 1972 and 70.4% in 1973), two egg clutches were next frequent (21.4% in 1972 and 19.1% in 1973), and the fewest number of clutches were made up of four eggs (10.4% in 1972 and 10.6% in 1973). The average clutch size of 2.89 in 1972 and 2.91 in 1973 shows the dominance of three egg clutches and the relative consistency of clutch sizes.

Clutches with three and four eggs demonstrated better hatching success each year over clutches with only two eggs. The best hatching success (58.1%) is shown by the 1973 three

Table 7a

NUMBER OF NESTS WITH KNOWN CLUTCH SIZE, INDICATING HATCHING

SUCCESS AND AVERAGE CLUTCH SIZE, 1972

1972 Study Area	Total Nests With Known Clutch Size	TWO Egg Clutch	Percent Hatching	THREE Egg Clutch	Percent Hatching	FOUR Egg Clutch	Percent Hatching	Total Eggs Observed	Total Percent Hatching	Average Clutch Size
J. R.	1	-	-	1	0	-	-	3	-	3.00 ± 0.0
C. R.	5	2	0.0	3	0	-	-	13	-	2.60 ± 0.24
York	13	5	0.0	5	66.7	3	16.7	37	32.4	2.85 ± 0.22
M. B.	5	2	25.0	3	55.6	-	-	13	46.2	2.60 ± 0.24
N.P.C.	26	4	12.5	19	56.1	3	75.0	77	54.5	2.96 ± 0.10
Rapp.	41	3	16.7	33	49.5	5	60.0	125	49.6	3.05 ± 0.07
F. B.	20	3	33.3	16	41.7	1	100.0	58	44.8	2.90 ± 0.10
Pot.	6	-	-	5	80.0	1	75.0	19	78.9	3.17 ± 0.17
Bay	7	3	0.0	3	66.7	1	25.0	19	36.8	2.71 ± 0.29
Ocean	30	11	18.2	17	31.4	2	25.0	81	27.2	2.70 ± 0.11
Total	154	33 (21.4)	13.6	105 (68.2)	47.6	16 (10.4)	51.6	445	43.1	2.89 ± 0.04

Numbers in Parentheses Indicate Percent of Total Nests with Known Clutch Size

Table 7b

NUMBER OF NESTS WITH KNOWN CLUTCH SIZE, INDICATING HATCHING SUCCESS AND AVERAGE CLUTCH SIZE, 1973

1973 Study Area	Total Nests With Known Clutch Size	TWO Egg Clutch	Percent Hatching	THREE Egg Clutch	Percent Hatching	FOUR Egg Clutch	Percent Hatching	Total Eggs Observed	Total Percent Hatching	Average Clutch Size
J. R.	-	-	-	-		-	-	-	-	-
C. R.	1	-	-	1	33.3	-	-	3	33.3	3.00 ± 0.0
York	17	4	25.0	10	50.0	3	50.0	50	46.0	2.94 ± 0.16
M. B.	9	5	20.0	2	50.0	2	62.5	24	41.7	2.67 ± 0.29
N.P.C.	27	6	0.0	20	58.3	1	75.0	76	50.0	2.81 ± 0.09
Rapp.	58	9	33.3	38	60.5	11	36.4	176	51.7	3.03 ± 0.08
F. B.	25	-	-	22	59.1	3	58.3	78	59.0	3.12 ± 0.06
Pot.	23	6	41.7	17	68.6			63	63.5	2.74 ± 0.09
Bay	13	-	-	13	69.2	-		39	69.2	3.00 ± 0.0
Ocean	26	8	31.3	17	39.2	1	0.0	71	35.2	2.73 ± 0.10
Total	199	38 (19.1)	26.3	140 (70.4)	58.1	21 (10.6)	44.0	580	51.9	2.91 ± 0.04

Numbers in Parentheses Indicate Percent of Total Nests with Known Clutch Size egg clutches. Two egg clutches show the poorest hatching success, 13.6% in 1972 and 26.3% in 1973. In 1972 four egg clutches showed better hatching success than three egg clutches (51.6% and 47.6% respectively).

Table 8 summarized the major causes of egg and hatchling loss during 1972 and 1973. Disappearance between visits comprises the major category for both egg and hatchling loss in both years. Egg disappearance between visits constitutes 64.7% of the total egg loss in 1972 and 65.3% in 1973. Hatchling disappearance between visits is 41.9% of the total hatchling loss in 1972 and 66.7% in 1973. Eggs that were deemed rotten (addled) represent 18.2% of the total egg loss in 1972 and 24.2% in 1973. Broken, cracked, dented, and pinholed eggs represent 10.9% of the eggs lost in 1972 and 8.3% in 1973. Major reasons for hatchlings failing to fledge other than disappearance between visits were death in the nest (23.3%) and destruction by storm (27.9%) in 1972, and in 1973, removal from the nest by humans (26.7%).

Hatchling Numbers and Fledging Success

Tables 9a and 9b present the known hatchling information from classes 3 and 4 of Table 1. Shown is the degree of fledging success and average number of hatchlings per known productive nest for each subdivision by year. During both years, nests containing two hatchlings were more abundant than nests containing one, three or four hatchlings.

Table 8

CAUSE OF OSPREY EGG AND HATCHLING LOSS, 1972 and 1973

Cause of Loss	1972 Eggs	1972 Hatchlings	1973 Eggs	1973 Hatchlings
Disappeared Between Surveys	167 (64.7)	18 (41.9)	181 (65.3)	20 (66.7)
Addled Eggs	47 (18.2)	-	67 (24.2)	-
Eggs Found Broken, Cracked Dented, or with Pinhole	28 (10.9)		23 (8.3)	
Storm or Wind Destroyed Nest	10 (3.9)	12 (27.9)	3 (1.1)	
Human Destroyed	6 (2.3)	-	3 (1.1)	
Hatchling died in Nest		10 (23.3)		2 (6.7)
Hatchlings Taken by Humans		2 (4.7)		8 (26.7)
Hatchlings Fell from Nest and Starved	-	1 (2.3)	-	-
Total Loss	258	43	277	30
Total Observed	450	227	580	355
Percent Loss	57.3	18.9	47.8	8.5

Numbers in Parentheses Indicate Percent of Total Egg and Hatchling Loss

Table 9a

NUMBER OF NESTS WITH KNOWN HATCHLING PRODUCTION, INDICATING FLEDGING

SUCCESS AND NUMBER OF HATCHLINGS PER PRODUCTIVE NEST, 1972

1972 Study Area	Total Nests with Known Hatchling Production	Nests with ONE Hatchling	Percent Fledged	Nests with TWO Hatchlings	Percent Fledged	Nests with THREE Hatchlings	Percent Fledged	Nests with FOUR Hatchlings	Percent Fledged	Total Hatchlings Observed	Total Percent Fledging	Average Hatchlings Per Productive Nest
J. R.		-	-		-	-	-	-	-	-	-	-
C. R.	2	1	100.0	1	100.0	-	-			3	100.0	1.50 ± 0.50
York	6	-	-	4	100.0	2	66.7			14	85.7	2.33 ± 0.21
M. B.	3	1	100.0	1	100.0	1	100.0			6	100.0	2.00 ± 0.58
N.P.C.	19	4	75.0	7	64.3	8	87.5			42	78.6	2.21 ± 0.18
Rapp.	43	14	78.6	19	84.2	10	83.3		-	82	82.9	1.91 ± 0.11
F. B.	14	6	83.3	4	75.0	3	100.0		75.0	27	85.2	1.93 ± 0.27
Pot.	9	-	-	6	43.8	3	77.8		-	21	66.7	2.33 ± 0.17
Bay	5	2	50.0	2	100.0	1	100.0			9	88.9	1.80 ± 0.37
Ocean	12	5	100.0	3	50.0	4	75.0	-	-	23	73.9	1.92 ± 0.26
Total	113	33 (29.2)	81.8	47 (41.6)	77.7	32 (28.3)	84.4	1 (0.9)	75.0	227	81.1	2.01 ± 0.07

Numbers in Parentheses Indicate Percent of Total Nests with Known Hatchling Production

Table 9b

NUMBER OF NESTS WITH KNOWN HATCHLING PRODUCTION, INDICATING FLEDGING SUCCESS AND NUMBER OF HATCHLINGS PER PRODUCTIVE NEST, 1973

1973 Study Area	Total Nests with Known Hatchling Production	Nests with ONE Hatchling	Percent Fledged	Nests with TWO Hatchlings	Percent Fledged	Nests with THREE Hatchlings	Percent Fledged	Nests with FOUR Hatchlings	Percent fledged	Total Hatchlings Observed	Total Percent Fledging	Average Hatchlings Per Productive Nest
J. R.	-	-	-	-	-	-	-	-	-	-	-	-
C. R.	5	3	100.0	2	100.0	-	-			7	100.0	1.40 ± 0.24
York	12	3	100.0	5	100.0	4	41.7			25	72.0	2.08 ± 0.23
M. B.	6	2	100.0	3	100.0	1	100.0			11	100.0	1.83 ± 0.31
N.P.C.	20	6	83.3	7	85.7	7	81.0		-	41	82.9	2.05 ± 0.18
Rapp.	45	10	80.0	16	90.6	18	98.1	1	100.0	100	94.0	2.22 ± 0.12
F. B.	22	3	100.0	10	100.0	8	100.0	1	100.0	51	100.0	2.32 ± 0.17
Pot.	26	5	100.0	13	92.3	8	100.0		-	55	96.4	2.12 ± 0.14
Bay	15	3	66.7	4	75.0	8	95.8			35	88.6	2.33 ± 0.21
Ocean	19	12	66.7	3	100.0	4	100.0	-	-	30	86.7	1.58 ± 0.19
Total	170	47 (27.6)	83.0	63 (37.1)	92.9	58 (34.1)	92.5	2 (1.2)	100.0	355	91.5	2.09 ± 0.06

Numbers in Parentheses Indicate Percent of Total Nests with Known Hatchling Production

During 1973, more nests contained three hatchlings (34.1%) than one hatchling (27.6%), a noticeable increase from 1972 when approximately equal percentages of nests contained one (29.2%) and three (28.3%) hatchlings. During each year a few nests were discovered containing four hatchlings, and probably more nests which possibly lost one or more nestlings between visits contained four hatchlings.

For both years the average number of hatchlings per productive nest was about 2.0 in each subdivision except the James and Chickahominy Rivers. No hatchlings were reported on the James for either year, and the Chickahominy averaged only 1.5 and 1.4 hatchlings per productive nest in 1972 and 1973 respectively.

Of all hatchlings observed, 81.1% in 1972 and 91.3% in 1973 fledged successfully. Nests containing two and three hatchlings successfully fledged a higher percentage of hatchlings in 1973 (92.9% and 92.5% respectively) than nests containing two and three hatchlings in 1972 (77.7% and 84.4% respectively fledged).

Calculated hatchlings and fledglings per active nest for 1972 and 1973 are presented in Tables 10a and 10b. Yearly averages of calculated hatchlings and fledglings per active nest show that 1973 was a more successful year than 1972. In 1973, 1.07 calculated hatchlings and 0.98 calculated fledglings per active nest were produced while averages for 1972 were 0.92 calculated hatchlings and 0.74 calculated fledglings per active nest. Each subdivision,

Table 10a

CALCULATED HATCHLINGS AND FLEDGLINGS PRODUCED PER ACTIVE OSPREY NEST, 1972*

1972 Study Area	Total Active Nests	Nests With Known Production	Hatchlings Per Known Productive Nest	Fledglings Per Known Productive Nest	Nests With Unknown Production	Calculated Hatchlings Produced	Calculated Fledglings Produced	Calculated Hatchlings Per Active Nest	Calculated Fledglings Per Active Nest
J.R.	5	0	0	0	0	0	0	0	0
C.R.	14	2	1.50	1.50	-	3	3	0.21	0.21
York	27	6	2.33	2.00	4	23.32	20.00	0.86	0.74
M.B.	14	3	2.00	2.00	-	6	6	0.43	0.43
N.P.C.	43	19	2.21	1.74	2	46.42	36.48	1.08	0.85
Rapp.	91	43	1.91	1.58	11	103.01	85.38	1.13	0.94
F.B.	40	14	1.93	1.64	8	42.44	36.12	1.06	0.90
Pot.	16	9	2.33	1.56	1	23.33	15.56	1.46	0.97
Bay	50	5	1.80	1.60	16	37.80	33.60	0.76	0.67
Ocean	44	12	1.92	1.42	2	26.84	19.84	0.61	0.45
Total	344	113	2.01	1.63	44	315.44	255.72	0.92	0.74

*Data Excludes Manipulated Nests

Table 10b

CALCULATED HATCHLINGS AND FLEDGLINGS PRODUCED PER ACTIVE OSPREY NEST, 1973*

1973 Study Area	Total Active Nests	Nests With Known Production	Hatchlings Per Known Productive Nest	Fledglings Per Known Productive Nest	Nests With Unknown Production	Calculated Hatchlings Produced	Calculated Fledglings Produced	Calculated Hatchlings Per Active Nest	Calculated Fledglings Per Active Nest
J.R.	4	0	0	0	0	0	0	0	0
C.R.	9	5	1.40	1.40		7	7	0.78	0.78
York	33	12	2.08	1.50	6	37.48	27.00	1.14	0.82
M.B.	17	6	1.83	1.83	1	12.83	12.83	0.75	0.75
N.P.C.	47	20	2.05	1.70	7	55.35	45.90	1.18	0.98
Rapp.	93	45	2.22	2.09	9	119.98	112.81	1.29	1.21
F.B.	40	22	2.32	2.32	4	60.28	60.28	1.51	1.51
Pot.	47	26	2.12	2.04		55	53	1.17	1.13
Bay	87	15	2.33	2.07	23	88.59	78.61	1.02	0.90
Ocean	68	19	1.58	1.37	8	42.64	36.96	0.63	0.54
Total	445	170	2.09	1.91	58	476.22	435.78	1.07	0.98

*Data Excludes Manipulated Nests

except the Potomac River, show increased hatchling and fledgling production in 1973 when compared to the 1972 production results. Although the Potomac River had more fledglings per active nest produced in 1973 than in 1972, more hatchlings per active nest were produced in 1972 (1.46) than in 1973 (1.17). Statistically, the yearly differences in calculated hatchlings and fledglings per active nest vary significantly (Student's t-test for paired data; $p<0.05$ and $p<0.01$ respectively).

Another way of expressing production results follows the procedure of Reese (1970) and Wiemeyer (1971) and is presented in Tables 11a and 11b. The average number fledged per nest producing fledglings is higher in 1973 (2.08) than in 1972 (1.88). Also, the average number fledged per active accessible nest in 1973 (0.84) is higher than in 1972 (0.61). Statistically, the yearly differences between the average number fledged per active accessible nest is highly significant (Student's t-test for paired data; $p<0.01$). The best production in 1972 as measured by the average number fledged per active accessible nest was on the Rappahannock (0.85) and Potomac (0.93) subdivisions. In 1973, the best production rates were on the Rappahannock (1.12), Fleets Bay (1.42) and Potomac (1.13) subdivisions.

Minimal Rate of Change

The minimal annual rate of change in the Virginia osprey population for 1972 and 1973 is presented in Table 12.

Table 11a

REPRODUCTIVE SUCCESS OF ACCESSIBLE OSPREY NESTS IN TIDEWATER VIRGINIA, 1972*

1972 Study Area	Total Active Nests	Accessible Active Nests[1]	Nests Producing Hatchlings[2]	Hatchlings Produced	Nests Producing Fledglings	Percentage Hatchlings Fledged	Average # Fledged Per Nest Producing Fledglings	Average # Fledged Per Active Accessible Nest
J.R.	5	5	-	-	-	-	-	-
C.R.	14	14	2	3	2	100.0	1.50	0.21
York	27	23	6	14	6	85.7	2.00	0.52
M.B.	14	14	3	6	3	100.0	2.00	0.43
N.P.C.	43	41	19	42	16	78.6	2.06	0.80
Rapp.	91	80	43	82	37	82.9	1.84	0.85
F.B.	40	32	14	27	12	85.2	1.92	0.72
Pot.	16	15	9	21	7	66.7	2.00	0.93
Bay	50	34	5	9	4	88.9	2.00	0.24
Ocean	44	42	12	23	11	73.9	1.54	0.40
Total (%)	344	300 (87.2)	113 (44.3)	227	98 (32.7)	81.1	1.88	0.61

*Data Comparable with Data Presentation of Wiemeyer and Reese

[1]Excludes Manipulated Nests and Nests with Unknown Production

[2]Based on Accessible Active Nests

Table 11b

REPRODUCTIVE SUCCESS OF ACCESSIBLE OSPREY NESTS IN TIDEWATER VIRGINIA, 1973*

1973 Study Area	Total Active Nests	Accessible Active Nests[1]	Nests Producing Hatchlings[2]	Hatchlings Produced	Nests Producing Fledglings	Percentage Hatchlings Fledged	Average # Fledged Per Nest Producing Fledglings	Average # Fledged Per Active Accessible Nest
J.R.	4	4	-	-	-	-	-	-
C.R.	9	9	5	7	5	100.0	1.40	0.78
York	33	27	12	25	10	72.0	1.80	0.67
M.B.	17	16	6	11	6	100.0	1.83	0.69
N.P.C.	47	40	20	41	17	82.9	2.00	0.85
Rapp.	93	84	45	100	43	94.0	2.19	1.12
F.B.	40	36	22	51	22	100.0	2.32	1.42
Pot.	47	47	26	55	25	96.4	2.12	1.13
Bay	87	64	15	35	13	88.6	2.38	0.48
Ocean	68	60	19	30	15	86.7	1.73	0.43
Total (%)	445	387 (87.0)	170 (43.9)	355	156 (40.3)	91.6	2.08	0.84

*Data Comparable with Data Presentation of Wiemeyer and Reese

[1]Excludes Manipulated Nests and Nests with Unknown Production

[2]Based on Accessible Active Nests

Table 12

MINIMAL ANNUAL RATE OF CHANGE IN VIRGINIA

OSPREY POPULATION, 1972 and 1973 *

Study Area	Calculated Fledglings per Active Nest, 1972	Annual Rate of Change 1972**	Calculated Fledglings per Active Nest, 1973	Annual Rate of Change 1973**
J.R.	0.00	-18.5	0.00	-18.5
C.R.	0.21	-15.2	0.78	- 6.4
York	0.74	- 7.0	0.82	- 5.8
M.B.	0.43	-11.8	0.75	- 6.9
N.P.C.	0.85	- 5.3	0.98	- 3.3
Rapp.	0.94	- 3.9	1.21	+ 0.3
F.B.	0.90	- 4.5	1.51	+ 4.9
Pot.	0.97	- 3.5	1.13	- 1.0
Bay	0.67	- 8.1	0.90	- 4.5
Ocean	0.45	-11.5	0.54	-10.1
Total	0.74	- 7.0	0.98	- 3.3

* Refer to Text for equation and calculations

** Decline equals minus percentage; Increase equals plus percentage

In 1972 all the subdivisions show an annual rate of decline ranging from the lowest decline rate on the Potomac River (3.5%) to the highest measureable decline rate on the James River (18.5%). Additional high rates of decline for 1972 are the Chickahominy River (15.2%), Mobjack Bay (11.8%) and Ocean (11.5%) subdivisions. For 1973, the rate of change for the total study area is again a decline (3.3%) which is 47.1% less than the total study area rate of decline in 1972 (7.0%). Statistically, the two years differ significantly at the $p < 0.01$ level (Student's t-test for paired data).

Each subdivision has a lesser rate of change in 1973. The Rappahannock and Fleets Bay subdivisions show positive rates of change of 0.3% and 4.9% respectively. Mobjack Bay and the Chickahominy River do not show as high a decline rate in 1973 (6.9% and 6.4% respectively) as in 1972 (11.8% and 15.2% respectively). The Ocean subdivision again shows a high rate of decline (10.1%), and the James River remained at the highest computable decline rate (18.5%).

Banding Results

The number of ospreys color banded by month in each subdivision are tabulated for both years of the study (Table 13). Banding operations progressed from May through July during each year of the study with the majority of birds banded in June (78.1% in 1972 and 73.1% in 1973). Bands were applied to the legs of young not less than three weeks old and usually not more than seven weeks old, since

Table 13

NUMBER OF OSPREYS COLOR BANDED BY MONTH IN EACH STUDY AREA, 1972 - 1973

Study Area	1972 May	1972 June	1972 July	1972 Total	1973 May	1973 June	1973 July	1973 Total
J.R.	-	-	-	-	-	-	-	-
C.R.		3	-	3	7	-	-	7
York		11	2	13	5	15	4	24
M.B.		9	2	11	-	8	-	8
N.P.C.	-	32	8	40	2	43	9	54
Rapp.	10	45	4	59		57	32	89
F.B.		22	3	25		36	13	49
Pot.		14		14		52	-	52
Bay		6		6		23	6	29
Ocean	-	4	12	16	-	12	12	24
Total	10 (5.3)	146 (78.1)	31 (16.6)	187	14 (4.2)	245 (73.1)	76 (22.7)	335*

*29 Additional Birds Were Banded on the Patuxent River, Maryland, June 28, 1973

Numbers in Parentheses Indicate Percent of Yearly Totals

the younger nestlings more readily lost the bands from their smaller feet and the older fledglings would prematurely attempt flight from the nest in avoidance of the bander.

There were 551 aluminum and color band combinations attached to young during the two year study. In the ten Virginia subdivisions 187 combinations in 1972 and 335 combinations in 1973 were used, and 29 combinations were used in 1973 on birds banded in nests on the Patuxent River, Md.

Manipulation Experiments

1972

The results of the 1972 manipulation experiments are summarized in Table 14a. Twenty clutches averaging 3.2 eggs per clutch were removed from nests to the laboratory incubator between April 9 and April 23. Of the 63 eggs removed, 82.5% showed some embryonic development (Via, 1974). The adult pairs from 80.0% of these manipulated nest sites laid second clutches which average 2.5 eggs per clutch. Dates that the first egg of the second clutch was laid were obtained for eight of the renestings. The average was 23.5 days after removal of the first clutch; however two nests contained an egg 18 days after removal of the first clutch.

Eleven chicks hatched from the laboratory-incubated eggs for a production rate of 0.55 hatchlings per nest. This figure is well below the 1972 total study area average of 0.92 calculated hatchlings per active nest. Also the production rate from each group of experimental nests is

Table 14a

COMPARISON OF FIRST AND SECOND CLUTCHES OF EXPERIMENTALLY MANIPULATED OSPREY NESTS, 1972

Study Area	Nest Number	FIRST NESTING Clutch Size	Percent With Embryonic Development	Hatchlings Produced Per Nest	Fledglings Produced Per Nest	Renest	SECOND NESTING Clutch Size	Hatchlings Produced Per Nest	Fledglings Produced Per Nest
York	CB-6	3	66.7	0	0	Yes	2	0	0
	CB-13	3	100.0	0	0	No	-	-	-
	Average	3	83.3	0	0	50.0%	0	0	0
Fleets Bay	FB-14	3	100.0	0	0	Yes	3	2(66.7)	2(66.7)
	FB-24	3	100.0	1(33.3)	0	Yes	2	0	0
	FB-28	3	100.0	0	0	Yes	2	1(50.0)	1(50.0)
	FB-34	3	66.7	0	0	No	-	-	-
	Average	3	91.7	0.25	0	75.0%	2.3	1.00	1.00
Mobjack Bay	Mat-31	3	100.0	0	0	Yes	3	2(66.7)	2(66.7)
	NPC-32	3	100.0	1(33.3)	1(33.3)	Yes	2	2(100.0)	2(100.0)
	WN-1	3	100.0	0	0	Yes	2	1(50.0)	1(50.0)
	Average	3	100.0	0.33	0.33	100.0%	2.3	1.67	1.67
New Point Comfort	Mat-4	3	66.7	1(33.3)	0	Yes	3	2(66.7)	2(66.7)
	Mat-7	4	75.0	1(25.0)	0	Yes	2	0	0
	Mat-10	4	75.0	0	0	Yes	3	0	0
	Mat-11	3	66.7	0	0	Yes	2	1(50.0)	1(50.0)
	Mat-24	3	100.0	2(66.7)	0	Yes	2	2(100.0)	2(100.0)
	NPC-16	3	100.0	2(66.7)	0	Yes	3	3(100.0)	3(100.0)
	NPC-17	3	100.0	2(66.7)	0	Yes	3	2(66.7)	2(66.7)
	NPC-23	3	0.0	0	0	Yes	3	0	0
	NPC-35	4	75.0	1(25.0)	0	Yes	3	1(33.3)	1(33.3)
	NPC-40	3	66.7	0	0	No	-	-	-
	NPC-43	3	100.0	0	0	No	-	-	-
	Average	3.3	75.0	0.82	0	81.8%	2.7	1.22	1.22
	Total Average	3.2	82.5	0.55	0.05	80.0%	2.5	1.19	1.19

Numbers in Parentheses Indicate Percent Produced per Nest

below the control production rate from the corresponding subdivision. For example, the clutches collected from the New Point Comfort subdivision produced an average of 0.82 hatchlings per nest while 1.08 calculated hatchlings per active nest (Table 10a) were produced in non-manipulated nests in the New Point Comfort subdivision.

Only one experimental hatchling survived to fledge for a production rate of 0.05 fledglings per experimental nest. Six hatchlings died within one day after hatching, two hatchlings died in the environmental growth chamber ten days after hatching, and two more hatchlings died in the field after introduction into foster nests at 8 days and 20 days after hatching.

The 16 second clutches were monitored in the field (Table 14a) and were found to produce 1.19 hatchlings and 1.19 fledglings per renest. Six of the clutches which produced hatchlings from incubation in the laboratory also produced hatchlings from second clutches in the field. Nests, from which three of the laboratory-incubated clutches were taken and which failed to produce any hatchlings, subsequently produced second clutches which also failed to produce any fledglings when incubated in the field. Two of the clutches which produced hatchlings from the laboratory incubation failed to produce any hatchlings from the field-incubated second clutches. Five of the field-incubated second clutches produced hatchlings although the laboratory-incubated first clutches failed to produce any hatchlings.

The 11 Potomac River clutches collected and flown to New Jersey on April 20, 1972, averaged 3.0 eggs per clutch (Table 14b). Five eggs hatched from three clutches and four of the hatchlings successfully fledged. The resulting 0.45 hatchlings and 0.36 fledglings per nest is below the Potomac River control nests for 1972 (1.46 calculated hatchlings and 0.97 calculated fledglings per active nest, Table 10a).

Nine of the 11 adult pairs (81.8%) laid second clutches which averaged 2.7 eggs per clutch. One egg from the second clutches hatched and subsequently fledged for results of 0.11 hatchlings and 0.11 fledglings per second nesting. The three clutches which produced hatchlings from laboratory incubation failed to produce hatchlings from the field-incubated second clutches. Five pairs failed to produce any hatchlings from either first or second clutches. The one pair which produced a hatchling from the field-incubated second clutch had failed to produce hatchlings from the laboratory-incubated first clutch.

When the 1972 experimental nests were separated into two groups based on the previous known reproductive success of birds at these sites, different results were evident. Nests with a history of success produced 28 hatchlings and 18 fledglings from 26 clutches (13 first and 13 second), while nests with an unknown history or a history of failure produced eight hatchlings and seven fledglings from 30 clutches (18 first and 12 second). Averages for the 56 clutches are 0.64 hatchlings and 0.45 fledglings per clutch.

Table 14b

COMPARISON OF FIRST AND SECOND CLUTCHES OF EXPERIMENTALLY MANIPULATED OSPREY NESTS, 1972

(POTOMAC RIVER OSPREY CLUTCHES COLLECTED BY PAUL SPITZER)

			FIRST NESTING				SECOND NESTING		
	Nest Number	Clutch Size	Percent With Embryonic Development	Hatchlings Produced Per Nest	Fledglings Produced Per Nest	Renest	Clutch Size	Hatchlings Produced Per Nest	Fledglings Produced Per Nest
V-1	Yeo-10	3	-	2(66.7)	1(33.3)	Yes	3	0	0
V-2	Yeo-11	3		0	0	Yes	2	0	0
V-3	Blak-1	3		0	0	Yes	3	1(33.3)	1(33.3)
V-4	Yeo-8	3		0	0	No	-	-	-
V-5	Yeo-7	3		0	0	Yes	2	0	0
V-6	Yeo-4	3		0	0	Yes	3	0	0
V-7	Yeo-2	3		0	0	No	-	-	-
V-8	Yeo-1	3		2(66.7)	2(66.7)	Yes	3	0	0
V-9	Heath-2	3		1(33.3)	1(33.3)	Yes	3	0	0
V-10	Heath-6	3		0	0	Yes	3	0	0
V-11	Heath-7	3	-	0	0	Yes	2	0	0
Total Average		3	Unknown	0.45	0.36	81.8%	2.7	0.11	0.11

Numbers in Parentheses Indicate Percent Produced per Nest

1973

Table 14c summarizes the manipulation experiments for 1973. All manipulated clutches collected from Milford Haven April 29, 1973 were three-egg clutches and were productive when incubated in foster nests. Embyronic development was 100% in six of the seven manipulated clutches; embryonic development was probably 100% in the seventh clutch, however egg disappearance between visits prevented certain determination. Eighteen young hatched and 15 fledglings survived from these first clutches, averaging 2.57 hatchlings and 2.14 fledglings per nest.

Six of the seven (85.7%) adult pairs laid second clutches which averaged 2.8 eggs per clutch. Four of the second clutches were productive, producing seven hatchlings and six fledglings for an average of 1.17 hatchlings and 1.00 fledglings per second clutch. Combining production for first and second clutches, 25 hatchlings and 21 fledglings were produced from 13 clutches (seven first and six second) for average of 1.92 hatchlings and 1.62 fledglings per clutch.

The laboratory-incubated clutches, which were presumably from nonproductive breeding adults, hatched six chicks from four different clutches. Three of the hatchlings survived in the field and were banded as fledglings. The other three died soon after placing in foster nests, apparently from a combination of causes, the most crucial being several severe thunderstorms that occurred soon after

Table 14c

COMPARISON OF FIRST AND SECOND CLUTCHES OF EXPERIMENTALLY MANIPULATED OSPREY NESTS, 1973

	FIRST NESTING					SECOND NESTING		
Nest Number	Clutch Size	Percent With Embryonic Development	Hatchlings Produced Per Nest	Fledglings Produced Per Nest	Renest	Clutch Size	Hatchlings Produced Per Nest	Fledglings Produced Per Nest
Mat-2	3	100.0	3(100.0)	3(100.0)	Yes	3	2(66.7)	2(66.7)
Mat-3	3		1(33.3)	1(33.3)	Yes	3	2(66.7)	2(66.7)
Mat-4	3	100.0	3(100.0)	3(100.0)	Yes	3	2(66.7)	2(66.7)
Mat-13	3	100.0	3(100.0)	3(100.0)	Yes	3	1(33.3)	0
Mat-20	3	100.0	3(100.0)	3(100.0)	No	-	-	-
Mat-24	3	100.0	2(66.7)	STOLEN	Yes	2	0	0
Mat-32	3	100.0	3(100.0)	2(66.7)	Yes	3	0	0
Total Average	3	Assume 100.0	2.57	2.14	85.7%	2.8	1.17	1.00

Numbers in Parentheses Indicate Percent Produced per Nest

transferal.

Weights and food intake of the 1972 and 1973 laboratory-incubated hatchlings are presented in Table 15. The 1972 average hatching weight is 44.6 grams (gm). Five hatchlings survived beyond the first day after hatching and these chicks showed average weight gains ranging from 6.9 gm to 11.5 gm per day. Average food intake for these five hatchlings ranged from 24.4 gm to 38.8 gm per day.

In 1973, the average hatching weight of the six laboratory-incubated hatchlings was 44.0 gm. Of particular note is the weight (33.0 gm) of the hatchling (HI-1-1) from the laboratory-incubated clutch removed from the nest near Jamestown Island. This hatchling is the first known hatchling from the James River in at least four breeding seasons. Appendix Table 3 gives a summary of 1973 nestling weights from field-reared hatchlings.

Table 15

LABORATORY HATCHLING WEIGHTS, 1972 - 1973

Hatchling	Hatching Weight	Net Weight Gain	Average Weight Gain per Day	Average Food Intake per Day	Number Laboratory Feeding Days
1972					
A	45.6[1]	126.3	11.5	38.8	11
B	44.1	0.4	0.4	4.3	1
D	40.6	-1.5	-1.5	21.0	1
G	46.4	71.9	7.2	33.1	9
H	44.3	67.5	9.6	31.6	7
I	40.5	-2.8	-2.8	2.3	1
J	41.8	50.4	8.4	28.6	6
K	46.7	27.5	6.9	24.4	4
L	45.3	-0.5	-0.5	9.2	2
M	48.0	-0.5	-0.5	3.7	1
N	47.8	-0.1	-0.1	6.0	2
Average	44.6				
1973					
CB-5-1	45.1				
CB-5-2	47.2				
Mat-10-1	43.1				
CB-3-1	47.6				
CB-3-2	47.8				
HI-1-1	33.0				
Average	44.0				

[1]Weights in grams.

DISCUSSION

The Tidewater Virginia osprey population has shown reproductive increases each year since 1971. The number of hatchlings fledged in 1972 and 1973 increased over the number fledged in 1971, and the 1973 reproductive rates are the most successful of any year from 1970 through 1973. However, present reproductive rates do not equal the success measured in Northumberland County, Virginia in 1934, when 70 fledglings were produced in 41 nests (nests where first clutches were taken are omitted) for averages of 1.71 fledglings per active nest and 2.06 fledglings per productive nest (adapted from Tyrrell, 1936). Further the current reproductive success is below the level of 1.22-1.30 young produced per active nest that has been calculated as the reproductive output necessary to maintain population stability (Henny and Ogden, 1970). Based on current reproductive success, the calculated minimal annual rate of change predicts a decline for the Virginia osprey population. But because the 1973 decline rate (3.3%) is significantly less than the 1972 decline rate (7.0%), and because 1972 and 1973 are consecutive years of reproductive improvement, the Virginia osprey population as a whole may be showing signs of improvement due to the discontinued usage of DDT in the state.

Four subdivisions in the present study area show particularly poor reproductive results. The James River produced no hatchlings in 1972 and 1973 making a total of at least four consecutive years without a single bird produced. The Chickahominy River and Mobjack Bay showed poor fledging success for both years, although both showed slightly better production in 1973 than in 1972. The Ocean side of the Eastern Shore also showed poor fledging success for both years, with some improvement in 1973.

The sport and recreational activities in all four of the above subdivisions are seasonally heavy. Skiing is particularly concentrated on the Chickahominy River where the ospreys build in Bald Cypress trees situated out in the river. Boat traffic comes near the nest trees and repeatedly causes the incubating or brooding female to fly off and attempt returns to the nest.

Fishing and crabbing are large businesses and sports in Virginia where seasonally the tourist and meatpacking industries are extremely active. Especially good fishing and crabbing are found in all four of the above subdivisions where osprey reproductive success is the poorest. Often boats are observed anchored at or tied onto the nesting structure with the adult female circling overhead. Also each season several nestlings are found absent from nests that during previous visits were in perfectly good condition. Possibly they became the souvenir of some curious passerby.

An indicator of Virginia osprey population reproductive success is found in the nest density measurements. The overall population density increased 19.4% from 1972 to 1973 with six of the ten subdivisions showing increases. The Potomac River is the one subdivision where more intensive surveillance probably resulted in substantial increases in the nest density recorded. The James River and Bay and Ocean sides of the Eastern Shore show the lowest nest densities, but only the James River does not show increased production rates in 1973 over those in 1972. Nest density of the Chickahominy River and Mobjack Bay decreased from 1972 to 1973, which would be expected with the high minimal annual rate of decline calculated for both of these subdivisions in 1972. The high minimal annual decline rate for the Ocean side of the Eastern Shore is not reflected in a decrease in nest density partly because of increased surveillance in this subdivision. The large minimal annual decline rate for the James River is also not reflected in decreased nest density; two reasons for this apparent discrepancy are: first, the minimal annual rate of change formula measures decline only up to 18.5%; and second, the small number of nests still on the James River are the remnants of a population that has drastically collapsed and these few remaining nests do not reflect a decline in nest density.

Although increases from 1972 to 1973 in total nest density correlate positively with increases in total calculated hatchlings and fledglings per active nest, the relationship does not hold for individual subdivisions within the study area. For example in the Mobjack Bay subdivision, there was a small decrease (10.5%) in nest density from 1972 to 1973, but calculated hatchlings and fledglings per active nest increased 74.4% from 1972 to 1973. Nest density does reflect fluctuations in reproductive success and possible movements within the study area. But, population numbers as measured by nest density are not the total reason for reproductive success or failure.

The average number of eggs per clutch and the average number of hatchlings produced per productive nest were essentially the same in 1972 and 1973. Further, these averages have remained consistent with clutch and hatchling averages reported by Tyrrell (1936) and Bent (1937) from records prior to the pesticide era. Therefore, with constant clutch size, hatchling production and nestling mortality, the point at which reproductive failure appears to occur is in the large number of eggs which fail to hatch in the population. Disappearance of eggs between survey visits without a definite reason for loss constituted the major category of egg loss and the number of eggs found rotten in the nest was yearly a large percentage of egg loss.

The condition of the eggshell has been suggested as a possible reason for poor reproductive success. Porter and Wiemeyer (1970) and Peakall (1970) have documented the effect of DDE on eggshell thickness. Kennedy (1971) reported a 15.7% average eggshell weight decrease for Virginia osprey eggs measured in 1970 and 1971 when compared to eggs collected prior to the widespread use of DDT. Spitzer (1970) reported that although some Connecticut osprey eggs show eggshell thinning of up to 25%, some eggs showing no such reduction contained dead embryos. This phenomenon was also reported by Via (1974), when no correlation was found between hatching success and eggshell thickness for Virginia osprey eggs from the 1972 breeding season. However, Via (1974) found that eggs with no embryonic development and eggs from nests where no hatchlings were produced showed the highest DDE levels.

Another possible reason for poor reproduction may be the relative success of ospreys utilizing the various nesting structures. About half of all nest sites were productive during both years of the study, but for both years the number of fledglings produced from man-made nesting structures was about four times greater than the number produced from natural nesting structures. Also, for both years, the fledging rate for nests on man-made nesting structures is about three times greater than the rate for nests on natural nesting structures.

Percentages of man-made nesting structures used by ospreys have steadily increased since 1970. Kennedy (1971) found a slight increase (2.7%) in the use of man-made structures from 1970 to 1971. The number of such structures being used as nest sites increased 12.9% in 1972 ad 22.0%

in 1973 over the 1970 total.

Because most man-made nesting structures are built off-shore and most natural nesting structures are on-shore, it is important to consider this factor in light of the increased reproductive success found. The availability of natural nesting sites may be steadily declining because of increased shoreline development, thus forcing the osprey onto more available sites off-shore. This condition is evident in Virginia where the human population for those counties bordering the study area has increased about 14% between 1962 and 1972 (University of Virginia 1962, and U.S. Department of Commerce 1973). Ames and Mersereau (1964) describe a similar loss of tree nesting sites in Connecticut. The increased demand for navigable channels for recreational and commercial boating has resulted in construction of more permanent aids to navigation such as day markers and lighted beacons. Duck hunting is responsible for construction of off-shore permanent duck blinds which annually increase 2-5% (Virginia Commission of Game and Inland Fisheries, personal communication July, 1974). Therefore, the increase in off-shore structures coupled with the osprey's adaptability for change enables the gradual shift from on-shore structures to those off-shore.

Further investigation is needed to determine the reasons for this trend toward off-shore nesting sites. The prominence of land predators has been suggested by Reese (1970, 1975) as a possible limiting factor to successful land nests. Therefore, a series of predator-proof trees should be studied to determine any improvement in reproductive rates.

One possible reason for the large increases in off-shore nesting sites and reproductive success during 1972 and 1973 may be the policy change augmented in March, 1972, by the Fifth Coast Guard District which covers the present study area. Present policy directs that aids to navigation which also serve as nesting sites for the osprey are to be protected by the Coast Guard and in the event such nests obscure visibility of navigation aids, temporary aids are to be erected until removal of the nest structure at the end of the breeding season (U.S. Coast Guard 1972). Before augmentation of this policy, the individual Coast Guard stations approached the problem of obscured navigational aids in different manners. Some notably did not disturb the nest and nest contents during the breeding season; upon the insistence of the public, some removed nests that blocked crucial aids and put nest contents in adjacent nests; but most drastic were the stations which blatantly removed all nests and nest contents from all navigation aids.

Annual comparisons from 1970 through 1973 plus statistical analysis of 1972 and 1973 data for each geographic subdivision suggest that each subdivision is unique. For example, the New Point Comfort subdivision varied from the total four year trend with the highest fledging success in

1971 and the lowest in 1972. This uniqueness points out the possibilities for erroneous population assumptions and predictions when estimates are based on individual bay, river, or estuary results. Further, by measuring only the success of accessible nests and those nests which were inaccessible but intensively studied with binoculars, the number of inaccessible nests where production outcome was not directly measurable are ignored and omitted from total reproductive success. Although this method does employ the sample technique which is basic to biological analysis, and does give a figure for productivity that is a reasonable estimate of what is occurring in the population, it does not give the closest possible estimate of population production numbers. The technique employed in osprey studies at William and Mary has been used to survey the study area more thoroughly each successive year and therefore each year it has more closely measured the total population in terms of total nests, adult breeding pairs, egg numbers, hatchling numbers, and fledgling success. Some nests undoubtedly are missed even with the most intensive survey, but the percentage missed is small and can only slightly affect the total production results. The production results of a single bay or estuary may vary from year to year as well as from adjacent bay and estuary populations. Such production results may not, therefore, be indicative of the total population of a region such as the northern Chesapeake Bay or the state of Virginia. More accurate population status values are attainable when several bays, rivers, and estuaries are grouped and all nests whether accessible or not are considered.

Of the last four consecutive years, 1973 showed the best reproductive rates, 1970 showed the next best rates, and 1971 showed the worst. Comparison of the data for Virginia with data collected by Reese (1975) on Maryland's Eastern Shore and Wiemeyer (1971 and personal communication 13 March 1975) on the Maryland shore of the Potomac River seems to indicate a general trend toward improved reproduction in 1973. Further, this trend points out the erroneous conclusion a one year study may provide about the overall population status when the reproduction rates fluctuate annually.

Manipulation techniques can effectively improve reproduction of osprey populations when histories of specific nest sites are available. Those nest sites chosen during 1973 for the double-clutching experiment had successfully produced young during at least one previous year. Reproductive histories are based on a particular nest site that has been occupied by presumably the same breeding pair for several years. Bent (1937) believes that ospreys are mated for life.

Manipulation of first clutches does not guarantee laying of second clutches. Although first clutches were taken as close to clutch completion as possible each year of the experiment, six of 31 pairs of breeding birds in 1972 and one of seven pairs of breeding birds in 1973 did not lay second clutches. But notably, the six pairs of breeding birds which failed to lay second clutches in 1972 had unknown reproductive histories or histories of failure.

Incubation of eggs by foster birds is more successful than artificial laboratory incubation. In 1973 when seven clutches from previously successful nests were transferred to seven previously unsuccessful nests, the hatching rate averaged 2.57. In 1972 using only those eggs from nests with a history of success, the hatching rate in the laboratory was 0.85.

The major benefits of the double-clutching technique applied to adult pairs with a history of reproductive success are the inclusion of more potentially productive eggs in the population, therefore increasing reproduction, and furthering the pair bond between breeding pairs which have had a history of failure.

The 1973 fledging success of birds incubated and reared by foster birds was greater than the 1972 fledging success of birds successfully hatched in the laboratory and fed in the environmental growth chamber. In 1972, 11 birds hatched from 63 eggs in the laboratory incubator and hatcher apparatus, but only one successfully reached fledgling age. In 1973, 18 birds hatched from 21 eggs with foster bird incubation and 15 reached fledgling age. Physical abnormalities, possibly the result of excessive moisture retention in the laboratory-incubated eggs during 1972, as well as sickness and disease in the environmental growth chamber, severely reduced fledging success of those birds hatched under laboratory conditions.

Results from those eggs flown to New Jersey and incubted at Rutgers University agree with those obtained at William and Mary (Spitzer, personal communication 25 January 1973). From 11 clutches taken, 1.45 hatchlings per nest were hatched in the incubator. Four of five hatchlings successfully reached fledgling age. However, Spitzer introduced the newly hatched chicks into foster nests the day of hatching, a method which could reduce disease and sickness encountered with laboratory-reared hatchlings.

The 1972 and 1973 data on clutch size agree with Kennedy's (1971) conclusions that second clutches are smaller in number. However the success of second clutches does not always surpass that of the first as displayed by 1973 data where a 46% decrease over first clutch hatching success occurred. The 1972 data do agree with those of Kennedy (1971) where the second clutches produced more hatchlings per nest than first clutches, but first clutches were laboratory-incubated in both samples. It appears that the tremendous number of variables introduced with laboratory incubation of osprey eggs may reduce the overall effectiveness of the double-clutching technique when utilizing mechanical incubators for collected eggs. Transplanting of eggs to the nests of other females for incubation is much more successful and could be the basis for a satisfactory technique of enhancing osprey productivity.

APPENDIX

Appendix Table 1

NUMBER OF ADDITIONAL NESTS IN STUDY AREA SUBDIVISIONS

FOR WHICH NO DATA ARE AVAILABLE, 1972 and 1973

Study Area	Additional Nests 1972	Total Nests 1972	Additional Nests 1973	Total Nests 1973
J. R.	-	5	-	5
C. R.	-	14	-	9
York	-	29	2	38
M. B.	2	19	-	17
N. P. C.	-	54	2	60
Rapp.	7	98	8	101
F. B.	1	45	-	40
Pot.	-	27	12	59
Bay	11	61	1	88
Ocean	11	55	1	69
Total	32	407	26	486

Appendix Table 2

TYPES OF OSPREY NEST STRUCTURES CLASSIFIED AS "OTHERS", 1972 - 1973

Description of Nest Structure	1972	1973
Utility Poles	9	16
Groups of Pilings	7	6
W&M Aluminum Platforms	7	8
Abandoned Dock	4	5
Active Dock	2	2
Man-made Platforms	1	8
Flood Light Poles	2	2
Marsh Shack Roof	3	5
Abandoned Fuel Platforms	3	3
Group of Oystersticks	2	3
Abandoned Water Tower	2	2
Abandoned Radar Tower	1	1
Abandoned Observation Tower	1	4
Abandoned Airport Beacon	1	1
Coast Guard Tower	1	3
VEPCO Powerline Tower	1	1
Measurement Station Platform	1	2
Boathouse Roof	2	1
Chimney of House	1	1
Abandoned Chimney	1	1
Bridge Span	1	1
Sunken Boat	1	1
Tar Platform	1	1
Generator Shed	-	1
Ground Nest	-	1
Total	55 (14.7)	80 (17.4)

Numbers in Parentheses Indicate Percent of Total Nests Studied

Appendix Table 3

NESTLING FIELD WEIGHTS - 1973

Estimated Age (days)	n	Weight Average (gm)
1	1	48.0
2	6	47.7
3	2	49.0
4	6	60.2
5	3	120.0
6	5	123.6
7	1	200.0
8	2	165.0
10	5	236.2
12	5	303.0
14	5	417.0
16	1	505.0
18	5	496.0
20	3	536.7
22	2	612.5
24	1	590.0
26	1	700.0

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